Third Report on Contract No. PIOT/633-0999-00142

BUILDING A NATIONWIDE SELF-SUSTAINING PROGRAM FOR TRAINING

IN

GEOGRAPHICAL INFORMATION SYSTEMS IN BOTSWANA

Presented to USAID/Botswana

by

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6 January, 1995.

Mr. Robert McColaugh
USAID/Botswana
P.O. Box 2427
Gaborone
Botswana

Dear Mr. McColaugh,

Third Report on Contract No. PIOT/633-0999-00142.

Please find attached the third report on the above contract. This report should have reached your office much earlier than now, but as has been pointed out in some reports on this contract that reached your office before this one, more effort on this contract has been put on trying to complete as much as possible of the work originally proposed for a two-year period within the one year that I received financial support.

Sincerely,

Musisi Nkambwe

Musisi Nkambwe

Third Report on Contract No. PIOT/633-0999-00142.

I. Introduction

This is the third report on the above contract. In this report the vendor, Musisi Nkambwe, is expected to provide information on a National GIS Conference conducted under the contract. The Conference was held between 6-7 June, 1994.

II. Objectives of the National Conference

As stated in the original proposal for this contract, the aim of the National GIS Conference was not to present quality scientific papers. It was meant to provide a forum to the graduates of, and trainees in, the GIS training program of the Department of Environmental Science, University of Botswana (ES UB) to discuss their work and share experiences with each other. It was also intended to give encouragement and re-assurance to this group that their contribution to the development of GIS in the country is being recognized.

III. Attendance

The attendance register shows that 36 people attended the conference. Perhaps more people could have attended the conference, but for the restrictions made on presentations: with only one exception, all oral and paper presentations were restricted to those individuals who had gone through ES UB's GIS training program. A list participants who were registered for the conference is attached to this reporrt as Appendix I.

IV. Presentations made at the National Conference

Altogether, there were 11 presentations made from GIS projects, an opening speech from the Permanent Secretary (PS) of the Ministry of Agriculture, Mr. C.M. Lekaukau, and a closing speech from the Deputy Director of USAID/Botswana, Mr. D. Mandel. In the opening speech (attached to this report as Appendix II), the PS appreciated the efforts that were being made by the University of Botswana in introducing GIS technology, and the financial support given to the program by various donors, including USAID in promoting this effort. He also appreciated ES UB's attempt to make the development of GIS self-sustaining. Unfortunately it has not been possible, up to the day of presenting this report, to obtain a copy of the closing speech from Mr. Mandel, and it is therefore not attached.

The official program listing all presentations, together with a sample of papers presented at the Conference is attached to this report as Appendix III. It was hoped that this report would have, as one of its attachments, edited proceedings containing papers presented and deliberations conducted at the National Conference. Unfortunately, several unforeseen circumstances have made this difficult, the most important of which has been movements of personnel, some of whom have been attending other training courses both in and outside Botswana.

V. Sponsorship of the National Conference

The Conference was sponsored by USAID/Botswana, various Departments of the Government of Botswana (GOB), and the University of Botswana.

VI. Achievements of the GIS National Conference

In my view the National Conference on GIS achieved its objectives. In particular the primary objectives of providing a forum to exchange ideas and share experiences in GIS development were achieved. The interest shown by senior management from various GOB Departments was also encouraging. As may be seen from the sample of papers presented, the quality of some of the presentations was not very high. One of the main lesson of the conference was the fact that presentation ability of the trainees had to be given some attention if scientists hoping to use GIS widely in future are to convince their directors in their various departments of the practical usefulness of GIS.

VII. Conclusion

In the original proposal for this contract it was suggested that National GIS Conferences should be conducted every year to provide a continuous forum for users of GIS in the country to exchange ideas on the development of GIS. The surest way of making this sustainable is to revive the GIS Users' Group which has been dormant for some time.

APPENDIX I

PARTICIPANTS REGISTERED FOR THE NATIONAL CONFERENCE ON GIS

No.	Name	Address	Phone	Fax
1.	Coyne B.	Box 93 Serowe	431033	430202
2.	Tema I.	Box 153 Gumare	-----	------
3.	Mphathi M.	P/Bag 003 Gaborone	350512	307057
4.	Sabone B.	P/Bag 0042 Gaborone	354291	307057
5.	Wennberg S.	P/Bag 0029 Gaborone	3600256	374372
6.	Silitshena R.	P/Bag 0022 Gaborone	531151	356591
7.	Verlinden A.	Box 131 Gaborone	371405	-------
8.	Adika G.	P/Bag 0022	351151	356591
9.	Larkin D.	Box 10072 Gaborone	312497	373598
10.	Aboneng	P/Bag 14 Lobatse	330327	332013
11.	Tsele K.	Box 10100 Gaborone	356281	356282
12.	Mpolokang A.	Box 10100 Gaborone	356281	356282
13.	Oteng B.	P/Bag 0042 Gaborone	354274	356015
14.	Stephenson M.	P/Bag 0037 Gaborone	309944	352709
15.	Hallam G.	P/Bag 0022 Gaborone	351151	356591
17.	Neher A.	P/Bag 003 Gaborone	350662	------
18.	Williams C.	Box 700 Gaborone	352831	------
19.	Masalila C.	P/Bag 003 Gaborone	350687	307057
20.	Rampha M.	P/Bag 0029 Gaborone	375516	374372
21.	Hulela M.	P/Bag 297 Gaborone	371619	-------
22.	Mulalu M.	P/Bag 003 Gaborone	350527	356027
23.	Stimela D.	P/Bag 003 Gaborone	350698	356027
24.	Sebego R.	P/Bag 0022 Gaborone	351151	3565591
25.	Rantshabeng V.	P/Bag 006 Gaborone	354225	-------
27.	Koorutwe G.	P/Bag 0022 Gaborone	351151	356591
28.	Makwiti B.	P/Bag 0022 Gaborone	351151	356591
29.	Vanderpost C.	P/Bag 0022 Gaborone	351151	356591
30.	Kennekae P.	P/Bag 003 Gaborone	350698	307057
31.	Brahmbhatt P.	Box 2427 Gaborone	353382	313072
32.	Rampha T.	P/Bag 0022 Gaborone	351151	356591
33.	Gondo A.	P/Bag 14 Lobatse	330327	332013
34.	Magowe M.	P/Bag 14 Lobatse	330327	332013
35.	Modisenyane J.	P/Bag 0022 Gaborone	351151	356591
36.	Mashaba M.	P/Bag 0022 Gaborone	351151	356591

APPENDIX II

Openig Speech by the Permanent Secretary of Agriculture, Mr. C.M. Lekaukau

SPEECH BY MR. C. M. LEKAUKAU, PERMANENT SECRETARY, MINISTRY OF AGRICULTURE ON THE OCCASION OF THE OFFICIAL OPENING OF THE NATIONAL CONFERENCE ON GEOGRAPHICAL INFORMATION SYSTEMS (GIS) ON THE 6TH JUNE, 1994 UNIVERSITY OF BOTSWANA

Ladies and Gentlemen,

I am pleased to be here in the University of Botswana's Department of Environmental Science, to officially open this important conference and training workshop in Geographic Information Systems (GIS). The Government of Botswana appreciates all those who have assisted in various ways, especially USAID and SAREC to the advancement of the GIS training programme so far.

GIS is a fairly new technology in Botswana. Introducing a new technology is always a difficult undertaking in any country and as such the introduction of GIS in Botswana has been no exception to this general rule.

In Botswana's case problems on the availability of up-to-date and appropriate spatial information has been responsible for less than expected achievements in many of our national development programmes. It is appropriate therefore that our national university should take up the task of building the capacity for using GIS technology that will enhance the management of information relevant to Botswana's efforts to achieve sustainable development.

Ladies and Gentlemen,

GIS technology is extremely important in the management of natural and human resources, from mapping to modelling the right path for sustainable development. Its use has already been widely taken up in various Government departments that deal with land use planning, regional and town planning, soil mapping, forestry, water management, rangelands monitoring, and wildlife management. In the Ministry of Agriculture, we recently created a GIS Unit to guide the development of this new technology, and I know this is the case in some other Ministries. In all the Departments where GIS is developing there is a high demand for officers who are competent to develop, maintain, and operate GIS's.

In our Ministry, the new GIS Unit would like to develop a network of officers competent in using GIS technology in compiling agricultural data and capable of executing the Ministry's programmes and projects using the same technology wherever appropriate throughout the country.

In building this network the personnel to run it in the field and at the centre is more important than locating sophisticated expensive equipment in our offices.

The new approach to capacity building in the use of GIS at this University has a number of advantages. Previously, we have been participating in the university's in-service GIS training programmes by sending individuals who then came back to the Ministries and tried to practice what they had been taught. The limited personnel to teach GIS at the University made it difficult for any one Ministry or NGO to send more than a few trainees to the courses. Under the new programme, the University of Botswana will assist the Ministries to develop their own capacity from within the Ministries by training trainers who will train others in the Ministries or within NGO's. This approach will emphasize development of GIS in the ministries through a team, not individual effort.

In addition this team will direct its energies more directly at the scientific applications relevant to a specific ministry.

It may be useful to emphasize at this point a number of other issues (besides the very important issue of training) which are of relevance to the use of GIS applications. The first issue which needs attention relates to the need to employ at various levels technical staff capable of maintaining and managing computer equipment along with those who are competent in GIS. Frustrations in computer equipment maintenance could easily be responsible for a less than an expected rate of GIS development even with personnel trained in the application of GIS technology. The overall issues of information technology development in the country, being addressed this morning at another forum in the Gaborone Sun Hotel, which include training personnel for computer hardware maintenance, are very relevant to the development of GIS. Experienced staff in this field are very difficult to attract but are also extremely important for the smooth running of GIS applications.

A second issue deserving attention, concerns the need for proper data management at all levels, with adequate standards relating to data capture, data updating, data sharing between users, etc. This issue is of national interest and the Government of Botswana has shown how important it is by commissioning a consultancy to study and suggest how the issue could be addressed. Many relevant suggestions are contained in the report from this consultancy to the National Committee on Cartography and Remote Sensing. It is hoped that in developing the network of trainers the importance of this issue will be emphasized.

Finally, it should not be forgotten that no matter how important new technological applications such as GIS may be, the degree to which these technologies will benefit the well-being of the people in both rural and urban areas ultimately depends on how they are applied. Sound judgement in this regard does not wholly come from the training of this nature alone, but it is hoped that when deliberating on the development of GIS this aspect of its application will not be forgotten.

With these few words I declare the workshop open and wish the participants and organisers faithful deliberations.

Thank you.

PULA!

APPENDIX III

The Official Program and Some Selected Papers Presented at the Conference

NATIONAL CONFERENCE ON GIS 6-7 JUNE , 1994

PROGRAMME

Monday 6 June, 1994

08.00-09.00 Registration

09.00-09.40 **Opening Ceremony**

Comments by the the Head, Department of Environmental Science

Opening of the Conference by the Permanent Secretary, Ministry of Agriculture.

09.40-10.00 Tour of the GIS/Remote Sensing Laboratory, Department of Environmental Science.

10.00-10.30 Tea/Coffee

10.30-12.30 Session I - Chair, Mr. Masego Mphathi, Chief Land Utilization Officer, Ministry of Agriculture

GIS Unit, Ministry of Agriculture
Developing an agricultural application system: the Central Agricultural Region as a case study.

Mulalu Mulalu
Overview of the project

Moses Kennekae
Data collection and compilation.

David Stimela
Data automation for the project

14.00-15.00 **Session II** - Chair, Mr. G.Hallam, Training Officer, MLGL&H

Victor Rantshabeng, Land Utilization, MLGL&H
Using GIS to monitor land use in Kgatleng District.

Boitumelo Oteng, DTRP, MLGL&H
Using GIS for settlement planning in Kgatleng District.

15.00-15.30 Coffee/Tea Break

15.30-16.30 **Session II** (continued)

C. Masalila, Range Ecology and Forestry, MoA
Using GIS to monitor temporal changes of vegetation in livestock producing areas: acase study from Tlokweng.

Reuben Sebego, Range Ecology and Forestry, MoA.
Using GIS to measure the encroachment of arable land on grazing land.

