120 Years of Surveys and Mapping in Tanzania (1893 – 2013)

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Abstract

The history of surveys and mapping in Tanzania has been influenced by two European cultures through its colonization; first by the German and then by the British. During the German Administration, surveys and mapping activities were carried out by the Department of Surveys and Agriculture from 1893 to 1914. When the British took over the mandate for the territory after World War I, the also used the "old" German maps until when they when they started the surveys to produce other topographic maps from 1946. In 1961, the Surveys and Mapping Division was created. The division was charged with the surveys and mapping activities in Tanzania. Today there are still topographic maps from the Surveys and Mapping Division, but there are also maps and 3D Terrain Modeling from GIS and Remote Sensing made by different other organizations. In 2013 Tanzania will record its 120th year since surveys and mapping officially started. A number development has been achieved since then. The purpose of this paper is, therefore, to narrate the evolution of surveys and mapping activities in Tanzania.

Key words: mapping, triangulation, atlas, benchmarks, remote sensing, geographical information systems.

1.1 Tanzania - Background Information

The 19th Century History of the area that is now the united Republic of Tanzania was fashioned by the extension of the caravan trade from Zanzibar into the far interior, to the eastern Congo and Buganda. The area, called Tanganyika was part of the German colony and was later incorporated into the German East Africa, which also included the present-day Rwanda and Burundi. After the end of the First World War, the treaty of Versailles, in 1919, granted Britain a League of Nations mandate to govern the former Deutch-Ostafrica (German East [2]Africa) which then acquired a new name, Tanganyika. In December 1961, Tanganyika became independent and, in April 1964, Tanganyika and Zanzibar united to form the present United Republic of Tanzania. Today Tanganyika is commonly referred to as Tanzania Mainland, and therefore, the rest of the information in this paper is for Tanzania Mainland. For the purpose of this paper, Tanzania is taken to mean Mainland Tanzania. Thus, the history of surveys and mapping in Tanzania had been influenced by the two European cultures through its colonization; first by the German and then by the British.

2.1 Pre-Colonial Surveys and Mapping of Tanzania

The maps of Tanzania and the whole of East Africa, produced in the nineteenth century largely ignore the scientific results obtained by explorers but reflect various concerns of Europe. These include the need for simple topographic information and for a solution to the mystery of the Nile source. Another major factor was an increasing concern with the political status of the region. Consequently exploration of East Africa during the time attracted enormous attention among both scholars and the more general European public. The European explores to Tanzania during the 1850's and before were the first to produce their travel records which were indispensable in providing data to make sketchy maps of the piece of land now known as Tanzania. Because several explorers wrote accounts of their journeys which evoked widespread interest among the contemporaries in Europe, their records were readily published and so remained accessible to others including those who were interested to publish maps of Tanzania. The explorers include, among others, Henry Morton Stanley, Richard Burton, David Livingstone and John Hanning Speke.

2.2 Surveys and Mapping During the German Administration (1884 – 1918)

Tanzania traces its early official surveying and mapping from the days of German colonial administration in the late nineteenth century when, in 1893, the then Department of surveying and Agriculture was set up under Dr. Franz Stuhlman who encouraged the collection of topographic information for mapping purposes (Mascarenhas

1971). Following the settlement of European farmers (then mainly Germans) in rural mainland Tanzania in the 1880s (ILife 1971), the areas which were occupied by them, notably along the then (1898) newly completed railway, Kilimanjaro, Meru, Kilosa, and Morogoro were surveyed first and mapped at 1:300,000 scale for cadastral purposes. The Germans continued with topographic mapping at 1:300,000 scale and by 1914, 36 multi-coloured map sheets covering the whole of Tanganyika, including the present Rwanda and Burundi, had been published. Some of these map sheets covered an area of 1.5^0 latitude by 2^0 longitude, others covered 1 x 1 degree. Each sheet was named by a letter and a number (e.g. Al, B3, etc.) as shown in Figure 1.

The information that was contained in them was mainly relief, location of various tribal settlements, the then principal exploration and communication routes and hydrological features. The names of the places shown in these maps were not the same as those found in the later maps published by the British. Tribal names were used to describe the location of some places. The surveys that led to the publication of these maps based on the isolated triangulation networks which, at that time, were primarily established for boundary surveys. The first triangulation network with a local astronomical origin (near Lushoto) was established between 1894 and 1911 (Rowe 1933) and covered the Usambara Mountains

Figure 1: Map Index during the German administration

This was extended later during this period to the North to cover the Pare, Moshi and Arusha areas as well as to demarcate the Anglo-German boundary between Kenya and Tanganyika. The second triangulation network was established in 1898, with another astronomic origin. This triangulation covered the Mbeya and Rukwa areas and was later used to demarcate the boundary between Tanganyika and Nyasaland. The third triangulation was observed between 1902 – 1906. For this, the geodetic longitude of Zanzibar which was used as the origin was transferred across the Zanzibar channel to connect to the Usambara Mountains triangulation. This and the whole triangulation network which covered the Tanganyika – Kenya boundary was recomputed and further triangulation extensions were made to cover the lake zone as far as Kagera. The primary intention of this later extension of the triangulation was to allow the demarcation of the boundary between Uganda and Tanganyika. The fourth network was established in 1907, with a local astronomical origin, in the south western corner of the country (Mbambabay). This triangulation network was used to demarcate the boundary between Tanganyika and Mozambique (Figure 2). The only triangulation network which was not used to demarcate the German East Africa boundary was that which was established between 1912 and 1914 in Morogoro area. It is believed that this triangulation network was purely for cadastral purposes since, at that time, Europeans were continually being settled in this area to start sisal plantations and a cadastral survey of these plantations needed as well controlled network. The network was, thus, used to provide controls for cadastral surveys.

