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Geographical Information Systems (GIS) in Botswana: Introducing a New Technology for Environmental Information Management

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GEOGRAPHICAL INFORMATION SYSTEMS (GIS) IN BOTSWANA: INTRODUCING A NEW TECHNOLOGY FOR ENVIRONMENTAL INFORMATION MANAGEMENT.

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Abstract

This paper outlines the development of Geographical Information Systems (GIS) in Botswana, tracing the country's GIS program from its inception. The paper particularly stresses the contribution of the University of Botswana, the country's national university, in this development and discusses a revision of the university's training program intended to make GIS training program intended to promote self-sustainable growth of GIS in the country.

A. INTRODUCTION.

Since Botswana gained political independence in 1966, her rural development strategy has been based largely on encouraging more intensive use of agricultural land, and the opening up of new lands for agriculture as a basic means of increasing production. Several programs were carried out under this strategy in the 1970's and 1980's to subsidize livestock rearing and arable farming (see for example Silitshena, 1982; Botswana, 1975; Chambers, 1977; Jones, 1981; Eskelli, 1989). This approach to rural development was made possible by two main factors. Firstly, although no part of Botswana is completely uninhabitable, the country has one of the lowest population densities in the world. With an area of 576,000 square kilometers Botswana had a population of 941,000 in 1981 (CSO, 1982) giving it a population density of 1.63 persons per square kilometer. By 1991 the population had risen to 1.3 million but the population density had only risen to 2.26 persons per square kilometer (CSO, 1993, Table 1.3, p.3). Secondly, increased receipts from mining operations from around 1973 made it possible to subsidize rural programs throughout the 1970's and 1980's with the objective stated above. Funds received from mining which accounts for approximately 80% of foreign earnings (CSO, 1993, Table 3.3b, p. 17) but employs less than 5% of the labor force (CSO, 1993, Table 6.1, p. 39), were justifiably used to advance policies in this strategy in the rural areas, where more than 70% of the people live[1]. By the end of the 1980's, this approach to development had started showing strain (Arntzen, 1989; Arntzen and Veenandaal, 1986). Receipts from an exhaustive mining industry were becoming uncertain, and the rural physical environment (especially land) seemed to be deteriorating faster than in previous years (Ringrose and Matheson, 1987). The Government of Botswana (GOB) has considered that conservation, particularly of land resources, and diversification of the country's resource base for development are essential for sustainable development (Botswana, 1990). In practical terms this means that it is necessary to broaden the base on which

[1]Definition of the rural population varies with different Government of Botswana departments. The Central Statistics Office (CSO) defines rural settlements as those with populations below 5000. The Department of Town and Regional Planning (DTRP) on the other hand uses a legal definition. Using the former, Botswana's rural population would be about 50% of the total. DTRP's definition is used here.

the country's spatial plans are formulated. The amount of data required for this broadened base, and the analyses necessary to comprehend the broader issues involved, have overwhelmed existing systems for handling and organizing data. GOB has consequently encouraged the introduction of Geographical Information Systems (GIS) to assist in long term and day-to-day planning operations to overcome this problem. This paper outlines the efforts being undertaken in the development of GIS in the country, particularly stressing the role of the University of Botswana (UB) in this effort.

The overall strategy in introducing GIS in Botswana has been shaped by local limitations on one hand, and knowledge of experience of similar efforts in other countries. Locally an extreme shortage of personnel with any competence of the technology at all levels has made it essential to start with broad-based programs on awareness, training and education in GIS. In-service training in particular has been identified as the fastest way of broadening the competence required for using the technology widely throughout the country. For overall systems development, descriptions of experiences from other countries has been useful (see for example Hyde, 1991; Yeh, 1991; Vasile et al., 1989; Al-Ankary, 1991). These descriptions reveal that, with a few exceptions (see for example Eyre, 1989), GIS development in general, especially in countries with socio-economic circumstances similar to those of Botswana, lacks overall planning, is project oriented, and is not integrated in the overall planning of the countries described. Botswana has tried to avoid similar problems by having an overall conceptual framework for the development of GIS technology in the country.