Tuesday 7 June, 1994

08.30-10.30 **Session III** - Chair, Mr. Selemokwe, Surveys and Lands

R. Stevenson, Surveys and Lands
Map projections used in Botswana

B.G. Aboneng, Geological Surveys
A GIS database to monitor geological mapping

10.30-11.00 Tea/coffee break

11.00-12.15 **Session IV** - Chair,

Modelling wildlife abundance and its relationship to NDVI.

Musisi Nkambwe, Environmental Science, UB
Some ideas on building a national network of trainers.

12.15-12.30 Howard Handler, Director USAID/Botswana
Closing remarks.

KGATLENG DISTRICT SETTLEMENT STRATEGY

BY

B. OTENG
DEPARTMENT OF TOWN AND REGIONAL PLANNING

KGATLENG DISTRICT SETTLEMENT STRATEGY

DEFINITION: District Settlement Strategies are a means towards implementation of the National Settlement Policy.

MAIN GOAL: The main goal of the settlement is to give guidelines for location of services of facilities within various levels of settlements in the District and ensure balanced development.

OBJECTIVES:

- To develop an appropriate hierarchy of settlement of the District based on the National criteria which will guide the provision of physical infrastructure and social services.

- To provide a framework for equitable distribution of development efforts and resources and provide a spatial framework for District Development Planning.

- To define and develop an appropriate road and communication network in the district which will enable easy access and linkages within and between settlements in the District and other Districts.

- To address issues of resources conservation and development.

- To provide guidelines for regulation and control of settlement development.

The National Settlement Policy

The National Settlement Policy was first introduced as a Government policy in the 5th National Development Plan (1979 - 1985). At the time of inception, Government was concerned about the prevailing bias of both public and private investment to urban areas in general, and Gaborone in particular.

"The inordinate growth of Gaborone and its inherent advantages as the National capital threatens the whole balance of development in Botswana to the detriment of other major centres, many of which have development potentials of their own. The main goals of the policy is to form a framework for the distribution of investment in a way that reflect the settlement size, population, economic potential, level of infrastructure and their role as service centres to surrounding regions".

The NSP is originally envisaged would take a comprehensive and coordinated approach to development and job creation especially in the rural areas ensuring that all sectors of the economy collaborate in this endeavours. The NSP, therefore has two major aims;

a) To facilitate the promotion of a more spatially balanced economic growth that ensures optimum distribution of productive activities and population.

b) To serve as a guide and information source for economic planners particularly when dividing the National pie; knowledge on various regions resources development potential and needs will be readily available. The National Settlement Policy will be a basis for the assessment of needs of each region and determine areas high potential for investment and the development.

The overall goal of the NSP is "TO DEVELOP A STRATEGY FOR NATIONAL PHYSICAL PLANNING AND TO PROVIDE A FRAMEWORK FOR THE DISTRIBUTION OF INVESTMENT IN A WAY THAT REFLECTS THE SETTLEMENT SIZE, POPULATION, ECONOMIC POTENTIAL, LEVEL OF INFRASTRUCTURE AND THEIR ROLE AS SERVICE".

The specific objectives of the National Settlement Policy are as follows:-

i) TO CONTROL EXCESSIVE MIGRATION TO URBAN CENTRES

This can be achieved through promotion of growth and development in other centres. Government policy efforts should emphasize balanced development not only in an urban context but also in its rural/region content. Government can through redirection of public and private investment from urban to rural areas through upgrading of infrastructure in major villages and small towns i.e. Serowe, Maun, Palapye, Mahalapye, Molepolole, Kanye, Orapa, Sowa, Kasane-Kazungula, Ghanzi and Jwaneng.

ii) TO PROVIDE GUIDELINES AND LONGTERM STRATEGY FOR THE DEVELOPMENT OF HUMAN SETTLEMENTS

Guidelines will through the use of a wide range of criteria be provided to facilitate the preparation of District Settlement strategies/spatial plans. A more realistic and practical definition of Primary, Secondary and Tertiary centres will be provided.

iii) TO RATIONALIZE AND PROMOTE THE OPTICAL USE OF LAND AND PRESERVATION OF THE BEST ARABLE LAND

The drawing up of Landuse plans for all districts and adherence to these plans is essential use of the land. The separation of uses for various purposes, arable and pastoral agriculture, wildlife, forestry, etc. could reduce landuse conflicts and land wastage at various levels. Suitable arable land in particular in scarce in this country efforts have to be made to ensure the preservation of

such land.

iv) TO PROMOTE THE CONSERVATION OF NATURAL RESOURCES FOR THE BENEFIT OF THE EXISTING AND FUTURE GENERATIONS

The effectiveness through which the national resources are used and managed need to be lead by an effective planning mechanism and approach i.e. landuse planning, proper management of human settlement etc. The geographic spread of resources and the characteristics of their different host environment require are specific approaches. Measures designed to ameliorate the harmful impacts on the environment have to be enforced and observed.

v) TO PROVIDE BASIS/GUIDELINES FOR THE ASSESSMENT OF THE NECESSARY INSTITUTIONAL FINANCIAL AND MANPOWER RESOURCES AND IMPLEMENT THE NSP OBJECTIVES

This could be achieved through the identification and assessment of the relevant actors, defining and clarifying each actor's role as well as identifying financial and manpower resources need to implement NSP objectives.

vi) TO PROVIDE BASIS/GUIDELINES OF THE DEVELOPMENT OF TRANSPORTATION NETWORK TO STRENGTHEN THE FUNCTIONAL LINKAGES BETWEEN SETTLEMENTS

Transportation and Communication networks are essential for the opening and sustenance of sound economic development and for the achievement of distributive justice. This is so, particularly with respect to opening new development areas, movement of people, commodity flows, the delivery and generally socio-economic activities.

NSP AND THE SETTLEMENT HIERARCHY

The main feature of the NSP is the Settlement Hierarchy which was created to facilitate the implementation of the policy. This settlement hierarchy would also facilitate the growth of both rural and urban settlement in support of agriculture and other productive activities. This concept of settlement hierarchy realises that each individual settlement has played a role in the economic and social structure of the country as well as the spatial distribution of both the economic and social benefits of the production. The settlement hierarchy is categorised in the following way:

i) **Primary Centres**

The primary centres are settlements with a high development potential. They should have more diversified economies consisting of sophisticated raw materials extraction eg. mining infrastructure and social services and population of 20 000 people or above. Primary centres include the four urban

centres and seven largest villages; Gaborone, Lobatse, Selebi-Phikwe and Francistown, Serowe, Kanye, Molepolole, Maun, Mahalapye, Mochudi and Ramotswa. Although there is a difference between urban and rural primary centres, the National Settlement Policy attempts to bring about a balanced development within these settlement.

ii) Secondary Centres

Include the two diamond towns of Orapa and Jwaneng and the rural settlements of Ramotswa, Palapye, Thamaga, Bobonong, Tonota, Hukuntsi, Kasane, Tsabong, Ghanzi, Gumare, Tobane, Letlhakane, Tlokweng, Goodhope, Moshupa. These are intermediate settlements that would improve heir capacity to act as market distribution and service centres for their surrounding regions.

iii) Tertiary Centres

Settlements envisaged as functional units, capable of being developed as production areas rather than individual settlements. They comprise of largely the remainder of the country's settlements and communities of a size and distribution that bridge the gap between agricultural needs of each family to live on its own land areas and farm; and the need to bring people together to provide them with service, seen today as essential. Cattlepost, land areas, tourist camps etc. are all in these categories. Tertiary Centres are subdivide into four categories:

a) **Tertiary Centre I (Regional Centre)**

These are service centres (or village) for production zones. This centre would have a population of 5 000 - 10 000 people. For example the Communal Area Development service centres are some of the most important centres i.e. Shakawe, Sehitwa both in Ngamiland. Facilities for theses centres could be Community Junior Secondary Schools, Clinics, serving a catchment population within a radius of 30 - 50 km or more depending on the remoteness of the district, Headman, Agricultural Demonstrator, Assistant Community Development Officer etc;

b) **Tertiary II (Local Centre)**

Service centre for a catchment area of 15km radius with a population of 1 000 - 5 000 people. Such centres should themselves have the distance factor taken into account;

c) **Tertiary III (Sub-Local Centre)**

Lands or cattlepost service centre for a catchment area of 15 kilometres radius with population of 500 - 1 000. The majority of settlements in this category may be grouped together to form viable economic units.

d) **Tertiary IV**

This settlement type is restricted only to remote areas. Due to socio-cultural reasons and the harsh environmental condition, Remote Area Dwellers must be accorded special treatment. The settlement type will cover a population cluster or catchment of 250 or more people. The economy of these are mainly hunting and gathering and to some extent agricultural production.

The criteria for the designation of the settlements hierarchy has been population distance, role of settlement as a service centre, development potential, etc. Although these criteria were followed, they fell short of differentiating the characteristics of the individual settlement. Settlements differs in terms of their origin, economic potential, social and cultural status. For example, the urban settlements whether primary or secondary have clearly defined economic base and a streamlined administration. All urban settlements except Kasane and Ghanzi have municipal councils with their own budgets. Rural primary and secondary centres are mainly agricultural, administrative and sub-administrative centres responsible for a large area. They compete for resources and attention with the rest of the district settlements.

KGATLENG DISTRICT SETTLEMENT STRATEGY

The main goal of the Kgatleng District Strategy is to guide Local Authorities in locating and prioritising development opportunities within the District. The strategy will specifically address the following:

a) Determine a settlement hierarchy within the District and identify settlements within each hierarchy in accordance with NSP;

b) Determine the priority and level of services and infrastructure provision to each settlement hierarchy in accordance with NSP;

c) Assess existing land use plans and land use planning activities and make appropriate recommendations leading to a more sustainable land use and development. Identify broad land use zones for various uses and determine how they could be used and developed 5,10 and 20 years;

d) Carry out a spatial analysis of the population, settlement and natural resources and determine the direction of population movements and, settlements with high development potential, and make recommendation for their possible upgrading from one settlement hierarchy to another;

e) Identify potential tourism attraction areas, such as wildlife parks, reserves or ranches; and bird sanctuaries; and areas of historic, architectural or cultural importance;

f) Determine the optimum numbers of livestock and wildlife and amount and variety of crops that can be produced in a sustainable manner in the next 5, 10 and 20 years in the district. Determine supplies and shortfalls in production and derive a system of balancing of livestock wildlife and crops;

g) Highlight the general environmental problems and opportunities for their mitigation;

h) Determine appropriate local policies/strategies for the protection and sustainable utilisation of valuable scarce arable land;

i) Assess the existing boundaries and township boundaries, in terms of administrative and service deliveries and make recommendation for changes where necessary;

j) Identify and assess advantages and disadvantages of concentrated and dispersed settlement patterns and make appropriate recommendations;

k) Identify all unrecognised settlements and infrastructure and services provided for each. Make a thorough assessment of the infrastructure and services provided in such settlements, taking into account existing and expected populations in each settlement in the next five, ten and twenty years, formulate a strategy of continued use of the already provided infrastructure and services whereby settlements will be encouraged to regroup or expand towards each other; and

l) Identify causes and impacts associated with the proliferation of settlements and how they can be reduced or halted.

EXISTING SITUATION

Inorder to do the project, a physical field survey of the district was conducted and the following factors were taken into account:-

Administrative set up of the district, Physical Infrastructure and Social services, Economic activities and Employment, Population and Settlements, Land Tenure and Landuse, Natural resources and Physical conditions.

Natural Resources

Kgatleng District consist of flat undulating land, except for a small range of hills from the Notwane river to the Kweneng border and an isolated outcrop in the South. The vegetation is of tree/bush savannah and is under considerable pressure from the interaction of livestock and drought.

Through the District runs the Metsimotlhaba River, making a confluence with the Notwane river at Morwa village. The Notwane river runs diagonally across the District to meet the Limpopo river at Palla Camp in the North-eastern corner of the District. The Notwane has the Tlhagale and Monametsana rivers/streams as its tributaries which run in an easterly direction through the middle of the district.

On the eastern border is the Madikwe river which meets the Limpopo river near Olifants Drift. These rivers flow during the rainy season and can be described as sand rivers from which water can be extracted throughout most of the year.

The north and central areas of the district contain sandstone and rock with some layers of coal. From Mochudi southwards, extending north along the Madikwe river, the underlying rocks are mainly granite types. Over-lying the west-central parts are recent sand and limestone deposits.