However, the German surveyors did not finish demarcating all the boundaries of Tanganyika; the work was later completed by their British counterparts by adopting some of the original German field observations and extending these as required.

2.3 Atlas Mapping During the German Administration

The first "atlas" of Tanganyika was compiled by Dr. Dietrich Fulleborn and published in 1906 as volume nine of a twelve volume set recording the physical and natural history and geography of German East Africa. Although it was published as an "atlas" it may be incorrect to define this publication as an "atlas" in the true geographic sense since this "atlas" consisted mainly of a series

of photographs that showed various landscapes and the indigenous people who occupied them. Also it would not be correct to define it as a "national atlas" as only two map sheets were included in the "atlas". The main map was at the scale of 1:1,000,000 and covered the southern part of the German East Africa Territory which included the present Ruvuma, Lindi, Morogoro, Iringa and Mbeya regions and extended as far North as Dar Es Salaam.

The second map is at the scale of 1:510,000 and only covers a small area north of Lake Nyasa. However, this "atlas" richly deserves its place in the History of mapping in Tanzania as the first atlas to record the physical and human geography of the country. Later, the first map which depicted the distribution of population in Tanganyika was compiled using, as its base, the 1:300,000 and 1:2 Million scale maps which had been drawn during the German administration (Gillman 1936).

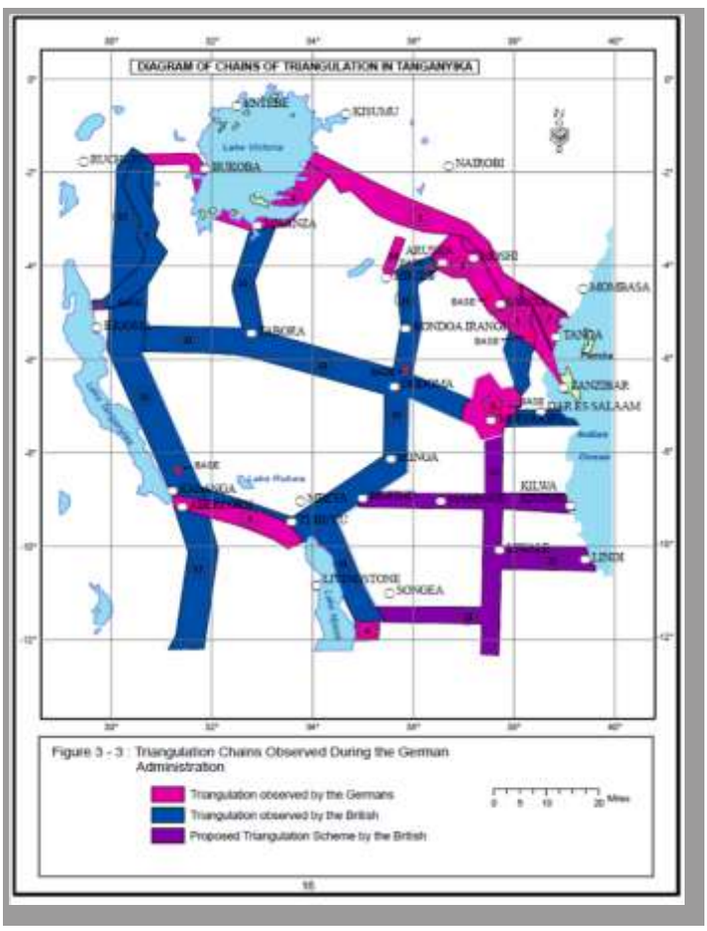

Figure 2: Tringulation schemes during the German and British administration

Administration (1918 – 1961)

The British administration (1919-1961) which took over from the German administration after the First World War formed the Surveying Department under the Ministry of Lands and Mines in 1920. Later it was moved to the Ministry of Lands, settlement and water Development. The Department resurveyed all the properties which originally belonged to German nationals. These surveys were so sporadic and unrelated to one another that it was considered necessary to unify and co-ordinate them on a common origin. Following the geodetic initiative to measure very long lines to help determine the shape and size of the Earth, a triangulation network along the Arc of the 30th Meridian (from North Cape in Norway to Cape of Good Hope in South Africa) started in South Africa in 1905. During the early part of the twentieth century (1905-1914), observations for this triangulation scheme had already been made northwards as far as Southern Rhodesia (now Zimbabwe), and a considerable amount of work had also been done in Uganda. There was, therefore, a break in this Arc represented by Tanganyika, Burundi and Rwanda (the German colonial territories). It was, therefore, logical for the British to continue with this network to cover that part of the Arc which crossed Tanganyika both to continue the geodetic/scientific work of which it formed a part and also so that the existing isolated triangulation networks and surveys could be connected together.

