WORKING WITH LOCAL KNOWLEDGE SYSTEMS IN A GIS FOR NATURAL RESOURCE ASSESSMENT, PLANNING AND MANAGEMENT IN NORTH CENTRAL NAMIBIA

by

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Participatory rural appraisal work indicated that there exists an elaborate indigenous knowledge system in North Central Namibia on the environment resulting in a classification of land units that serve various purposes. This recognition was followed up by a study exploring the possibility of linking this indigenous knowledge system with conventional scientific classifications and observations in a participatory GIS. The linkage was possible and it appeared that the presence, distribution and abundance of the land units, eventually mapped out using Landsat TM imagery, are more decisive factors in farmers' resource management strategies than previously thought. The knowledge appeared to be not gender, wealth or age specific and very widespread. The local knowledge systems do not differ to a great extent from conventional knowledge. The approach improved the understanding of rural livelihood strategies at individual and community level and pointed to the importance of rules and norms for the management of resources in shortage that were previously not recognised. Those norms are adapted to changes in local conditions with respect to rainfall, water availability, grazing and new opportunities. The norms point to the existence of a social organisation within communities regarding use and control of resources. Further work should explore the possibility of strengthening the local social organisation to control and manage natural resources, as part of development projects and local government initiatives.

1. INTRODUCTION

1.1. Study area

Northern Namibia is a relatively densely populated (12.9 people/sq. km with a central area having over 90 people/sq. km) communal area bordering with Angola. It is situated in the Cunene River basin, is part of the Mega Kalahari basin and has a unique fluvial/aeolian environment on the west coast of Southern Africa. The central portion of the area is occupied by a low-angle alluvial fan system (the Oshanas) in Southern Africa, formed possibly much like the present Okavango (McCarthy 1993). The eastern and western portions are covered by linear Kalahari dunes or dune remnants.

North Central Namibia was a main area of armed conflict for over 20 years before independence in 1989. Consequently, little development work to benefit local communities could be undertaken and the area remained largely neglected until after independence.

1.2. Environmental and socio-economic profile

The main environmental constraints identified in the region are:

- lack of perennial surface water resources within the region
- low and often erratic rainfall with a very long dry season
- high potential evaporation rate
- most arable areas are covered with sandy soils with low fertility, low water retaining capacity and deficiency in some important nutrients
- high salinity of soils in many seasonally flooded oshanas and pans
- limited resources of potable groundwater and high salinity of deep groundwater in the Cuvelai basin area

The most important natural resources that people depend on are:
- fresh and potable water
- grazing for livestock
- suitable soils for crop cultivation
- trees for firewood, construction, fodder and edible fruits
- fish in 1 out of 3 years

High population pressure results in the following environmental problems:
- deforestation in most densely populated areas
- local depletion of grazing land around water points and pipelines
- unplanned development of water points
- declining soil fertility in cultivated croplands due to land shortages
- changes and disturbances to surface flows in oshanas due to infrastructural developments
- unsustainable use of groundwater resources in some areas
- contamination of surface waters due to human and animal waste
- uncontrolled accumulation of solid waste and rubbish within and around settlements and in oshana beds
- the virtual disappearance of wildlife as a major resource
- uncontrolled fires in specific livestock areas away from the Oshanas

Socio-economically, the land-use system can be characterised as an agro-silvo-pastoral system that combines crop cultivation, livestock rearing, management of trees that provide edible fruits, fodder, construction and firewood. Diversification is a major strategy in coping with low soil fertility and high uncertainty (climate, economy).

Since the beginning of this century an important element in the central northern economy has been migrant labour. This transition from subsistence to a cash economy leads to increased pressure on women and increased dependence of income from employment. There is a breakdown of the extended family, based upon matrilineal descent, leading to reduced support systems, essential during droughts, and to a culture of independence in which some families do well and become rich, while others fail and become poor. In the regions, a lot of exchange of goods and services is done by bartering without money, although the extent is unknown. Although the contribution of agriculture to GDP is small, an estimated 70 %, mostly women, depend to a greater or lesser extent upon it. An estimated 40 % of the households are female-headed. Unemployment is estimated to be as high as 45 % in the rural areas. Households without off-farm income are stuck in a poverty trap in the central area. Individual household strategies to cope with these changes have not been studied thoroughly.

More and more cattle are owned by fewer people, and it is estimated that 50 % do not own cattle. Larger herds are generally considered less productive, although it appears that in the fenced areas a trend towards commercial ranching is present. Traditional transhumance systems have broken down to a high but unknown extent because of the development of water supply systems and fencing of huge portions of traditional dry season pastures. The ripple effect originating from the restriction of boreholes and grazing land through large-scale enclosure is inducing some communal farmers to more closely define their own property rights in relation to water and grazing land. It is likely that these changes in livestock management are affecting and changing the environment to a great extent.

The unclear status of land tenure and resource usage rights is thought to lead to abuse of common resources, especially of common woodlands, water and grazing land. The introduction of secure, exclusive tenure at the community level is considered the most important policy reform needed. Local bodies capable of sustainable management of natural resources within their community should be strengthened.

Opportunities lie in the region of improved environmental management and land-use planning. Legal and institutional frameworks for effective land-use planning are still rather weak in Namibia, as is environmental awareness. However, there appear to be no major institutional constraints to initiate a planning process by starting to develop the professional capability to carry out the tasks involved in overall land-use planning and development of the institutional framework. The lack of information-sharing is seen as a major stumbling block in sustainable environmental planning and management.

1.3. Institutional background

The Northern Regions Livestock Development Project (NOLIDEP) is a 7 years programme started in 1995. It works in the 4 Northern Communal Areas bordering with Angola. Its budget is provided by the Government of Namibia, IFAD, the Governments of France, Belgium, and Luxembourg, as well as by the involved communities themselves. The NOLIDEP operates with the Directorates of the MAWRD (Ministry of Agriculture, Water and Rural Development of Namibia).

The NOLIDEP aims at improving people welfare through livestock development, through 5 main components, of which the development of sustainable management of pastoral resources by communities themselves (water point development, range management, etc.) is the most important for the present study.

The Northern Namibia Environmental Project (NNEP) is a 3.5 years project of the DfID (British Co-operation) started in 1997. It works in North

Central Namibia in the most populated communal area formerly called "Owamboland". The NNEP aims more generally environmental sound management practices of natural resources at regional and local (community level). The NNEP has established a Planning Resource Center within the Ministry of Environment and Tourism (MET) providing the various Ministries with various databases on issues of their concern, especially through the use of Geographic Information Systems (GIS).

At its inception, NOLIDEP was supposed, according to the initial design by IFAD, to extend techniques used in private commercial farms. However, it was soon realised that this approach was not suitable to the situation.

Based upon the technical assistance assessments, an approach has been chosen allowing technicians and farmers to comprehensively and jointly address the main constraints and opportunities, based on the assumption that "farmers have good reason to do what they are doing", due to the knowledge of their environment they have got. As a result, the project started relying at an early stage on indigenous knowledge of the farmers.

As part of the Farming Systems Research and Extension, an approach involving Community Based Organisation (CBO) is preferred, as part of devolving authority of resources to the local communities.

A decentralisation process has started in Namibia with handing over more power to regional governments. For example, a far-reaching decentralisation process has started in the Department of Rural Water Supply with the final aim of handing over responsibility, management and maintenance of all rural waterpoints to communities.