B. THE ORIGINS GIS IN BOTSWANA - THE GIS USERS' GROUP.

The official GOB committee responsible for the development of GIS in the country is the National Committee for Cartography and Remote Sensing (NCCRS). Although this committee had been interested in GIS for a long time, its agenda did not allow it to commit the time necessary to develop GIS at the rate that was required to overcome the problems stated in A above. More importantly, it was not clear that enthusiasm for GIS development was high in the committee while people with greater enthusiasm and knowledge of the potentials of GIS were not members and could not express their views or support for GIS development in the committee. A new amorphous and very informal group, the GIS Users' Group, was formed in mid-1989 basically to discuss enthusiasm in GIS.

The GIS Users' Group was an excellent forum for discussing ideas on the development of GIS in Botswana. It had members from GOB (including most of the members of the NCCRS and officers working in the field at various tiers of Government), the private sector (especially consulting companies), local and international NGO's (the IUCN, the Kalahari Conservation Society, the Forestry Association of Botswana), the academic community, and donor agencies. One highly placed officer of USAID\Botswana, for example, was a loyal supporter of the idea of a users' group from its inception. In the beginning the majority of members in the group, though very competent in their various fields, had only enthusiasm, not skills or experience, in GIS. Over time, however, this group has changed from that of "the

blind leading the blind", to include many people who have developed competence in GIS.

The most important contribution of the GIS Users' Group has probably been to encourage the NCCRS to think of a national conceptual framework in the development of GIS. Most significantly, there were concerns in the Group related to the fact that different units, departments, and ministries in Botswana, were planning to develop uncoordinated GIS programs without any overall guidelines. Although there was a wide range of environmental and socio-economic data and there was freedom to exchange same throughout GOB departments, each department had collected, sometimes duplicating, data using its own format and standards. The Central Statistics Office (CSO) has had the mandate to advise and control the collection of socio-economic data and to advise other GOB departments on the standards expected. CSO, however, has never had the personnel to completely be up to date for the data it is supposed to organize directly (which includes data on population, trade, education, transportation, etc.). Environmental data on the climate, soils, hydrology, etc, were collected by the different relevant departments without reference to CSO or to each other. Freedom to exchange data collected and stored under such circumstances was seen to be unsatisfactory in the development of GIS. It was feared that unless policies and standards for this development were outlined, it might eventually be difficult to exchange information, and that little empires of information would result, defeating one of the most advantageous elements of GIS's. In mid-1992 it was decided that ARC\INFO should be the standard software and that in all GIS related work where exchanges of data between or with GOB departments are expected, software compatible with ARC\INFO should be used. In April, 1993 a contract was awarded to Associates in Rural Development, a consulting company in Burlington, Vermont, to assist in an effort to further standardize GIS development. Recommendations have been made from this consultancy on the general national framework, policies, functions of key Departments, prioritization, and training, in the development of GIS. The consultancy provides a unique opportunity for Botswana to start off with national standards not available in many countries in the Southern African region. The guidelines from this consultancy when approved by GOB will be the basis under which individual GOB departments, other GOB related organizations and institutions, and private companies, may develop their more detailed requirements.

C. GIS DEVELOPMENT IN VARIOUS MINISTRIES[2].

Traditionally the different ministries have had the mandate to collect and store data relevant to the sector of their activities. It was therefore considered appropriate that the development of GIS should be sectoral based on ministries. However, to take advantage of the benefits of GIS, an overall framework coordinating projects in the different ministries was recommended. Various levels of coordination have been suggested for the final national organizational network, ranging from a mega-GIS centralised as the sole depository of all data to be exchanged, to a loose coordination

[2] A complete listing and detailed description of current and planned projects in various ministries may be obtained from an unpublished consultancy report presented by Associates in Rural Development to the Government of Botswana (December, 1993) entitled *GIS Development in Botswana.* A request for this report may be made to The Director, Department of Surveys and Lands, Private Bag 006, Gaborone, Botswana.