In 1931, Major M. Hotine, R.E. led a field survey party to Kigoma in the western part of the country to continue the triangulation work along the Arc (Hotine 1934). Observations were made from the south eastern corner of Lake Tanganyika, where a base was established at Kate, extending northward to Kasulu where another base was measured. This triangulation was connected to the existing network along the Arc in Northern Rhodesia (now Zambia) and, to the triangulation network observed by the Germans in 1898 (Figure 3).

2.4 Surveys and Mapping during the British

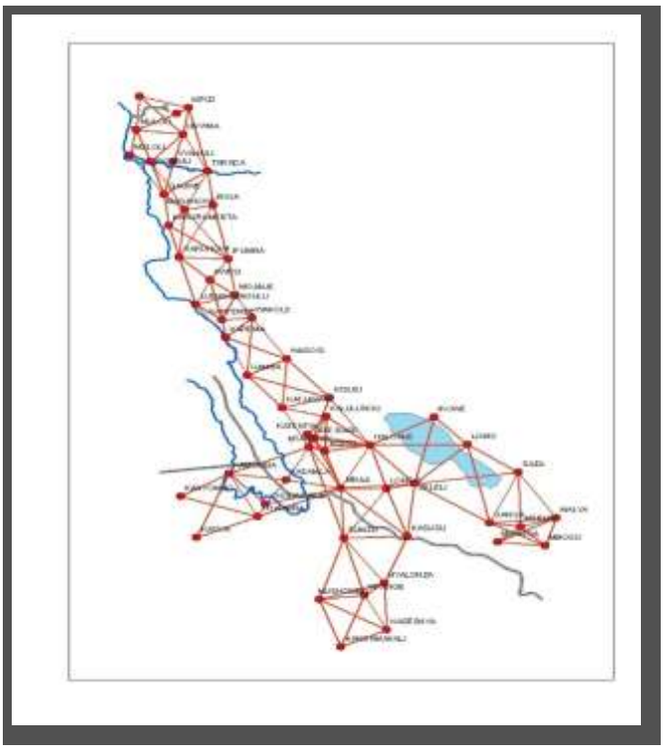

Figure 3: Triangulation scheme observed by major Hotine during the British administration

Later, in 1944, the British Colonial Surveys and Geophysical Committee put forward the argument that geodetic survey is essentially a matter which must be planned for a whole geographic region. The strength of this argument was such that, when the Directorate of Colonial Surveys came into being in 1946 and started its operations this policy was adopted in the British territories in East and Central Africa through the integration of various existing triangulations as they existed (Humphreys 1955).

Although Uganda and Kenya already had a considerable amount of triangulation, this had been done in piecemeal fashion and the networks were of variable quality. In Tanganyika, other triangulation networks that had been observed in the period from 1931 to 1938 had not been computed, thus leaving the triangulation networks in the three East African countries disconnected. As a result, in 1950, it was decided to re-compute the Arc triangulation between Southern Rhodesia (now Zimbabwe) and Uganda. The Tanganyika and Kenya circuits which were linked to the Arc were then recomputed and adjusted to the same datum.

In 1953 a new triangulation chain of 960km in length was observed by the Directorate of Overseas Surveys (DOS), breaking off from the existing triangulation near Morogoro and running southwards to the Tanganyika-Mozambique border. Here it joined up with the Portuguese triangulation. Finally it turned northwards along the mountains east of Lake Nyasa to rejoin the main Tanganyika circuit. This work was completed in 1954 (Figure 4).

The Arc and its attached loops of triangulation networks established during the British administration formed a foundation for the mapping of the whole of Central and East Africa. This control framework now constitutes the basis of accurate control surveys for geodetic and topographic mapping activities in Tanzania.

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2.5 Atlas Mapping During the British Administration

The first official national atlas of the country was produced in 1942 and was named "Atlas of the Tanganyika Territory". This atlas was significant as it was the only national atlas published in the whole world during the years of World War II. The atlas was printed in full colour and contained 29 pages incorporating 44 individual maps at various scales, a statistical section and tables, short descriptive text panels and a gazetteer (Shand, 1997). The majority of the 18 full size map plates were at the scale of 1:4,000,000 and portrayed topics relating to physical and natural environment. A second edition of this atlas was published in 1948 with revised information and the addition of 5 new maps and graphs of mineral production. The new maps portrayed soils, hydrology, vegetation, malarial areas and principal mines.

Third updated and last edition of atlas during the British administration was published in 1956 and renamed the "Atlas of Tanganyika" (Shand, 1997). The changes in content from the previous edition included the increase in scale of the majority of maps to 1:3,000,000, the combination of the three population maps, the complete removal of the historical section and the addition of 5 new map plates giving a total of 27 map plates.

The 5 new map plates portrayed meteorological data, the distribution of labour, main labour routes, water supplies and extracts from published large scale maps of Dar Es Salaam, Tanga, Dodoma and Morogoro at various scales.