1.4. Integrating local knowledge for resource management and planning

NNEP had quickly success in addressing the needs for information at higher decision making levels at national and regional local government levels, but was much slower in reaching farmers and communities with the information. The main reason is that only little research work has been undertaken to date to develop a community-integrated GIS (Abbot et al. 1998). Initial work concentrated on improving maps produced during Participatory Rural Appraisal (PRA) work in order to integrate the information into a land information system. Aerial photographs and GPS were the main tools to improve the diagrams drawn by people. This resulted in scaling up of most of the locally obtained information through Participatory Rural Mapping (PRM) due to the higher precision and scale of the GIS. However, the need to develop a true community-integrated GIS was recognised in the early stages of the project. Capturing local knowledge and integrating this in a GIS is one step in such a process. Such a participatory GIS could simply be extractive and not empower local voices to more effectively influence policy (Abbot et al, 1998). A GIS can turn local knowledge out of local control, as it might distribute the extracted information without permission. The approach we followed here was to develop such a GIS together with strong communities, together with community based projects who were working with CBOs or in the process of establishing these. This ensured the local control of the GIS products. During our field work, we found that the local or regional wealthy had long before us worked with information obtained from local people to their own benefit. This leads to the suggestion that a wider distribution of local information, controlled by communities could empower, rather than disempower.

A breakthrough in the approach of working with local knowledge on the environment for a community-integrated GIS came through a collaboration between NOLIDEP and NNEP in 1998 in a grazing management study (Dayot & Verlinden, in press). This was expanding previous research work carried out by Dayot (1998), Rigourd et al (1998) and Shitundeni & Marsh (1998) in farming systems studies and local tree management studies where local names were noted that were thought to represent soils. Although some names indeed represent soils, some field work and training sessions with extension staff carried out at the same time by NNEP indicated that the names represented the way the farmers see their own environment and that the names are part of a more holistic knowledge system of the environment than a soil classification system, a notion also put forward by Dayot (1998). Rather than trying to translate the units in western concepts on the environment, an approach was developed to describe the units in detail in a participatory way. Most units found so far can be best understood as representing a landscape. Interestingly, in contrast with the soil names that only relate to particular uses and do not cover all soil types, local people classify all the land into landscape units that serve various purposes. They differ in suitability for resource use and are recognised on the basis of vegetation structure, geomorphology, soils and sometimes indicator species. It was established during discussions with communities and key informants that resource management and management strategies vary according to the presence, abundance and geographical distribution of these units. Initial tests with a limited number of descriptions suggested that the land units could be scientifically described, analysed and possibly even mapped using high-resolution satellite imagery, as Landsat TM imagery is good in capturing vegetation structure. This initial work was expanded to 5 pilot communities in 1999 to cover more agro-ecological zones and more local language groups.

Central to the approach followed here is an attempt to describe and analyse the local knowledge with scientific methods. If this could be done, the comparison with the indigenous and conventional knowledge systems becomes possible. The indigenous knowledge enables to understand better the local constraints and opportunities, while the conventional knowledge systems allow information transfer to the local farmers from similar, better known environments elsewhere. The comparison would also improve the discussion and knowledge transfer between scientists, extension technicians and farmers.

As it appeared that the geography and distribution of the land units is important in resource management decisions and management strategies at local level, mapping these units becomes crucial in understanding the management and resource use at community level. The work presented here explored the possibility of mapping of the local land units using Landsat TM imagery and the possibility of linking the local classifications with the Geographical Information System (GIS) being set up for North Central Namibia. Furthermore, because land units serve various purposes or are characterised by various potential uses, the potential of deriving thematic maps to assess the quality and the distribution of the resources according to farmers' point of view was explored.

Integrating the indigenous knowledge of natural resource management within a broader socio-economic framework in the GIS could result in several practical management applications to assist rural development and improve the livelihoods of rural people that would otherwise be very difficult to obtain.

The approach followed here also concentrated on linking the findings of the study with practical management implications. Most of these emerged during discussions at various stages with the local people. Initially, work concentrated on integrating information from communities in the GIS and on information exchange, but not on implementation of management options to improve rural livelihoods. Work has recently started on those topics, although it was outside the scope of the initial study.

2. METHODOLOGY

Preliminary field work indicated the need of an ecological approach to the identification and description of the local landscapes, in addition to the participatory appraisal of the various uses of the units. As this appraisal needs travel, working with an entire community in the field was not feasible. It was decided to work with communities that were already in the process of mobilisation and were working with development projects like NOLIDEP and NNEP. At least one of the researchers and many outside team members were known to the 5 communities and farmers during work carried out previously (Dayot, 1998, Dayot & Talavera, 1998).

Field work started with discussions with community leaders leading to identification of key informants to work with in the field. The team consisted of an agronomist, an ecologist/GIS specialist, a representative of MET, representatives of MAWRD, NOLIDEP, extension technicians of the area, a facilitator and key informants. The key informants took the team to examples of local landscapes. The team frequently asked to identify landscapes encountered on the way. At each site identified by the informants, a detailed description of the vegetation and some environmental characteristics were noted.

All sampled locations were positioned using GPS. The vegetation was assessed with the NOLIDEP manual for natural resource assessment (Sweet and Burke, 1998), but incorporating all woody species and grasses instead of only the main species. The key informants supplied the vernacular names of species. These were combined with scientific names and assessments of cover (Coates Palgrave, 1990, Drummond, 1995, Mueller, 1984, Van Wyk & Van Wyk, 1998). Notes on the physical environment included land form, soil characteristics (texture, colour, hardness). Open-ended discussions on management and resource uses provided understanding of the local management, the available resources (plants, animals, soils) and differences in suitability for various uses. The information concentrated on functional knowledge, and did not include details of uses based on belief (e.g. the use of *Croton gratissimum* to protect a home from lightning). A critical assessment and discussion of the notes with the team helped in making this distinction. Collaboration during fieldwork with the Spanish sponsored soil survey project within the MAWRD from The Cartography Institute of Catalonia added a soil science component to the ecological work. The soil profiles in different local landscapes were described and soil samples of the different horizons were taken for subsequent physico-chemical analysis in the laboratory. The results are not yet available.

The vegetation and environmental data collected were analysed with Canonical Correspondence Analysis, using CANOCO for Windows (ter Braak, 1998). This provided insight in the consistency of the local units using the ecological descriptions. The initial work concentrates on the scientific analysis of the indigenous knowledge on the land units, as this is an essential step in the comparison between indigenous and conventional scientific knowledge.

The samples provided the training sites for a supervised classification of a portion of a Landsat-TM scene of 29 April 1997 for all study sites. The scene is representative of an average rainfall year. The supervised classification, using the Maximum Likelihood classification method, was carried out on bands 3,4 and 5 simultaneously using ER-Mapper software (Earth Resource Mapping, 1997). As our initial field work indicated the importance of vegetation structure characteristics, the choice of satellite imagery is clear. Successful classification of a satellite image is an additional test for the internal consistency of the landscape units. Inconsistent units would provide unreliable training sites and classification results. The classified image would be incomprehensible for the local people.

The classified images were incorporated in a Geographical Information System, allowing overlays with information on settlement, water points, road networks and other relevant information for planning and management purposes. A hardcopy of the resulting classified image with overlays of villages and tracks was taken back to the community and farmers for discussions on farming systems woodland and grazing management, with emphasis on local cattle movements between landscapes in different seasons. Two community meetings and ten small farmer group discussions were held, each taking several hours. The discussions with small groups of farmers focused also on local norms and rules on resource use and management using maps detailing villages, homesteads, water points, tracks and pans. Sociological norms and rules were identified by discussing these maps, while combining them with the information on the landscapes.

When all people appeared satisfied with the resulting classification, on-screen digitising was used to vectorise and simplify the classified image. Vectorised maps consisting of lines and polygons are easier to understand and to work with. Some thematic maps were produced, indicating land suitability for cropping, for finding surface and ground water, of grazing quality and of the intensity of bush encroachment. Together with land issues, these were the main environmental issues identified in PRA sessions and subsequent in-depth interviews.

3. RESULTS

3.1. Description and evaluation of a land unit: the example of "Omutunda-Ekango".

Over 30 land units have been described so far in the pilot areas. It is outside the scope of this paper to give a full description of the landscapes and species lists encountered in the study areas. An example of one unit is given below.

