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National Mapping in Africa –
Namibia launches new national map products as a part of their NSDI

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Abstract

This paper is a presentation of how the Namibian National Mapping Agency, DSM – Directorate of Survey and Mapping, in co-operation with Swedesurvey AB has produced, revised and launched new National and Regional map products as a part of the National Spatial Data Infrastructure development.

In September 2005, the Ministry of Lands and Resettlement in Namibia funded a project, “Map Edition and Offset Printing of maps”, in which Swedesurvey AB was selected as project partner.

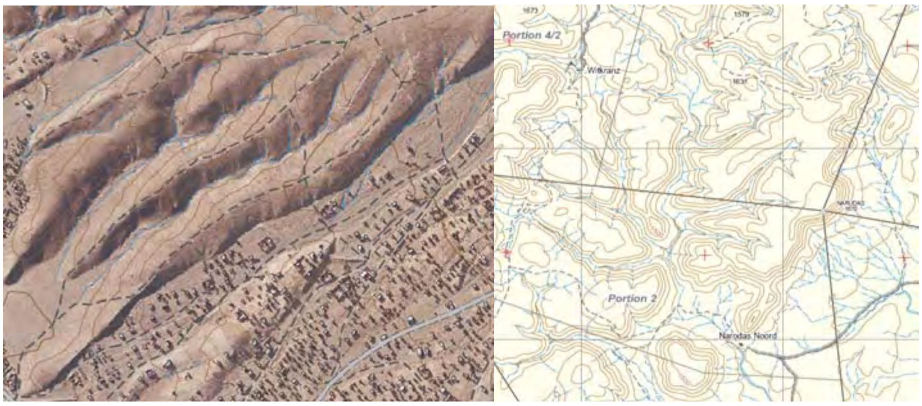
Advances in computer technology and GIS have significantly increased the options available for map visualization. Visualization of objects and phenomena in 3 –D is now a reality. New systems allow computers to simulate and model reality by using visual and auditory cues in three dimensions. These same systems might be used to create virtual maps in which users can traverse and study real and simulated environments and landscapes.

The flexibility of GIS procedures and the ease of editing electronic map display have made it easier and inexpensive to develop several **design prototypes** before making a choice. Mapping software provides cartographers with the same type of mileage that text-processing software offers writers. GIS technology is providing cartographers with the accurate drafting that has

traditionally required tremendous manual skill, patience, and training. They have also revolutionized map revision procedures, and broadened the horizon to experiment with layout, composition, and symbolization, and to duplicate information from one map to another when producing series of maps. Nevertheless, its use requires that the cartographer be just as familiar with the strengths and limitations of each automated system as with principles of effective communication.

The approach to this project was to ensure that the geographic information delivered by the project would become the foundation for the National Base map- from the perspective of a National Spatial Data Infrastructure (NSDI). It was also a necessity that the project should contribute to the development of DSM's own capacity with respect to GIS and cartography. The project produced various cartographic products, ranging from 1:1 Million to 1:10 000 in scale, all derived from one specifically produced homogeneous national GIS-data base, in a very short time.

This paper gives an introduction to how this was achieved and presents how the data produced will form a base for future operations such as developing a Namibian Spatial Data Infrastructure



1. INTRODUCTION

Namibia embarked on a comprehensive revision of the national topographic map series in 1995. The revision programme had tended to follow the trend in technological development. This paper is a presentation of the concept that guided the map revision programme and the production of national and regional map products as part of the development of a National Spatial Data Infrastructure, (NSDI). The long term objective of the map revision programme is to provide the fundamental datasets needed to develop the Namibian Spatial .Data Infrastructure. The concept, status and approach are discussed in section two.

The developments in Geographical Information Systems, cartographic packages and web-based technologies have improved the possibilities available for map visualization. A primary objective in designing a map is to offer the user a visual appreciation that is in consonance with the map's purpose. In September 2005, the Directorate of Survey and Mapping, (DSM) in collaboration with Swedesurvey AB embarked on an project, "map edition and offset printing of maps." This project has resulted in the development of new products and the modification of existing ones. These products include site-centered maps, 1:100 000 topographic maps and tourist maps. These and other existing products are briefly described in section 3.

2. NATIONAL SPATIAL DATA INFRASTRUCTURE (NSDI)

In the past, geographical information was mostly presented in the form of paper maps. Increasingly today, geographic information is being captured in digital form and used through a Geographical Information System (GIS). This change has altered the concept of what Geographic information (GI) is and has introduced new challenges in handling GI. Concomitant with this change is the concept of spatial data infrastructure. Like any other infrastructure, for example, roads and telecommunications, it undergoes different phases like development phase, implementation phase, and maintenance phase. All relevant features must be captured in the first place, changes to these features need to be reflected in the database and database maintained and displayed in such a way that it serves the divergent needs of users. These are the challenges faced by national mapping organisations.