of GIS projects in various departments of GOB. As an interim measure, the individual ministries have been encouraged to start or continue developing their separate GIS following the broad guidelines of the NCCRS on a standard software of exchange stated in Section C above. The most advanced in this effort is the Department of Water Affairs (DWA) (Ministry of Water and Mineral Resources) which has used ARC\INFO in its development of the National Water Master Plan. Its models of demand for water resources have identified water supply problems for future developments. Currently, however, the most active ministry is that of Local Government, Lands and Housing (MLGL&H) especially its Departments of Surveys and Lands (DSL), Town and Regional Planning (DTRP), and its Lands Division. DTRP is responsible for regional development and the development of settlements both of which have a high demand for environmental information. The department has conducted several pilot projects (see Zao, 1993) and has strongly supported training of its staff. DSL has traditionally been the supplier of maps to all map users and has attempted to digitize several maps of large settlements with assistance from Swedesurvey of Sweden.

For environmental information, three GOB Departments stand out in their current activities and future plans, namely the Department of Meteorological Services (DMS) (Ministry of Works, Transport and Communications); the Department of Land Utilization (DLU) (Ministry of Agriculture); and the Department of Wildlife and National Parks (DWNP) (Ministry of Commerce and Industry). DMS has data that can provide time series climatological statistics and which it plans to analyze to study climatological trends using GIS. It also plans to collaborate with the relevant departments to study the impact of these trends on wildlife, desertification, farm production, ground water replenishment, and reservoir management. DWNP has started several training programs and has collected environmental data for wildlife habitat mapping, management of wildlife sanctuaries, and studies on conflicts between wildlife and domestic animals. DLU has collected and compiled environmental data for its on-going efforts to map crop production potential. The main objective of this effort is to study present land use and to try to improve it regarding type of land use and management.

It may be observed from the descriptions above that there is still a lot of duplication in compiling data for the development of GIS projects in various ministries. No GOB department, at this time, has the ability or the capacity to supply much data to other departments. In some cases the digital data is only a disguised form of the old format and may not be very useful to receiving departments. DSL, for example, has developed digital databases which are available in DXF or ARC\INFO UNGENERATE format. The database, however, has been developed mainly for cartographic purposes and may not be very suitable for analysis in a GIS. Roads, for instance, have been digitized as double sided features. Probably more importantly, it is clear from the developments of GIS in the various ministries that the decision to have all development compatible with ARC\INFO is not sufficient for seamless exchange of information between GOB departments. Various departments are 0digitizing DSL maps independently without reference to one another. Consequently, boundaries even for the same features do not match; there is not even a common national boundary being used by different departments. These developments are

likely to make the exchange of information difficult and DSL has been urged to develop a common boundary database as soon as possible.

D. THE TRAINING AND RESEARCH PROGRAM.

The major bottlenecks in the development of GIS in Botswana have been shortage of trained personnel and lack of relevant applied research. Both training and research have received assistance and advice from educational institutions from outside the country. While this advice and assistance is highly appreciated and has made significant contributions in the transfer of GIS technology to Botswana, the development of the overall program has been directed and controlled from the Department of Environmental Sciences, University of Botswana. Donors who have contributed to the development of the program have strongly encouraged and appreciated this approach.

1. Training.

The training program has gone through a number of stages since its inception. The main trend in the development of the program has been directed at making it more appropriate to addressing environmental and resource management issues in the Southern African region. Two key principals are particularly followed in this development. Firstly, the program has focused on solving problems which trainees identify in their daily work rather than on the various GIS software available. Each trainee is encouraged to identify his or her problem related to his daily work and , with assistance, to carry out a project using GIS to solve that problem. Secondly, the training program does not attempt to produce specialists in GIS but is aimed at building competence of the trainees in using GIS to increase productivity. In achieving this aim it has deliberately taken an incremental approach, starting with the simplest GIS software. Trainees are encouraged to move from what they already are familiar with (e.g. the map), with new ideas in GIS being introduced in incremental doses, making sure that trainees are comfortable with any new ideas or techniques being introduced. Although this may sound pedestrian, it is one of the main reasons for the success of the training program. OSU MAP-for-the-PC, donated by the GIS Laboratory, Ohio State University, was the starting point before trainees were introduced to MAPINFO and IDRISI. Although the training program has gone far beyond this as will be shown below, simple stages in the beginning have given it a firm foundation.