Figure 4: Triangulation scheme by 1955 during the British administration

2.6 Pre-world war II Aerial Surveys

The first aerial surveys were carried out in Tanganyika territory in 1931 by the Air Section, which was under the Director of Surveys and Aviation (Gethin, 1931). From these aerial photographs, topographic maps covering the tsetse-fly areas in the territory were produced at 1:50,000 scale. It is not known how many sheets were published as a result of this project, but it is understood that parts of the Lindi, Mtwara and Tunduru areas in the Southern part of the territory were covered by these maps. Aerial surveys continued to be carried out in Tanganyika throughout the 1930s and, in 1939, more photography was flown in the areas south of Mount Kilimanjaro and Mount Meru, and for the first time, height information obtained from parallax measurements on the photographs was incorporated to produce contoured maps.

2.7 Post World War II Topographic Mapping

After the Second World War, the Directorate of Overseas Surveys (DOS) carried out extensive mapping operations at 1:50,000 scale using aerial photographs taken by the Royal Air Force and the Directorate of Military Surveys (DMS) between 1946 and 1958. During this time, priority was given to the mapping of the areas which were considered as agriculturally viable. As a result of this policy, the areas south of Lake Victoria (between Tabora and Mwanza); the south-western part of the territory (Rukwa, the Usangu plains and Mbeya); the north – east coastal area; and the Kilombero River Valley and Masasi were mapped first.

All these areas were mapped at different times between 1954 and 1961. It is also interesting to note that the first task of map revision was carried out in 1956 by the DMS to revise map sheets covering the area around Lake Tanganyika as part of the training programme for military surveyors.

2.8 The Primary Leveling Network in Tanzania

The scheme for the primary leveling was originally conceived in 1960 by the then Commissioner for Surveys, Mr. C.W. Hindle, under whose direction a major part of the project was undertaken. The major routes were chosen to follow the railway lines, because roads were more liable to re-alignment. A total of 53 fundamental bench marks (FBM) were proposed, with each FBM being named after the town or locality in which it was built (Figure 5).

In 1961, the first lines from Arusha to Tanga – numbered 24 to 28 in loop A were undertaken. The leveling continued to be done piecemeal because of the lack of funds. Despite the problems of funds, by 1964 the leveling was connected to tide gauges in Dar Es Salaam, which was established in 1959; Mwanza (Lake Victoria), which was established in 1957 by the East African Railways and Harbours (E.A.R. & H.); and Kigoma (Lake Tanganyika), installed in 1957, also by E.A.R. & H.

Figure 5: Proposed leveling loops in Tanzania as of 1961

3. 1 Surveys and Mapping in Tanzania after Independence.

By 1961, when Tanganyika gained independence, DOS had already published map sheets at 1:50,000 scale covering 1/3 of the country. Also 70% of the territory had been covered by small scale aerial photographs. After independence Tanganyika established the Directorate of Surveying and Mapping to oversee the mapping activities in the country. However, most of the basic mapping at 1:50,000 scale has been carried out through foreign aid programmes. This will be explained in detail in section 3.1.1

3.1.1 The Existing Topographic Map Coverage in Tanzania

Mapping, as categorized at the Division of Surveys and Mapping (DSM) in Dar Es Salaam, ranges from large scale, through medium scale to small scale.

Mainly these will be considered for the purpose of this report. The maps falling under this category are the basic topographic maps at the scale of 1:50,000. Small scale maps are those derived topographic maps at the scales of 1:200,000 to 1:500,000. Atlas maps are those individual map sheets which have gone into the making of the Atlas of Tanzania; these are at the scale of 1:3,000,000 or smaller. Other maps are made under the category of special Maps. Most of these special maps are related to tourism and do not play any significant role in this report.

3.1.2 1:50,000 Scale (series Y742)

This is the basic mapping scale covering the whole of Tanzania mainland in a series of map sheets. In fact, it forms part of the huge series of maps of East Africa (Uganda, Kenya and Tanganyika) at that scale which were produced by the UK Directorate of overseas Surveys from 1953 onwards. Prior to independence, the three countries were closely linked in many aspects (e.g. in terms of currency, customs, transport services (railways, airlines, etc.), universities, etc) and a common topographic map series was regarded as being quite logical at that time. Individual map sheets cover an area of ¼ x ¼ degrees and are sometimes referred to as quarter degree sheets. They are mapped on the Universal Transverse Mercator Projection. Maps in this series have been compiled by photogrammetric methods and ground control.

All recent maps are published in five colors (red, blue, green, brown and black) and show a wealth of detail. Relief is represented by contours which are currently at intervals of 20 meters, although earlier sheets had a contour interval of 50 feet. A few of the earlier (provisional) sheets in the series gave planimetric detail only and, did not show relief. A total of 1,294 sheets would be needed to cover the whole of mainland at 1:50,000 scale (the islands comprising Zanzibar and Pemba have their own separate mapping programmes). By 1990, only about 70% of the whole country has been mapped although complete coverage was scheduled for 1986. These maps are the basis for all derived maps. The equivalent basic maps for the Unguja and Pemba are at the scale of 1:63,360. Two sheets cover each island. Foremost, among the foreign contributors to the mapping of Tanzania's 1:50,000 scale topographic mapping has been the Directorate of Overseas surveys (DOS) of the UK. As noted above, it carried out much of the original topographic map coverage in the period of the 1950s and 1960s, and this work continued into the 1970s. Since then, during the 1980s DOS has also carried out a considerable amount of remapping-cum map revision covering 94 sheets in the north-east part of the country starting from Arusha along the Kenya border and continuing to the south of Dar es Salaam to the Rufiji delta. Aerial photography was flown at 1:65,000 scale. While most of the

photogrammetric compilation and the cartographic work were done in the UK, final printing was carried out locally by the Tanzania Surveys and Mapping Division (Petrie 1993). Again, quite a significant contribution has been made by Canada through a series of aid programmes. This includes a considerable programme of 1:50,000 scale topographic mapping mostly in the southern part of the country - around Mtwara (1979), Mbeya (1985), and Songea (1991), also Kagera (1987) near Lake Victoria.