The soil pattern follows the underlying rock types. Thus the largest area has sandy soils which are coarse and infertile in the northwest. To the southeast the soils are more mixed with areas of red-brown loam soil and patches of grey-black clay which are more fertile.

The annual rainfall of the district is 450 - 550mm with a 35% variation, except during drought periods when it drops significantly. Temperatures average 20 degrees centigrade annually, with average maximum and minimum temperatures for the year being 28 degrees and 13 degrees centigrade, respectively. The rainy season is normally from September to March, and the Winter season is normally from September to March, and the winter season is characterised by dry weather with lower temperatures.

Population and Settlement

The population of Kgatleng has been growing at a slower rate that the National average (2% vs 3.6%), probably due to the decline of agriculture and the attraction of jobs in Gaborone and other towns. The total district population has grown from 44,461 (1981) to 57,770 (1991) and is expected to continue growing to about 2.4% per annum to reach 62,000 by 1966 and over 77,000 by 2006. Almost half of the district population lives in Mochudi which is growing much faster than the rest of Kgatleng, at between 4% and 5% per annum.

The second largest village is Bokaa with 2,420 enumerated in 1991, Oodi is the third in the population hierarchy having 2,282, followed by Mmathubudukwane with 1,943, Modipane with 1,809, Morwa with 1,748, Malolwane with 1,604, Rasesa with 1,366, Sikwane with 1,216, Artisia with 885, Mabalane with 827, Matebeleng with 599 and Pilane with 540.

Economic Activities

The economy of Kgatleng has been based on traditional subsistence agriculture and this is still the basic livelihood for about 70% of the Bakgatla. Figures on landholding and cattle ownership are not very detailed but generally indicate a rather skewed situation, but less so than the national picture.

Most farming household incomes are supplemented to varying degrees by transfers or modern sector wage contributions from one or more family members. Most of these jobs have historically been in South Africa and more recently in the towns and mining centres of Botswana, particularly Gaborone. Various surveys have shown that between 10-30% of Bakgatla are employed outside the district; but still transfer funds back to extended family members. Others are commuters who travel daily to the city to work but keep their regular household life in Kgatleng.

In the past ten years or so, there has been a growing trend towards investing surplus from either farming or urban employment in small scale commercial or industrial enterprises in the district, especially in Mochudi. Many types of shops have been set up, with a degree of overtrading in the more popular ones such as small general dealers, restaurants, butcheries, fresh produce, bars and bottle stores.

Commerce

Apart from the more common types of businesses, of which there are now several dozen of each, more specialised retail outlets are few and tend to be owned by outsider or even foreign owned companies. Mochudi has two large wholesalers, one a national chain and the other a locally owned by the Coop. Branches of three large clothing and shoe retail chains have moved into Mochudi over the last five years. There is some concern on the part of the local Chamber of Commerce that over-trading and outside competition is tending to weaken the otherwise growing local commercial establishment. The Trade Licensing committee and the village planning committee and to introduce some control into the situation, although commercial pattern of growth.

Small Scale Industry

Since Independence, Kgatleng has been the leading centre for small industrial craft development. Starting with a tannery and several leatherwork producers, and expanding into brick moulding, knitting, sewing, carpentry, welding and several others, the craft industry base has become firmly established with over twenty businesses in Mochudi alone and about a dozen in other Kgatleng villages.

The closing of BEDU and SEISMO has both weaken and strengthened the

local producers forcing them to be more independent and to make contacts with other wholesalers and technical support services. Regrettably, at present many of these are outside Botswana.

Agricultural linkages have not been as quick to be developing as many may have thought looking at the Kgatleng Development Board in the 70's. The biggest success has been with sorghum milling at Pilane and Sikwane, owned by the Coop. The prospect of an atchar production unit at the Ramonaka Horticulture Estate is still delayed by management and financial constraints. FAP has helped many of these small producers to get started and will continue to aid expansion and diversification.

Informal sector

Although overlapping with both the above commercial categories, the growth of self-employed activity in the form of hawking, vending, moonlighting, building labour and other forms of piecework or partime jobs, are adding to the large number of seasonal agricultural labourers, who earn their living from majako and mafisa.

Medium and Large Scale Industry

A relatively new addition to the district economy is the arrival of several big factories, which are generally branches of international companies with some local shareholding in a few cases. Starting with the expanding tannery, the maize mill and tallow processing candle producer, the industrial site at Pilane looks set to expand quite rapidly in the next five years. A major textile factory employing 400, a domestic utensils plastics factory, an electric machine shop, two gas distribution bottling plants and a possible steel scrap re-cycling plant are being allocated land.

The availability of services and low cost land and the labour force in Kgatleng will exercise a strong attraction to industrialists from the region, particularly those seeking to avoid the growing economic and political instability of south Africa. The additional advantages of rail spurs, road networks and nearness to the container depots, plus adequate water and power will enable the Mochudi-Pilane-Mmamashia axis to become a second major industrial focus outside Gaborone.

Educational Facilities

Kgatleng District has about twenty six primary schools of which nine in Mochudi, four vocational training and four day care centres.

Three community junior schools were built, bringing the total of six in the District including 4 in Mochudi. The new schools are Bakgatla Community Junior Secondary between Bokaa and Morwa and Radikolo Community Junior

Secondary in Boseja Mochudi.

Health Facilities

Kgatleng District has one hospital in Mochudi, one private surgery, seven c clinics (four with maternity wings), sixteen health posts and forty three mobile stops spread all over the District.

Workdone

As far as the project is concerned the following data has been digitized: District boundary, Communication network, water resources, settlements, educational and health facilities.

The aim of this project is to super impose the data as the first stage of analysis. However this the first time to use GIS for District Settlement Strategy. The intention is that is that we should have map overlays and through analysis, to back the development proposals particularly to landuse zoning.

MONITORING OF EXPANSION OF ARABLE LANDS IN KGATLENG DISTRICT BETWEEN 1977 -1989

INTRODUCTION

The Department of Lands through the district based resource management institutions, Land Boards, is charged with the responsibility to prepare district integrated land use plans. These plans form the basis for land allocation to different uses. Ever since the Land Boards were established, there has been problems with maintanance of land records pertaining to land allocation and uses. One area of interest is the conflict that occur between arable lands uses and areas designated grazing. As many people become involved in agricultural development more land is required and often potential expansion is towards areas that are designated grazing.

This paper examines the expansion of arable land in an area around Mochudi, in kgatleng district between the years 1977 - 1989. In particular the project is intended to establish whether the purported land shortage for arable agriculture in the district does force farmers to acquire and use marginal land for crop production. This examination is carried out with the use of ARC-INFO, a vector based geographical information system.

BACKGROUND

As many people turn to arable agriculture for survival, pressure on land is increasing. Much of these pressure is exercebated by the fact that methods of land cultivation have not become very intensive. As a result of the low production capacity of the land, more land is required to maintain the level of subsistence. As more land is turned into arable production, there resuslts an increase in the development of adverse environmental impacts, e.g. deforestation as farmers attempt to protect their crops from livestock damage, soil erosion as the soil is tilled etc..

The longterm environmental effects of arable agriculture has necessitated an application of ecological approach to land allocation and development. The white paper on agricultural sector policy of 1990 place much more emphasis on the development of productive systems based on ecological principles and concern for the stability of the environment in light of the increasing human population for food.

The emphasis on sustainable agricutural development learn much on the suitability of the land for particular uses. Although the ecological principle command adherence to this line of development, with shortage of arable land becoming increasingly evident in kgatleng District(District Development Committee, p 55) the scientific evaluation of land is bound to be at variance with the decisions of the land users. This is likely to lead to a situation whereby the suitability of the land for particular uses play a lesser role in land allocation.

STUDY AREA

The study area is located between 400000E 7290000N, 400000E 7310000N, 420000E 7310000N and 420000E 7290000N and covers a land area of approximately 40 kilometre squares. The area is predominatly used for arable agriculture with patches of grazing areas in between. Soils range from sandy loam to loamy which is good for arable agriculture.

FINDINGS

Evidence show that since 1977, there has been a tremendous expansion of arable lands in the study area. While much of the expansion is attributed to growth of population whose economy is largely based on traditional susbistence agriculture, the increasing availability of assistance to arable farmers through Arable Land Development Programme and the discontinued accelerated Rainfed Arable Programme appear to have made arable agriculture more appealing as government met part of the land development costs.

At the sametime the growth of settlements notably Mochudi did not have much impact on the arable land. The growth of the village expanded much on areas which were not used for arable purposes. Probably during the establishment of the village large areas were left for future expansion. Appropriated lands areas are insignificant given the total arable expansion between the years 1977 and 1989. Though no efforts were made to find out the situation about those who lost their arable lands to the expansion of settlements, it is inferred that some of the new allocations might be a replacement of the lost land or are developed arable lands which were allocated prior to or in 1977 but remained undeveloped until sometime before 1989. Map 1 shows the status of arable lands as of 1977 while Map 2 reflects changes that took place up to 1989.

Past evidence has shown that land allocation for arable agriculture and associated agricultural assistance programmes tend to put strong emphasis on quantitative increase in land development and lesser concern on quantitative aspects such as deforestation and erosion etc.. These impacts on environment are often overlooked until serious physical deterioration has occured.

In order to attain sustainability on agricutural development, there is a need for the development of an efficient system on which the aspects of land allocation on the total productive capacity of the agricultural land can be assessed. Geographical informations systems provide an opportunity to integrate various aspects of land and facilitate the determination of appropriate uses.

FUTURE LAND ALLOCATION AND DEVELOPMENT STRATEGY

With the use of geographical information systems by the Department of Lands, it is planned to carry out a major land allocation mapping exercise which will enable existence of detailed information on the capacity of the land in relation to various uses. Such information will constitute the basis for land allocation so that the best agricultural land are protected from being swallowed by other uses while those not suitable for arable agriculture are protected from the blade of a plough. Additionally the impact of land development on vegetation will be encorporated as part of the development monitoring exercise.

However, the success of this project will depend much on interdepartmental cooperation in data sharing and adherence to agreed levels of accuracy. Though many departments seem to have adopted different geographical information systems which is likely to constrain data sharing, it is felt that the use of compatible data exchange formats will for now be the solution.

CONCLUSION

Between the year 1977 - 1989 the study area has seen a tremendous increase of arable lands. Much of this expansion is on good soils though there is a reflection that some of the previous used areas for grazing have been encroached upon by arable lands.

In order to facilitate the development of sustainable agricultural development it is necessary that a land database is developed which will contain information on the various uses and capabilities of land so that land allocation in particular arable is targeted to those areas that can sustain that use. This will not be an easy task but with greater interdepartmental cooperation the exercise is achievable.

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THE TRANSKGALAGADI ROAD PROJECT

1.0 The project involves the construction of a dual road across the Southern, Kgalagadi and Ghanzi districts. It starts from Sekoma to Charles Hill and will serve as a major link between Botswana and Namibia. It is also a long awaited service by the residents of Ghanzi and Kgalagadi Districts settlements through which the road passes.

1.1 **Background**

1.2 The Trans-Kgalagadi road project is funded by THE AFRICAN DEVELOPMENT BANK which has set certain conditions to be complied with by the Government of Botswana. One of the conditions is that of temporary bans on Land and Water allocation within the distance of 15km from the centre line of both sides of the road, especially on unsettled areas.

1.3 This condition requires that Land Use Plans or zoning of land should be prepared before any unplanned developments take place along the route. Development along the Trans-Kgalagadi route need to be planned such that they guide settlement patterns in the areas where the road will run through.

1.4 In order to avoid spontaneous settlements which might be attracted by the road after its completion, settlement planning needs to be undertaken before such unplanned developments spring up. This should include village boundaries, direction of village growth, allocation of boreholes, livestock growth, human water requirements near the road, fencing along the route and commercial developments outside existing settlements.

1.5 There are few settlements and cattle posts where the Trans-Kgalagadi road runs through in the Southern District which this project study will be covering. The main settlements along the route in the Southern District are: SEKOMA, MABUTSANE, MOTSOBONYE AND MORWAMOSU.

1.6 The population distribution of the settlements according to the 1991 Population and Housing Census are SEKOMA (599), MABUTSANE (1,032), MOTSOBONYE (130) and MORWAMOSU (505). Associated localities of these settlements have less than 100 people as most of them are cattle posts and their population range from 0-100.