Table 1 . general description of "Omutunda-Ekango"

Criteria	Description		
Landform	Elevation		
Topsoil texture	Loamy sand		
Topsoil colour	Grey brown to darkish grey		
Vegetation class	Acacia erioloba - Combretum hereroense wooded shrubland		
Vegetation structure (% cover on the ground of each layer)	Tree: 10	Shrub: 23	Grass: 22

Table 1 presents the general description of the land unit "*Omutunda_Ekango*". The unit can be found on elevations next to "Ekango" (a pan). Soil characteristics do not indicate that the unit can be found on a unique soil type, although descriptions of the profiles of "Omutunda_Ekango" had in common the presence of a shallow duricrust (a petrocalcic horizon consisting of calcrete) within 1 m of the surface and a heavier structure and texture than the sand of the dunes.

Table 2 details the species composition of the vegetation layers. *Acacia species* and *Ziziphus mucronata* are the most conspicuous species in the tree layer. The most abundant shrubs are *Combretum hereroense, Croton gratissimum, Acacia species and Baphia massaiensis*. Typical abundant grasses are *Urochloa brachyura, Brachiaria nigropedata* and *Cynodon dactylon.*

Farmers explained that livestock first graze this unit in the wet season, because of the high palatability of some of the grasses. It is potentially a very valuable landscape for grazing and browsing, but as it is also the most suitable land for cropping, most of the farms are found here. Farmers indicated that the land unit is considered to be of high fertility. Some farmers of cattle posts indicated that the decreased availability of the land unit for grazing caused them to move away from the small villages in search of unfenced and not farmed "Omutunda_Ekango".

Table 3 and Table 4 gives some examples of the local uses of the woody species and grasses. In both tables the common uses and available scientific evaluations and the indigenous assessments of value are compared. Both tables serve as a demonstration of how conventional knowledge can be compared with local knowledge at the species level. The tables are used as a cross check with the assessments of suitability and ranking of uses at the land unit level.

Table 2. The detail of the vegetation composition and structure

Tree layer

Vernacular name	Scientific name	Cover
Omwoonde	Acacia erioloba	2.25
	Acacia hebeclada	0.25
Omupapa	Baikiaea plurijuga	0.25
Omunghudi	Boscia albitrunca	0.50
Omutundungu	Burkea africana	0.25
Omupupwaheke	Combretum collinum	0.75
Omukadhikuku	Combretum hereoense	0.25
Omushendye	Combretum zeyheri	0.75
Ombango	Croton gratissimus	0.50
Omupanda	Lonchocarpus nelsii	2.00
Omuwe	Ochna pulchra	0.50
Oshifiku	Ozoroa insignis	0.50
Omwoolo	Terminalia sericea	0.75
Omusheshete	Ziziphus mucronata	0.50

Shrub Layer

Vernacular name	Scientific name	Cover
Omwoonde	Acacia erioloba	1.75
Omangandjamba	Acacia fleckii	1.50
	Acacia hebeclada	0.50
	Acacia nilotica	0.25
Ofufe	Baphia massaiensis	0.75
Omutwankuta	Bauhimia petersiana	0.50
Omunghudi	Boscia albitrunca	0.50
Omunaluko	Combretum apiculatum	0.50
Omupupwaheke	Combretum collinum	1.25
Omumangahupa	Combretum engleri	0.50
Omukadhikuku	Combretum hereoense	2.00
Omushendye	Combretum zeyheri	0.75
	Commiphora africana	0.25
	Commiphora pyracanthoides	0.25
Ombango	Croton gratissimus	3.00
	Croton menyhartii	0.50
Ongete	Dicrostachys cinerea	1.50
Omuhe	Grewia flava	0.75
Omupanda	Lonchocarpus nelsii	0.50
Oshifiku	Ozoroa insignis	0.75
Omupombo	Rhus tenuinervis	3.00
Omwoolo	Terminalia sericea	1.25
Oshimbu	Vangeria infausta	0.25
Omusheshete	Ziziphus mucronata	0.25

Grass layer

Vernacular name	Scientific name	Cover
	Acrotome inflata	0.75
	Anthefora pubescens	0.25
Olukateko	Aristida adscensionis	1.75
Omushoke	Aristida stipioides	0.75
	Asparagus sp.	0.50
Oshilundunde	Brachiaria nigropedata	1.75
Ongwena	Cynodon dactylon	1.75
	Dactylotenium giganteum	0.25
	Eragrostis dinteri	0.50
	Eragrostis rigidor	2.00
Omulyanana	Eragrsotis tricophora	4.00
	Hyparrhenia rufa	0.50
Okombambi--komasha	Melinis repens	0.25
	Perotis patens	0.25
Ombambi	Pogonarthria fleckii	2.00
Oshinaukali	Schmidtia pappophoroides	0.25
Oknamanga	Stipagrostis uniplumis	0.50
Epele	Urochloa brachyura	3.50

Table 3 . Use and potential of the woody species locally exploited

Scientific name	English	Kwanyama	Common uses and evaluation (bibliography)	Vernacular use and evaluation
Acacia ataxacantha	Flame thorn	Enghono		Goats eat leaves and pods. Cattle also eat pods. Wood used for utensils like knobkerries and fence material. Fibre sometimes used for ropes.
Acacia erioloba	Camel thorn	Omwoonde	Pods are edible bay stock. Wood strong and durable. Gum edible. Bark and pods used medicinally.	Pods eaten by cattle (salty taste). Wood used for making pounding sticks and poles for fencing.
Acacia erubescens		Okadilanghono		Bark or fibres are used for making ropes. Wood is used for fencing poles.
Acacia fleckii	Plate thorn	Omumanaandjaba		Bark used as building material.
Acacia hebeclada	Candle thorn			Leaves and pods are browsed by goats. Pods are soaked in salt water to be given to young goats as supplement feeding. Wood is used as fencing material.
Acacia hereoensis	False hook-thorn			Cattle browse sprouts. Wood or bark or fibre is used for making ropes. Gum is edible.
Acacia kirkii	Flood-plains thorn	Omuhaluveya		Goats browse leaves.
Acacia reficiens		Omuhu		Wood, fibre or bark, used for making ropes or as construction material. Seen as an indicator of fertile soil.
Acacia tortilis	Umbrella thorn	Omuxu	Leaves and pods make a very nutritious fodder and are browsed by stock. Bark is used medicinall. Wood provide also good fuel.	Wood, fibre or bark used for making ropes and as construction material.
Albizia anthelmintica		Omuhanguti		Browsed by game and occasionally goats. Bark is used medicinally for both human and animal intestine deworming. Wood is used for making small utensils like spoons. Also used as fencing material.
Baikiaea plurijuga	Zambezi teak	Omupapa	Important timber tree. Wood is dark red-brown, hard, strong and durable.	Wood is used as fuel and construction material.
Baphia massaiensis	Sand camwood	Ofufe		Sprouts are browsed by stock. Leaves are browsed by cattle. Top branches are even cut and distributed as fodder to stock at the end of the dry season. Ofufe is seen as the main forage during the dry season.
Bauhinia macrantha		Omutwanghuta		Leaves are browsed by cattle.
Berchemia discolor	Brown ivory	Omuve	Browsed by game. Wood yellow-brown, hard is attractive and suitable for furniture. Bark and leaves are used medicinally. Fruit edible fresh or processed; sweet-tasting and used in making beer; also boiled in water which, after the fruit is removed, is used to make a pleasantly flavoured porridge.	Sprouts are browsed by stock. Fruit (eembe) are edible and harvested.
Boscia albitrunca	Shepherd's tree	Omunghudi	Heavily browsed by stock. Roots and fruits are edible; roots pounded and made into porridge, or roasted and used as substitute for coffee; fruits pulp mixed with milk and used as side dish) Leaves and roots used medicinally.	Green leaves are browsed by cattle and small stock. Leaves and roots are used for medicinal purposes; leaves are used to treat flu or headache. Roots are put in milk to make it sour.