This was organized by the Canadian National Mapping Organisation (EMR) and executed by various Canadian commercial air companies (Petrie 1993). Further assistance with Tanzania's 1:50,000 scale mapping programme has come from the Japanese government and comprised of the production of 22 sheets covering part of the north – west of the country around Mwanza on Lake Victoria. A similar methodology to that the DOS has been adopted: the aerial photography has been taken at 1:60,000 scale , while the ground control operations was undertaken by the Division of Tanzanian surveys and Mapping (DSM) and the aerial triangulation and stereo plotting were being undertaken in Japan (Petrie 1993). Essentially this was a remapping project, the original maps having been produced by DOS.

3.1.3 1:250,000 Scale (Series Y503)

Topographic maps at this scale are compiled from the 1:50,000 scale series. Again this series originated with the Directorate of Overseas Surveys in 1953, a decision made in parallel with the development of the 1:50,000 scale series. Individual sheets cover 1 degree latitude by 1.5 degrees of longitude. These sheets are layered with altitude tints. In areas where full colour coverage is not yet available, unlayered versions exist as first editions. A total of 65 sheets cover the whole of Tanzania; all but ten have been published. Both the 1:50,000 and the 1:250,000 scale maps fit together the IMW 1:1 Million sheet system.

3.1.4 1:100,000 – 1:500,000 scale District Maps

These scales are used to map Districts as well as Regions for purely administrative purposes. These are essentially planimetric maps showing each administrative District or Region on a single sheet at scales which vary from 1:100,000 to 1:500,000 depending on the size of the District or Region. Prominent on these maps are the names and locations of new villages which came into being after the villagilization programme. Other information shown on these maps include communication routes, settlements (including villages), administrative boundaries, forest reserves and large farms.

3.1.5 1:1,000,000 scale (Series IMW 1301)

Topographic maps at this scale form part of the so-called International Map of the World (IMW) Series on the 1:1 million scale. These are published in accordance with the internationally agreed specifications for this series which include sheet size (4 degrees of latitude x 6 degrees of longitude), legend layout and representation of relief. Six sheets cover the whole of Tanzania at this scale. All have been published.

3.1.6 1:2,000,000 scale

This is the smallest scale map which shows the whole country on one sheet. The first edition of the map was published in 1965 by the Directorate of Overseas Surveys (DOS).It shows relief by contours and layer tints, roads, railways, towns and other urban centres. It also shows Regional and District boundaries, which are accentuated in pink. This is the base map from which the various atlas maps have been derived.

3.1.7 1: 3,000,000 scale

This is the typical scale used in the National Atlas of Tanzania. Tanzania has had several edition of the atlas produced during its mapping history. As explained before, the Germans published their atlas in 1906. The British then published three edition of the atlas between 1919 and 1956; the first two editions were published at 1:4,000,000 but there are no records about the dates of publication. The third edition was published in 1956 by the Surveys Division and the individual maps were at the scale of 1:3,000,000, the scale which has been adopted in all the later editions. It had 26 map sheets and 2 sheets of statistical information. Since independence, two editions of the atlas have been published. The first post-independence edition of the Tanzania National Atlas was published in 1967

by the Directorate of Overseas Surveys (DOS). It had 28 sheets with descriptive information on aspects such as physical features, climate, vegetation cover and population distribution. The last published edition of the atlas was second edition which was produced in 1976 by the Division of Surveys and mapping. This consisted of 38 pages of maps on a diversity of topics, including population distribution, rainfall, etc.

3.1.8 Township Maps (Large scale maps)

These maps are intended to cover the legally defined township areas of Tanzania. Each township is covered by a series of basic maps at the scale of 1:2,500 or in the case of Dar es Salaam city, 1:5,000. The larger urban areas are in addition covered by derived composite map sheets at smaller scales. Typical large scales are 1:2,500; 1:5,000; 1:20,000 and in the case of Dar Es Salaam city, 1:25,000. The 1:2,500 scale maps are compiled photogrammetrically and are the main source of information for the making of the smaller scale urban maps. These maps, both basic and derived, show plot boundaries, individual buildings, communication routes and represent relief by contours. In addition, a large project funded by NORAD (Norwegian International Development Agency) to produce township maps for nine towns was carried out in the 1990's. The towns that were covered by this project were parts of Dar es Salaam, Arusha, Moshi, Tanga, Tabora, Morogoro, Iringa, Mbeya and Mwanza. For this project, maps were compiled photogrammetrically in Norway by Norconsult Consortium of Norwegian survey companies (Viak and Blom Oppmalling), while the field completion was being done by surveyors from the Surveys and Mapping Division.