Groot and McLaughlin in de Vries & Beerensi , 2002 defined Spatial Data Infrastructure (SDI) as encompassing the networked geospatial databases and data handling facilities, the complex of institutional, organizational, technological, human and economic resources that interact with one another and underpin the design, implementation and maintenance of mechanisms facilitating the sharing, access to, and responsible use of geospatial data at an affordable cost for a specific application domain or enterprise.

The development and implementation of NSDI is still in its infancy stage in Namibia, especially with respect to institutional arrangements and standardization of data formats. This infrastructure would require a wide approach that encompasses legislation and policies, organisational cooperation and delivery mechanisms. However, development of the fundamental datasets has reached a significant stage. This means that the foundation is already there. The fundamental data sets usually include:

- geodetic control network,
- digital terrain models ('height'),
- topographical maps,
- geographical names,
- administrative boundaries,
- hydrography,
- cadastral data,
- land use/cover,

The concept is such that, based on these fundamental datasets, users can add their own specific information regarding, for example, forestry, resource management, property management, environmental preservation, geology, health management, disaster management, navigation and industrial development.

In order for these subsequent applications to be reliable, efficient, economical and effective, the fundamental datasets need to be complete, up to date and in a digital format that will enhance access and enable the incorporation of the information about the data, commonly referred to as metadata.

In this new situation, the DSM is being transformed from being just a map producer to being content provider and co-ordinator of national SDI efforts. In many countries (Österberg, et al., 2006) focus has already been moved from being a "map factory" with a few, well-known products to being a custom-oriented co-ordinator striving towards satisfying the needs for geographic information in society. This includes increased co-operation with authorities, municipalities and private sector companies, contracting out parts of the production, increased development and implementation of GI standards, restructuring of the core databases to object-oriented models, and to set up metadata services and Internet based services for easy access and distribution of geographic information. It will also include extension of the network of permanent reference stations and support to high quality geodetic measurements, development of new geodata products, and development of efficient workflows – internally and related to co-operation with other agencies

2.1. Proposed Concept of a National Base Map

Namibia has a complete national coverage of the topographic map series at the scales of 1:50 000 and 1:250 000. The problem had been that most of the maps were more than twenty years out of date and they were mainly in hard copies. The digital revision of the 1:250 000 topographical maps for Namibia was completed in 2006. This revision campaign started in 1995 with the acquisition of aerial photographs of the whole country completed in 1998. The revision was based on geo-referenced digital orthophotos derived from 1:80 000 small-scale aerial photography. For the 1:50 000 scale, about one third of the country has been revised and now reflect conditions that are less than ten years old. For all the areas covered, there exists also the corresponding cartographic database. The database of the revised maps is in GIS format and includes the metadata. For the cadastral datasets, the database design and implementation strategy would be deployed in a few months time. The digital data capture of the plots have commenced. The cadastral datasets and the topographical datasets would form the bedrock for the NSDI.

Presently, in Namibia, the two primary datasets were developed to serve different purposes and are usually managed separately, thereby creating inconsistency. This separation is inefficient and uneconomical and could hamper the implementation of sustainable development. A separate development and maintenance of the cadastral and topographical systems would involve duplications with attendant escalation of costs on data collection and maintenance. The current strategy is to configure the datasets into a multi-purpose database to serve wide ranging applications. A study carried out by Österberg, et. Al, 2006 recommended developing a seamless geo-database that would integrate rural and urban data sets – Topographic Base map Level R covering the entire country and Primary topographic data Level U covering towns and villages. This would constitute the National Base Map from a NSDI perspective. The structure of this base map is given below.

Base maps rural areas

Coverage	Entire Namibia
Level R1 (northern)	Densely populated areas in the northern regions
Level R2 (farm land)	Remaining areas – mainly farm land
Geodetic datum	New geodetic datum linked to ITRF
	Geoid model EGM 96
Projections	Modified Traverse Mercator with one degree zone
Transformation parameters	Known relation between old and new system

Contents	Administration boundaries, Transportation, Hydrography, Place names, Geodetic framework, Contours, Digital orthophoto,
Target scale	
Level R1 (northern)	1:10 000
Level R2 (farm areas)	1:50 000
Geometric accuracy	
Level R1 (northern)	<1 metre
Level R2 (farm land)	5 metres
Actuality	5 – 10 years

Base maps urban areas

Coverage	Municipalities, towns, villages and settlements (approx. 150 areas)
Geodetic datum	New geodetic datum linked to ITRF Geoid model EGM 96
Projections	Modified Travers Mercator, with one degrees zone
Transformation parameters	Known relation between old and new system (A number of geodetic points (min 4) defined in both systems for each village**)**
Contents	Transportation, Hydrography, Place names**,** Powerlines, Geodetic framework, Contours, digital orthophoto
Target scale	1:5000
Geometric accuracy	0,25 metre
Actuality	3 – 5 years

