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Analysis and Modelling of Cartographic Services among the East African Community Member States

By

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July, 2020

DECLARATION

I, Sabina Nyoroka Baariu, hereby declare that this is my original work. To the best of my knowledge, the work presented here has not been presented for a degree in any other University.

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DEDICATION

Ken,

Of all the special gifts I ever got in life

whether great or small

To have you as my son

was the greatest gift of all

A special time,

A special face,

A special son,

I can't replace you

With a broken heart

I whisper low

I miss you son

And love you so

Gilbert

I would have preferred it if you were alive and well

I know you are happier and smiling from up there!

Because this was your vision

I had to do it for you

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ABSTRACT

Economic and political integration of East Africa has been expanding since its second founding in 2000, more so with the accession of Rwanda and Burundi (2007) and South Sudan (2016). Driven by the provisions of the common market protocol, greater regional integration is foreseen and it is expected to stimulate the demand for cartographic information to support development planning and other applications. Such information can be best served through a harmonized cartographic service which is not only lacking, but even the status of the current national services is largely unknown. This motivated the study to determine the status of the cartographic services in the East African Community (EAC) member states and to subsequently derive a roadmap for harmonized, state of the art cartographic services in East Africa. The study was accomplished by survey via semi-structured questionnaires distributed to 255 respondents in national and private mapping organizations and academic institutions. Supplementary data was got via interviews, review of country reports and map catalogues. Results revealed a lot of historical commonalities among the original member states but largely, the present cartographic services were characterized by inadequate and out of date basic datasets, low levels of computerization, lack of metadata, non-uniform spatial reference systems, limited use of mapping standards, inadequate funding, out dated laws, inadequate cartographic personnel in some countries plus the associated training facilities. Due to the fact that these cartographic service shortcomings are at different levels in the different EAC countries, it was proposed that the first step towards their regional improvement be their harmonization, so that they are largely at par. A design of this harmonization has been done, and it is estimated to take 36 months and to cost USD 45 million. The resulting harmonised EAC model was then compared to the European EuroGeographics service, considered as state of the art for purposes of this study. The comparison yielded gaps, and an upgrade design to fill the said gaps has also been carried out. It is estimated to take 60 months and to cost USD 23 million. It is concluded that even though these costs are large, the benefits of such a regional improvement exercise would by far surpass the costs, as 80% of decision making involves geo-spatial data. It is recommended that the first step towards implementing the improvement could be a legal instrument, passed by the EAC legislative assembly, similar to the directive that enabled the setting up of the European INSPIRE. This study has contributed a hard-to-find body of knowledge on the EAC cartographic services and provided a roadmap for their harmonization, then improvement to the state of the art. Areas for further research include data and map use trends prior to committing the funds for the harmonisation.

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ABBREVIATIONS

ADOS	African Doppler Survey
AESI	African-European Spatial Infrastructure Alignment
AFREF	African Geodetic Reference Frame
AFRICOVER	Land Cover Map and Geodatabase for Africa
AGEO	Australian Umbrella Organization for Geographical Information
AGI	Association for Geographic Information
AGILE	Association of Geographic Information Laboratories Europe
AISBL	*Association Internationale sans But Lucratif International* (Non- Profit Organization)
APSEA	Association of Professional Societies in East Africa
ARU	Ardhi University
ATM	Automated Teller Machine
BCG	*Bureau Decentralization Des Geomatique*
BKG	*Bundesamt Für Kartographie und Geodäsie of Germany*
B.Sc.	Bachelor of Science
BoK	Body of Knowledge
CEN	European Committee for Standardization
CERCO	*Comitee Europeen Des Responsables De La Cartographie Officielle*
CGIS	Centre for Geographic Information Systems and Remote Sensing
CIP	Competitiveness and Innovation Programme
CLGE	Council of European Geodetic Surveyors
CMP	Common Market Protocol
CODIST	Committee on Development Information Science and Technology
CORS	Continuously Operating Reference Station
COTS	Commercial Off the Shelf Software
CPD	Continuous Professional Development
CRS-EU	Coordinate Reference System _European Union
DG	Director General
DGPS	Differential Global Positioning Systems
DKUT	Dedan Kimathi University of Technology
DOS	Directorate of Overseas Surveys
DPW	Digital Photogrammetric Workstation
EA	East Africa
EA-GI	East African Geo-Information
EABC	East African Business Council
EAC	East African Community
EALA	East African Legislative Assembly
EAQFHE	East African Qualification Framework for Higher Education
EBM	EuroBoundaryMap
EC	European Commission
ECA	Economic Commission for Africa
ECOWAS	Economic Community of West African States
ECTS	European Credit Transfer System
EEGECS	European Education in Geodetic Engineering, Cartography and Surveying
EGAR	EuroGeographics Annual Report
EGHO	EuroGeographics Head Office
EGM	EuroGlobalMap
EGN	EuroGeoNames
EIS-Africa	Environmental Information Systems-Africa
ELF	European Location Framework
ELS	European Location Services
EQF	European Qualifications Framework
ESDI	European Spatial Data Infrastructure
ETRS89	European Terrestrial Reference System 1989
ETeMII	European Territorial Management Information Infrastructure
EU	European Union
EUPOS	European Position Determination System
EUREF	European Reference Frame

EuroSDR	European Spatial Data Research
EuroDEM	European Digital Elevation Model
EUROGI	European Umbrella Organization for Geographic Information
FAO	Food and Agriculture Organization
FGDC	Federal Geographic Data Committee
FI/IGN	France International/ *Institut Geographique National*
FIG	International Federation of Surveyors
FOSS	Free and Open Source Software
GDP	Gross Domestic Product
GFM4	GeoInfoModule4
GI	Geo-Information
GI-N2K	Geographic Information Need to Know
GIM	Geo-Information Management
GiMoDig	Geo-spatial Info-Mobility Service by Real-Time Data-Integration and Generalization
GIS	Geographical Information System
GIS &T BoK	Geographic Information Science and Technology Body of Knowledge
GLCN	Global Land Cover Network
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
GSDI	Global Spatial Data Infrastructure
IAG	International Association of Geodesy
ICA	International Cartographic Association
ICC	International Cartographic Conference
ICT	Information Communication Technology
IGEBU	Geographic Institute of Burundi
IGN	*Institut Geographique National*
IGB	*Institut Geographique De Belgique*
IGNB	*Institute Geographique National Belgium*
ILMIS	Integrated Land Information Management System
INDSB	National Spatial Data Infrastructure for Burundi
INSPIRE	Infrastructure for Spatial Information in the European Community
IPR	Intellectual Property Rights
ISCGM	International Steering Committee for Global Mapping
ISK	Institution of Surveyors of Kenya
ISO	International Organization for Standardization
IST	Institution of Surveyors of Tanzania
ISU	Institution of Surveyors of Uganda
IT	Information Technology
ITC	International Institute for Geo-Information Science and Earth Observation
ITRF	International Terrestrial Reference Frame
IUCEA	Inter-University Council of East Africa
JICA	Japan International Cooperation Agency
KENREF	Kenya National Geodetic Framework
KENs	Knowledge Exchange Networks
KISM	Kenya Institute of Surveying and Mapping
KNSDI	Kenya National Spatial Data Infrastructure
KOICA	Korea International Cooperation Agency
LBS	Location Based Services
LIDAR	Light Detection and Ranging
LIS	Land Information System
LSB	Land Surveyors Board
MAFA	Mapping Africa for Africa
MEGRIN	Multi-Purpose European Ground Related Information Network
MEP	Member of the European Parliament
MLHUD	Ministry of Lands, Housing and Urban Development
MRA	Mutual Recognition Agreement
NAFTA	North American Free Trade Agreement
NATO	North Atlantic Treaty Organization
NCIC	National Cartographic Information Center

NCS	National Cartographic Service
NEPAD	New Partnership for Africa's Development
NGIA	National Geo-spatial Information Authority
NGO	Non-Governmental Organization
NMA	National Mapping Agency
NMCA	National Mapping and Cadastral Agency
NMO	National Mapping Organization
NSDI	National Spatial Data Infrastructure
NUR	National University of Rwanda
NUTS	Nomenclature of Territorial Units for Statistics
OGC	Open Geo-spatial Consortium
PC-IDEA	Permanent Committee for Geo-spatial Data Infrastructure of the Americas
PDF	Portable Document Format
Ph.D.	Doctor of Philosophy
PMO	Private Mapping Organization
PPP	Pubic Private Partnership
PSCP	Private Sector Competitiveness Project
PSI	Public Sector Information
PTA	Permanent Tripartite Agreement
QGIS	Quantum GIS
RCMRD	Regional Centre for Mapping of Resources for Development
RGA	Republic Geodetic Authority
RICU	Research and Innovation Coordination Unit
RMP	Rwanda Metadata Portal
RNRA	Rwanda Natural Resources Authority
RSDI	Regional Spatial Data Infrastructure
RSM	Remote Sensing for Mapping
RTK	Real-Time Kinematic
RTN	Real Time Network
SABE	Seamless Administrative Boundaries of Europe
SADC	South African Development Community
SAR	Synthetic Aperture Radar
SCR	*Service de Cartographie du Rwanda*
SDI	Spatial Data Infrastructure
SI-EGN	Survey/Inventory on European Geographical Names
SMD	Surveying and Mapping Department
STC	Survey Training Centre
SoK	Survey of Kenya
TIGER	Topologically Integrated Geographic Encoding and Referencing
TTM	Tanzania Transverse Mercator
UAV	Unmanned Aerial Vehicles
UCLAS	University College of Lands and Architectural Studies
UK	United Kingdom
UN	United Nations
UNECA	United Nations Economic Commission for Africa
UNGEGN	United Nations Group of Experts on Geographical Names
UNGGIM	United Nations Global Geo-spatial Information Management
USA	United States of America
USD	United States Dollar
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
VGI	Volunteered Geographic Information
WFS	Web Feature Services
WG	Working Group
WGS84	World Global System84
WMS	Web Map Services
WP	Work Package
WTS	Web Tile Services