The input from the Tanzania end also involved the inclusion of the cadastral information for each of the towns. To this end, NORAD installed a PC-based digital mapping system in the surveys and Mapping Division, which led to the establishment of the Digital Mapping Unit in the mapping section.

3.2 Cadastral and Village Mapping

Cadastral survey is perhaps the surveying activity which is best known to the common man in Tanzania. Primarily, cadastral surveying involves the determination of plot and/or estate boundaries. From these surveys, deed plans are drawn and are used in the registration of the individual pieces of land. For each piece of land, based on the cadastral survey, a certificate of the right of occupancy is issued and can be used as a security for, in many cases, a mortgage. Cadastral surveys are carried out by rigorous ground survey methods as dictated by the Land Surveying and Surveyors Act of 1959. The Act also established the Board of Control and Licensing of Surveyors including dealing with complaints against licensed surveyors.

In addition to the Act, Government Notice No. 173 published on 5/6/1959 provides for the Land Survey (General) Regulations dealing with registration of surveyors, and, Government Notice no. 174 also published on 5/6/1959 provides for the Land Survey and Surveyors Regulations instructing the licensed surveyors on the technical procedures in carrying out cadastral surveying. Occasionally, the Director of Surveys and Mapping issues Survey Technical Seculars to address specific issues in order to quality control surveying and mapping practices.

Parallel to the cadastral surveys are the village surveys. Until recently, the majority of cadastral surveys undertaken in Tanzania were urban surveys which were executed from plan data. This situation changed in 1983 when the Agricultural Policy of Tanzania became fully operational. Since then, the greater part of cadastral surveys had been concerned with the delineation of village boundaries and farms (Silayo 1987). In these surveys, the boundaries of the villages are determined and the individual properties existing within them. But instead of using ground survey methods, these village surveys are performed photogrammetrically. Boundary points within each village are identified on the aerial photographs and are plotted photogrametrically using stereo plotters. These plots are used as the basis for deed plans and a certificate of occupancy is issued for the villages.

3.3 Atlas Mapping after Independence

3.3.1 Atlas of Tanzania (1967, 1976)

Following the independence of Tanganyika in 1961 and its subsequent union with Zanzibar and Pemba to form the United Republic of Tanzania in 1964**,** the first edition of a national Atlas of Tanzania was published by the Surveys and Mapping Division, in 1967 (Shand, 1997). The atlas retained its map scale

of 1:3,000,000 but varied significantly in content from the three previous atlases of the country with the omission of 4 map plates and 1 graph plate and the addition of 6 new maps giving a new total of 24 map plates plus 3 full plates of graph and statistical diagrams. Several of the existing maps had been extensively revised and redesigned. The map format was changed as the atlas was now available as a complete volume in a more convenient loose – leaf binding form and, since 1969; it had also been available as individual map sheets.

Among the changes to contents was the omission of the physiographic map, the tribal and ethnographic map, the labour maps and the mineral production graphs. New major additions to the map plates included a map of potential land use, a geophysical map, a rainfall probability map, antiquities and monuments map, a fisheries map and setoff maps, figures and texts depicting population characteristics. What is significant about some of the new maps was the move from factually based maps such as a geology map to a more analytical type of map such as potential land use map. A fully revised and extended second edition of the national Atlas of Tanzania was published in 1976, again by the Surveys and Mapping Division. Statistical data for 1972 was utilized where available, the exception to this being the use of the 1967 population census data, in addition to changes in the map content, other major changes included an increase in volume and an extensive rewrite of the descriptive text panels together with the inclusion of many new photographs and diagrams.

3.3.2 Map Production for Tanzania National Atlases

The base maps used for all editions of the national atlas are compiled and derived from the 1:2,000,000 scale topographic map since this is the largest published scale that covers the whole of the country on a single sheet. Technical production initially involved the use of traditional analogue techniques such as pen and ink drawing, combined with the use of typeset lettering and positive masks. Area fills relied on a limited selection of glass line screens and pre-printed adhesive tones and patterns.
The latest (1976) edition of the atlas has seen the introduction of stable polyester films as the base material for the cartographic production process utilizing scribecoat (dyed in blank to create a positive) for linework, peelcoat for masking , and photographic stripping film and wax for name and symbol stick-up, Higher resolution percentage line and dot tints screen were also available to create higher quality area fills and positive working colour proofing on while opaque astrofoil was also introduced (Shand, 1997).

3.3.3 Specialist/Thematic Atlas of Tanzania Tanzania in Maps (1971, 1975)

According to Prof. L. Berry, the 'Tanzania in Maps' book was aimed primarily at the people of Tanzania both within and out with formal education who wish to know more about the spatial aspects of their country and to those outside Tanzania who require a general overview of the country and its economy. The book, printed in monochrome (blank), contains 89 maps, 61 tables, diagrams, statistical data, extensive descriptive text and a comprehensive bibliography of the information sources used. It also includes chapters and maps of the physical environment (geology; soils; climate; relief; hydrology, etc) and maps of the natural environment portraying aspects of both biogeography (population; culture; industry; commerce; communications etc.) The first edition of the national Atlas of Tanzania is acknowledged as a major source for the data with several government organizations contributing to the non-spatial data and statistical information.