2.2. Development of cartographic databases.

Establishment of a cartographic database is a logical step in conforming to the trend in the industry. Maps are usually not printed directly from the GIS database. Some cartographic editing needs to be applied before the maps can be printed. Depending on the use and scale of a map, some features in the GIS database may be omitted, generalized or simplified in generating a cartographic database for that particular map. A map is always a simplification of the actual landscape. On a medium to large scale (such as our 1:50 000), many landscape features are represented on the map in a symbolic way, or are not represented at all. The aim of a map is to give a more convenient way to analyse what's on the surface of the Earth. The decision about what appears on the map and how it is drawn is related to the scale of the map (and to some extent to the aims of the map). On large-scale maps (up to 1:10 000), it is usually possible to represent the objects by symbols having the right (scaled) size: a road of 10 m width is represented by a 10mm thick line on a 1:1 000 map for instance. When smaller scales are concerned, this is no more possible. Their graphical representations are defined by the generalization rules. Generalization involves simplifying lines, combining features, etc., so as to reduce data complexity for the target scale and maintain the characteristics of geographic reality represented by the map, without violating the cartographic specifications.

Based on the above analysis and decisions, the generalized cartographic database is then created, from which the maps can be printed. Map design considerations determine whether a map is legible and easily interpreted. Since maps must necessarily be smaller than the areas mapped, their use requires that the ratio or proportion between comparable measurements be expressed on the map.

The production of a cartographic database enables us to print on demand and also offer our clients an a la carte menu of maps. Just like one goes to a restaurant and chooses from a variety of dishes, our customers can also make similar choices. Our customers, can, unlike a typical restaurant ask for what is not on the menu. Quite often, a user may only be interested in, for example, contours, rivers and infrastructure, but he/she has to be inundated with all other unnecessary features. Having a cartographic database means that customers pay for only what they need. One other advantage of the cartographic database is that we could avoid wastage of money by doing offset printing for only those maps that are high in demand, thereby saving money and storage space. Presently there are thousands of maps that have been gathering dust due to low demand.

Technology has made it possible to use one GIS database to generate multiple cartographic databases. Previously, for each scale, one had to produce two databases. With this possibility, the 1:50 000 GIS database was used to produce other smaller scaled maps, thereby reducing cost and logistical problem significantly. This possibility for multiple cartographic databases means multiple visualization options. This is the subject of the next section.

3. MAP VISUALIZATION

A primary objective in designing a map is to elicit in the mind of the user an environmental image appropriate to the map’s purpose. It involves the representation of geographical data, concepts and relationships. The presentation of spatial information range along a continuum from general-purpose maps such as atlas or topographic maps, to the thematic maps such as choropleth and dot maps.

When designing a general-purpose map, one should encode each attribute in a unique way, so that ambiguity and confusion with any other attribute would be avoided. The primary aims should include legibility and graphic contrast among symbols. Visual dominance should be restricted to features of great importance otherwise no class of marks should dominate.

The task of the map designer is to enhance the map user's ability to retrieve information while the task of the map user is to understand the mapping process. For an effective spatial representation, one has to consider so many inter-related issues as examplified in figure 1