CHAPTER 1: INTRODUCTION

1.1 Background

In the world today, many national economies are integrating into regional inter-governmental economies with the aim of enhancing trade through the removal of regional trade barriers among members. Examples are the European Union (EU), North American Free Trade Area (NAFTA), South African Development Community (SADC), Economic Community of West African States (ECOWAS), to name but a few. The East African Community (EAC) is one such regional bloc with cooperation that dates back to 1900 when a customs collection centre for Uganda was established in Mombasa. In 1917, a customs union was formed between Kenya and Uganda; Tanganyika joined in 1922. The treaty for the establishment of the initial EAC was signed in 1967 but collapsed in 1977. Again in 1993, an agreement to set up the Permanent Tripartite Agreement (PTA) was signed followed shortly by the treaty for the second generation EAC in November 1999 that came into force on 7th July 2000 (Kiraso, 2009). In 2007, Rwanda and Burundi joined the Community while South Sudan joined in 2016.

The EAC is founded on four pillars as stated in Article 5 (2) of the EAC Treaty, *"the Partner States undertake to establish among themselves and in accordance with the provisions of this Treaty, a Customs Union, a Common Market, subsequently a Monetary Union and ultimately a Political Federation in order to strengthen and regulate the industrial, commercial, infrastructural, cultural, social, political and other relations of the Partner States to the end that there shall be accelerated, harmonious and balanced development and sustained expansion of economic activities, the benefit of which shall be equitably shared"* (Secretariat EAC, 2000). The achievement of the EAC objectives needs strong geo-information services to deliver precise and consistent cartographic information and services in a well-organized infrastructure, since sustainable development needs access to data, information, knowledge and understanding about the environment and natural resources including socio-economic opportunities (Ottichilo, 2006). Besides, the significance of critical decision support systems is nowadays more pressing than ever due to contemporary regional challenges such as urbanization, environmental degradation, terrorism, climate change, and food insecurity. Also, the importance of GI and allied technologies such as geographic information systems (GIS) in a regional accession process cannot be underrated in relation to development of

'infrastructures' essential to enhance the procedure of modernizing public administration (Craglia *et al*, 2001).

One of the initial motivations for global collaboration in cartography emanated from the Economic and Social Council resolution 131 (VI) of 19 February 1948, entitled "Coordination of cartographic services of specialized agencies and international organizations" issued by the United Nations on 24th February 1948 (United Nations, 2000). The question that comes to mind is*: Have these goals for global cooperation been achieved today?* The significance of global mapping for sustainable development was again demonstrated in the Agenda 21 conference in Rio de Janeiro in 1992 where world governments approved its application. In the Agenda 21 plan, eight chapters concerned the need to provide geographic information, while particularly, Chapter 40 pointed at reducing the gap in availability, quality, standardization and ease of access of data between states.

Rhind (2000) predicted the forces promoting globalization in mapping as:

- Political and visionary effects such as the Al Gore Digital Earth vision.
- International activities that irrespective of national boundaries need actual monitoring.
- Military supplies for aggressive mediation activities world-wide that require international harmonisation of content, detail accuracy and even style of mapping; an important goal for military planners' wherever it can be achieved at sensible costs, such as in the NATO Vmap programme and the former Soviet equivalent.
- Requirements for global Aid establishments who require reliable information access at national and international level. Data reliability assists in reduction of costs hence make best use of the quality of the analytical processes.
- Business openings from those necessitating wide area connectivity data (e.g. car tracking) to wide area ''micro-geography'' queries (e.g. location of Automatic Teller Machines (ATMs) and Web enabled services offered by citizens themselves (like sites of private events). Strictly, those in the micro-geography group do not require seamless international mapping but reliability of content and form which significantly eases the work of the multinational service provider.
- Benefits attained by profit-making administrations and national mapping organisations (NMOs) working in the transnational market who cut costs because of consistent specifications.

Further attempts towards global standardization in Cartography and GI are seen in the concept of national spatial data infrastructures (NSDIs). The NSDI concept emerged with the aim of assisting the transmission of data from producers to the community of users through an infrastructure. This ensures that data is collected once and used severally without duplication. In Europe for instance, the INSPIRE aims to prompt the formation of a European spatial information infrastructure that provides to the users unified spatial information services to enable them identify and access GI from a variety of sources, from the local to the global level, in an interoperable way for a variety of uses (Data Policy and Legal Issues Working Group, 2002).

The background to the work of the Multi-Purpose European Ground Related Information Network (MEGRIN) was the fact that all National Mapping Agencies (NMAs) had common concerns in technical, organizational and legal areas which benefited from a discussion and exchange platform, and that cross-border issues had increased, requiring dedicated and permanent resources and a business-like structure (United Nations, 2000). MEGRIN is a precursor to EuroGeographics which is an association of European National Mapping and Cadastral Agencies (NMCAs) established in 2001 with the aim of supporting cooperation between European NMCAs by helping them to convince their governments of the significance of GI policies (Eurogeographics, 2001). The benefits of this cooperation were pan-European products and services and support for the development of the European Spatial Data Infrastructure (ESDI).

In East Africa today, many infrastructures are being shared, such as the railway, road networks, airports, coastal ports, Lake Victoria, hospitals, banks, schools and colleges and this is predicted to increase the need for more cartographic information. Although the EAC national mapping organisations (NMOs) are known to engage on a country by country basis and through the Regional Centre for Mapping of Resources for Development (RCMRD), they seem to have failed to recognise the need for regional geo-information integration. RCMRD is an inter-governmental organisation for East and Central Africa whose contribution to the development and usage of GI for sustainable development in contracting Member states cannot go unnoticed. In addition to capacity building through short courses and Diplomas in GI and Earth sciences, the centre offers advisory services, research, and maintenance of GI equipment among other services. Studies done within the East African context such as: *Geo-information policy in EA* by Kalande and Ondulo (2006), *Evaluation of Geo-information*

market environment in EA by Tukugize (2005) and *Evaluation of fundamental geo-spatial datasets in East Africa* by Economic Commission for Africa (2007) have largely focused on GI policy, GI market analysis and fundamental datasets in EA respectively. In relation to cartographic services, very little is known or even documented.

The study hopes to fill this gap by recommending a roadmap similar to the EuroGeograhics, which was chosen as the state of the art model. The expected results include: status of each member state's cartographic services; how they compare and what to do to harmonise them; how they compare with the state of the art, and subsequently a framework roadmap to a state of the art East African Cartographic Service. This roadmap is a plan of how to achieve harmonised EAC specifications: data model, standardised metadata, common and current GI policy, technical architecture, Atlas and Geographical names gazetteers with web access, regional level national datasets at various scales, complete digital coverage of fundamental datasets, harmonised GI curriculum for different levels, harmonised pan-EAC datasets based on national datasets and a GI association.

Experience from long service puts the researcher in a position of familiarity with the challenges of timely access and retrieval of cartographic information and services due to bureaucratic procedures, out-dated maps and poor records retrieval among others.

1.2 Statement of the problem

According to Article 4(1) of the EAC, '*the overall objective of the Common Market is to widen and deepen cooperation among the Partner States in the economic and social fields for the benefit of the Partner States'* (EAC, 2009). The close cooperation between the EAC states based on their objectives call for increased geo-information sharing to support timely decision making as challenges such as security, environmental monitoring, disaster response, disease surveillance etc. can only be effectively tackled through joint actions using standardised GI. Although the development of fundamental datasets is the mandate of each of the EAC-NMOs, they lack formal state-level agreements on GI exploitation and exchange. According to meteorologist J. Kivuva, (personal communication, April 16, 2019), geo-information has not been given any consideration at the EAC secretariat level. Hence, geo-information in EA lacks policies to regulate and coordinate its production and exchange, and where it exists, it is characterized by individual country specific policies, institutions and legal frameworks (Kalande and Ondulo, 2006).

The EAC is therefore characterised by inadequate topographical coverage in some areas, out-dated maps and language barriers are common leading to high costs of doing business, inability to utilize technology due to system and data incompatibilities, low awareness, and unclear levels of cartographic manpower, lack of professional cartographic associations and lack of cartography research. In addition, a synopsis of the EAC situation is the general deficiency of GI administration systems where existing data and information are unknown to decision takers, data are not shared, have difficulties of access, are of unknown or questionable quality, are not standardized and are very much dispersed among several organizations, and this is the national context (Albites, 2008).