3.3.4 Other Specialist/Thematic Atlases

The Regional Economic Atlas of Mainland Tanzania was published in 1968 as a research paper by S.B.A. Jensen of the University of Dar es Salaam and contained 18 maps at various scales. A report on the relative location of health and population in the rural regions of Mainland Tanzania by I.D. Thomas of the University of East Anglia, U.K. comprised as series of volumes including volume 3 which was published as a regional atlas of the Population and Health Facilities in Tanzania, 1978. This atlas, which covers mainland Tanzania only, contains a complete volume of monochrome pen and ink maps at various scales using proportional circles to plot population data against healthcare.

3.3.4.1 School Atlas for Tanzania

It should be noted that school atlases are often referred to as being atlases for a particular country rather than an atlas of a country. This distinction is important since these atlases, while they may

contain a specialist and detailed section on Africa and the home nation; also contain maps of the rest of the world as the major content within the atlas. Since the majority of school atlases for Tanzania and East Africa have been produced since the 1960s, they have benefited from the availability of national atlases as source data and changes in technology. These technological changes had been the introduction of high quality cartographic production processes using scribecoat, peelcoat, and photographic films. The use of full colour illustrations and photographs in these atlases has been a major factor in the introduction of the four-colour production process and the move from letterpress printing to the offset lithographic printing process.

3.3.4.2 Ramani kwa Shule za Primary (1963)

This primary school atlas, also titled "Tanganyika – our country", is published in Swahili and may have been the first school atlas published for Tanzania. Like many school atlases; this atlas was published in a small format with a series of simplified general and specialist/ thematic maps at various scales for Tanzania and for the rest of the world.

3.3.4.3 Atlasi yenye Picha kwa Shule za Msingi za Tanzania (1969-1983)

Intended as a primary school atlas and again published in Swahili, this full colour atlas dedicates a total of 18 of its 40 pages to Africa and Tanzania and also contains many small illustrations as a complement to its maps. Tanzania is covered by 4 maps at scales of approximately 1:7,000,000 and 1:10,000,000, Zanzibar and Pemba are covered by two maps at the unusually large scale for small format atlas, of approximately 1:300,000 and 1:500,000 respectively.

3.3.4.4 Atlas 'Kwa Shule za Msingi 'Tanzania (1987)

This is another Swahili language atlas published by McMillan, and appears to be an updated, redesigned and extended version of the above atlas. A total of 37 of its 66 pages are dedicated to maps of Africa and Tanzania. It contains 14 maps of Tanzania at approximately 1; 7,000,000, 1:10,000,000 and 1:20,000,000 scales and a special 10 map section on Zanzibar and Pemba. Numerous statistical graphs, charts, diagrams and tables have been added to this atlas and the illustrations of the previous atlas have been substituted by full colour photographs.

3.3.4.5 New Secondary School Atlas for Tanzania (1988)

Published in English by the Longman Group and intended for secondary schools in Tanzania, this atlas probably contains the most comprehensive set of maps for Tanzania published to date in a school atlas. A total of 61 of its 152 pages are dedicated to maps of Africa and Tanzania. It contains 25 maps of Tanzania at 1:5,000,000 and 1:12:000,000 scales and includes a special 10 map section on Zanzibar and Pemba at approximately 1:1,000,000 scale, and 2 urban land use maps of Dar Es Salaam. The maps in the atlas are complemented by the extensive use of graphical images such as full colour photographs, statistical graphs, charts, diagrams and tables.

This atlas is one of the first atlases in which the cartography, produced by Wm. Collins & Sons, contains maps generated by digital mapping and desk top publishing technology. The maps have been created on a PC-based manual vector digitizing system and the map design and specification had been completed on an Apple Macintosh system utilizing vector based graphics and desk top publishing software. The output of the cyan, magenta, yellow and black final film separates for plate making was generated on a high resolution (1,240 - 2,400 dpi) raster image setter (Shand, 1997).

4. The Current Aerial Photography Coverage

Tanzania has been completely covered by aerial photography of varying ages and scales (Figure 6). Generally the photography used for the basic mapping at national level (i.e. at 1:50,000 scale) is in the scale range from 1:30,000 to 1:60,000. Photography taken for urban mapping (at 1:2,500 scale) is usually at 1:12,500 scale.

5. Current Mapping with GIS and Remote Sensing in Tanzania.

Although traditional aerial photogrammetric techniques dominate the mapping of Tanzania, the mapping community is quite aware of satellite images and their potential applicability to mapping. Most of the satellite images available in the country

have been acquired by other government agencies, mostly concerned with agricultural or forestry developments or with environmental problems. Thus, for example, quite a number of satellite images have been acquired by Ardhi University, the University of Dar es Salaam and Sokoine University of Agriculture.