2.0 **The Purpose of The Project**

2.1 The project was intended to find out;

(a) Which settlements will need land use plans immediately to avoid unplanned developments.

(b) The use of boreholes by the people, cattle, wildlife and the road construction, whether there will be enough water from the existing boreholes.

(a) The road reserve and the new road alignment

3.0 **The Approach To The Project**

3.1 Having observed that the Trans-Kgalagadi Road runs through three districts which are: The Southern, Kgalagadi and Ghanzi, the project covered the area in the Southern District only, because of time limit during the study period. The area covered by this project is from Sekoma to Morwamosu in the Southern District.

3.2 On the basis of the settlements population distribution in the area which is not very high, there were no up to date maps showing settlements and village boundaries in either Sekoma, Mabutsane, Motsobonye and Morwamosu. These settlements have not been mapped since 1978 and the maps which have been used are from 1:50 000 sheets which indicate where the settlements are located.

3.3 Normally settlements which are less populated are tertiary centres and they do not have potential development. The settlements which are covered by this project are least developed. Hopefully this will change with this major construction of a dual road which will attract investors in the future. Already the districts along the route are receiving applications for commercial and industrial plots and other business proposals. Therefore this makes the need for Land Use Plans the highest priority.

4.0 **Land Use Planning/Plans**

4.1 The settlements which need Land Use Plans immediately along the route in the Southern District are Sekoma and Mabutsane. In Sekoma area the road has been completed already. The settlement is located about 80km from Jwaneng and the spill over of the township population which might occur should be avoided by having land use plans which will guide the growth of the settlement. Unplanned allocations are not allowed and until land use plans are prepared, the ban will continue to be enforced on 15km of either side of the completed road which the districts feel they might not be able to hold on to for too long as people need the developments and to develop in the area.

5.0 **The Use of Boreholes**

5.1 The use of boreholes by the people, cattle, wildlife and the road contractors has been designated for different uses. According to the LOAN AGREEMENT boreholes should not be allocated close to the road especially for wildlife and cattle. At the present moment the ban is in place for allocations of boreholes as well. The problem encountered so far regarding water was that in some areas the water was salty hence people, cattle, wildlife and constructors were allowed to drill boreholes 20 metres apart along the route to use for constructing the road. They however did not find suitable water in other areas and where they found suitable water, they had or have to take it in tanks from one place to the other where the constructors and residents in settlements along the route could both use the borehole.

5.2 The cattle and wildlife are not allowed to water any where near the route for fear of overgrazing. This ban will still stand even after the completion of the road or will have to be discussed further whether the ban should be imposed forever. The boreholes with suitable water along the route will be allocated to residents and those which are outside 15km will be used for watering cattle. The project covered boreholes with suitable water only in the Southern District.

6.0 **The 15km Road Reserve and Alignment**

6.1 The Trans-Kgalagadi Road alignment has been designed as a winding road from Sekoma to Charles Hill. It has been deliberately designed this way in order to reduce accidents as it is a very long distance. The new road alignment is constructed close to the existing route.

6.2 The 15km road reserve or bufferzone imposes bans on developments temporarily until such time that planning has been done. After the land use plans have been prepared for settlements along the route, the ban will be lifted and allocations will be made or done. The road reserve will not be fenced as there are fears that his might disturb wildlife migration. Allocations for watering wildlife and cattle will be restricted along the road reserve.

6.3 The road will by-pass settlements with feeder roads to serve the settlements at a distance of 1.3 to 1.5km. The Landscape along the route is flat, gentle and dry in most places. Along the route about 80% of the land is Tribal, Freehold is 10% and Stateland 10%. It is hoped that the route will improve communications of that region and other parts of the country.

7.0 Project Implementation and Problems Encountered

7.1 Using Geographical Information Systems and a software called Tosca a map showing the district boundary, settlements, new road alignment, road reserve and boreholes with suitable drinking water was digitized. The map's coordinates were calculated accordingly with the maximum and minimum x and y coordinates of the grid to fit the map boundary.

7.2 Once the coordinates were set, about six vector files were created and they are ROADCON, BOREHOLE, TRANROS, TRANSRD1, TRANSETT and ROADBURF3. After creating the vector files which showed general information of settlements, new road alignment, bufferzone, boreholes and the district boundary, the files were later rasterized using other GIS methods or command such as reclass and this method enabled the settlements and the road bufferzone to be shaded.

7.3 The vector system and Raster system are different but are used to produce data as desired. The vector system is good for network as it produces smooth lines which can be joined together by segments or nodes to produce whatever feature is desired. The raster system gives shades to features as desired and the two systems can be manipulated to produce the best results. When digitizing the vector system was used and later the raster system was applied to give a better looking or colourful map.

7.4 Problems were encountered when digitizing the boreholes file. The boreholes were digitized using the grid reference x and y coordinates which indicated where each borehole is located along the route. Later they were also rasterized using point ras command but the boreholes appeared on the centre of the road which should not be the case. However it was later realised that probably the scale of the map was the cause and time did not allow to rectify the problem.

7.5 The other problem which was also encountered later was when plotting the final results of the map. some features like the legend, the district boundary and Sekoma settlement were displaced. The features of the map appeared normal on the computer screen but when plotted the features did not appear where they showed to be on the screen. There was also not enough time to rectify this problem. One had to do with what ever results came out see attached TKR map.

8.0 **Limitations of the Project**

8.1 There was a lot to be done on this project but due to lack of time, part of the project was left out. The project could have covered the whole Trans-Kgalagadi route from Sekoma to Charles Hill, showing all the settlements, the new and old boreholes along the route, the new road alignment and the bufferzone all the way.

8.2 All the necessary data was collected and compiled but only a quarter of it was utilized and hopefully during this workshop or after, time will be set to do this project again and this time land use plans will be included. Hopefully the university GIS lab might be requested to help if possible.

8.3 Having been exposed to GIS and the three levels of the course run at the university, it has been worth while and a lot of experience has been gained and will be fully utilised at the working station as equipment is now available.

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Appendix

Map showing boreholes which have suitable water for drinking purpose, road reserve of 15km on both sides of the road and a few settlements along the route in the Southern District.

Source of Information

Department of Town and Regional Planning and Roads Department (Road Reserve and the new Road Alignment).

Department of Water Affairs (Boreholes) Central Statistics Office (Population of Settlements).

Map Projections in Use in Botswana

I hope you are all well aware of the fact that you cannot project a sphere or spheroid accurately on to a flat piece of paper. The normal comparison is to imagine wrapping up an orange in a sheet of paper. It can't be done without crumpling the paper. When we project the sphere onto a map we don't crumple the paper but stretch it and this changes the scale across the map. This produces distortions. What manner of distortion you accept depends on the purpose of the map.

A SPHERE is like a tennis ball, evenly curved in all directions. A SPHEROID is almost a sphere but not quite. A rugger ball is one version of a spheroid and a discus is another version.
You can produce a sphere by spinning a circle about an axis and as it is a sphere it doesn't matter which axis.
Which type of spheroid you get depends on whether you spin about the short axis (a discus) or the long axis (when you get a rugger ball).

In any spatial work you need coordinate systems. On a flat piece of paper you can work in either polar or rectangular coordinate systems.
In the rectangular system you establish an origin and an azimuth which becomes one axis of the system and a second axis at right angles to that in the plane you are working. These axes can be called anything you like X,Y, N,E. The points are expressed as a distance down one axis and then an offset parallel to the other axis for another distance. This system working on a flat plane can be continued indefinitly.
If you need 3-dimensional coordinates you add a third axis and coordinates at right angles to the plane defined by the first two axes.
In the polar system you have a fixed origin and an azimuth, all points are expressed as distance from the origin and as an angle round from the azimuth. (you establish a convention as to the direction of your azimuth and whether you measure clockwise or anticlockwise). If you want a third dimension you either add a value for the slope of the radial line or use the same system as in rectangular coordinates. This is you can see already getting complicated and the longer the radial lines the more precisely you have to define their directions in both planes. There is a further disadvantage that points are only related to the centre and while you can solve the interpoint distance quite easily in 2 dimensions it gets tricky in 3 dimensions. In rectangulars it remains as simple in three dimension as in 2.

On a sphere the situation is rather different. Luckily we are dealing with a spinning sphere so there is one obvious axis, the polar axis and the plane of the equator gives the plane for the other two axes. The origin for these two axes has changed often. Europeans have used Jerusalem, Rome, Madrid, Lisbon, Paris and London (or rather Greenwich). By international agreement everyone now uses Greenwich to define that origin and the other axis is at right angles to that.
Traditionally surveyors are working on the surface of the sphere (the bottom of the Mariana trench to the top of Mt Everest is about 19.8 km compared to an average radius of 6365m - this is

the equivalent of half millimetre dimples on a basketball and slightly less than the difference between the two semi-axes). When working on the surface the distance from the centre is constant so a polar system becomes useable. The system used is to measure up from the equator using the plane of the equator as an origin which gives latitude and round from the plane through Greenwich to get Longitude. Lines of equal latitude are called circles of latitude and lines of equal longitude are called meridians of longitude.
Now that we are using satellites for navigation and mapping purposes we are working in a much deeper zone and for many purposes surveyors find it easier to work in geocentric cartesian coordinates especially when doing spheroid to spheroid conversions. The Z axis runs up the polar axis the X axis is in the plane of the Greenwich Meridian and the Y axis goes out to Longitude 90°E

When producing an atlas you are normally covering quite large portions of the globe on each map and the potential distortions caused by the problem of fitting flat paper to a sphere become serious.
The manipulation, choice and tolerance of distortion is the whole purpose of the study of map projections. One of the early choices to be made (heavily influenced by the purpose of the map) is equal area or orthomorphic (which is frequently taken to mean correct shape).
The equal area projections are used for distribution maps in atlases and are very rarely used for any other purpose. In them equal areas on the sphere have equal areas on the map. To achieve this the scale factor on the meridian has to be the reciprocal of the scale factor on the parallel of latitude. In this approach it doesn't matter if Botswana appears roughly 1000km north-south and 1000km east-west or 1200 north-south and 833 east-west or vice-versa. In fact those ratios would be very acceptable; 1600 to 625 would be approaching the conventional acceptable limits.
The orthomorphic projections do not actually give correct shape; the scale factor at any point in any direction is equal to the scale error in any other direction. This means that all angles at a point are also correct. On the Mercator projection the scale east-west and the scale north-south are equal so it is orthomorphic but to achieve this as you go further from the equator the scale factor increases. The result is that a map of the north American continent shows Canada as much bigger than the United States which it isn't. It is this sort of distortion which causes my rather pedantic rejection of the term correct shape.

There are three basic ways of applying a piece of paper to a sphere.
A zenithal projection where the paper remains flat and in cross section appears as a tangent;
a cylindrical projection where the paper is wrapped round the sphere like a tube;
a conical where the paper forms a cone touching the sphere on a line. This line forms a curved line on the paper.

A further pair of definitions is needed here.
A GRID is precisely that a series of theoretical lines at right angles used to define rectangular coordinates.
a GRATICULE is a representation of meridians of longitude and circles of latitude. It doesn't even have to be a on a flat piece of paper it is still a graticule if drawn on a globe.

It can be argued that the cylindrical and zenithal are the two extremes of the conic series. In the cylindrical case the radius of the curved line has increased to infinity while in the zenithal case the radius has shrunk to zero.
All these can be either equal area or orthomorphic.

In all mapping in Botswana Surveys and Mapping use transverse cylindrical projections. In these transverse projections the line of contact is not the equator as in the Mercator projection but a chosen line of longitude.
We have three choices, Gauss Conformal (Lo), a 2 degree wide belt, Universal Transverse Mercator (UTM), a 6 degree wide belt or a projection especially designed for Botswana by Brigadier Collins in 1967 which for want of a better name I call the Collins Projection; this has only one belt which is 10° wide.

As these are all transverse Mercator projections the mathematics is the same for each. The only variation is the scale factor on the central meridian and the actual central meridian. By the very nature of the projection the scale factor increases as you go further from the central meridian - proportionately to the square of the distance from the central meridian. So as the belts get wider the scale factor on the CM has to get smaller if the scale factor at the edge is to stay within reason.