1.3 Research objectives

1.3.1 Overall objective

To determine the status of the cartographic services in the EAC member states and to subsequently derive a roadmap for harmonized, state of the art cartographic services in East Africa.

1.3.2 Specific objectives

i. To determine the status of each EAC member state's cartographic services (including their historical development) and how the services compare amongst themselves,
ii. To determine what needs to be done to harmonize them,
iii. To compare the harmonized EAC model with the state of the art services (modelled on the European EuroGeographics), and
iv. To derive a roadmap for the state of the art EAC cartographic services, including estimated time frame and cost.

1.4 Conceptual framework

The conceptual framework of this research considers a national cartographic service as an arrangement with various elements and leading stakeholders in the GI industry that include: NMOs, Private Mapping Organizations (PMOs) and academic institutions. They presumably work collectively towards a common goal: to formulate essential policies, to avail funding, to train and hire GI human resources who collect and process mapping data and the application of best practices in the use of technology to meet citizen needs. The dependent variable was the national cartographic service (NCS) of each East African Community member state, whose status was determined by the availability or lack of the independent

variables. The study set out to evaluate the variables at the national level on their status, comparing them amongst themselves, harmonising them and comparing the harmonised EAC with the state of the art, subsequently developing a roadmap to upgrade the EAC cartographic services to the EuroGeographics standard. Figure 1 is an illustration of the study conceptual framework.

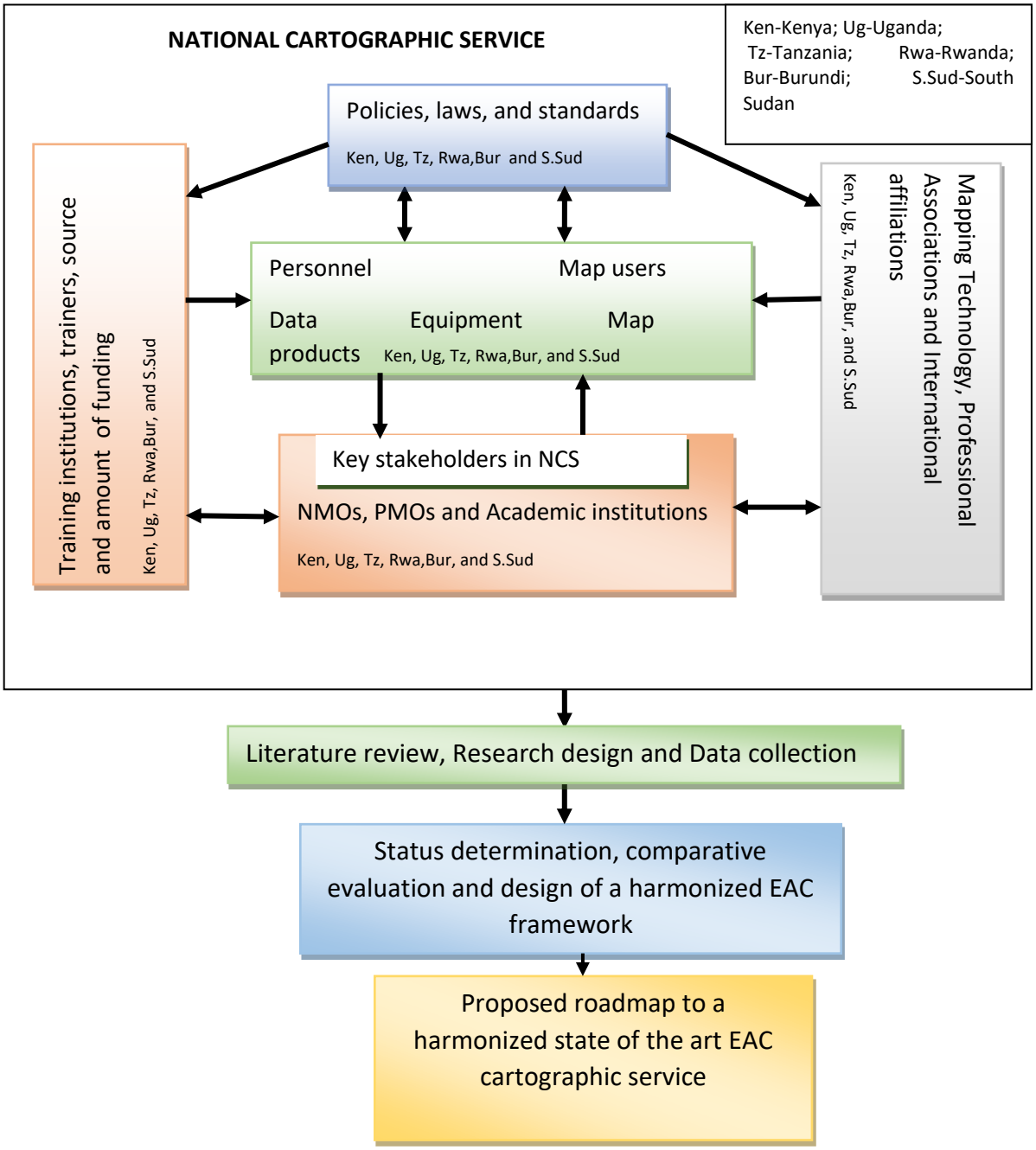

Figure 1: The study conceptual framework

1.5 The organization of the thesis

The thesis is organised into seven chapters aligned to the research objectives (save for chapters one, six and seven). Chapters two, three, four and five follow a similar structure to help the reader understand the key points. These chapters may be read independently; however, a more comprehensive picture emerges through reading all four together due to the linkages between them as results from one provide data for the next. They begin with a chapter summary, introduction, literature review, methodology, results plus discussion and conclusions.

Chapter one gives the background and context of the study, problem statement, research objectives, study conceptual framework and the organisation of the thesis chapters.

Chapter Two: This gives the status of each EAC member country's cartographic services (including their historical development) and how the services compare amongst themselves. This is done using descriptive statistics, summary tables, graphs and maps.

Chapter three: Using best practices, the EAC member states cartographic services are harmonised to the best practice standard which is applied to all the variables. The results are an improved and harmonised EAC cartographic service.

Chapter Four: The EuroGeographics as the state of the art model is reviewed. The gaps between the EuroGeographics and the harmonised EAC services form the basis for the roadmap to the harmonised state of the art EAC cartographic service.

Chapter Five: This chapter addresses the implementation by designing a framework for the roadmap to the harmonised state of the art EAC cartographic service.

Chapter six gives a summary of tools to support the state of the art cartographic service implementation. They include the proposed operational structure, proposed EAC cartographic general specifications and proposed technical architecture.

Chapter seven gives the conclusions, recommendations and the contribution of this study.

CHAPTER 2: STATUS OF CARTOGRAPHIC SERVICES IN THE EAC MEMBER STATES

Chapter summary

The present events in the EAC, and the block's sustained growth necessitate the generation and sharing of much GI to support the associated policy making (Baariu *et al*, 2019). Such GI can be best served over a harmonised cartographic service which remains absent, while the status of the existing national services is also mostly unknown. This chapter reports on a study done to investigate the status, as characterised by eleven components of a cartographic service. Literature was reviewed with special focus on national cartographic services' historical development, current status and practices. Data was then collected through a questionnaire that targeted respondents from the national mapping, private mapping and academic institutions in the EAC member states. Supplementary data was obtained through interviews, review of country reports, maps and map catalogues and web searches.

The analysis used descriptive statistics where frequencies, percentages, means and texts were used to summarize the questionnaire data. The questionnaire response rate was 65%, considered good as it was supplemented with interviews and other secondary methods. The study results showed that the current national services are characterized by insufficient fundamental datasets that are mainly analogue and lack metadata, non-uniform spatial reference systems, country-specific laws, insufficient cartographic staff and absence of shared mapping standards; in addition, finance for mapping arrangements remains low in state budgets. The study recommends that the EAC cartographic services should be improved and harmonised to support unified geo-information data sharing across the EAC region, which is necessary for regional processes and growth.

2.1 Introduction

2.1.1 Background

National Cartographic Service concept, definition and functions

The term ''national cartographic service'' was coined out of necessity to characterise a national organization dealing with map making in the service of the state and the public. A Google search for each word yielded the following results:

i. According to the Cambridge dictionary, national is ''as relating to or typical of a whole country and its people, rather than to part of that country or to other countries''…("National", 2019)

ii. According to the Cambridge Advanced Learner's Dictionary and Thesaurus, cartographic is defined ''as relating to the making or drawing of map''… ("Cartographic", 2019).

iii. The Cambridge dictionary defines service ''as a government system or private organization that is responsible for a particular type of activity, or for providing a particular thing that people need''…("Service", 2019).

Loosely interpreted and combined, "a national/state organization that specialises in making and providing services related to maps''. This was combined with the functions of cartography garnered from a report by Mwangi (2015) to give a complete definition *as the collection of activities in which cartographers plan, design, produce, reproduce, store, disseminate and provide services associated with maps and other cartographic materials such as plans, diagrams, atlases, globes, photographs, et*c. It is the public primary national source of authentic cartographic information and services as it is *public* and *national*.