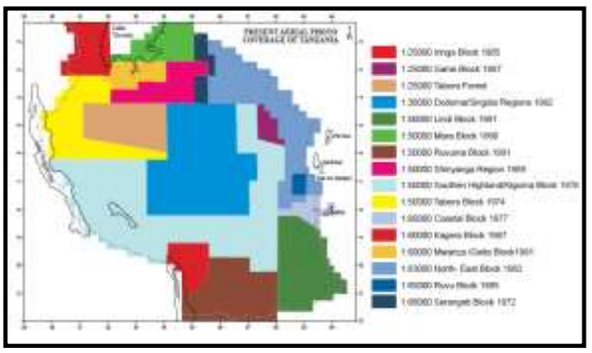

Figure 1: Current aerial photo coverage in Tanzania

It is also useful to note that the first map from satellite data in Tanzania was made as an experimental image map for Tabora and the area covering the West and Central parts of Tanzania at 1:1,000,000 scale from Landsat MSS imagery. The image map was produced by the U.K Directorate of overseas surveys (DOS). This image map had been produced in two editions (Bolderstone 1987). The first edition was produced by mosaicing together hardcopy prints of the 17 images covering the area. Additional information such as water features, railways and swamp areas were interpreted from RBV imagery and existing IMW maps. The second edition was produced in system of the Geodata Unit of the University of Southampton and the film writer facilities of the National Remote Sensing Centre (NRSC) in the UK. Landsat 3 and 5 MSS images as well as Landsat TM data were used as the basis for this edition

6.0 Training in Surveys and Mapping in Tanzania

In 1936, the first experiment to train primary school leavers as survey technicians. However, the programme was discontinued two years later, because the school leavers could not cope with course (Silayo, 2005). Between 1951 and 1953 attempts were made to resume training of school leavers, but again proved to be unsuccessful. The Survey training started again as a Department in 1956 as the Survey Training Centre (STC) at Mgulani area in Dar Es Salaam. This time the centre trained the field chainmen who had already been involved in field surveys. The objective then was to improve their technical and theoretical understanding of surveys and mapping. The training took variable times between six month and one year depending on the expected assignment for the particular group. The recruitment did not specify any qualifications in order to join the centre nor did it give any certificates after completion of the training period.

In 1958, the Centre was moved from Mgulani to the location currently occupied by Ardhi University. Then, the Centre was also charged with training of Cartographic draughts men as well as Survey Technicians. At this point a more rigorous training programme started. At this point, entry qualifications were specified, where, those with primary education (Standard Four) were allowed to join the centre. Later, entry qualifications were raised; where, those who had completed Standard Eight education were recruited for the training.

Professional surveying at degree level (Bachelor level) was not carried in Tanzania. Students were sent overseas, particularly to Canada, Poland, Hungary, and Russia; and to the University of Nairobi (Kenya) to get their degrees. Quite a number of surveying professionals who worked in Tanzania from 1972 were graduates from these countries.

However, in 1972, following the government's policy of decentralization of its activities to the regions, demand for more and better trained surveyors was felt. The STC status was therefore changed to the former Ardhi Institute. The Institute was charged with training of mid career sub professionals in Land Surveying, Land Management and Urban and Rural Planning. Training for these courses lasted for two years. Graduates of the institute were conferred with Ordinary Diplomas in their respective disciplines.

In 1974, the Institute was re-established by the Act of Parliament and its roles were modified. The institute then started offering full professional courses of three years duration. At the same time Tanzania stopped sending its students to Nairobi with the anticipation that the 'New' Ardhi Institute could now cater for the need of producing high level professionals in Land Surveying. Successful students who graduated from Ardhi Institute were awarded Advanced Diploma in Land Surveying.

The diploma programmes were rated as degree equivalent.

In 1996, Ardhi Institute was affiliated to the University of Dar Es Salaam and became a University College of Lands and Architectural Studies (UCLAS). UCLAS started offering Bachelors Degree programmes in Land Surveying and other areas of expertise. In 2007, UCLAS acquired University status in the Name of Ardhi University (ARU) and in the process the school of Geospatial Sciences and Technology was established. While Ardhi Institute and later Ardhi University were offering professional degrees in surveying and mapping, another institution, Ardhi Institute –Morogoro was conducting ordinary diploma level and certificates in the same discipline. The courses in Morogoro were tailored to produce technicians capable of carrying out cadastral and engineering surveys under guidance of a better qualified person.

7. Conclusion

For the past 120 years, as elsewhere in the world, mapping is still an active activity that is going on in Tanzania. The private sector in surveying has also expanded. However, the National Land Policy which came into effect in 1995 put new directions on how to handle land matters including surveys and mapping. In particular, Section 5 of the policy stipulates how surveys and mapping activities should be handled. For example, while in the past all surveying and mapping activities were carried out by the Government, Sub-section 5.1 sets a policy statement which now encourages the private surveyor to play a bigger role in executing cadastral survey while the Government should larges limit itself to undertake all basic and control surveys (topographic, geodetic, hydrographic and triangulation); supervise, check and approve all cadastral surveys in accordance with the laid down laws and procedures. Also, on realizing the increased demand for accurate and up to date topographic maps, the policy insists that the government rather than the private sector to concentrate on the production of topographic maps of the scale of 1:50,000 and the urban maps at the scale of 1:2,500. Subs-section 5.2 further, emphasizes that village demarcation should be done to protect use of natural resources within villages. The surveying and mapping authority does not operate in ideal circumstances, indeed the conditions under which it conducts its operations, are not dissimilar to those found in other developing countries. Fundamentally, the budget is tight for the purchase of equipment and materials. This makes me conclude that in spite of its importance to the nation's development, insufficient attention has been paid to the surveys and mapping processes in Tanzania.

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