The north-south grid lines are parallel to the central meridian on all TM projections. This gives a very messy effect when you get a zone boundary on a map. In Botswana two of the 1:500 000 series show this with grid lines converging as you go south on the map.
It was this potential untidiness on the finished map and the fudging necessary to produce the map that caused DSL to ask Brig Collins to design the special transverse Mercator projection for Botswana. He was designing a small scale map (1:1 000 000) and he could afford a slightly larger scale factor than in UTM projections. Unfortunately we do not know what that scale factor was !
By measuring on the maps I get a value of 0.99666; this would be great for mapping Boponong or places west of Mamuno or Charles Hill but not good for the rest of the country. Working theoretically a scale factor of 0.999 seems better. This didn,t mattered in the past as the map was compiled in Harare in 1968 and has merely been revised and reframed since then.
The 1:1.5M is a photographic reduction of this map and when we digitise that we want to use the surveyed coordinates for boundaries. For this we need to use the projection data. We had it 25 years ago but it has been mislaid.
We are going to use 0.9992 as a scale factor.
There will be a false eastings of 500 000m
the northings will start from the equator at 20 000 000m

This Collins projection is one solution to single sheet maps of Botswana. Another is the oblique zentithal stereographic centred on 24 E and 22 S. Eith of these will give you a good map with tolerable scale factors at the edges - but neither will fit with a map produced on a standard projection or even a similar with different origins.

In the UTM series of projections the central meridians (the contact line) are spaced round the sphere every 6^0 starting at 177^0W and continuing to 177^0E. Botswana falls in zones 34 and 35: there is a mathematical relationship between zone number and central meridian value. Zone Number = 31 + (CM-3)/6
The zones are 6^0 wide as this gives an optimum combination of the minimum number of zones and scale error. Scale error increases by the square of the distance from the central meridian. To keep this error within reason a scale factor of 0.9996 is introduced on the central meridian. Using this factor the scale error at the zone edge is reduced from 1.0018 to 1.0014.
The UTM is a comparatively recent development; before that we used a different transverse cylindrical projection. This was the Gauss conformal projection. The finer details for this projection were developed in South Africa so the southings increase positively going south while angles are measured clockwise from south. Its primary purpose was for cadastral surveys. As a result there is no scale factor on the central meridian and to compensate for that the belts are only 2^0 wide. Because of the proliferation of belts in this system it was necessary to specify the central meridian with each set of coordinates hence Lo 25 meaning Longitude of origin 25^0 or whatever value the central meridian had. This projection is still used for all cadastral and large scale surveys while we use the UTM for medium scale surveys and the Collins for map series which cannot easily be split along 24^0 E.

The major and obvious differences between the Gauss Conformal and the other systems is the coordinates. They all use metres and the same spheroid but UTM and Collins has the origin 500 000m west of the central meridian and, in the southern hemisphere, 10 000 000m south of the equator while the Gauss Conformal has the origin on the equator and the central meridian. If you look at the examples the difference between the systems is distinctive.

Lat	Long	Gauss Conformal Y	Gauss Conformal X	UTM Eastings	UTM Northings
-21 0	21 0	0.00	2322879.14	500000.00	7678050.01
-21 15	21 0	0.00	2350556.84	500000.00	7650383.39
-21 30	21 0	0.00	2378235.37	500000.00	7622715.92
-21 45	21 0	0.00	2405914.74	500000.00	7595047.62
-22 0	21 0	0.00	2433594.97	500000.00	7567378.47
-21 0	21 15	-25993.30	2322899.46	525982.90	7678029.70
-21 15	21 15	-25949.78	2350577.36	525939.40	7650362.87
-21 30	21 15	-25905.76	2378256.08	525895.40	7622695.22
-21 45	21 15	-25861.25	2405935.65	525850.90	7595026.72
-22 0	21 15	-25816.25	2433616.07	525805.92	7567357.38
-21 0	21 30	-51986.97	2322960.43	551966.18	7677968.75
-21 15	21 30	-51899.92	2350638.92	551879.16	7650301.34
-21 30	21 30	-51811.88	2378318.23	551791.15	7622633.10
-21 45	21 30	-51722.86	2405998.37	551702.17	7594964.02
-22 0	21 30	-51632.85	2433679.36	551612.20	7567294.11
-21 0	21 45	-77981.39	2323062.05	577950.19	7677867.17
-21 15	21 45	-77850.80	2350741.52	577819.65	7650198.78
-21 30	21 45	-77718.73	2378421.81	577687.64	7622529.56
-21 45	21 45	-77585.18	2406102.92	577554.15	7594859.52
-22 0	21 45	-77450.17	2433784.87	577419.19	7567188.65

An alternative presentation with sets of coordinates in their relative positions is below.

-21 00 00	21 00 00	-21 00 00	21 15 00	-21 00 00	21 30 00
0.00	2322879.14	-25993.30	2322899.46	-51986.97	2322960.43
500000.00	7678050.01	525982.90	7678029.70	551966.18	7677968.75
-21 15 00	21 00 00	-21 15 00	21 15 00	-21 15 00	21 30 00
0.00	2350556.84	-25949.78	2350577.36	-51899.92	2350638.92
500000.00	7650383.39	525939.40	7650362.87	551879.16	7650301.34
-21 30 00	21 00 00	-21 30 00	21 15 00	-21 30 00	21 30 00
0.00	2378235.37	-25905.76	2378256.08	-51811.88	2378318.23
500000.00	7622715.92	525895.40	7622695.22	551791.15	7622633.10
-21 45 00	21 00 00	-21 45 00	21 15 00	-21 45 00	21 30 00
0.00	2405914.74	-25861.25	2405935.65	-51722.86	2405998.37
500000.00	7595047.62	525850.90	7595026.72	551702.17	7594964.02
-22 00 00	21 00 00	-22 00 00	21 15 00	-22 00 00	21 30 00
0.00	2433594.97	-25816.25	2433616. 7	-51632.85	2433679.36
500000.00	7567378.47	525805.92	7567357. 8	551612.20	7567294.11

The boundaries between zones are not watertight. Tlokweng falls in zone Lo27 while Gaborone is in zone Lo25 but we have extended zone Lo25 so that we have a continuous block of maps. Similarly my old organisation Overseas Surveys used to compute the UTM coordinates in both zones for all points which fell within 15' of the zone border. The point is you can go over the zone border and tolerate a scale error but if you use the coordinates from two zones at once you will get huge errors.

The distance between 22°S 24° 05' and 22°S 24° 10' would be 8611.33m in zone 35 or 8613.03 in zone 34 but working with mixed zones it is 628 157.68m or 610 936.635m depending on where you start your mistake. The only thing to be said for an error of that size is that you should see that something is wrong. A good software should give you some idea of

how well the control points are fitting when they are digitised and this size of error should show.

Another problem is conversions; from geographicals to grid, grid to geographicals and grid to grid. The last one should not be done although I have seen files from private surveyors where it was done by a conformal transformation. That is tolerable over a few sq km if you are working in the right parts of the country. By that I mean the CM of both projections is on the same side so that the scale factor is increasing in the same direction. To do the conversion accurately you have to convert to geographicals and then to the new grid.
There are two ways of doing these conversions. The old way using American Army Map Service tables and the new way where you program your computer. If you are handling or proposing to handle a large number of coordinates which are already on the computer there is no real choice. I am not going into the mathematics of that today. It is possible, Ebbe Ericsson did it in 1992 using Fortran from scratch and I have done it more recently using ex-Oversesa Surveys programs as I wanted a specific output format for import into our suite of mapping programs. All the formulae are given in Allan, Hollwey and Maynes's text book alternatively I can give you a copy of the Fortran listing which I imagine could be converted to any other language without much difficulty.

The other solution is to rely on your GIS software.
For instance using a routine called (I think) project in Arc Info you just feed in certain parameters for the input and output projections and your conversion is done for you without disturbing all your linkages between graphic and dbase data.
There are three items which have to be specified;-

<u>units</u>; ie metres, feet, cape feet, indian chains but preferable metres.

<u>scale factor</u>; this should be simple from the projection data but to get gauss conformal coordinates with north at the top we need a negative scale factor. Also someone may have done something odd to the coordinates. Importing from another GIS should be safe but taking data from a CAD package can produce odd effects.

<u>constants</u>; the false values for the origin or possible a leading digit which was dropped for convenience.

	Gauss	UTM	Collins
units	metres	metres	metres
scale factor	1.000	0.9996	0.9992
eastings constant	0.00	500 000.00	500 000.00
northings constant	??	10 000 000.00	20 000 000.00

The only way you will find out the northing constant for Gauss (which should be zero) is by looking at the coordinates and looking up what they should be. Very frequently the constant is 20 000 000.0 but if you are working from a CAD package it might be 23 500 000.0.

THE IMPACT OF LIVESTOCK PRODUCTION ON VEGETATION USING GIS APPLICATIONS.

CASE STUDY - TLOKWENG COMMUNAL GRAZING AREA.

BY MS. CONSTANCE MASALILA

THE IMPACT OF LIVESTOCK PRODUCTION ON VEGETATION USING GIS APPLICATIONS.

CASE STUDY - TLOKWENG COMMUNAL GRAZING AREA.

1.0 INTRODUCTION.

Livestock production is one of the main sources of income in Botswana's economy. There are three main types of livestock production systems practised country wide. These are; Commercial, where farmers have enclosed ranches and they control stock numbers. Semi-commercial, where farmers have enclosed ranches (some may be paddocked) but they do not control stock numbers. Communal, where the use of land is free for all and no rangeland management systems are practised.

The communal production system is one of main the causes of rangeland degradation, because resources are communally owned and there is no control over stocking levels as every individual is aiming at maximising production (Harding, 1968). The effect of high stocking levels on rangeland is exacerbated by rainfall which is highly variable both temporally and spatially. Batswana pastoralists have the general feeling that there are no long term changes in the condition of their rangelands because of overstocking. Very often it takes a long time (even too long for the inhabitants of any given area) for a change in the state of the environment to be obviously noticeable (Van Vegten, 1984).

The use of tribal land was traditionally controlled by the chief, acting through ward headmen and grazing overseers, but this system has gradually declined (Abel, Flint, Hunter, Chandler, Maka). The conservation and the use of land resources is now supposed to be regulated by the Land Boards, national Agricultural Resources Board through Districts Conservation Committees, supported by a battery of legislation. In practice the more stringent aspects of the law, particularly those concerning stocking rates and grazing pasture conservation, are not enforced. Thus current management practices and stocking rates are the aggregate outcome of the state or the traditional authority (CARG, 1984).

The decline of coordinated land management has occurred at a time when the land is under increasing pressure from a growing human and livestock population. In addition the herbivore population which originally utilized Botswana's rangeland were, in the main browsers, these were displaced by the introduction of livestock, which are mainly grazers. Such changed pressures are bound to affect rangeland composition even if stocking rates remain light. The increase in cattle is itself associated with wage labour and remittances (Hubbard 1984). Kerven (1982) found a positive correlation between the quantity of money remitted and the likelihood of a household owning cattle. Communal grazing area though is gradually declining throughout the country due to expansion of arable and residential area.

Tlokweng communal grazing area is part of the Greater Gaborone Region. Demand for residential land in Tlokweng because of the influx of people from Gaborone, is taking a sizeable amount land from the grazing area. The vegetation is seriously affected by man through; livestock grazing, cutting of firewood, clearing areas for cultivation and collecting of materials for construction of bush fences and residential properties. Gaborone is a major consumer of local fuelwood supplies, and competes directly with rural residents in the consumption of these resource. Bush encroachment may thus be marked by removal of a proportion for fuelwood. Deforestation of some trees/shrubs like Acacia might result in coppicing leading to changes in the vegetation structure.

1.1 LITERATURE REVIEW.

The Commons Theme originally ("commons" originally referred to resources) had a social and legal dimension as well as an economic function, for in those days the resources were communally shared by a recognised community where legal rights of access and use were territorially and socially defined by the size of the village, and social relations and customs that were associated with each settlement (O'Riordan and Turner, 1983). It is interesting to note that the physical and legal entity of the commons began to disappear as population increased and there were pressures to improve the productivity of the best land. This principle is true for communities in Botswana like Bangwaketse (Abel, Flint, Chandler, Hunter and Maka) and Batlokwa, originally the communities were overseers of their resources but this has declined.