Table 3 (part 2). Use and potential of the woody species locally exploited

Scientific name	English	Kwanyama	Common uses and evaluation (bibliography)	Vernacular use and evaluation
Burkea africana	Wild seringa	Omutundungu	The dried and crushed bark is used as a fish poison. Bark and roots used medicinally and for tanning. Wood is pale brownish to reddish brown, hard, heavy and tough but prone to borer attack.	Plants are browsed by cattle. Wood is used for making mortars, yoke for ploughing and as general construction material (same quality as omupapa). Okavakole worms are collected from these trees (dry season food).
Combretum collinum	Variable bushwillow	Omupupwaheke,	Leaves are browsed by game.	Sprout leaves are browsed by large and small stocks. Wood is used as fuel.
Combretum engleri		Onahatanga		Important browse tree. Cattle and goats browse leaves when they are green.
Combretum hereroense	Russet bushwillow	Omukadikuku	Browsed by cattle. Roots used medicinally. Fruits can be made into tea. Seeds should be considered as poisonous.	Sprout leaves are browsed by stock. Wood is used for making handles of various implements.
Commiphora angolensis	Sand corkwood	Omboo	Roots are edible. Wood used for carving household utensils.	Wood is used for making small utensils like cups. Wood is also as live and dead fencing material.
Dicrostachys cinerea	Sickle bush	Ongete	Pods eaten by stock. Bark yields a strong fibre. Wood is hard and durable, used for fence poles and much sough after as firewood. Various parts used medicinally.	Pods are collected and mixed with salt to be given to goats as a supplement during the dry season. Wood can be used as fencing material and fuel.
Lonchocarpus nelsii	Kalahari apple-leaf	Omupanda	Leaves are browsed by stock.	Browsed by cattle mainly from August to October. Wood is used to make yokes.
Mundulea sericea	Kurkbos	Omumbaganyana	Leaves browsed by stock. Bark contains retanone and is used as fish poison. Leaves, bark and roots are used medicinally.	Leaves are browsed by stock throughout the year because they remain soft even dried-up.
Ochna pulchra	Peeling plane	Omuwe	Wood is pale brown with a curious papery feel when planed smooth; suitable for small ornaments. Seeds yields an unpleasant-smelling greenish brown oil which is used to make soap.	Leaves are browsed by cattle at the end of dry season. wood is used to make small utensils like shallow bowls, spoons, snuff containers, pipes.
Pterocarpus angolensis	Wild teak	Omuuva	Heartwood is attractive, moderately dense, easily worked and widely used for high quality furniture and ornaments. Leaves and pods eaten by game.	Wood is used as general and valuable construction material.
Rhus tenuinervis	Kalahari currant	Omupombo	Heartwood is pink or reddish brown, dense and hard, very attractive and excellent for carving. Leaves used as flavour condiment. Ripe fruits are edible.	Leaves are browsed by goats. Fruits are edible. Leaves are also used for medicinal purposes.
Schinziophyton rautanenii	Manketti tree	Omunghete	Dried fruit pulp used to make porridge. Seeds are rich in oil.	Fruit (Omanghete) are edible and mainly collected from June up to July. Nuts are eaten and used to make sauce.
Terminalia prunoides	Lowveld cluster-leaf	Omuhama	Browsed by game. Wood is hard, tough, and used for implement handles and in hut construction.	Wood is used as construction and fencing material. Leaves bark and roots are used for medicinal purposes.
Terminalia sericea	Silver cluster-leaf	Omwoolo	Wood, yellow and hard, suitable as a general timber. Roots widely use medicinally.	Spouts are browsed by cattle at the end of the dry season.

Table 4 . Use and potential of the grass species locally exploited

Scientific name	Kwanyama name	Local use	P-A	Scientific assessment
Anthephora pubescens			P	Highly palatable. (2) Very high : valuable and palatable, high nutritive value, high potential production.
Brachiaria deflexa			A	High forage acceptability.
Brachiaria nigropedata	Oshilundunde or Etolongolo	Valued because first shooting	P	Valuable and palatable. (2)Very high: palatable and high production.
Cenchrus ciliaris			P	Mostly high: palatable, high leaf production.
Cynodon dactylon	Ongwena	Valued for high palatability, nutritious	P	Provide good grazing.
Digitaria eriantha	Onhuululu	Valued for high palatability, nutritious(salty in Apr), mainly grazed in March-Apr	P	Palatable but dispersed in the veld. (2) Mostly very high: highly digestible and palatable, high leaf production.
Digitaria seriata	Omundjadu	Valued for first shooting, best grass in Apr-Jun	P	
Eragrostis spp. (tricophora)	Omulyanana	Valued for its abundance and palatability	P	Fairly well utililized in the absence of other palatable grasses.
Panicum coleratum	Wanenuna	Dry food in dry season (cut it as forage)	P	Very valuable. Mostly very high : palatable with high production.
Schmidtia appendiculata	Omutiwongombe		P	Valuable, palatable, high nutritive value.
Schmidtia pappophoroides	Oshinaukali	Valued for high palatability, nutritious	P	Variable. Mostly high: very palatable with a limited leaf production.
Stipagrostis uniplumis	Okanamanga	Valued because present in big quantity in the veld.	P	Palatable and valuable grass, widespread in occurrence. (2) Average to high: Fairly valuable pasture grass of variable palatability (well utilised at young stage)
Urochloa brachyura	Epele	Valued for its palatability, dry season food		
Schmidtia kalihariensis	Oshinamume	Thatching	A	Reasonably valuable as fodder in the dry condition. Grazed before flowering stage and later, when dry.
Echinochloa holubii	Eyangwa	Thatching, grazed if shortage of other, emergency food	P	Fairly palatable.
Aristida congesta	Okashilakanyanga	Grazed when fresh	P	Low: can be palatable in semi-arid areas.
Aristida stipioides	Omusheke	Thatching and grazed when fresh	A	Worthless
Aristida stipitata	Okanamanga	Thatching and grazed when fresh	P	Little value. Very low: owing to its general hardness and low leaf production.
Eragrostis pallens	Omaoleole	Valued for being eaten all year round, early shooting	P	Valueless (hardness). Low: unpalatable.
Eragrostis nindensis			P	Valuable and palatable. Average: relatively palatable, tends to sprout early in the rainy season.
Echinochloa colona	Ombode		A	Palatable.
Aristida meridionalis		Thatching, broom making.	P	Not good but leaves sprout early in spring. Low: fibrous utilised in young stage
Asparagus spp.				
Chloris virgata	Kakalahambo		A	Low:fast growing palatable grass but low leaf production.
Cymbopogon sp.				In general poorly utilised.
Dactyloctenium aegyptium	Kakalahambo		A	Average: palatable but rarely important in the veld, eaten at young stage.
Enneapogon cenchroides			A/P	Usually low: hardy spp., particular value in low rainfall areas.
Eragrostis curvula	Type of Omaoleole		P	Average: Highly productive, early grazing in spring, easy establishment, palatability medium to low.
Eragrostis echinochloidea			P	Valuable while still green. Low to average
Eragrostis lehmanniana			P	Mostly average: reasonably palatable, withstand to heavy grazing, well grazed in young stage
Eragrostis rotifer	Omukashulwa	Thatching grass	P	Remains green for a long time (readily eaten in dry times)
Eragrostis viscosa	Okaheneidi		A	Poor: low leaf production
Heteropogon spp. (contortus)			P	Reasonably good before flowering (hardness). Average to high
Heteropogon spp. (melanocarpus)			A	Valueless (hardness)
Hyparrhenia rufa		Thatching	P	Unacceptable: fibrous and hard

3.2. Consistency of local landscape units

To test the internal consistency of the units three vegetation layers were recognised: a tree layer, a shrub layer and a herbaceous layer. Woody plant species in the shrub layer were treated as different from individuals of the same species occurring in the tree layer. This serves the purpose of recognising that structural differences influence the classification, while also enabling to trace regeneration of tree species. This is a simplification, local people recognised at least the following possible layers: a herbaceous layer, a layer of shrubs not higher than about 1 meter, a shrub layer of between approximately 1- 3 or 4 meter, a lower tree layer and an upper tree layer. To test the consistency in detail, one has to recognise 4 woody layers instead of only 2. To test the consistency with only 2 layers, those units that were differentiated on the basis of more vegetation layers were grouped.