Current GIS training may be divided into two: that taken as part of an M.Sc. program, and that given as part of an in-service program for GOB officers serving in the field.

a. The M.Sc. Program.

The M.Sc. program is offered as a two year degree in environmental

planning at ES UB, but includes a substantial part on remote sensing and GIS. The program has attracted students from a number of countries in the Southern African Development Community (SADC) region; the 1991/2 and the 1992/3 had respectively 50% and 40% of students enroled in the program from the region outside Botswana. Applications for admission for the 1993/94 academic year included those from Kenya, Uganda, Tanzania, and Sudan. The numbers of students trained under this program are, however, still small, being only around 11 in both Year I and Year II combined. The effect of the program on the introduction of GIS in the country has therefore been minimal up to now.

b. The GIS in-service training program.

In-service GIS training has been the more effective program in providing a broad base for introducing GIS in Botswana. There have been a number of *ad hoc* in-service training sessions for various departments or units of GOB, but ES UB has the only continuous program. However, the multiplicity of training programs has been useful in exposing a much lager number of people to GIS than ES UB would have been able to do. Lack of coordination in these programs has been regrettable. Some people are re-trained on levels they have already achieved under previous training programs, while others are put in courses where they lack necessary pre-requisite skills. It would be preferred that ES UB takes the responsibility of giving advice to all trainers in the country, but since training outside ES UB is largely donor driven, this is difficult to achieve.

In-service GIS training at ES UB is currently (early 1994) under review. Before describing the revised program, it is useful to outline the program as it has been ran so far to comprehend why the revision has been considered necessary. The program started in 1990, and was originally tacked on to a more general in-service program started in 1987. At that time the latter offered a series of ad hoc courses to a wide range of officers with various backgrounds. ES UB, in collaboration with the Ministry of Local Government, Lands and Housing (MLGL&H) , streamlined this into a series of courses that offered continuous training. The whole in-service training program as conducted by ES UB, was not limited to GIS. It had six stages starting with an introduction to cartography and map reading and ending with using sophisticated GIS software. Most of the trainees are college graduates, some of whom have M.Sc. degrees. Some, therefore, would have taken, and were exempted from, the lower stage courses of the program. Otherwise each of the trainees was expected to go through all the stages of the in-service program, or up to a stage that is most relevant to duties at his or her post. The GIS component in this program started at Stage 3 (referred to as GIS Level 1) and continued to Stage 6 (GIS Level 4). For each of GIS Level 1 to GIS Level 4,

trainees came to the GIS Laboratory of ES UB for a two week intensive training program.

The arrangement until the end of 1993 was that about 12 to 15 trainees would start GIS Level 1 in May, for the basic principles of GIS and a very elementary introduction to digitizing. MAPINFO was used at this level because of its user-friendliness and because its products were very similar to the map that trainees would have known before. A very simple introduction to the raster model was made with IDRISI to prepare trainees to work with IDRISI at the next level. In GIS Level 2 in the December of the same year, trainees would concentrate exclusively on raster based GIS using IDRISI. GIS Level 3 was taken in the July of the following year. In the interim period between GIS Level 2 and GIS Level 3, a program to develop the trainees' independence with GIS was conducted at their posts. Each trainee was given a booklet of exercises to complete in the first part of this period with minimal assistance from the trainers who visited his post intermittently, or on his/her request. For the rest of the interim period each trainee would design, again with minimal assistance from staff at ES UB, a real life project related to his or her daily duties. This stage was the major jump when trainees tried to view and solve problems in their own work using GIS with minimal assistance.

GIS Level 3 training in July/August (one year after GIS Level 1), focused on discussing the individual projects carried out in the interim period between GIS Level 2 and GIS Level 3. Each trainee was given an opportunity to present his or her project, stating, among other things, how his/her project was relevant to his/her duties, what his/her objectives were, what he/she wanted to achieve, and who were to benefit from the project. After each presentation, a discussion was carried out in which each of the trainees was given an opportunity to present his/her views and to comment on the project under discussion. During the rest of the GIS Level 3 training period, trainees would try to carry out as much of their projects as was possible.