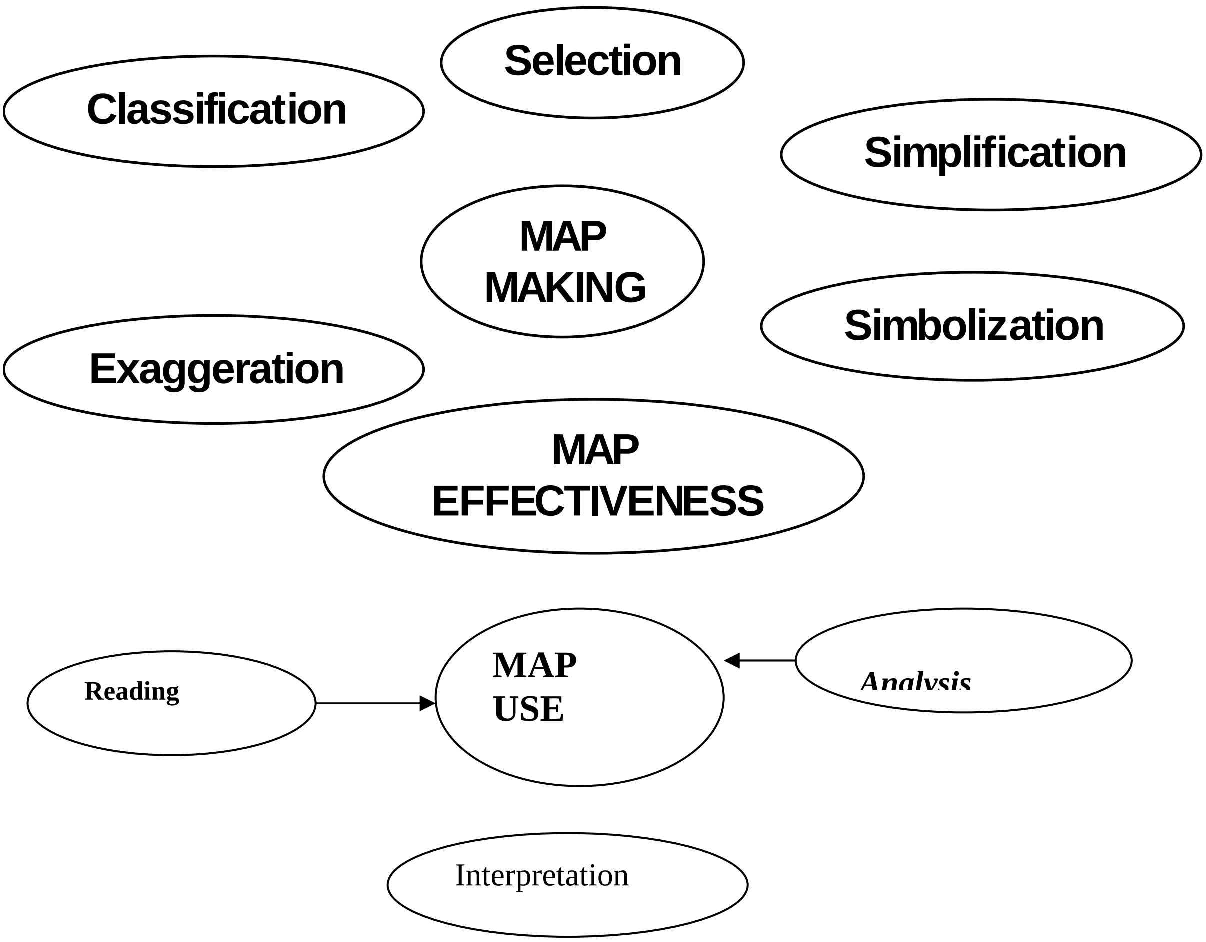


Figure 1: Map Effectiveness in thought and communication
(After Robinson, H. A. et al, 1995)

3.1. Basic Design Principles

For presentation, the most important principles observed by cartographers are legibility, visual hierarchy, figure-ground, and hierarchical structure. The design of a map is also influenced by external factors. These factors include:

Purpose: This is one of the most important factors that determine the shape or form of the map. The purpose determines the content of the map. The purpose can be **substantive** or **affective.** Substantive objective relates to the content of the map. General reference maps are inherently multi-purpose unlike thematic maps that focus on a particular theme. The affective objective is primarily concerned with the how the content is presented. The decisions that should be made include how the map should appear, for example, should it be crowded or open, precise or approximate, etc.

Reality: The character of a feature is fixed and the designer may not have control over this. This could affect hierarchical organization. The object to be emphasized may be smaller than the ones to be faded in as the ground. An important item may occur in a difficult location or a colour convention may prevent the colour series one would like to use. These type of problems affect the general purpose maps like the topographic maps more than the thematic maps.

Audience: The general-purpose and thematic maps serve a variety of audiences. These range from professionals to novices. Each group may differ in terms of familiarity with mapping conventions, geographic knowledge and perceptual limitations. People with some basic knowledge of map interpretation for example, often use topographic maps. A high density representation using abstract symbols may be tolerated here. This is not the case with thematic maps. On the other hand, unsophisticated users often are the audience for thematic maps. These type of users often prefer more intuitive pictorial symbols. Perceptual considerations are also important. Older people have more difficulty reading small letters and symbols.

3.2. Geographic Information Systems/Technology and Visualization of Maps

GIS have significantly improved the design process. With GIS, the design steps are much more integrated, and the design stages are less distinct. The design of a GIS output is hinged on the cartographic design principle, since in both situations, the operative link is between the image and the eye. A map communicates by creating an image. The map gives both the intrinsic (spatial location) and extrinsic information (frame of reference). The problem of cartography is therefore (Petch James, 1998) how to give visual effect to an ordered characteristic and how to display several characteristics.

GIS is designed to promote the collection, storage, analysis and visual representation of objects and phenomena with spatial characteristics. In a traditional map database, features are held as passive data: coordinates and attributes. In the new object-oriented world, this constraint is broken as dynamic objects replace static features.

Advances in computer technology and GIS have significantly increased the options available for map visualization. Visualization of objects and phenomena in 3 –D is now a reality. New systems allow computers to simulate and model reality by using visual and auditory cues in three dimensions. These same systems might be used to create virtual maps in which users can traverse and study real and simulated environments and landscapes. One only needs to visit Google Earth to witness the myriad of possibilities that GIS and computer technology have provided.

The flexibility of GIS procedures and the ease of editing electronic map display have made it easier and inexpensive to develop several **design prototypes** before making a choice. Mapping software provides cartographers with the same type of mileage that text-processing software offers writers. GIS technology is providing cartographers with the accurate drafting that has traditionally required tremendous manual skill, patience, and training. They have also revolutionized map revision procedures, and broadened the horizon to experiment with layout, composition, and symbolization, and to duplicate information from one map to another when producing series of maps. Nevertheless, its use requires that the cartographer be just as familiar with the strengths and limitations of each automated system as with principles of effective communication. The point is that GIS can be used to produce poor maps as readily as good maps and the responsibility to know the difference rests with the cartographer. Perhaps the thought to keep in mind is that *computers don't make good or bad maps, cartographers do.*

3.3. ***Development of new Products***.