A Canonical Correspondence Analysis of the species composition with cover rates not transformed was carried out on 74 samples of Eastern Ohangwena woodland. The result of the two main axes of sample ordination is presented in Fig. 1. Each dot represents one sample. The closer samples are situated to each other, the closer they resemble each other. The different locally recognised units are marked with different symbols. The graph shows that most samples belonging to the same local unit are found close to each other. There are a few exceptions though. Closer investigation showed that some were misjudged (or misunderstood). In other samples the reason for anomalies were related to the importance attached to some species (which could be solved by weighing those species in the statistical analysis), or related to the fact that some samples were transitions between units. The key informants frequently indicated these transitions in the field. Nevertheless, the majority of local units (over 90 %) are consistent. In other study areas no anomalies were found, because of a clear differentiation between the recognised units based on a simpler vegetation structure.

The findings presented here suggest that consistency of local units can be tested statistically. Results should improve when taking into account all the structural layers recognised by the local people.

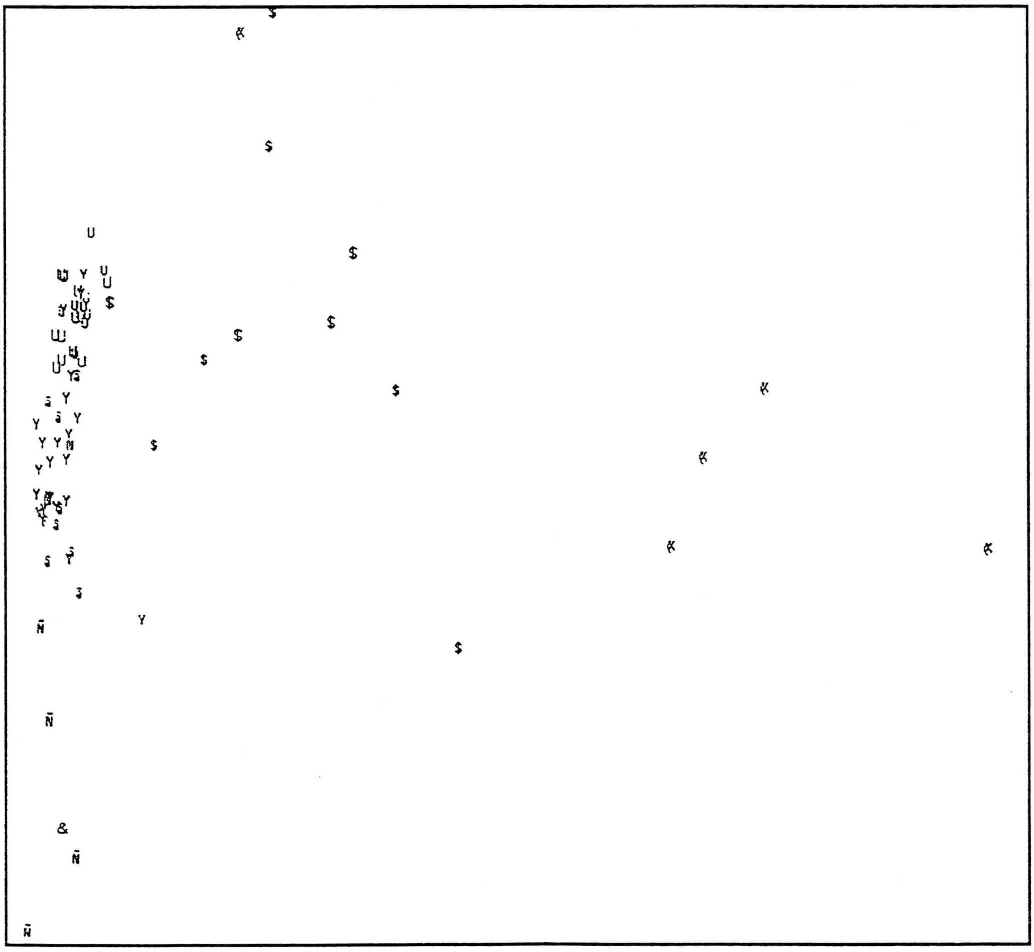

Fig. 1. A canonical correspondence analysis (CCA) of 74 vegetation samples in Eastern Ohangwena. Local land units are marked with different symbols.

3.2. Supervised Classification of Landsat TM satellite images

Up to now, 4 areas have been classified using portions of Landsat TM imagery in three different language groups. The classification of the Eastern Ohangwena portion of the satellite image resulted in 18 units. The classified image was taken to feedback meetings with communities where a first checking of the units was carried out. There was overall agreement with the units and a few test sites satisfied the community members of the validity of map. Four thematic maps were derived from the classified image. Fig. 2 is the result of the participatory ranking of the local units with respect to suitability for cropping. Fig 3 locates the landscapes most suitable for finding surface water in the wet season and for finding shallow potable groundwater. Fig. 4 ranks the land units with respect to grazing quality, a result of participatory ranking and checked by the presence and cover of palatable species in samples. Because of the influence of water points on the grazing quality, there are some differences within units. Using GIS analysis, one could correct this, based upon established relationships between cover and water point distance (Verlinden *et al.* 1997). These relationships have not yet been established for this area at species level. An overlay of existing fields with suitable cropping land in Fig 2 demonstrates that in the study area already a large proportion of most suitable areas for cropping, have been converted into crop fields and fenced. A comparison of Fig. 2 and 3 suggests that most of the land units suitable for cropping, are also the most suitable for finding surface water or shallow ground water. A comparison of Figs 2, 3 and 4 shows a high degree of overlap in the distribution of the highest quality areas for the three main resources. This suggests the possibility of competition for resources in a limited number of crucial areas. This notion was confirmed in discussions on grazing management, were informants pointed out that the main reason for leaving more densely populated areas like the larger villages was the shortage of good quality grazing areas that were increasingly converted to crop fields.