GIS Level 3 was a pivotal point in the training program because it provided the training staff with an opportunity to select those trainees who could go on to GIS Level 4 at which training on ARC\INFO would be carried out. Experience with the trainees showed that it was not appropriate to expect most trainees to go beyond GIS Level 3, for one or two reasons. Firstly, for most of the trainees, the daily duties they execute would not require software more sophisticated than was used at this level. Since the main aim of the training program was to assist trainees to become more competent in carrying out their duties, further intensive training for trainees in this category would be difficult to justify. Secondly, by the end of GIS Level 3, it was very clear that some trainees were either unable or unwilling to conduct analytical GIS operations, their interest having been saturated with the elementary

operations of digitizing and simple displays of digitized layers.

The program described above was run until the end of 1993 by which time it had run into several problems the most important of which was associated with the mobility of the trainee officers within the Botswana civil service. It was obvious that in selecting trainees to enter the program, various departments did not consider the career path of the individuals concerned. The better trainees were commonly promoted to positions where their responsibilities had no relevance to their training in GIS. Thus while the four Level strategy with interim periods of practice at post was ideal for continuous training over a long period, many problems have made it essential to revise it.

A revised program launched in early 1994 collapsed the four levels into two training sessions of four to five weeks each to be conducted between May and August. The objectives and advantages of the revised program are outlined in Section F below which discusses the future of the program.

2. Research.

ES UB is the focus of all research on GIS in Botswana. There have been a wide range of research investigations including biomass estimation, underground water modelling, analyses of urban and suburban land use changes, investigations of rural transformation, and modelling land use competition and dynamics. Some of these investigations are being carried out or are planned in collaboration with academic researchers outside Botswana. The biomass study originally carried out for the Forestry Association of Botswana (van Heist, 1991), evolved into research for modelling fuelwood availability around sub-urban villages. Underground water modelling on small streams is being carried out in collaboration with academic staff from the University of Stockholm, as is the research on land use competition and dynamics. Currently, the two biggest planned research projects in the Department are: the Kalahari Ecosystem Functioning (KEF), a combined effort of about 10 scientists from various academic disciplines; and the Resource Utilization and Regional Planning Information Systems (RURPIS), to be carried out in collaboration with various GOB Ministries and Departments (Nkambwe, 1991). The former, in its planning stages, is aimed at monitoring changes in the Kalahari ecosystem over a seven year period. RURPIS on the other hand has slowly gone through preliminary stages over the last two years and is designed to investigate in general the availability of and demand for various resources over time. At the heart of this interest is the relationship between the growth and spatial expansion of population and livestock and the critical resources of land, water, and wildlife. Recently RURPIS received a major boost through a reserarch grant awarded by USAID to scientists from Kansa State University, Alabama A&M University and UB to advance one aspect of this project over a period of one year.

E. DONOR AND INTERNATIONAL ORGANIZATION SUPPORT.

Donor support, though uncoordinated, has been a key element in the development of GIS in Botswana. Virtually all programs being developed at the moment have some element of donor support either in full or on a cost-sharing basis with GOB. Other than GEMS\UNITAR, mainly interested in regional environmental monitoring, no donor agency or international organization has committed itself to supporting a continuous national program for the development of GIS. However, individual organizations have identified projects relevant to their overall programs and have provided hardware and\or software; assisted in training; or provided personnel assistance to various projects. SIDA, for example, has been involved with the development of a number of water related for the Department of Water Affairs, while FAO has supported various projects in the Ministry of Agriculture.