The condition and trend of the rangelands has undoubtedly become a great concern to a number of writers (e.g. Campbell and Child, 1971, van Rensburg, 1971, Cooke, 1981) and the government. In 1975 the government acknowledged the national problem by formulating the Tribal Grazing Land Policy (White Paper No.2 1975). Two causes of the suspected problem were - the decline of traditional management, and the increase in cattle numbers. Evidence of environmental deterioration is mainly concerned with the identification, measurement, and description of the effects of overgrazing on the rangelands. The evaluation report on Livestock Management and Production in Botswana (Carl Bro International AS. 1982) concluded: "virtually all range studies conducted over the past two decades point unequivocally to spreading conditions of overstocking and degradation of the vegetation". According to Cooke (19) land degradation takes a variety of forms, and does not merely affect the vegetation. It includes the following:

-the extension of completely bare ground, especially around watering points, through excessive grazing and trampling;
-the disappearance of the more palatable grass species and their replacement by less desirable woody and thorny shrubs;
-loss of the top-soil by wind and sheet and gully erosion.

Bhalotra (1987) states that "it is essential to minimize the degradation of rangeland that frequently occurs in the arid and semi-arid areas as a result of an imbalance between livestock population size and rangeland carrying capacity, a degradation that is easily accelerated during drought episodes. Natural ecosystems usually recover from even prolonged drought when the rains return, though it might lead to changes in the vegetation composition especially of the lower layer. However, if the misuse of land through overgrazing and indiscriminate cutting of trees etc. has already weakened the natural system and caused it to lose its capacity to recover, then drought often leads to degradation."

Management problems of communal African rangelands have been perceived for some considerable time, as the control of rangeland degradation through the control of excessive livestock numbers. The scientific basis for this concern has been the concept of rangeland carrying capacity defined and measured according to assumptions about the impact of herbivores on plant succession. This concept has provided the standard against which African rangelands are judged to be overstocked, overgrazed and ultimately degraded (Sandford, 1983).

1.3 OBJECTIVES.

The overall goal of the study is to assess the impact of livestock production on the vegetation overtime using aerial photographs for 1975 and 1989, taking into consideration human impact as they also have a part to play.

-The impact of livestock production on vegetation depicted by increase in bare ground or increase in bushes (bush encroachment).

-Human impact on vegetation, due to deforestation for domestic purposes.

Grazing resources are bound to change in both quality (change in species composition) and quantity (total area available). Mentis, (1984) said "*grazing quality is the proportional species of the veld as influenced by abiotic and biotic factors including defoliation history*". The quantity and quality of grazing are determined by the following climatic and edaphic factors; rainfall, temperature, humidity, radiation, infiltration, soil texture, moisture retention, fertility and depth.

2.0 DESCRIPTION OF THE STUDY AREA.

Tlokweng communal grazing area is limited as there is no room for expansion. This area is divided into wards which were originally managed by the headmen, who reported directly to the Kgosi. At present this management has declined. Around 1928 a drift fence was constructed to separate arable from grazing area (the

construction and maintenance as the responsibility of each ward). This did not only reduce the herding duties but it provided rotational grazing opportunity.
Livestock water is from Mmamogafu dam and other small seasonal dams.

2.1 LOCATION

Botswana lies between latitudes 18° S and 27° S and longitudes 20° E and 29° E. The country encompasses the hardveld in the east and sandveld in the west. Tlokweng communal grazing area is in the south eastern part of Botswana, the hardveld, and falls between latitudes 24° 36'S and 24° 42'S and longitudes 25° 57'E and 26° 10' E. This area is bordered by arable area (drift fence) to the north, east and south Gaborone to the west.

2.2 CLIMATE

The climate of the study area is semi-arid. Rainfall is highly variable in space and time. Ninety to ninety-five percent of rainfall is concentrated in the six-month period from November to April, and the mean annual rainfall for the country ranges from >250mm in the southwest to <650mm in the north. The mean annual rainfall for the study area ranges between 450mm and 550mm. The coefficient of variation ranges from 30%in the north to 45% in the extreme southwest and the extreme east where rainfall is minimum. The prevailing high daytime temperatures throughout the year, but especially in summer lead to high daily rates of open water evaporation, which may reach 7.5mm per day (Cooke).

2.3 SOILS

Soil types occurring in the area, as described by Moganane(1988), range from the Ferric and Chromic Luvisols in the grazing area, to Petric Vertisols in the arable area to Calcaric Cambisols along drainage lines.
Ferric Luvisols are very deep, well drained, strong brown to dark red sandy clay soils.
Chromic Luvisols are very deep, moderately well to well drained, yellowish red sandy clay loams.
Petric Vertisols are deep to very deep, poorly drained, dark greyish brown clays.
Calcaric Cambisols are moderately deep, moderately well drained dark greyish sandy loams to sandy clay soils.

2.4 VEGETATION

The vegetation type in the area has been described as Tree savanna -arid sweet bushveld, composed of Peltophorum africanum, Combretum hereroense, Dichrostachys cinerea, Acacia flekii, A. mellifera, A. erioloba, Aristida congesta, Eragrostis lehmaniana, Eragrostis rigidior and Tragus berteromasus (Weare and Yalala, 1971).
Currently the lower layer is poor and is mostly dominated by Aristida species and the upper layer is dominated by Acacia

species.

2.5 DEFORESTATION

The location of the study area makes it easily accessible for deforestation. The products are used as fuel, fencing and building materials.

3.0 METHODOLOGY.

Base map for the area was produced from thematic map (Surveys and Lands 1987). For digitizing in IDRISI I used Tosca. Digitizing was done in layers- rivers, boundary of grazing and arable area.

Aerial photographs for the years 1975 and 1989 covering the study area were used. Vegetation types and settlements were delineated from the aerial photographs and then digitized as different layers. The output in Tosca which is in vector form was saved as polygons, and then cycled to create raster images in IDRISI. Four vegetation types were digitized in this area, these are;
-Mixed tree and shrubs; composed of *Peltophorum africanum, Combretum hereroense, C. zeheri, Dichrostachys cinerea, Acacia erioloba, A. flekii.*
-Acacia dominated zone; *A. tortilis, A. flekii, A. erioloba, A. mellifera.*
-Riverine forest; *Ziziphus mucronata, C. hereroense, A. mellifera.*
-Woodland; *Boscia albitrunca, P. africanum, A. erioloba.*

The species list was collected from the ground, from each vegetation type delineated. This was done to verify whether there is a difference in the species composition of the vegetation types.

The following images were produced ;

Vegetation types of Tlokweng area in 1975.
Vegetation types of Tlokweng area in 1989.

To find out if there has been changes in the vegetation types, the two images were crosstabulated. The operation of Crosstab offers cross-classification of two images, which can be linked to multiple overlay. This operation results in a new image showing the locations of all combinations of the categories representing non-zero entries. That is, the image shows only the vegetation types that have change. All the types that have not changed are assigned a value zero and these are not shown.

The image showing the changes in the vegetation types was produced and is titled -

Cross-classification veg75z:veg89new
Vegetation changes over-time in Tlokweng area (75-89)

4.0 RESULTS.

Visual analyses of aerial photographs from 1975 and 1989 show substantial changes ,indicated by an increase in the frequency of occurrence of light toned patches, density of tracks, number of dams (mostly seasonal) and expansion of settlement.
On the ground there is considerable amount of tree cutting in the area indicated by stumps.

The vegetation is composed of Acacia mellifera, A. erioloba, A. karoo, Ziziphus macronata, Peltophorum africanum, Aristida congesta, Eragrostis lehmaniana, Cloris vigata, Tragus berteronianus,
Despite rainfall received between October 1993 and March 1994, the condition of the lower is poor, but the livestock are in good condition. Around Mmamogofu dam and settlements near the arable area the grazing condition is worse.

5.0 DISCUSSION.

Changes in the vegetation structure are thought to be associated with an increase in number of grazers (cattle) as opposed to browsers. Increase in cattle numbers lead to; reduced grass biomass, reduced infiltration which is magnified by capping (observed by Biot, 1986, at Morale), reduced soil moisture and increased run-off (Abel,Flint,Hunter,Chandler,Maka).
The reduction of grass also reduces competition with seedlings of woody plants which can therefore become established in some years. Encroachment also depends on texture of the soil, as vegetation cover decrease due to overgrazing can initiate long term changes in texture and structure as silt, clay and organic matter are lost.
Vegetation cover is the primary regulator of erodability (Stocking 1981), and a decrease caused by grazing can initiate long-term changes in texture and structure as silt, clay and organic matter are lost. The result is less soil moisture, a decline in grass productivity, and a further decline in cover independent of direct loss to grazing animals.
By reducing grass production, bush encroachment has a negative effect upon herd growth and milk and meat production during season for bush is inferior feed to the grass it replaces. Bush encroachment may limit cattle mortality during the dry season, and thus enable herds to grow in the long run despite a decline in grass cover. However, the productivity of animals is likely to decline, so that more are needed for a given output.

5.1 CONCLUSIONS

There is a clear indication of downward trend in the quality of grazing , depicted by the increase of light toned patches in the aerial photographs. This is verified by the dominance of poor species composition on the ground, Aristida species and Acacia species.

6.0 RECOMMENDATIONS

1. Batlokwa should consider introducing grazing fees to try and control stock numbers.

2. The community should be encouraged to manage their grazing area to improve production, this might include paddocking the area, culling, and adhering to stocking rates. This system would work well once the New Agricultural Policy takes off as it encourages management of resources.

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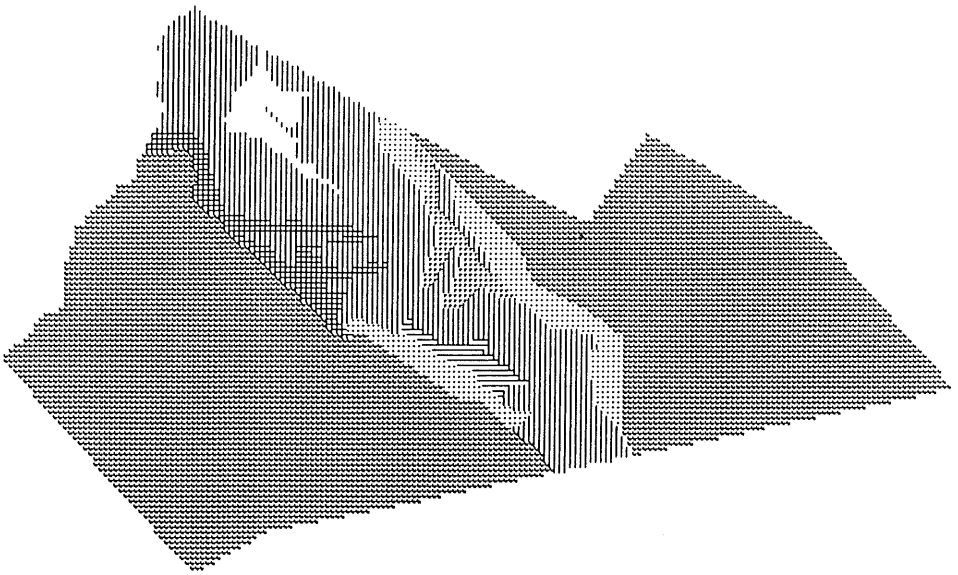
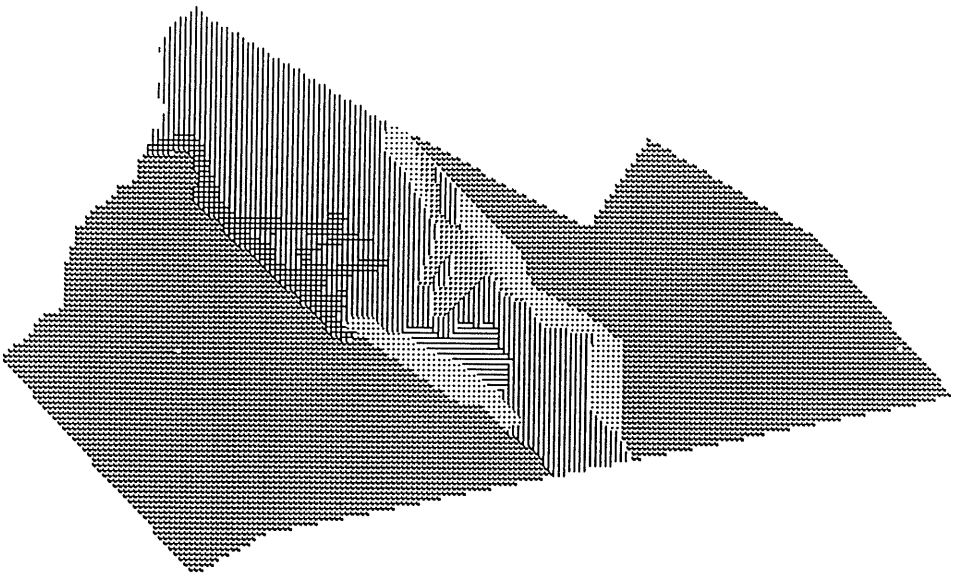
VEGETATION TYPES IN TLOKWENG AREA FOR 1975.