The DSM has taken advantage of this technology to develop new products. The revised digital topographic maps were used to generate more products that could be beneficial to a larger society and not just the professional. Some of these products include national tourism maps, regional tourism maps and regional topographic maps, site centred maps, village maps, etc. (These maps are shown in figures 1 to 9).

Site centred maps

Urban areas have been mapped using high resolution colour aerial photography, both for the actual data extraction as well as for the colour orthophoto backdrop. Line mapping in 3D and extraction of terrain models has been added with field checks as well as collection of attributes and location of social and tourist services. This data has been used for producing site centred maps of 17 villages in Karas region at the scale of 1:10 000 and 1:50 000

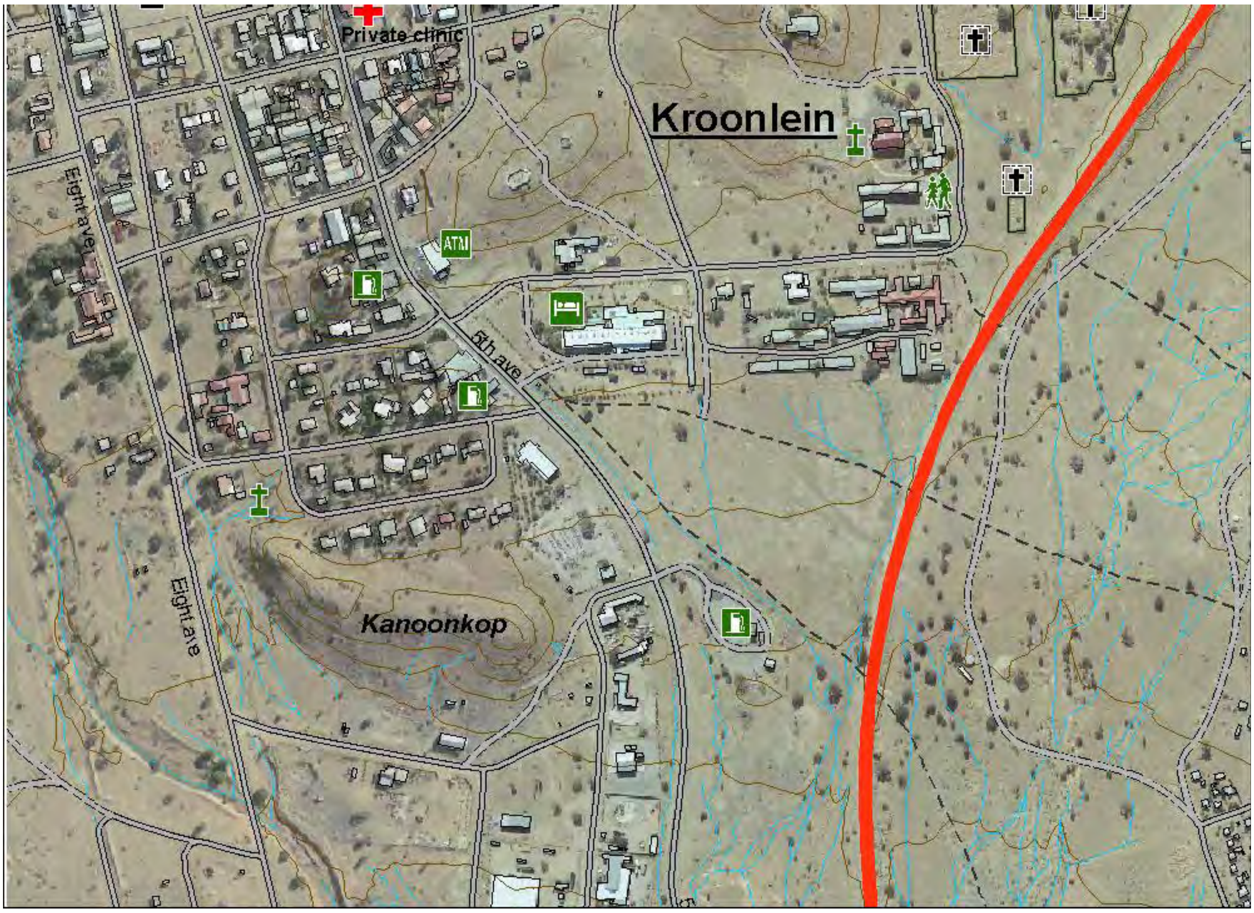


Figure 1 Village Map in 1:10 000

Figure 2: Topographic Map in 1:50 000

Topographic maps in 1:100 000 and 1:250 000

A new concept, depending choice of scale has been adopted in the production of topographic map products. The 1:50 000 scale is only used for urban areas, all other areas are covered with topographic maps to the scale of 1:100 000 as well as 1:250 000. Line mapping in 3 D extraction of terrain data is collected from 1:80 000 scale b/w aerial photography, complemented with cadastral information and attribute information from various agencies e.g. Roads Authority, National Planning Commission.