The definition largely concurs with the United States Geological Survey (USGS) definition of National Cartographic Information Center (NCIC), established by the USGS, Department of the Interior, in July 1974 as: 'provides a national information service to make cartographic data of the United States more easily accessible to the public and to various Federal, State, and local agencies' (Kleppe and McKelvey, 1976).

Carried out by cartography researchers, educators, practitioners, librarians, map printers, and distributors, a NCS involves the following activities: Planning, collecting, designing, compiling, drawing, customizing, producing, publishing and revising maps, plans and charts; Geo-spatial data collection, modelling and verification; Control of map dissemination; Acquisition, compilation and publication of the National Gazetteer on Geographical Names; Planning, designing, compilation, drawing, production and publication of the National Atlas; Maintaining and updating land survey and mapping records; Development of human capacity in Cartography; Support and coordination of activities with other professional organizations and institutions involved with cartographic information; Influencing of government policy on cartographic information and development and implementation of quality standards for cartographic production and reproduction (Mwangi, 2015). In case of the NCIC, the initial goal was to provide information on the most useful US cartographic data existing and planned, accept orders for data produced and distributed by other organizations thus providing a one-stop information and ordering services for data users who do not know where

to obtain the data (Kleppe and McKelvey, 1976). Originally, the emphasis was only on USGS data but this was changed to allow data from local state agencies.

Cartographic information and Geo-information concepts

These terms are closely related and since they are used intermittently in the report they are worth defining.

Cartographic information in essence consists of the products of the mapping process which includes data such as: survey computations, satellite imagery, aerial photographs, photogrammetric plots; maps such as topographic maps, charts, cadastral plans, atlases and the gazetteers, mostly analogue in format. Goodchild, (1997) in website http://stats.oecd.org/glossary/detail.asp?defines defines geo-information or geographic information as:

- Information about places on the earth's surface
- Knowledge about where something is
- Knowledge about what value is at a given location.

Although geo-information is traditionally 'stored' in analogue format on paper maps, currently it is handled like other types of information in computerized systems.

Cartography and Spatial Data Infrastructure (SDI)

The most commonly used definition of the term spatial data infrastructure is as follows: "the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data" (GSDI, 2009). A number of authorities have extended this description to include base or framework data and standards (Fortes and de Araújo, 2013). The SDI concept emerged with the aim of facilitating the transmission of data from producers to the community of users. The NCS and national spatial data infrastructure (NSDI) concepts, while having some overlapping functions, are different in many ways. Cartographic information is used in the development of SDI by providing fundamental and other datasets. The collection and processing of data is the mandate of NCS, and this brings to attention the importance of creating consistent and correctly collected and maintained spatial data, which on its part establishes a relationship between cartography with SDI (Albites, 2008). Cartography offers a methodology for making effective cartographic visualizations, and presenting design solutions for SDI relevant user types that enable gaining

useful GI at the interface between SDI and their users as a result of the map viewing and interpretation process (Hopfstock and Grünreich, 2009).

The value of cartography in the establishment of SDIs is worth mentioning. Visualisation is important because information should be communicated to the users in an appropriate way thus, 2-D media like screen and paper are still the main channels of visualisation; as a result, map projections are indispensable contributions of cartography to SDIs. The significance of cartography in creating the reference framework is obvious; many of its elements have been established by cartographic science (Toth and Smits, 2007). The three frameworks namely the geodetic, the topographic, and the geo-informatics frameworks, demonstrate that cartography is a necessary aspect of the SDI concept, and cannot be separated from SDI development, but the relevant skills must be put into SDI development processes.

Cartography and GIS

The International Cartographic Association (ICA) defines cartography as "The art, science, and technology of making maps, together with their study as scientific documents and works of art. In this context it may be regarded as including all types of maps, plans, charts, and sections, three dimensional models and globes representing the Earth or any celestial body at any scale" (Govorov, 2007). The USGS (2019) defines a Geographic Information System (GIS) as a computer system that analyses and displays geographically referenced information using data that is attached to a unique location.

From these definitions, GIS and cartography apparently have one common goal, the communication of geographically referenced information, the media notwithstanding. Notable variance is the emphasis on representation of spatial relationships for cartography and analysis and display for GIS. Thus, Maps, whether for traditional cartography or GIS, are tools for communicating, sharing, exploring, and analysing spatial data (Krygier and Wood, 2005). While digital mapping technology should be a welcome reprieve for the cartographer, this is not the case due to the misconception that maps can be designed by anyone with access to a computer and appropriate software. This has prompted the current on-going debate. It should be appreciated however that digital technology has delivered both time saving, friendly data re-use, flexibility and innovation opportunities to make cartography a very interesting, interactive and interoperable task which has improved product transformation.

Aronoff (1989) sees the main functions of the cartographic system as to generate computer stored maps while the function of a GIS is to create information by integrating data layers to

show the original data in different ways from different perspectives. The problem arises when these maps are drawn without regard for accuracy and quality because their main function is decision support. Silayo (2002) notes that the possibilities today for maps without ethics are compounded by the spread of off-shelf computer programs allowing non-cartography trained persons to produce maps that may look good, but are not consistent with any recognised professional standards or conventions. Of concern are key cartographic principles such as map projections, symbolisation, generalisation, scale, layout and overall design of maps which are important elements of good cartographic communication, which cannot be acquired without proper training.

2.1.2 Statement of the problem

The EAC states currently share key infrastructure such as the railway and road networks, airports, coastal ports etc. The management of these, plus the increase in cross-border activities which involve geo-information exchange (such as the Lake Victoria development projects, navigation on the lake, managing of population dynamics, climate change, terrorism, etc.) has enhanced the demand for cartographic information such as maps, plans and the associated digital data sets, which can be best shared in a harmonized cartographic service (Baariu *et al*, 2019). The significance of cartography and maps in enabling human users to understand complex situations cannot be overstated. Thus, in order to take optimum decisions, cartographers not only have *to provide the appropriate spatial information* but also *visualise it correctly and provide supportive imagery that informs about the quality of the visualised data for the task at hand* (Konecny, 2001).

Further, Dahlberg (1981) notes that two major gaps in cartography education are absence of technician training programs and the paucity of programs of continuing education in cartography. Studies done on GI in East Africa have tended to evade the topic of cartography for unclear reasons. Concerning cartographic services, very little is known and documented, hence this study investigated the services focusing specifically on fundamental datasets, metadata, SDI status, policy and laws, hardware and software (technology), national atlas, geographical names gazetteer, funding, professional associations, training institutions and personnel, which were considered as key elements of a cartographic service. So as to meet the increased demands in a regional context, the status of the EAC cartographic services required an appraisal by answering the research question; *what is the current status of each*

EAC member state's cartographic service (including its historical development) and how do the services compare amongst themselves?

2.1.3 Objectives and research questions

In answering the research question; what is the status of each EAC member state's cartographic service (including their historical development) and how the services compare amongst themselves, the study realized the following tasks:

i. To document the mapping history of each EAC member state's cartographic service
ii. To determine the status of each EAC member state's cartographic service, and
iii. To compare the EAC member states cartographic services amongst themselves.

2.2 Mapping history in the EAC states

2.2.1 History of mapping

(Refer to Figure 3)

i. Tanzania

The history of mapping in EA is attributed to European dominance in the late 1800s. Thus, mapping in Tanzania experienced two European cultures of the Germans and later British. The British came after the First World War but continued to use the German maps until they made their own. The first triangulation network with a local astronomical origin was established between 1894 and 1911 for the determination of Anglo-German boundary between Kenya and Tanganyika. Other networks quickly followed for the delineation of Tanganyika and its neighbours and for cadastral work to survey the European plantations. In 1905, a triangulation network along the Arc of the 30th Meridian; from North Cape in Norway to the Cape of Good Hope in South-Africa (Caillard, 2003) was established. Data for topographical mapping in the European's settlements was gathered and maps covering the entire country, including present day Rwanda and Burundi were completed. The first atlas of Tanganyika was published in 1906.

The Surveying Department was established in 1920 by the British to unify and coordinate German surveys which they considered sporadic and unrelated. In 1946, the Directorate of colonial Surveys (DOS) was formed and a policy for integration of the different triangulation networks approved. For instance, Kenya and Uganda had extensive triangulation networks of uneven qualities hence; an agreement to connect them was reached. A new triangulation network chain of 960 Km was observed from Morogoro to the Tanganyika-Mozambique

border linking up with the Portuguese triangulation. This Arc and its connected networks formed the basis for mapping of the whole of East and Central Africa, and is also the base for accurate control surveys for geodetic and topographic mapping in Tanzania. Areas where agriculture was more developed were given priority e.g., the south of Lake Victoria and the North East coastal areas.