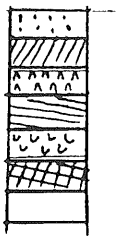


VEGETATION TYPES IN TLOKWENG AREA FOR 1989.

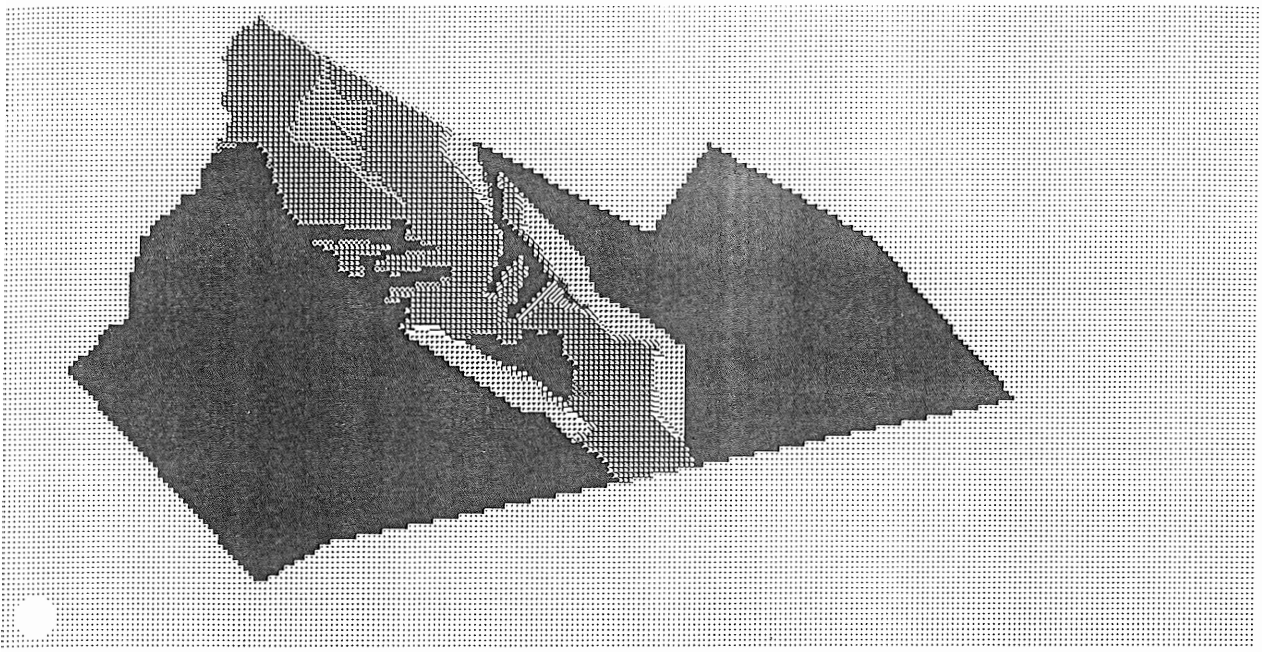


LEGEND

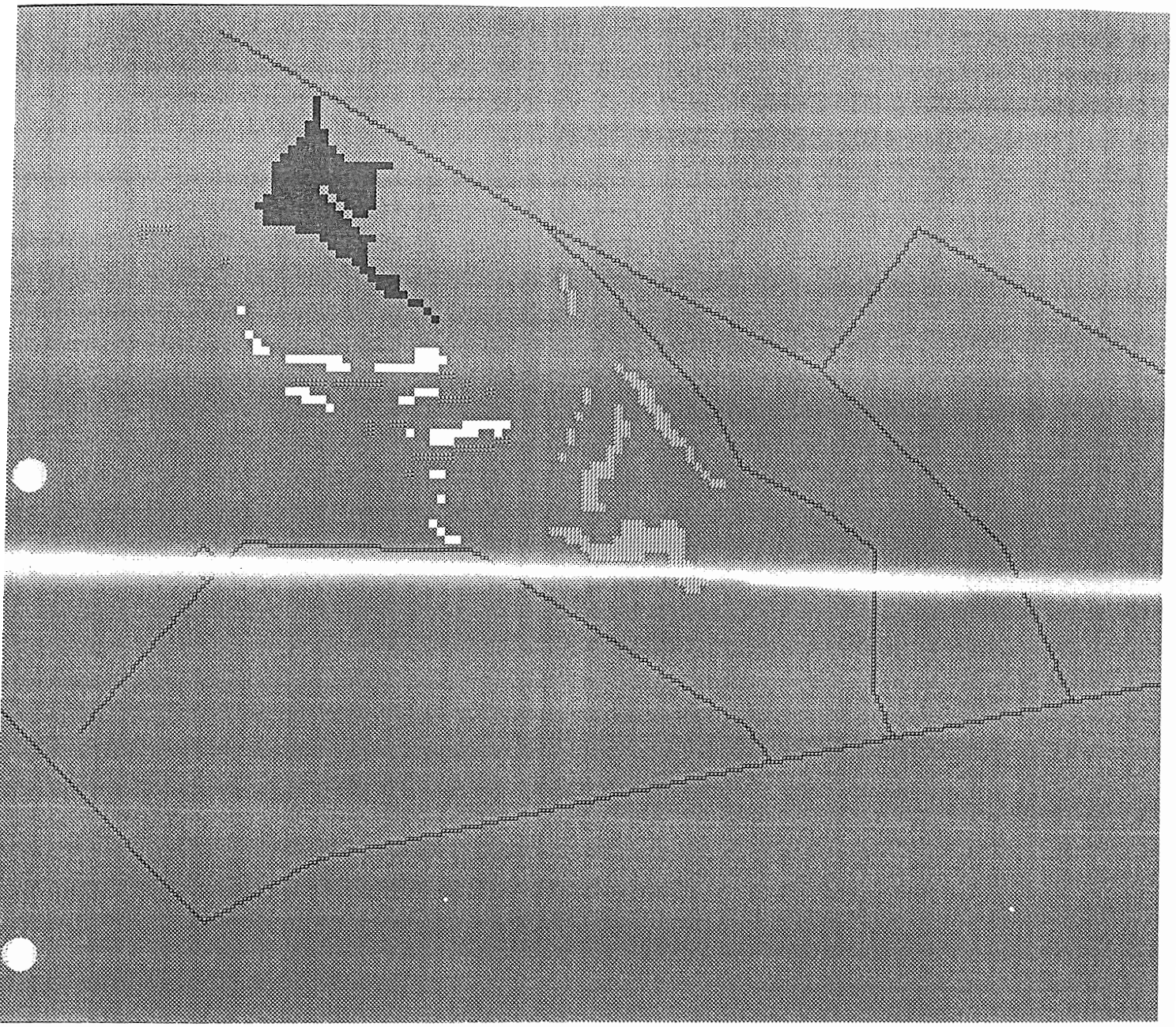
Settlement
Trees /shrubs
Acacia
Trees/bare ground
Arable
Riverine
Degraded area



CROSS-CLASSIFICATION 1979.1989.



VEGETATION CHANGES OVER TIME IN TLOKWENG AREA: 1975 and 1989.



USING GIS TO MEASURE THE EXTENT OF ARABLE LAND AND ITS EFFECT ON THE QUALITY AND QUANTITY OF GRAZING

A PAPER PRESENTED AT THE TRAIN THE TRAINERS WORKSHOP HELD AT

THE

UNIVERSITY OF BOTSWANA

PRESENTED BY: R.J.G. SEBEGO

DATE: 06-06-94

INTRODUCTION

A large number of rural people in Botswana are dependent on subsistence agriculture whereby both livestock rearing and arable agriculture are practised. These activities are two competing land uses mainly because of the following reasons:
Firstly the majority of farmers do not have the means of running cattlepost and lands at the same time, secondly, being subsistence farmers they rely mostly on animal draught power except where subsidies are available to enable them to hire tractors, lastly, land for whatever use is getting scarce. In the agricultural sector the increase in the livestock numbers and the increase in the amount of land being put under cultivation has put pressure on the land's resources.

OBJECTIVES

The overall goal of this study was to assess the impacts of land clearing for the purpose of arable farming on grazing resources using GIS.

The main objectives of this study were to assess the following:
i) the total area of land that has been converted into arable land between 1982 and 1989 with the aim of ascertaining an assumed pressure (high stocking rates) on the rangelands as a result of loss of grazing land.

ii) the impact of the expanding area under cultivation on the quality and quality of grazing.

THE STUDY AREA

The study was carried out in the Ditshukudu Agricultural extension area near Lentsweletau in Northern Kweneng. The area was selected mainly because:
i) of familiarity with the ecology of the area due to earlier grazing assessment of the area.

ii) the 1982 and 1989 aerial photographs (1:50 000) are available for the area.

iii) arable land has expanded rapidly in the in the area in resent years.

iv) the study area is partly in the hardveld and partly in the sandveld, making the study area to be more applicable to the rest of the country.

LOCATION

The study area is and extension area east of Lentsweletau. It covers an area of about 282 km2. As a lands area this means that it is an area zoned for arable agriculture. It fall between the Dikolakolane river in the in the north and the Kopong hill range in the south. The eastern boundary is formed by the

Lentsweletau-Medie road (see fig. 1.0, Map of the study area).

VEGETATION

The study area displays both the sandveld and the hardveld characteristics and as a result supports a vegetation type that is described by as (arid-sweetveld) (Weare and Yalala, 1971). In the hardveld the dominating tree species include Ziziphus mucronata, Combretum apiculatum, and Dichrostachys cineria. On the herbaceous layer species such as Schimidtia pappophoroides, Eragrostis lehmania, E. rigidior, and some scanty occurrences of Cymbopogon excavatus. In the sandveld, the dominating tree species are Peltophorum africanum, Terminalia sericea, Burkea africana and Boscia albitrunca. The grass layer is mainly comprised of digitaria eriantha, Eragrostis lehmania, Triraphis species, Porgonarthria squarosa, Schimidtia Pappophoroides and eragrostis rigidior.

The river valleys are mainly composed of dense thorn shrub of the species Acacia tortilis, A. erubescence, A. erioloba, A. karoo and Boscia albitrunca. On water logged soils are some patches of spirostachys africana (Weare and Yalala, 1971).

MAJOR LAND USE

The dominant land use types found in the study area are arable agriculture and grazing or livestock rearing. The main village is Lentsweletau with other residential places conveniently situated near the fields. The area is mainly a lands area, but livestock are kept and do graze in between the fields during the growing season and on the fields after harvest.

METHODS

a) Vegetation sampling- fifteen plots were sampled throughout the study area. Undisturbed areas and regenerated fallows were used to check for differences in grazing quality. The following parameters were measured:-

-frequency of the herbaceous layer
-canopy cover for the herbaceous layer
-density of the woody layer
-soil was analyzed for texture, type and ph.

The quality of grazing was based on those described by Field (1976).

Analysis for vegetation cover and frequency were carried out in lotus 123 and SPSS (cluster analysis).

These results are shown in figures 4 and 5

Airphoto interpretation of 1982 and 1989 was carried out to determine the rate at which arable fields are expanding and hence the grazing land is being lost. A preliminary classification on the different cover types was undertaken from which land use types were ascertained. The cover types were delineated based on tonal contrasts for both the 1982 and 1989 sets of

photographs. After all the cover types had been identified and taken out, they were classified, delineated and then digitized in MapInfo.

General land use maps were produced through digitizing. These maps show the extent of the arable fields for both 1982 and 1989. MapInfo was used to measure the area of land used for arable agriculture and what is left for grazing. The spatial extent of these two major land uses are summarised below.