ES UB has been particularly fortunate in having substantial donor support for its GIS research and training programs. The GIS Laboratory where the training and research stated above is carried out was started with funds from the Swedish Authority for Research and Cooperation (SAREC). USAID has also provided funds for some software and hardware. Currently the laboratory has 27 IBM-compatible personal computers (PC's), 15 of which are new 80486 machines. A SunSpark workstation is also available mainly for research. The laboratory has a wide range of peripherals including two A-0 Calcomp 9500-series digitizers and six 12 by 12 inch Calcomp drawing boards, a Roland DPX-3500 pen plotter and a NOVAJET II color inkjet plotter. A wide range of software has been installed in the lab, including OSU MAP-for-the-PC, IDRISI, MAPINFO, and ARC/INFO. Three digital image processing software, ILWIS, microBrian (both PC based), and a workstation version of ERDAS are also available. Also, for three consecutive years (1990 to 1993), SAREC provided funds for academic staff from the University of Stockholm to assist in the development of the M.Sc. component of GIS training. Support for the GIS in-service training originally came from a World Bank fund provided to the Ministry of Agriculture for various operations. More recently, it has come from the Ministry of Local Government, Lands and Housing, and from a cost-sharing arrangement between GOB and USAID\Botswana. The latter provided funds for academic staff from Kansas State University to assist with training GIS Level 2 and supplemented GOB funds for staff from Clarke University to assist with GIS Level 3 in 1992 and 1993. The arrangement has been that for each GIS Level, a request is made for assistance to train for the first time that level is conducted. After that first time that level is run by the staff of ES UB without assistance. A fellowship was given in 1993 by USAID to a member of the academic staff at ES UB to work at different academic and research centers in the US to strengthen the ability of ES UB to conduct these courses independently.

F. THE FUTURE OF GIS DEVELOPMENT IN BOTSWANA.

As pointed out in Section D above, a lot of programs have been planned in various

GOB departments. The future of most of these seems bright but their coordination seems uncertain. However, the GIS program has gained a momentum quite unique within the Southern African region, and this momentum should be maintained.

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The surest way of keeping the momentum of current developments alive is to increase, as fast as possible, the competence of people directly concerned with the application of GIS to specific problems in the field. ES UB received financial assistance from USAID at the beginning of 1994 to start a two year project aimed at ensuring that the in-service training program will become self-sustaining. Various strategies have been planned to achieve this objective. Specifically, the training program has been revised to increase its output and to strengthen its support base from the various departments of GOB in the following ways.

1. **Building a nationwide network of trainers to promote a self-sustaining training program.**

   Although the GIS laboratory at ES UB has recently been expanded, the training program within the department cannot keep up with the momentum that it, and other GIS programs, have generated throughout the country. A much higher output of graduates is required than ES UB can handle at this time. Also, general and elementary training is no longer sufficient for the increasingly sophisticated GIS programs in various Government departments, NGO's and the private sector; individuals have to be guided in using GIS in their special fields by specialists in the relevant disciplines. Currently there are a few expatriate GIS specialists in a limited number of GOB Departments including DWNP, DWA, and DTRP all working independently. The amount of daily work related to systems maintenance and GIS programs delopment has made it difficult to give much attention to GIS personnel development. Fortunately, however, many of the graduates of the current GIS training program at the University of Botswana are very competent in their various fields of specialization and are capable of advancing training programs in their departments with assistance from the University. Under the revised program, these graduates will be used to start a nationwide network of trainers within their various departments as part of the University's training program and henceforth, from each graduating class, a few people will be selected to join this group of trainers. This revision of the current program will have several advantages. Most importantly, it will build up a group of confident trainers who will be the basis for a sustainable development of GIS in the various GOB departments and NGO's throughout the country. While the training as has been run so far concentrates on developing competence in using GIS for individual trainees, the revised program will shift this to developing these skills in the GOB departments participating in the program. Prospective trainers will be carefully selected from various departments in each ministry to ensure widespread intra-ministry GIS training.

2. **Building teaching materials and linking the training program at ES UB with GIS projects in the field.**

The main method of building the network outlined above will be through a combination of providing teaching materials to the prospective trainers, and linking various on-going projects throughout the country with applied research using GIS at the University. Results from local projects carried out under both the M.Sc. and the in-service program over the last three years will be used to compile teaching materials for the prospective trainers to use in training other officers at their duty post. Each trainer, during the course of his own training, would have carried out a project which he will be encouraged, with assistance from ES UB, to use as the starting point for building up his own exercises more relevant to his daily work and the daily work of those he will be training. This will have the major advantage of giving a more focused training program for GOB officers in different ministries. Although some of the training will still be carried out at ES UB under the revised program, by spreading some of the effort to the ministries and districts, it will be possible to have a higher number of graduates than has been the case under the current training program.