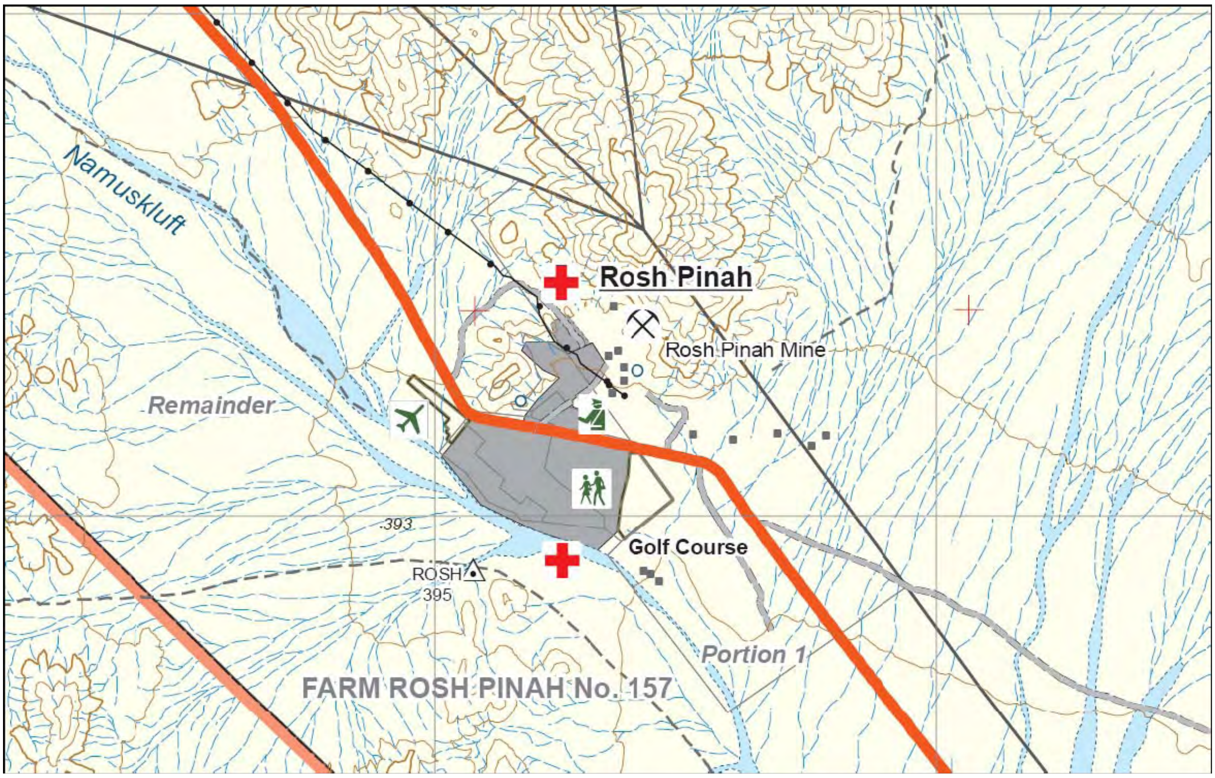


Figure 3 Topographic map in 1:100 000

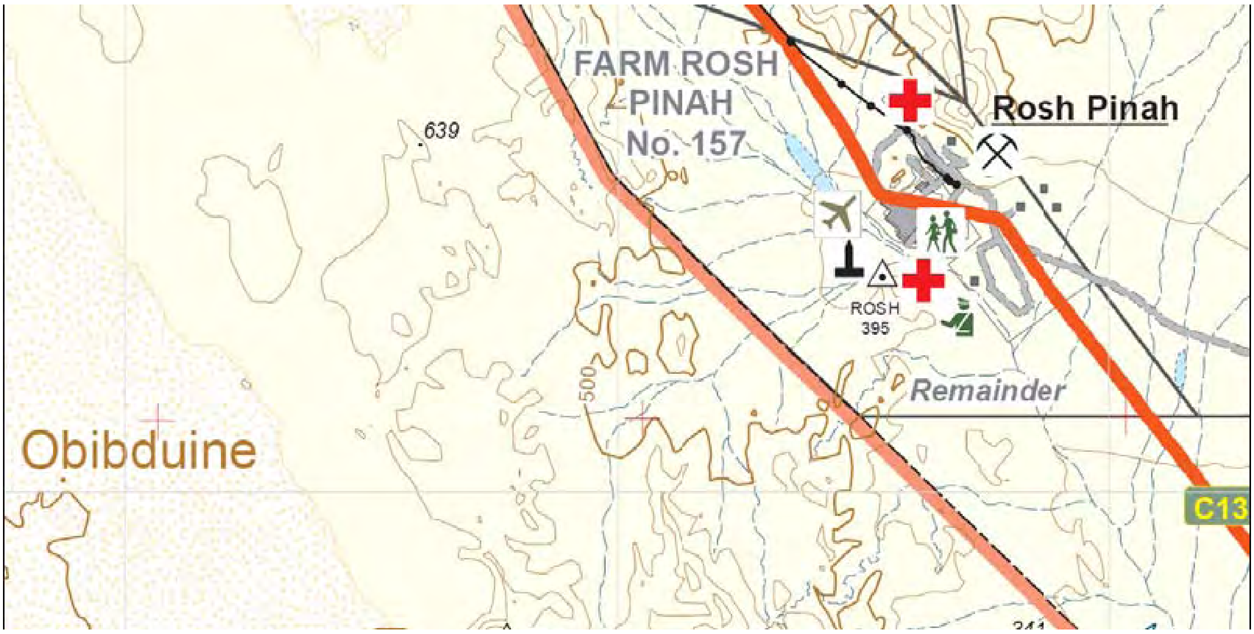


Figure 4: Topographic map in 1:250 000

<u>Tourist maps</u>

The regional tourism maps concentrate on highlighting the tourist potentials of each region. By using the data collected in the mapping process as well as from the field verification process, information necessary for producing on the demand products such as tourist maps are in place. Depending on market needs, products on regional as well as village level has been produced, using data collected from the topographic revision.

Figure 5: Tourism Map in 1:20 000

Figure 6: Tourism Map in 1:500 000

Figure 7: Tourism Map in 1:500 000