At Independence the DOS had published 1:50,000 maps covering 1/3 of the country and accomplished 70% air photo coverage. After independence, foreign aid programs such as the Canadian National Mapping Organization and the Japanese government facilitated more topographic mapping at 1:50,000. Appendix H1 shows the index map of 1:50,000 scale coverage. Established in 1961, the Survey and Mapping Division (SMD) is one of the six divisions within the Ministry of Lands, Housing and Urban Development with the responsibility for all topographic mapping in the country. Tanzania has embraced the new mapping techniques using GIS and remote sensing although at a slow pace. The following are notable achievements:

- The on-going implementation of the new geodetic framework, network maintenance, transfer of existing mapping and data to the new datum, capacity building and public awareness campaign to support the move to the new system;
- A number of projects are being implemented by the SMD e.g., the Integrated Land Management System (ILMIS) under the Private Sector Competitiveness Project (PSCP);
- Land survey Ordinance of 1957 (Land Survey Act no. 324) is set to be reviewed with the support of World Bank Funds under PSCP and
- The completion of the new Dar base map based on the International Terrestrial Reference Frame (ITRF).

ii. Kenya

The current boundaries between Kenya and her neighbours resulted from lawful descriptions through negotiations and later survey. Before the introduction of full topographical survey section in1907, topographical maps were compiled by the war office from reconnaissance surveys, boundary commission surveys and exploration sketches (SoK, 1954) but their accuracy was uncertain, hence the need for topographical surveys albeit with inadequate trigonometrical control. In 1903, the survey department for the East African protectorate was created, and although it concentrated on cadastral surveys; topographic mapping continued to

be carried out by the military until 1914 (Böhme, 1989). Save for isolated surveys for military needs not much mapping was done during the war.

In an effort to organise mapping activities in the British East African colonies, a colonial survey committee was formed with its first meeting held in 1905. The meeting approved the two survey departments [Uganda and East Africa Protectorates (Kenya)], standardized topographic map scales at 1:62,500, 1:125,000, 1:250,000, and 1:1,000,000, approved the Clarke 1858 ellipsoid for Africa and settled on the spelling of place names on maps (Mugnier, 2003). The Arc of the 30th meridian was acknowledged as the basis of triangulation in the East African colonies. Basic topographic mapping initiated by the DOS in 1947 resulted in topographical maps at 1:50,000 for the more populated and economically major areas and 1:100,000 scales for the arid and semi-arid parts, mostly northern and north eastern Kenya as illustrated in Appendix H3. In 1948, the standing Committee on Geographical Names was formed under the chairmanship of the Director of Surveys.

The first topographic map series (Y731) at 1:50,000 were produced in 1950 in single colour without contours, mapping was extended to the less populated areas and metric units adopted instead of feet. The 1:100,000 sheets (Y633) series were made by SoK and the DOS but these have been superseded by the 1:50,000 series. Another map series, the 1:250,000 (Y503) was derived from the 1:50,000 and 1:100,000 series and covers the entire country. Kenya is covered by 7 sheets of the 1:1,000,000 International Map of the World. The most frequently used geodetic parameters for maps produced by the Kenyan establishments are: Arc Datum 1960 referenced to the Clarke 1880 (modified) ellipsoid, Universal Transverse Mercator (UTM) projection with coordinates on the UTM grid (Mugnier, 2003). Kenya's cadastral maps were computed on Clarke 1858 and the Cassini projection.

One of five departments in the Ministry of Lands, Housing and Urban Development; the Survey Department is the only Government Agency mandated with Surveying and Mapping guided by the Survey Act, Cap 299 of the Laws of Kenya. The following are notable achievements in the recent years through the Kenya government funding, Korea International Cooperation Agency (KOICA) and Japan International Cooperation Agency (JICA) technical assistance:

- Completion of the multimillion shilling Kenya national spatial data infrastructure (KNSDI) building;
- Hiring of over 400 GI technical staff from different cadres;

- More than six hundred (600) personnel from SoK registered to the membership of the Institution of Surveyors of Kenya (ISK);
- Establishment of large-scale spatial data framework (digital maps) for the cities of Nairobi and Mombasa, the sea Port of Lamu and Environs and Malindi municipality;
- Over sixty thousands (60,000) land survey records scanned;
- Large-scale digital maps for the proposed resort cities on-going;
- Finalization of a draft KNSDI Policy document;
- In capacity building over 200 technical officers have been trained locally, in Japan and Korea in Geographic information systems (GIS), Geographic information management (GIM), Global navigation satellite systems(GNSS) and Remote Sensing for Mapping (RSM) and
- Creation of data standards documents (Digitization manual, operation procedures manual and mapping specifications (Mbaria, 2014).

iii. Uganda

The Department of Surveys and Mapping (formerly the Lands and Surveys Department) was formed around 1900 and advanced quickly into a well-staffed department. According to Kitutu (2016), the original record of mapping was by Speke who crossed the Kagera River in 1862 and established the Equatorial source of the Nile. The first map was compiled by Lt. Col. Macdonald R.E. at a scale of 1 to 10 miles and made by the war office in 1899. The survey office was established between 1900 and 1901 at Entebbe. The British DOS furnished the department by providing operational and technical assistance up to 1970. This enabled the establishment of survey control, compilation of topographical and thematic/special purpose maps. These maps were printed by the Survey of Egypt between 1921 and 1923 but from 1923 to 1952 by the Ordinance survey, private printers and government printers, Nairobi. In 1931, the first air survey was carried out by the Air Survey Company and resulted in the production of 45 printed sheets of 15 by 15 minutes at 1:50,000.

The first edition of the atlas of Uganda was produced in 1962; in 1968, conversion to the metric system begun and the second edition of the Atlas was published. Later in 1969, the 1:50,000 map cover for the whole country was completed (Kitutu, 2016). This is shown in Appendix H2 by the standard sheet index. Noteworthy is the fact that up until the Military coup in 1970, Uganda was probably one of the best placed countries in Africa in respect of its map coverage. The DOS programme stalled in 1971 after the Military coup when equipment

at Entebbe and the District offices responsible for local cadastral surveys were damaged and looted. It hasn't been easy re-stocking the department due to limited funding hence maps are out of date and in dire need of revision. Currently the Department is under the Ministry of Lands, Housing and Urban Development which is mandated with the planning and implementation of all basic surveys and mapping activities for the country, co-ordination and supervision of all Surveying and mapping activities carried out by other public and private institutions in the Country (Economic Commission for Africa, 1993). It is the primary source of basic topographical data. Recent achievements include:

- Contract for roll out phase of the Land information system (LIS) between the Government of Uganda Ministry of Lands, Housing and Urban Development (MLHUD) and France International/ *Institut Geographique National* (FI/IGN) France Consortium signed and at 15%;
- Ortho-photography covering the entire country at 15 cm resolution for Urban/peri-urban and 40 cm resolution for rural areas available;
- 60% of maps scanned and 54% georeferenced at Surveys and Mapping Department (Asizua, personal communication, December 14, 2016);
- In 2015, a contract for the production of base maps to support land administration was signed;
- Realized aerial photography coverage of 80% (40 cm) and 75% (15 cm) and the ongoing work for the establishment of Ground Control Points (Oput, 2017).

iv. Rwanda

Although Rwanda was initially colonized by the Germans up to 1916 and the Belgians afterwards, no maps were found. According to RCMRD (2011), a terrestrial control network was established between1926 and 1959 by the *Institute Geographique National Belgium (IGNB*). The African Doppler Survey (ADOS) project with 13 stations were coordinated in the old national terrestrial system from 1983-1984. The Global positioning system (GPS) Campaign of 1991-92 was carried out by *Landesvermessungsamt RheinlandPfalz* and *the Universität der Bundeswehr München* in cooperation with *Service de la Cartographie National du Rwanda*(SCR).

The network consisted of 28 central stations, and resulted into "*Système Rwanda 92 (SR 92)"* (RCMRD, 2011). The Belgian Institute of Cartography produced the first vertical black and white photographs of the entire country from 1958 to 1960. From 1978 to 1982, another

mission at the scale of 1:20,000 provided data for the production of colour topographic maps (1:50,000) of the entire country (Twarabamenye, personal communication, October 27, 2016). The maps were produced in 1988 by the Belgian Institute of Cartography in collaboration with Rwanda National Service of Cartography. The SCR was in charge of topographic and cadastral mapping. The Belgian *Institut Geographique National* (IGN) made multi-coloured maps in 74 sheets at 1:50,000, whose fate could not be ascertained. The country was also mapped at 1:20,000 scale *commune* maps by an Italian survey company Technosynesis. Rwanda's current topographic mapping at 1:50,000 scale has 52 sheets as shown in Appendix H4.

Lands and Mapping is one of the four departments of the Rwanda Natural Resources Authority (RNRA) responsible for surveying and mapping in Rwanda. Before RNRA was established, a mapping service at the National University of Rwanda (NUR) under the Department of Geography used to produce thematic black and white maps manually for the entire country which were printed using mechanical machines. The service served as repository for aerial photographs (missions 1959, 1973 and 1980). The service was functional until July 1994 during the genocide when it collapsed and the equipment vandalized. Key achievements include:

- Completion of Continuously Operating Reference Stations (CORS) Geodetic Reference Network based on the ITRF 2005;
- Launch of the new Rwanda Base map 1:50,000;
- Launch of National Land Use Planning Portal and
- Completion of the demarcation and adjudication of all lands, with issuance of title deeds on-going.

v. Burundi

The cartography of Burundi dates back to the colonial era after the first map was published in 1907 by the Germans when explorers Speke and Grant did the first reconnaissance between 1852 and 1860. The Triangulation from the Cape to Cairo by the German colony was achieved in 1907, while the first topographical map of Rwanda-Urundi at 1: 200,000 (Figure 2) was made by the Germans. When the Belgians expelled the Germans, they densified the triangulation network and in 1936 the topographical map of Rwanda-Urundi at 1: 100,000 by the Belgians was made. Later in 1953, the Triangulation of Bujumbura and mapping of the city of Bujumbura at 1: 2000 by the Belgian and Burundian surveyors of the Kingdom were

realized. Aerial photographs of Burundi at 1: 50,000 and production of the map of the city of Gitega at 1: 5,000 and that of the Mosso at 1: 10,000 was accomplished in 1959 (T. Bwarwihigire, personal communication, November 24, 2016).