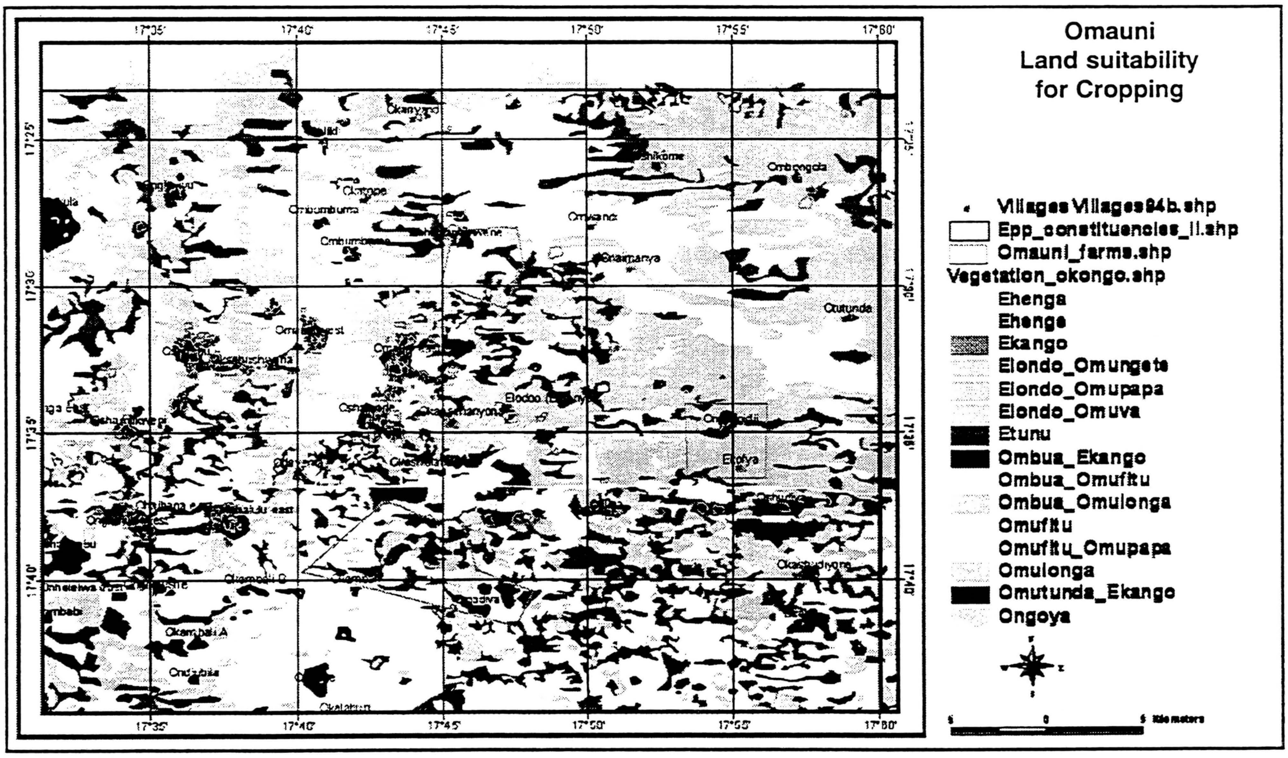

Fig. 2. Landscape unit suitability for cropping (mainly Pearl Millet Omahangu)

White areas are unsuitable, lighter hatches indicate very low suitability, while only the darkest hatches indicate high suitability

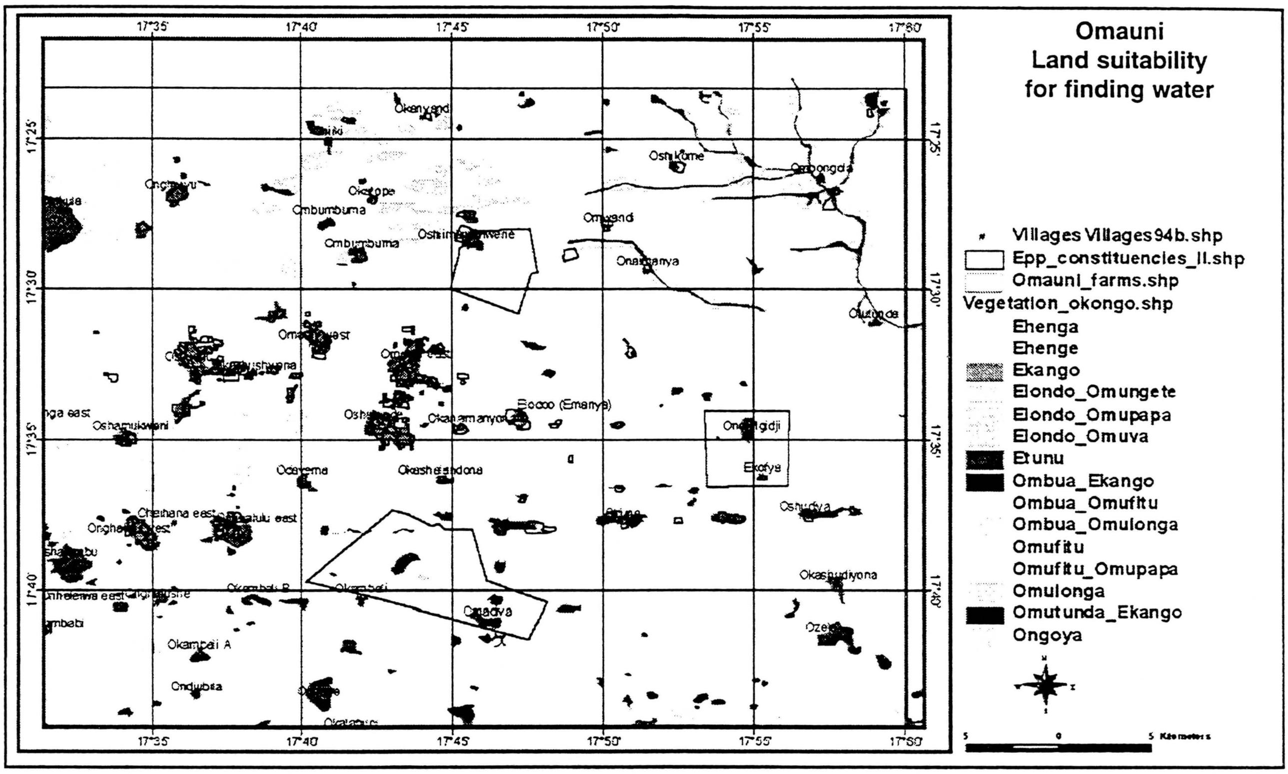

Fig. 3. Land unit suitability for finding shallow groundwater or surface water (mainly during the wet season). White areas are unsuitable, lighter areass indicate very low suitability, while only the darkest areas indicate high suitability.

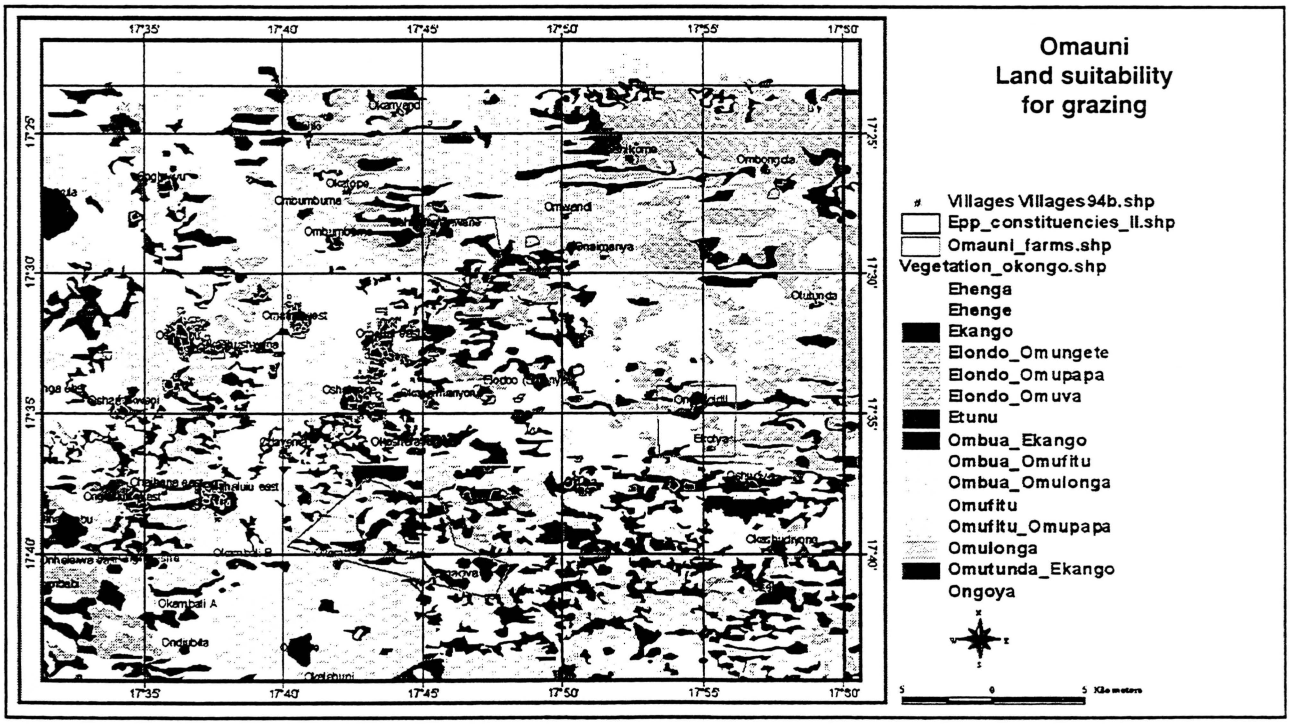

Fig. 4. Land unit suitability for grazing. White areas indicate a low number and low cover of palatable grasses, light areas have medium suitability, darker areas have high suitability and darkest areas have a very high suitability for grazing.