Regional Topographic Map

The regional topographic maps have each region represented on one map sheet as opposed to many sheets, and in addition to the topographic features, highlight some salient and peculiar features of that region. An example is shown in figure 8 below.

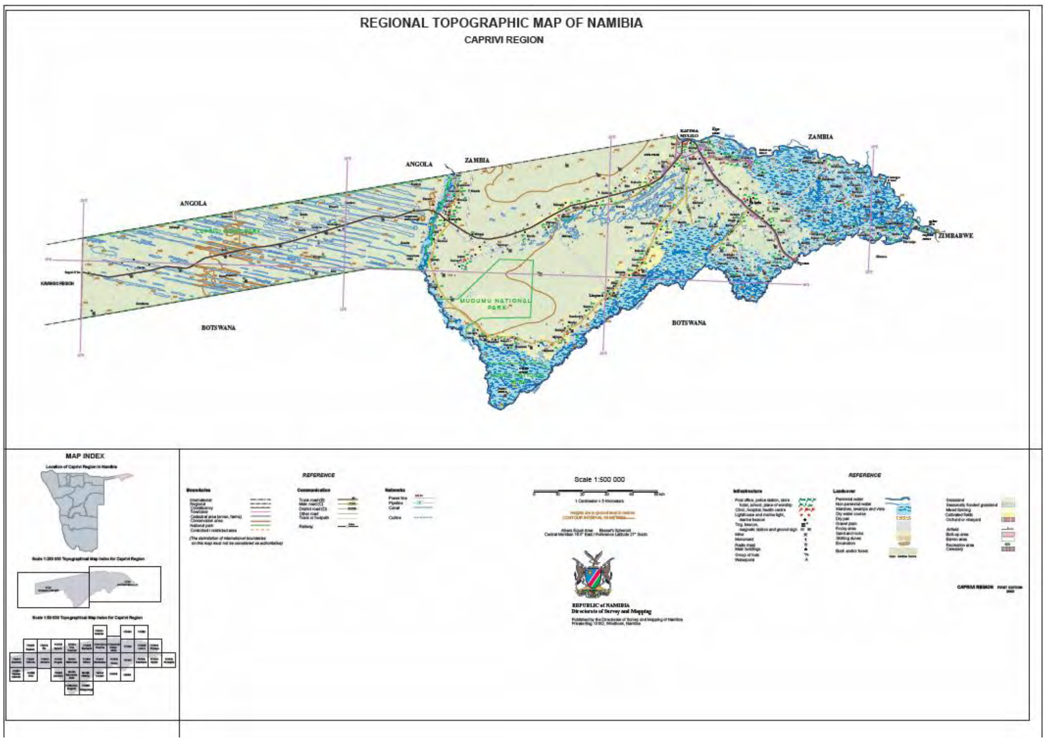


Figure 8: Regional Topographical Map

National Maps

Administrative maps have always been important in the product range of the DSM. These maps highlight regions, magisterial districts, constituencies, cadastral information, national parks and main infrastructure. The map is derived from GIS-data at a scale of 1:250 000, data that will also constitute the new national GIS database.