In building up the network of trainers, the University, at this time, has decided to concentrate its efforts on those most directly working in natural resources management and in various areas related to the environment. The major advantage of this focus is that it will be possible to link projects under the revised training program with on-going research in ES UB once the level of a self-sustaining training program discussed above is under way (expected to be by the end of 1994). Many of the projects so far undertaken in the in-service program (and many to be designed under the revised program at this stage) fit into various research programs especially on resource management nad environmental monitoring.

3. Building confidence in using GIS with local conferences.

There is need to strengthen confidence in the potential of GIS to increase productivity. Also, many of the graduates of the training program need encouragement and re-assurance that they are making substantial contributions, in the development of GIS in the country. Both these can be achieved through local conferences at which graduates and trainees of the revised program will meet, exchange ideas and share experiences.

4. Communicating the training program to the rest of SADC

During 1993, UNITAR\Nairobi started informal discussions both with GOB and ES UB on how Botswana's GIS training program could be expanded to accommodate trainees from the Southern African Development Community (SADC) region. Training for the SADC region would make it possible to export the Botswana GIS development "model" to neighbouring countries. As a starting point it has been proposed that the training materials to be compiled under the revised program should be made available to selected institutions of higher learning within the region. The training program would be the starting point and with it will be exported the ideas of developing local exercises, and the concept of a self-sustaining GIS training program. Also, through the

training program, Botswana will be able to share its experiences with other SADC countries on the usefulness of a GIS Users' Group, and the problems experienced in establishing nationwide standards. Assistance will eventually be given to national universities in the region to link projects in the field of people who will have graduated from the program and research projects at the universities. The aim in training for the SADC region would not be to make ES UB a permanent training center for the region, but to assist other SADC countries to consider (modify if necessary) the Botswana "model" for the development of GIS. So far none of the countries in the region has attempted Botswana's broad based nature of GIS development, and many do not have a national plan for this development outlined.

G. CONCLUSION.

There are many points worth noting in Botswana's efforts in introducing GIS technology for environmental information management and other activities related to environmental planning.

1. The established committees of Government do not always have the most appropriate ideas in the development of GIS technology. A much more informal group like the GIS Users' Group mentioned in B above may be a more fruitful starting point as a pressure group to encourage committees' decisions on GIS development.

2. It is not necessary to have an expert or a couple of experts to start the introduction of GIS. Indeed it may be more profitable to have a large number of specialists in different fields whose enthusiasm is driven by problems which can be solved using GIS technology. This has two major advantages: for one, the disappearance of the expert (common in the Southern African Region) does not kill the development of GIS; for another, this starts off GIS development with a typically applied approach, concentrating on the problems to be solved rather than the technology. The best arrangement, of course, would be a combination of both people competent in the use of GIS and a wide range of enthusiasts.

3. It is usually difficult to judge at what level to start GIS development, and there may be several arguments for starting at different levels of sophistication, especially in terms of GIS software and hardware. In Botswana, different GOB departments have had a lot of freedom in choosing the level of sophistication they wanted to start at. ES UB started with the simplest software and built up to more sophisticated ones, proving both to itself and to its sponsors that higher levels of sophistication were needed whenever they were introduced. This approach, looked at as pedestrian in the beginning, has won over other GOB departments which chose to start with the most sophisticated software. Given the technical (especially computer) ability of most people involved in GIS development throughout the SADC region, the ES UB approach seems more appropriate, and builds sure confidence though slowly.

4. Donor support may be critical in the development of GIS. In the beginning, uncertain promises of future increased productivity using GIS may not be sufficient to encourage decision makers to vote for the development of a technology which may reduce their power of control on information flow. In Botswana's case donor support has helped to make the possibility of increased productivity real. Results from projects carried out under the program will be used to stress this point in future. Botswana's experience, however, is that using donor support to develop a GIS program should not be equated with buying software or hardware. Very sophisticated computer hardware and GIS software may be counter-productive by creating a feeling of frustration and incompetence.

The most notable realization that Botswana has had in the development of GIS is probably that competence once built up should be used to build more competence in an effort to develop a self-sustaining GIS development program. The ability of graduates from such a program in using GIS may be suspect, but with proper supervision their contribution at the beginning of a national effort to develop GIS will be invaluable given the technological level that the country has.

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