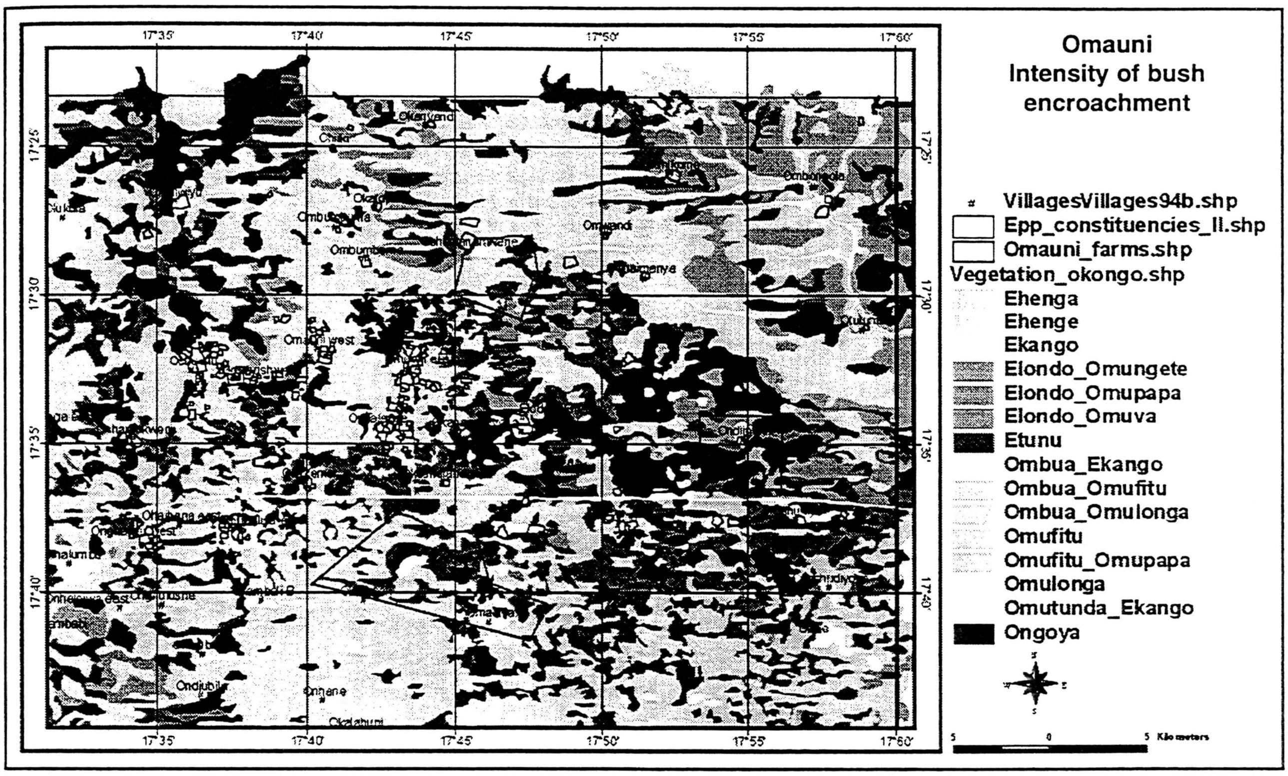

Fig. 5. Intensity of bush encroachment in different land units. White areas indicate only a slight degree of bush encroachment, light gray a medium degree of bush encroachment, dark gray a high degree and black indicates bush encroached areas ("Ongoya").

3.3. Rules and norms in resource management

One of our findings of the PRA approach when not enough time is spent on indigenous knowledge on resource management, is that existing rules and norms on resource use are not fully captured. Only when the informants and communities understand that the interviewers work with the local understanding of the environment, bits of information that are crucial for understanding management approaches in a communal area are shared. Good baseline maps with detailed farm boundaries, villages, water points and local landscapes appeared essential during these discussions. Again, only a few examples can be presented as a systematic overview cannot be given due to the large variations between the studied communities.

In one community with only traditional wells, rules on water use were agreed at the water point over a period of a few weeks at the end of the wet season. Depending on the water level, the labour provided by community members for digging wells, family ties, having a cattle post or not, the following rules are agreed: watering frequency and timing of the livestock, number of stock watered, exclusion of people (depending on labour provided or on voluntary basis, also based on lineage). Community members know at that time who is going to the cattle post with their livestock, who will be using the wells at what time and frequency, who will move to permanent waterpoints. People from outside entering the grazing area can be asked to leave or not to come back the next year. The grazing area is to different extents shared. Grazing areas around farms have almost exclusive access, the norm is that one avoids crossing farms and the surrounding area, except when necessary for watering livestock. The further away from the farm, the less access to grazing. One is frowned upon when infringements happen regularly and it might cause conflicts with neighbours and traditional leadership with limits posed on access in the future. When there is a drought these norms relax and there is a reluctance on enforcing rules or formalising the rules because of risks of limiting access to other areas in bad times.

When discussing grazing management in an area with 4 cattle posts close together, it appeared that the presence and size of certain landscapes had consequences for the grazing patterns followed by livestock. The main active management is herding the animals separately for a short distance in 4 different directions after watering the livestock on the common water point. Cattle however then select the best grazing areas. When they are available in sufficient size, cattle will not move quickly to other areas. When depleted, cattle will move to the second best areas and only end up in the less suitable grazing areas at the end of the dry season. In cattle posts without enough grazing areas of high quality, cattle end up much earlier in less suitable grazing areas. In such cases there is no grazing reserve or resting period. This serves as an example that farmers very close together will have very different attitudes and needs towards range management, based upon the difference in grazing quality of their areas. Some farmers will have more need to manage bush encroachment, or to manage browse species than others. Knowledge of the geographical distribution of the local landscapes will assist addressing the right people with the right messages.

The data so far collected suggest that there is a more elaborate social structure regarding resource use and management than usually thought in a so-called "open access" area. Current discussions on how to devolve authority of resource management from government to communities currently move in the direction of strengthening this social structure through more formalised committees where traditional authorities form part of the membership. The Traditional Authorities Act of Namibia empowers traditional authorities control over various aspects of land use.

3. DISCUSSION

Incorporating local knowledge in conventional planning systems and especially GIS is a new development (Weiner et al. 1995). Although the approach used here to link indigenous knowledge with conventional knowledge is new as it has local descriptions as the basis, rather than interpretations ("locals say you find good soils here"), the methods used to describe and analyse the indigenous knowledge are not new and have demonstrated their use in various areas and applications. PRA, Canonical Correspondence Analysis has been used in a very wide range of applications and so has the Maximum Likelihood Analysis of Landsat TM imagery. Where previously research on indigenous knowledge has concentrated on ethnobotany and on local ideas of suitability of soils without an apparent in-depth analysis of the locally used characteristics to define the units, the scientific analysis of land units approach followed here has demonstrated that many farmers and communities in the study area have a holistic, consistent and meaningful thorough picture of their environment. The units were found to be consistent within Owambo language groups with many units common between Owambo languages. For North Central Namibia this means that one has to expect up to 5 local classification systems with many common units and some language-specific units. Preliminary research with Ovahimba and other Herero speaking people indicated the existence of a similar classification system, based more on landform than other characteristics. This is possibly the result of their areas being more mountainous. It was observed that people look at the most conspicuous characteristics first in order to recognise the land units. It is likely that similar land unit classification systems exist or existed in many areas in Southern Africa (a recent war zone is not likely to be an ideal environment to encounter culturally little changed people). Although each system will be unique, the approach to detect, describe and analyse will be applicable throughout the region.