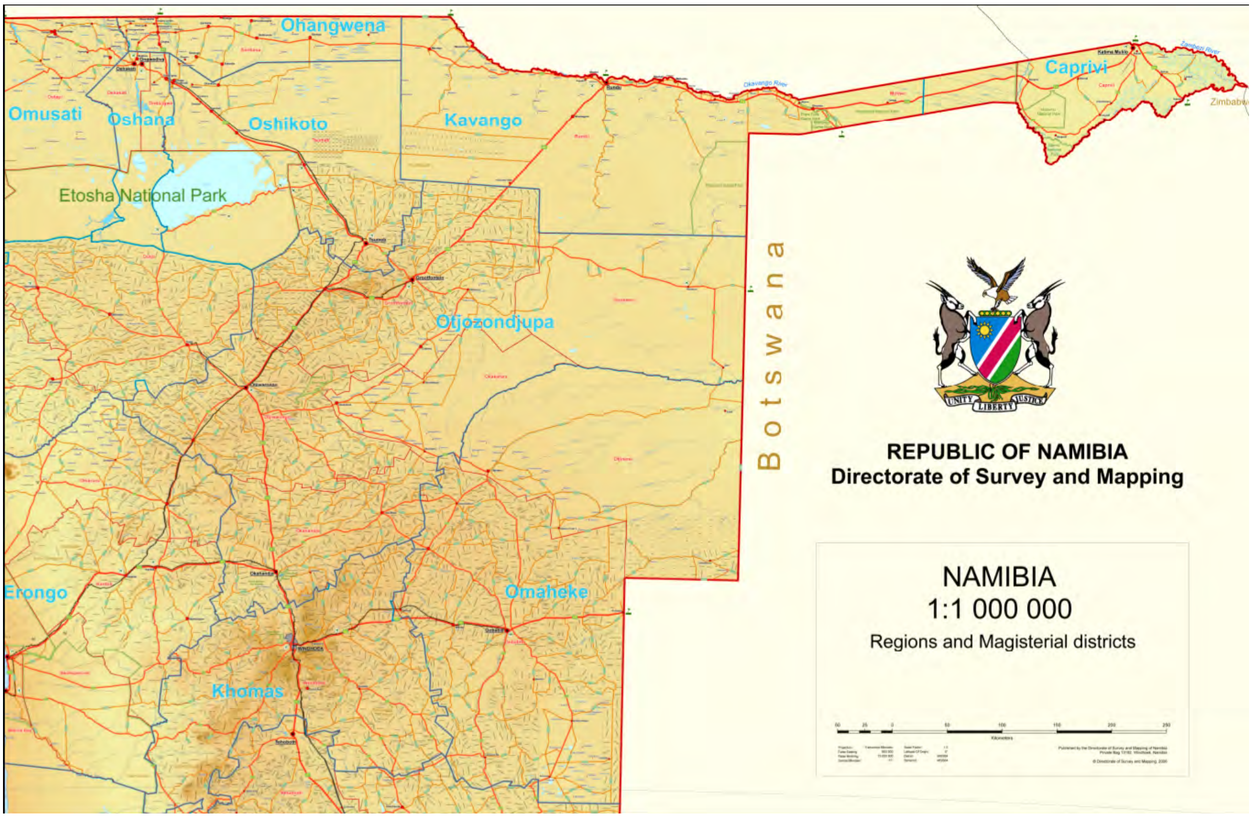


Figure 9: National Map at 1:1 million

3.4. *Web based mapping*.

The use of digital geographic information has often been limited to those who have access to appropriate GIS software. With web mapping, any person with a computer running a web browser can, using a catalogue, locate a dataset of interest and view it over the web. It is no longer absolutely necessary for one to acquire own data set and own software before one can enjoy the infinite possibilities inherent in spatial information. Quite often, merely being able to view geospatial data in the form of a map, may be all that is required in order to plan or make a decision. This greatly increases the number of potential users of geospatial data, as this group is no longer limited to those who have the relevant GIS software and expertise to be able to manipulate digital geospatial datasets.

The Open Geospatial Consortium (OGC), has contributed significantly in the definition of specifications for web mapping interfaces. OGC is a non-profit, international, voluntary organization that is leading the development of standards for geospatial and location based services.

Many software products are available to publish geospatial data in the form of maps through the Web. A significant contribution of OGC has been to define specifications for web mapping interfaces. This has opened the way for the visual overlay of geographic information residing on different servers. These possibilities are being explored and exploited in publishing Namibian spatial data on the web for wider accessibility.

4. CONCLUSION

Namibia has come a long way in her topographical map revision programme. There is currently a complete coverage of orthophotos with resolutions ranging between 1 m and 5m for the different areas. The topographical map series have also been revised. The focus now is on developing a Namibian Spatial Data Infrastructure. The by-product of this process include the development of new products. The development of these new products was largely facilitated by the tremendous development witnessed in recent times with respect to GIS, computer technology and cartographic software.

The strategy was to ensure that the geographic information delivered by the project would become the foundation for the National Base Map from the perspective of a National Spatial Data Infrastructure. The project produced various cartographic products ranging from 1:1 million to 1;10 000 in scale, all derived from one specifically produced homogenous national GIS database.

GIS technology is providing cartographers with the accurate drafting that has traditionally required tremendous manual skill, patience, and training. They have also revolutionized map revision procedures, and broadened the horizon to experiment with layout, composition, and symbolization, and to duplicate information from one map to another when producing series of maps. The flexibility of GIS procedures and the ease of editing electronic map display have made it easier and inexpensive to develop several **design prototypes** before making a choice. Nevertheless, its use requires that the cartographer be just as familiar with the strengths and limitations of each automated system as with principles of effective communication. The point is that GIS can be used to produce poor maps as readily as good maps and the responsibility to know the difference rests with the cartographer. Perhaps the thought to keep in mind is that *computers don't make good or bad maps, cartographers do.*

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