The Geographical Institute of Burundi (IGEBU) is a public scientific institution created by decree No. 100/146 of 30th September 1980 with the mission to oversee geographical information activities in Burundi. In Burundi currently, topographical maps are out of date, hence users are encouraged to use as reference the 50 cm orthophoto available from the *Bureau Decentralization des Geomatique* (BCG). BCG is a permanent executive secretariat responsible for implementation of policy and strategic directions that include the development of the national spatial data infrastructure for Burundi (INDSB), unifying of activities of public institutions in geo-spatial data management to enhance data exchange and sharing (Ntumigomba, n.d).

BCG is developing GI data standards and a web portal. Burundi lacks enough human capacity to implement policy; hence, BCG has tasked all institutions and universities to deposit any geo-spatial data they develop plus its metadata with them for documentation and archiving. Key achievements by IGEBU include:

- Completion of aerial photography for the production of topographical maps of the city of Bujumbura at 1: 25,000 and 1: 5,000 scales and topographic map of the city of Gitega and its surroundings at 1: 5,000 in 2012;
- From 2014-2016, production of thematic maps at several scales completed;
- Development of the digital topographic map for the city of Bujumbura in 1: 5,000 through technology transfer;
- Establishment of ortho-photo plans for the whole country at 50 cm resolution;
- Development of land database through demarcation for land tenure security and
- The establishment of a National Infrastructure for GIS in 2013 with support from the EU, which is work in progress.

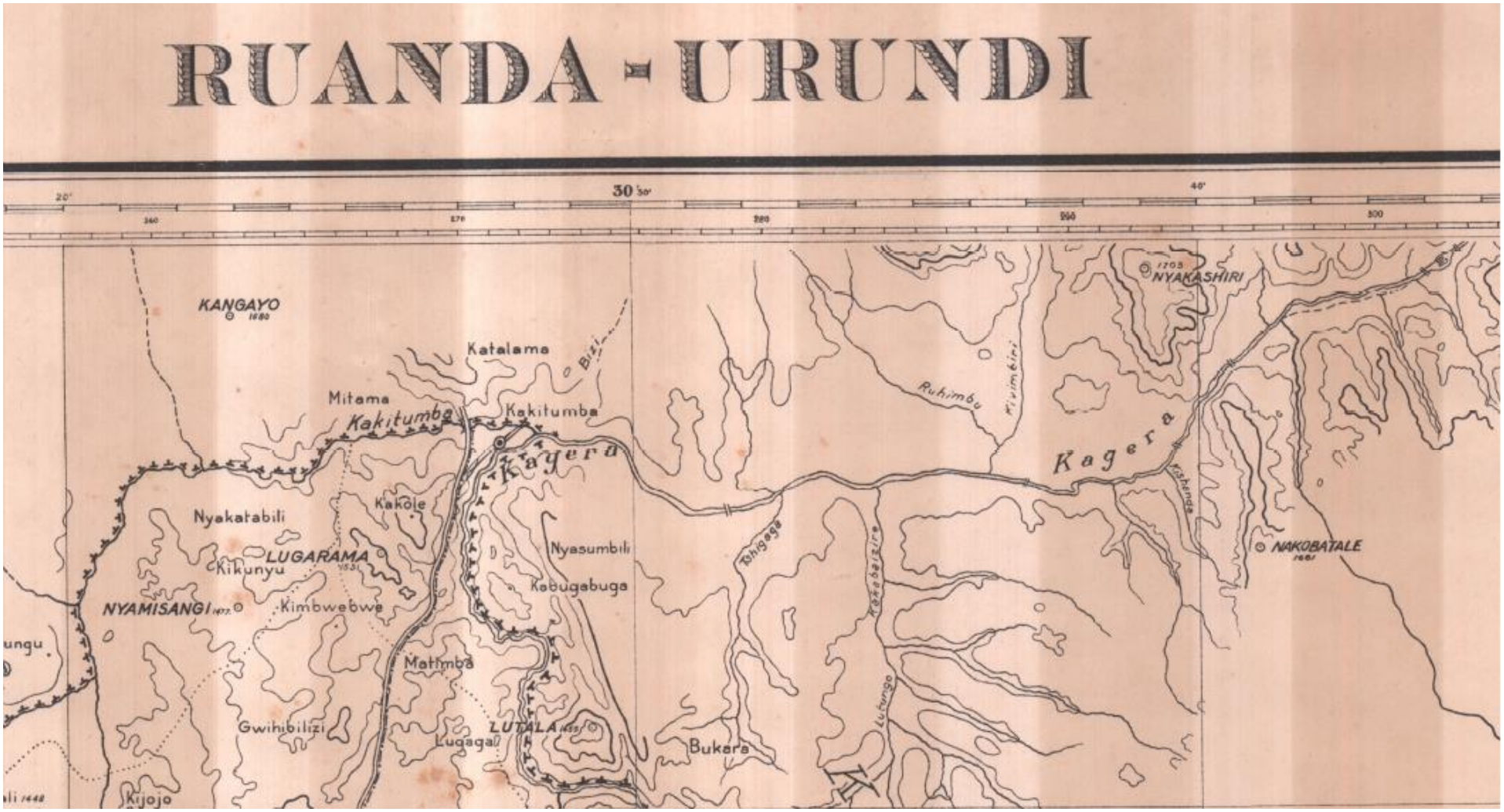

Figure 2: An extract from the first topographical map of Rwanda-Urundi at 1: 200,000

2.2.2 History of education and training

i. Tanzania

Training in Surveys and Mapping begun in 1936 when initial efforts to train primary school leavers as survey technicians failed. The Survey training started in 1956 at the Survey Training Centre (STC) at Mgulani area in Dar Es Salaam (Liwa, 2013), where they trained chainmen with practical experience in field surveys. No qualifications were required to join and no certificates were awarded. In 1958, the centre moved and begun a rigorous training program for cartographic draughts men and survey technicians. There was no professional surveying at degree level (Bachelor level) in Tanzania but students were sent to Canada, Poland, Hungary, and Russia; and to the University of Nairobi (Kenya) for their degrees. Later, STC status was changed to the former Ardhi Institute, which offered Ordinary Diploma in Land Surveying, Land Management and Urban and Rural Planning (Liwa, 2013) for two years.

After it was re-established by an Act of parliament, full professional courses were offered until 1996. Ardhi Institute became an affiliate of Dar-Es-Salaam University and started offering Bachelor's degrees up to 2007 when it acquired University status in the name of Ardhi University (ARU) and the School of Geo-spatial Sciences and Technology was established. The school currently offers BSc. (Geomatics and Geoinformatics), PGD and MSc. (Geomatics) and Ph.D. (Geospatial science). Universities offering similar degree programs have since been established in addition to lower level public institutes that train diploma and certificate courses in geo-information. There are also private colleges that focus on GIS training.

ii. Uganda

Surveying and mapping education begun in 1922 when the first African youths were trained in Makerere for two years and later attached to European surveyors. The first survey training school (currently Institute of Survey and Land Management) in East and Central Africa was opened at Katabi in 1944 to train survey technicians and cartographers in East Africa. Few trainees from Tanganyika graduated in 1954 and 1956 before the establishment of the Survey Training school in Dar Es Salaam. This soon transformed into Ardhi Institute in 1974, and later into University College of Lands and Architectural Studies (UCLAS) in 1996 as part of the University of Dar Es Salaam. In 1950, the first five native Kenyan surveyors graduated from Survey Training School in Entebbe preceding the establishment of its own Survey of

Kenya Training school in 1950 which later converted to Kenya Institute of Surveying and Mapping on 1st October 1994. It was not until 1966 that East Africa had a Bachelor's degree course in Surveying at the University of Nairobi (Kitutu, 2016). Today, GI training is offered in various Universities such as Makerere and Kyambogo at BSc., MSc. and Ph.D. levels. Diploma training in cartography and land surveying is offered in the Survey Training Institute which is a government institute.

iii. Kenya

GI education goes way back to1950 when the first five native Kenyan surveyors graduated from the Survey School at Entebbe, Uganda. At around the same time, the first Survey of Kenya Training School was established at Ngong near Nairobi, mainly for the European soldiers who were to train in surveying (Mwero, 1996). Elsewhere, according to W. Muchae (personal communication, June 10, 2019), the Survey of Kenya in-house training was being carried out at the SoK field headquarters, Ruaraka for surveyors, cartographers, photogrammetrists and map printers. The trainees were examined for occupational Trade tests, Grades 3, 2 and 1 respectively and awarded certificates accordingly. In 1970, the Kenya Polytechnic started offering Diploma courses in Land Surveying and Cartography which necessitated the SoK to suspend their in-house training and sponsored their trainees to the Kenya Polytechnic. The idea of starting a Diploma training school was compelled by the increased demand for accurate cartographic products to support planning and decision making.