It was found that people had in several cases difficulties with changes in the environment and resulting changes in the landscape, due to changes in management caused by less well understood factors. Although it was obvious from descriptions that the land units had changed in such cases, they still referred to the land units that occurred there before. This led however to interesting discussions during the community feedback between people who understood the changing environment better and could indicate possible management solutions. This is perhaps the main advantage of the approach: an increased ability to understand the environment the way local people have learnt it, to understand the social structure related to resource use and management and an increased ability to discuss environmental issues with local resource users. Without this approach, one would not quickly understand that land most suitable for cropping, was also most suitable for grazing and suitable for finding water. Without using the satellite image, it would have been very difficult to assess that these suitable areas are very small.

It was found difficult to incorporate the social structure into the GIS. Although it is possible to produce layers of informal boundaries of access, the lack of definition and the highly dynamic nature (GIS has problems with process) make it difficult to produce a clear picture of the social structure. Schematic drawings with arrows and informal boundaries on top of maps produce however understandable schemes. More research seems to be needed to incorporate this dynamic social structure as layers into a GIS.

Institutionally, the collaboration and teamwork between two ministries improved the links between the research team and the communities and farmers concerned. The network of extension technicians in MAWRD and the Directorate of Forestry is essential in the approach, although the average number of farmers of around 2000 per MAWRD technician is very high.

Because of this, implementation of projects is delayed. It is possible that projects might have to encourage the set-up of NGOs involved in rural livelihoods or rural development projects to assist ministry staff in implementation to avoid sector-oriented approaches.

4. MANAGEMENT IMPLICATIONS

4.1. Eastern woodland areas

The approach followed in this study allowed to name, locate and assess jointly with farmers and communities those factors that contribute to the restrictions in natural resource management options and livelihood strategies, resulting from the decreased access to crucial areas.

The work carried out in the Eastern woodlands shows that suitable land for cropping, grazing and finding water is restricted to a few land units that are scarce. In addition to this, it appears that good grazing land occurs mainly on the same land units that are most suitable for cropping. As a consequence, the more suitable grazing land is cleared for cropping, or fenced of, the less options are open for the poorer households with livestock to manage their livestock and the environment in a sustainable way. This has resulted in a vast increase of a certain unit, "*Ongoya*" characterised by high, impenetrable bush cover.

Previous grazing systems studies have pointed out that by large-scale fencing and increased land clearance, traditional livestock management might become unbalanced, yet they remain vague about the environmental factors contributing to this possible imbalance. The present study demonstrated the imbalances, an increase of "*Ongoya*" and an increase in fencing "*Etunu*" and "*Omutunda-Ekango*" areas (Figs 2-5). Additionally, it became clear that there exist norms and rules regarding uses of grazing land and wood use. The systems studied were not "open access". This might pave the way for more sustainable resource management on community basis, starting from existing social structures, rather than setting up new ones that might conflict with the existing ones.

The increase of fencing was of particular concern, as was the increase of the "*Ongoya*" unit at the expense of "*Epumbu*" and "*Etunu*", who had a much higher grazing value. "*Ongoya*" means literally "one cannot pass" and indicates a high degree of bush encroachment and the indicator to decide if a land unit can be characterised as "*Ongoya*" or not. Various plants were recognised as having better grazing value. The scientific analysis suggested that various potentially nitrogen-fixing species were involved. Several management options to increase some valuable, indigenous species were proposed by the informants (burning, reseeding, rotational grazing).

It was also recognised that "Ongoya" has a high grazing potential, provided appropriate management measures are carried out. These are mainly concerned with bush cover reduction. Further discussions have addressed the options of firewood sale, charcoal making, selective debushing, and burning. The community of one village has shown interest to set up a pilot project allowing these applications to be implemented in the field. Based upon the existing CBOs and its strong leadership, the context looks very favourable to carry out some activities resulting from the present work findings.

4..2. Recognising indigenous management units in Community Forest Management Plans.

Work in 4 villages with Community Forestry projects resulted in a keen interest to base management of these community forests on the indigenous management units. Instead of putting up artificial boundaries, it was recognised that the indigenous land classification in those areas was the most appropriate starting point for the zoning of the management units, facilitating the mutual understanding of the environment the way the local people see it. A consultant is now working in one village to implement this approach. Progress is followed closely to be able to implement it in other Community Forests.

4.3. Transferring knowledge from on-farm FSRE experiments to other farms

Farmers informed us about the differences in suitability for cropping of the various land units. Within some good cropping units ("*Omutunda*", "*Etunu*") variation between regions in species composition and soils was found. This lead to differentiation to subunits (e.g. "*Omutunda_ekango*", "*Omutunda_okuti*") which were accepted by farmers during the discussions. Differences in farming practices between these subunits need to be researched and taken into account in extension messages.

With the decrease in availability of land, a trend towards the cultivation of less suitable units becomes apparent. The increased heterogeneity of cultivated land units will require adaptive management (e.g. levels of fertiliser, soil preparation techniques). Integrating FSRE experiments with the indigenous knowledge on land units and especially their potential for cropping and grazing will facilitate the choice of relevant extension messages. Research with the FSRE unit in the region is now underway to investigate this.

4.4. Participatory assessing erosion in the central alluvial fan (Oshanas)

Although the alluvial fan is very flat and therefore not at very high risk of accelerated erosion, the infrequent occurrence of flooding events in a heavily grazed area might induce such a process. In the Oshanas area, the presence of a shallow hard pan is an influential factor in suitability for cropping and grazing and observations indicate that its much lower permeability causes sheetwash of the thin sand layer on top of it. Local landscape units link the vegetation structure directly to the depth of the hard pan. In units unsuitable for cropping ("*ehenene*", "*ehalala*") woody plants are absent and the hard pan is found within 20 cm of the soil surface. Sheet erosion is observed frequently in these units in heavily grazed areas, especially where no biomass is available to fence of cropped areas. Lack of fencing might accelerate erosion. These local land units could be mapped using satellite imagery and aerial photographs. Research is now ongoing using aerial photographs and GIS to verify if local land units being eroded are larger in deforested and heavily grazed areas in similar environments.

5. PERSPECTIVES FOR FURTHER ACTIVITIES TO BE IMPLEMENTED

The research into the potential of linking indigenous knowledge systems on land unit classifications and resource management with GIS is planned to continue until June 1999.

Because of the importance of the involvement of communities and extension workers in the work, a process approach rather than an output oriented approach is preferred. Otherwise the study would be limited to extracting information from communities. Rather than producing a landscape classification map covering North Central Namibia, it is proposed to explore how the approach could assist processes by which communities could strengthen social structures to increase control and management of the resources. This means spending time on the follow up of the processes already underway in the community forestry projects and spending time on the implementation of some of the above mentioned management implications. It is possible that attempting to cover the whole area without involving agriculture and forestry extension staff together with farmers and communities will result in just one more of these maps gathering dust. Moreover, the vast amount of field work involved precludes the production of a reliable information system on such a short time span.

The approach and method should be considered as only part, but an essential one, of the process to understand the livelihood strategies of rural people and to start a participatory planning process. The current methods allow to understand and exchange views on the biophysical environment the way local people see it and can give insights in some of the existing social structure around resource use and management. The work should be complemented with research on local institutions and the way people cope or fail to cope with changes in the environment, policies and institutions.

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