Table 1. Summary of the changes in land use	Year	Area km^2
Total extent of extension area	1993	282
Total area under cultivation	1982	37
	1989	56
Total area under fallow	1982	24
	1989	9
Total area remaining for grazing	1982	221
	1989	217

In summary, these results show that:
i) fallow land has declined as most fallow fields were put back to production (arable) in 1989.

ii) the total area reserved for grazing is not greatly affected by the increase in arable land between 1982 and 1989. In order to get a clearer picture of the change in land use between the two time period, the maps produced in MapInfo were converted to Idrisi with the aim of performing and overlay operation.

The conversion to Idrisi is summarised as follows:

FLD_89 BDY EXP FLD_89 MBI 2IDR FLD_89 INITIAL

EMPTY POLYRAS

In the above example, FLD_89 is a file name for the 1989 land use map, the conversion was also done for the 1982 map.
The two categories of land use were given different values in order to separate them. This was done using the ASSIGN module of IDRISI.

Figures 2 and 3 are the rasterised maps showing the extent of arable fields in 1982 and in 1989 respectively.

Having both maps in the Idrisi program, they were then overlaid and the results revealed the following.

-Areas with matching polygons or fields- these are those fields where the same fields have been ploughed both in 1982 and 1989.

-Areas of overlapping fields- these represent those fields which have been extended after 1982, presumably as a result of the agricultural subsidies introduced in the 1980s.

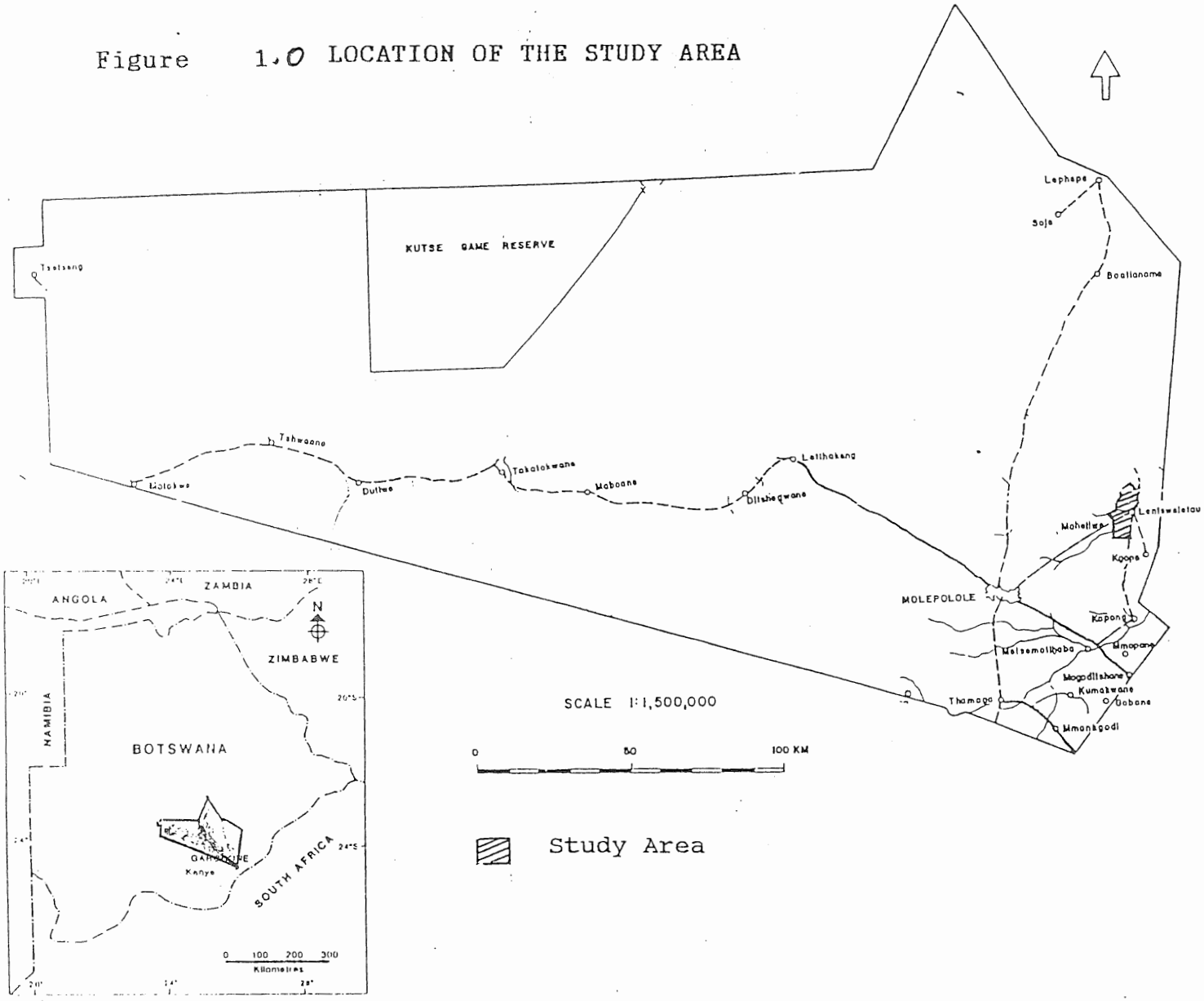
-New polygons/fields - these are representative of all the new fields established after 1982.

RESULTS OF GRAZING QUALITY

Results have shown that there is not much difference in the quality of grasses between undisturbed and fallow areas.

The quantity of grazing is slightly reduced because some old fallows had been brought back to arable production. Much of the increase in arable land is brought up by extending the existing fields.

Figure 1.0 LOCATION OF THE STUDY AREA



LAND USE 1982

grazing

arable field

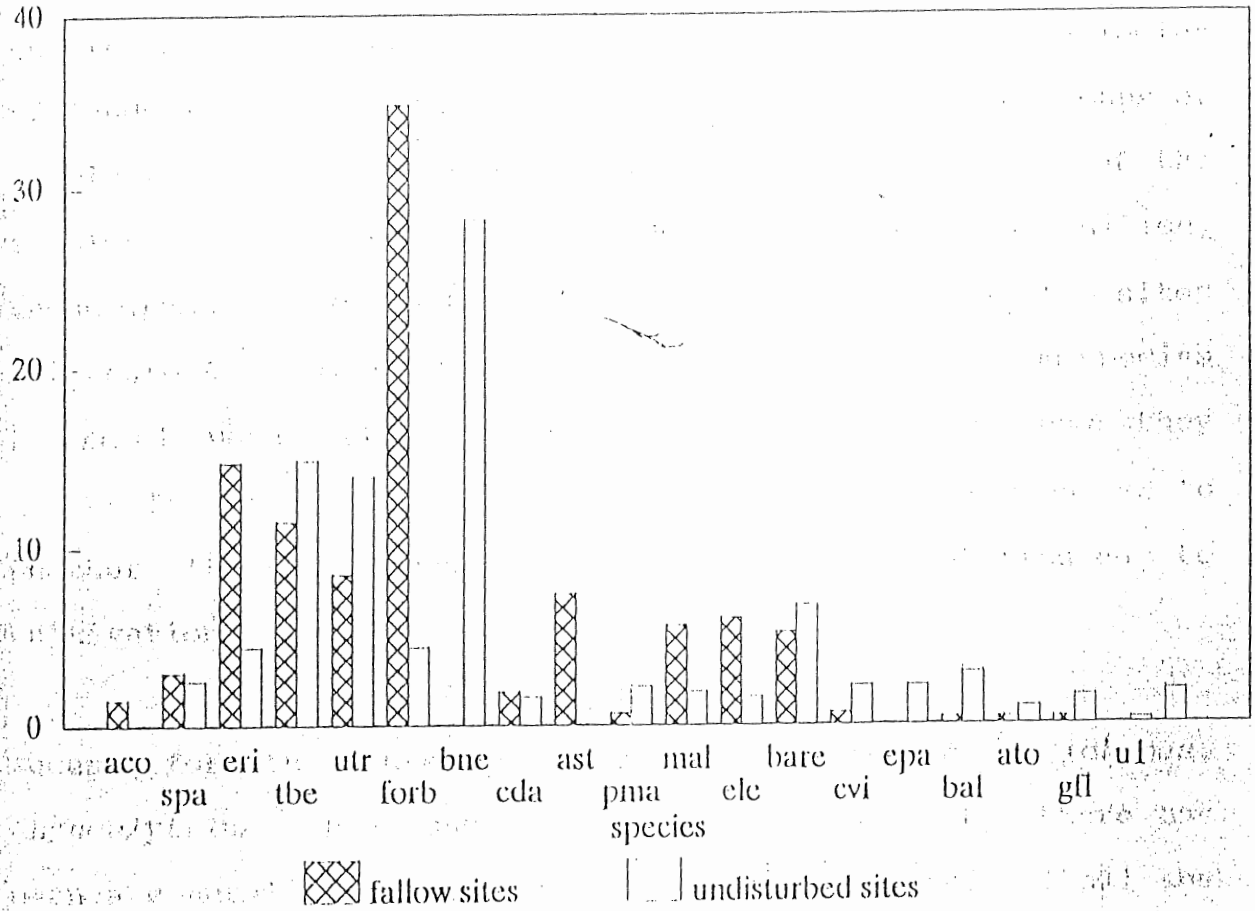
Idrisi

FIGURE2

IGURE3 1989 LAND USE

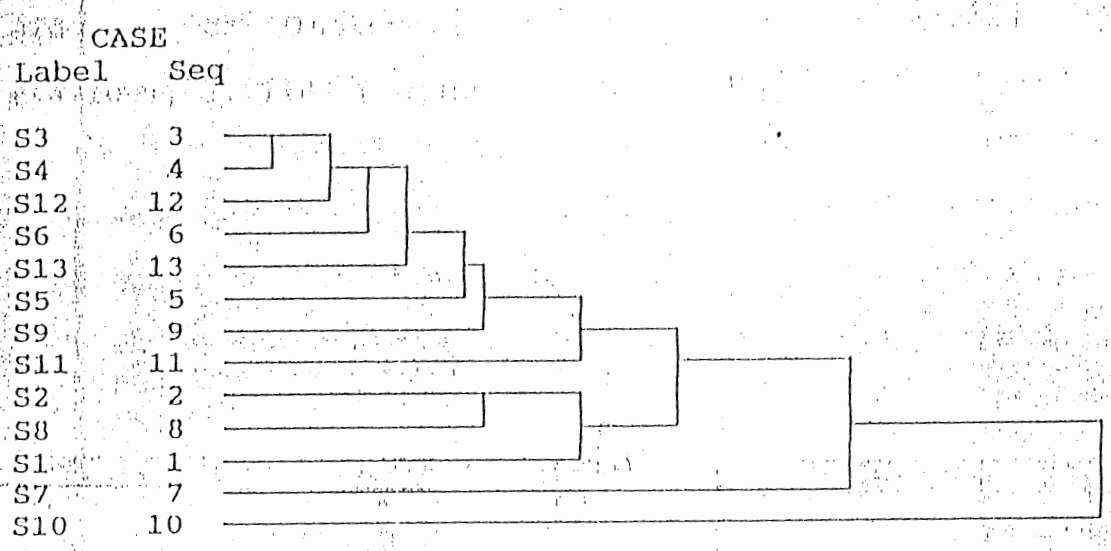
Figure 4.0 Frequency of the herbaceous layer

(disturbed (fallow) versus undisturbed sites)



KEY

Spa	Schmidtia	pappophroides
Ele	Eragrostis	lehmanniana
Sve	Setaria	verticiliata
Psq	Pogornathria	squarrosa
Spy	Sporobulus	pyramidalis
Mal	Megaloprotachne	albescens
Sun	Stipagrostis	uniplumis
Apu	Anthephora	pubescence
Unl	Unknown	species 1
Aco	Aristida	congesta
forb	Forbs and	Sedges
Bni	Brachiaria	nigropedata
Dgi	Digitaria	species
Utr	Urochloa	trichopus
Epa	Eragrostis	pallens
Cda	Cynodon	dacylon
Ast	Aristida	stipitata
Rre	Rhycelytrium	repens
Ece	Enneapogon	cenchroides
Bin	Borthriochloa	insculpta
Eri	Eragrostis	rigidior
Tbe	Tragus	berteronianus
Cvi	Chloris	virgata
Pma	panicum	maximum

Figure 5.0 Tree diagram of Cluster

(Dendrogram using Average Linkage (Within Group))