The Kenya Institute of Surveying and Mapping (KISM) was founded in January 1996 under the project-type technical cooperation between Survey of Kenya, the Ministry of Lands and Settlement and Japan International Cooperation Agency (JICA) (Une *et al*, 2003). KISM offers Diploma courses in land surveying, cartography, photogrammetry and remote sensing and map reproduction, and in-service Higher Diploma courses in land surveying, cartography and photogrammetry and remote sensing that last three and two years respectively. From 1998, KISM in collaboration with JICA begun to offer third country training programs on GPS Surveying and GIS which benefited fifteen participants from thirteen countries from eastern and central Africa but has since ceased.

The history of the Bachelor's degree in Surveying can be traced to way back in 1956 when Surveying was introduced as one of the first programs to be set up in the Department of Land Surveying at the then Royal Technical College of East Africa - the predecessor of the

University of Nairobi (University of Nairobi: Department of Geo-spatial and Space Technology, 2019). The first Bachelor of Science (B.Sc.) degree in Survey was awarded in 1967, and the department which was renamed to Geo-spatial and Space Technology has continued to train Geo-spatial Engineers at all levels. Currently, several universities (such as Jomo Kenyatta University of Agriculture and Technology, Kimathi University and Technical University of Kenya among others) are offering degrees (including M.Sc. and Ph.D.), while middle level colleges (such as KISM, RCMRD and Eldoret Technical Training Institute among others) are offering diplomas in geo-spatial information.

iv. Rwanda

Since 2000, the Department of Geography at the National University of Rwanda (NUR) embarked on computer mapping training using GIS funded by the Dutch Embassy. The Centre for Geographic Information Systems and Remote Sensing (CGIS) was established in 2002 and it has continued to be a leader in training of GIS professionals in Rwanda. Currently, there is significant increase in GIS infrastructure development, well trained GIS staff, and GI partnerships in Rwanda. The NUR has also been offering Bachelor of Science (B.Sc.) degree in Geography together with GIS and remote sensing where the first batch graduated in 2003. Due to the high demand for GI training, other institutions have been set up such as INES-Ruhengeri University which offers both diploma and degree GI programs but specifically Land surveying.

v. Burundi

Burundi has only one public university, the University of Burundi that has several satellite campuses in and outside the City of Bujumbura. These offer various programs but none that offers Cartography as a profession but only as a support course to programs like Geography, Geology, Civil engineering and urban planning. The main problem with cartography is that even the trainers are not specialist cartographers. The few GI professionals have been trained and they train others on the job through knowledge transfer.

2.3 Cartographic information and related studies

2.3.1 Global mapping perspectives

The importance of GI in sustainable development cannot be argued as demonstrated in various global and regional incentives to create national and multi-national policies that support GI standardization. For example the Global Mapping Project is an attempt by the National Geo-spatial Information Authorities (NGIAs) to develop a Global map. The

objectives of the project are clearly defined in Article 2 of the Rules of the International Steering Committee for Global Mapping (ISCGM); which is to examine measures that relevant national, regional and international organizations can take to foster the development of Global Mapping in order to facilitate the implementation of global agreements and conventions for environmental protection as well as the mitigation of natural disasters and to encourage economic growth within the context of sustainable development (Ubukawa *et al,* 2013).

The Global Map project was launched in 1992 with the objective of creating basic geo-spatial information of the entire globe through cooperation of the NMOs across the world. It was directed by the ISCGM while the Geospatial Information Authority of Japan acted as the secretariat. The Global Map Specifications describe the Global Map itself, as well as the structure, attributes, metadata and format of the dataset, which give mutual understanding of the dataset to the data users and developers (Ubukawa *et al,* 2012). It is these specifications that were used in the creation of the Global Map datasets of several countries after the initial release in 2000 with over 79 countries having complied as of 2012. Since February 2017, the number of participating countries and regions in the Project was 184, while the number of Global Map data-releasing countries and regions was 122 (Sasagawa *et al,* 2017). Further, the ISCGM and related organizations accomplished several capacity building activities that enabled many nations including developing countries to develop and release the Global map. It was generally accepted that the Global Map objectives had been achieved hence, a resolution to end the project in March 2017 was adopted in the 23rd ISCGM meeting held in August 2016. All the Global Map data were to be transferred to the United Nations.

In another study, results from the status of mapping in the world showed that only 30% of the world is mapped at 1:25,000 and 75% at 1:50,000. It was also demonstrated that authoritative mapping by governments offers consistent geo-spatial infrastructure, which is used for many public and private uses, but which is expensive, difficult and slow to maintain (Konecny *et al,* 2016), hence some maps are up to 30 years old. This has incentivised private entrepreneurs such as Google, Microsoft and Navigation system suppliers to take up the challenge by providing solutions hitherto a preserve of authoritative mapping. These private entrepreneurs have introduced many initiatives which are offering quick updates in areas where they are needed. The applications do not substitute official authoritative cartography, but they complement it, because such efforts apply official cartographic products as a base to start their value added processes (Konecny *et al,* 2016). Examples are Google maps, Google Earth,

Yandex, Microsoft Bing Maps etc. used in orienteering and car navigation. Partnering with such entrepreneurs would therefore go a long way in supplementing the NMOs needs for current authoritative geo-information.

2.3.2 African mapping perspectives

The task of providing standard topographical coverage of any country is usually carried out by a national agency which may be a survey department, a geographical institute (civilian or military), a topographic service or geological agency (UN department of economic and social affairs, 1960). Other agencies build upon this framework that is of very high accuracy. For instance in Kenya, the cartography section is responsible for the production, maintenance and distribution of accurate geographic information in form of maps to ensure security of land tenure, socio-economic development, and territorial integrity in order to satisfy a range of users from government departments to private organizations (Mwangi, 2015). Consequently, for successful implementation of its core mandate, a National Cartographic Service requires fundamental datasets, specialised personnel, equipment, relevant policy, standards to mention a few. Fundamental datasets provide a base upon which other datasets can be built since they are based on a common standard.

Fundamental data sets are the minimum primary sets of data that cannot be derived from other datasets, and that are required to spatially represent phenomena, objects, or themes important for the realisation of economic, social, and environmental benefits consistently across Africa at the local, national, sub-regional and regional levels (Schwabe and Govender, 2009*).* They are needed for various applications for instance, the topographical maps are the base for cartography as they increasingly cover a country. In Africa, only about 23.8% of the land is covered at 1:50,000 scale, 18.2% at 1:100,000 scale and 85% at 1:250,000 scale (Brandenberger and Gosh, 1985). Moreover, only 2% of the current maps are revised in any one year (Economic Commission for Africa, 2007).

This status paints a dismal image that does not support the goal for GI interoperability. The poor state of affairs has led the United Nation Economic Commission for Africa (UNECA) in collaboration with the International Cartographic Association (ICA) to launch the Mapping Africa for Africa (MAFA) initiative ((Economic Commission for Africa, 2007), whose objective was to solve the problem of imprecise, unreliable and outdated fundamental geo-spatial data in Africa. The MAFA project has since accomplished the definition, inventory and catalogue of fundamental geo-spatial datasets for Africa.

The Africa Reference Framework project (AFREF) is an African initiative with international support designed to unify the co-ordinate reference systems in Africa using Global Navigation Satellite Systems (GNSS) and, in particular, the Global Positioning System (GPS) as the primary positioning tool (Wonnacott, 2005). Designed to support the goals of the new partnership for Africa's development (NEPAD), the AFREF project plans to achieve a standardized and reliable coordinate system all over Africa. One of its priority areas is focused "on the provision of essential regional public goods (such as transport, energy, water, information communications technology (ICT), disease eradication, environmental preservation, and provision of regional research capacity), as well as the promotion of intra-African trade and investments (Wonnacott, 2005). This is in sync with the goals of EAC of integration in all areas for mutual interests. A number of African countries are in the process of developing SDIs, with some at the conception stage; with only South Africa having an operational SDI. UNECA's Committee on Development Information, Science and Technology (CODIST) and the Environmental Information Systems (EIS) _Africa have been at the forefront of African SDI development efforts.

There are various initiatives in Africa that are gathering geo-information. Some key examples include the AFRICOVER initiative that falls under the Global Land Cover Network (GLCN) of the Food and Agriculture Organisation (FAO), the Global Mapping Project being implemented by the ISCGM, the Geohazards project as part of a Global Earth Observation System of Systems and the Topologically Integrated Geographic Encoding and Referencing (TIGER) initiative (United Nations Economic Commission for Africa, 2005). AFRICOVER-EA is a FAO initiative at the application of twelve African countries to deliver accurate and reliable land cover information, based on a systematic and consistent land cover classification system and on uniform cartographic and mapping specifications for the whole continent of Africa (Di Gregorio and Latham, 2009). This has facilitated timely and location-based land cover data for ten African countries.

2.3.3 East African mapping perspectives

Prior to the formation of the East African Community (1967) that later collapsed in 1977, mapping of East Africa was done so as to promote "interoperability". Hence, the only scale at which the whole of EA is shown on a single topographic sheet is 1:4,000,000 published by SoK in 1963 as a combination of features on the relief and communications maps supplied by the Natural Resources of East Africa (O'Connor, 1966). As early as 1958, the UK war office

directed the three national survey departments of Kenya, Uganda and Tanzania to produce the 1:250,000 topographic maps that regardless of being mapped separately fitted together well within the 1:1,000,000 world system forming a single series for East Africa. Other maps of EA done by individual countries adhered to the East African Topographic mapping specifications, an important commonality is the basic topographic framework.

Over 80% of GI is used in all procedures of development planning and policymaking at all levels thus, national, regional, continental and global. Sustainable development demands access to data, information, knowledge and understanding about the environment and natural resources as well as socio-economic opportunities (Ottichilo, 2006). Access to GI is a tedious and frustrating process especially in developing countries because records are analogue, not up-to-date, poor archiving, bureaucratic procedures, security restrictions etc. For instance, in SoK large-scale (1:2,500 and 1:5,000) topo-cadastral map series have remained in a dilapidated state in spite of the wealth of information they hold. The scenario is likely to be replicated in other EA countries and this needs to change. Tukugize, (2005) noted that most EA National Mapping Organizations were managed by colonial mapping legislations of the 1960s, hence not relevant for current needs.

Rhind (2000) adds that from the point of view of the NMOs, the obstacles to globalization in mapping are these: the precedence to perform in a national setting; the legacy effects of national mapping and inter-departmental variances in priorities concerning the departments controlling NMOs; differences in government finance rules and *pro bono publico* attitudes so far as NMOs are concerned; the unfeasibility of any one NMO producing a global map devoid of cooperation with other NMOs and with other parties; the fights amongst the various military and civilian interests and the absence of resources to enable harmonization work in organizations charged with international responsibilities, especially the UN agencies.

Such approach by NMOs has resulted in lack of regional initiatives to manage GI policy as governments have country level initiatives, policies and institutions that require synchronization for regional growth through support for regional development concerns. This can best be done by the formulation of not only a sound regional GI policy but also national policies in the member states (Kalande and Ondulo, 2006). Noteworthy are various unsuccessful attempts at establishing a regional SDI in East Africa, which can be attributed to the lack of functional NSDIs at national level and the community's support. In fact, the EAC secretariat lacks in its strategic plan any program relating to GI or mapping. The findings of a similar study carried out in the European Union suggest that GI policies and relevant

technologies such as geographic information systems have key roles to play in regional accession (Craglia and Messer, 2002).

The lack of a regional GI body and the enrolment of the member states in numerous other continental bodies means the pan EAC GI products and policies cannot be easily harmonized to common standards. This may delay the regional dream of integration of environmental, economic, social and political issues hence, objectives of forming the EAC community may for a long time remain unachieved (Kalande and Ondulo, 2006).

2.4 Methodology

2.4.1 The study area

The EAC states cover a physical area of about 2.5 million square kilometers, and they have a combined population of approximately 173,583,000 as per 2017 estimates. Lake Victoria, the world's second-largest fresh water lake is shared by Uganda, Tanzania, and Kenya. Likewise, East Africa is home to the highest mountain in Africa, Mt. Kilimanjaro (5895 m) in Tanzania. East Africa boasts of extensive habitat for large herds of big game animals, mountains for great apes, and abundant prey for the big cats such as lions and cheetahs. Most residents here earn their living through agrarian practices. The official languages of the EAC are English and Kiswahili with the latter designated for development as the lingua franca of the community; there are also numerous local languages spoken across the region. While Rwanda's and Burundi's authorized language is French, this is gradually changing to English ever since their entry into the community. South Sudan was ultimately excluded from the study because the poor security situation there could not allow safe entry and movement for data gathering.

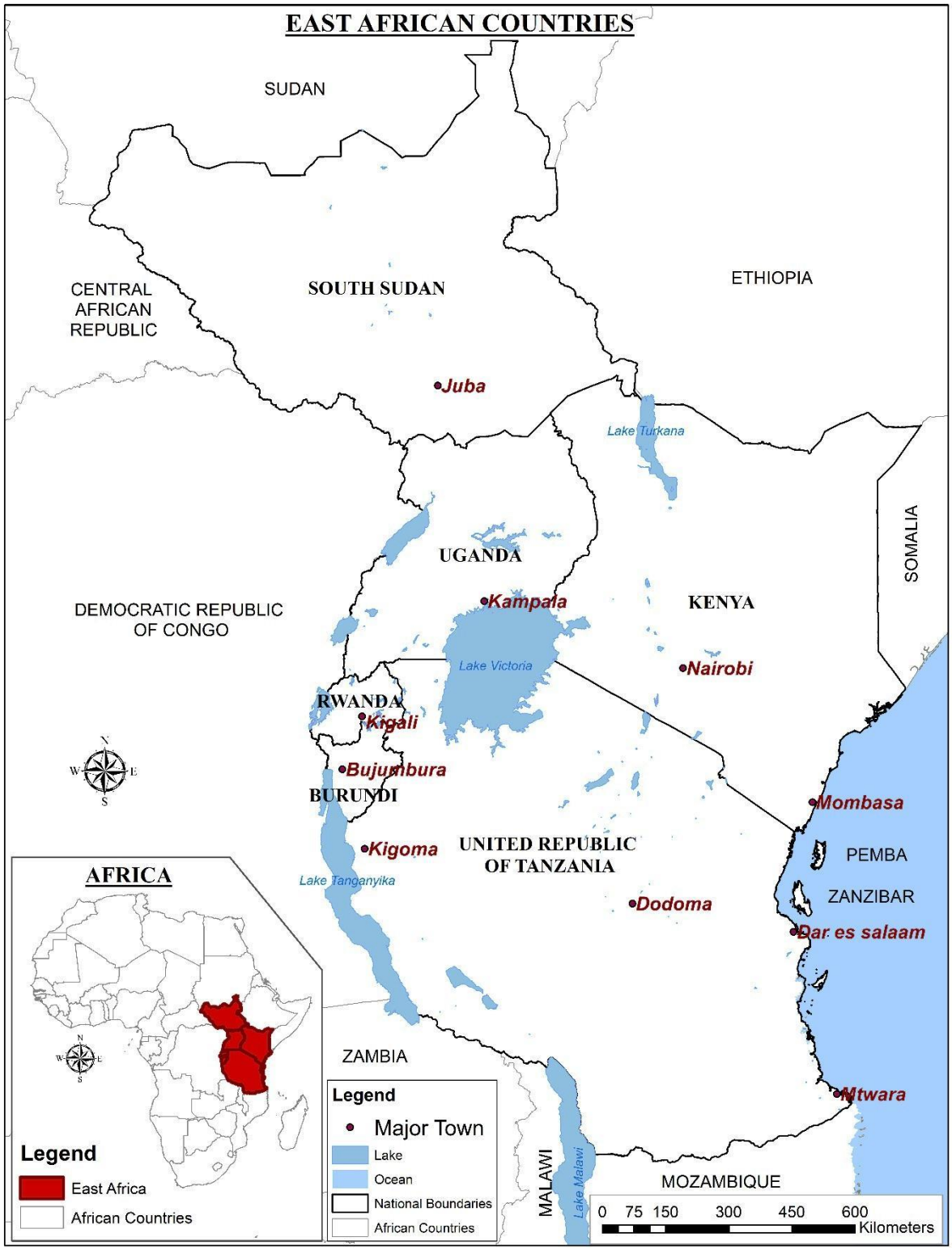

Figure 3: The Study Area

2.4.2 Research and sample design

The study was accomplished by a survey design which offers an opportunity to enrich the study with various views from a diverse group of respondents using qualitative and

quantitative techniques. Semi-structured questionnaires were distributed to 255 respondents in national mapping organizations, private mapping organizations and academic institutions. The target population was the geo-information community consisting of surveyors, cartographers, photogrammetrists, GIS professionals, senior geo-information managers and relevant academic staff. Stratified purposive sampling was chosen whereby the geo-information community was divided into three units showing within-unit similarity resulting into three categories; the National Mapping Organizations (NMOs), Private Mapping Organizations (PMOs) and academic institutions. Though the different groups responded to shared questions, each also had some specific questions. Within each category, purposive random sampling was applied making sure that only target informants were surveyed thus increasing the reliability (Baariu *et al*, 2019).

To determine the sample size, a statistical formula was used based on the following assumptions:

i. That the geo-information population in all the six states was equal.
ii. That the private mapping organizations engaged the highest number of geo-information practitioners, followed by NMOs and academic institutions with a population of 1000, 800 and 200 respectively.

The choice of purposive sampling was justified as it ensures that only target informants are interviewed. Based on these assumptions, proportional allocation was then used to determine the sample size from the total population. In proportional allocation, the sizes of samples from different strata are kept proportional to the size of the strata. That is, if P_i represents the proportion of population included in stratum i, and n represents the total sample size, the number of elements selected from stratum i is $n.P_i$ (Kothari, 2014). For example in this study, the required sample size was n=50 from each country drawn from a population of 2000 which was divided into three strata thus:

Private Mapping Organizations (PMOs) or N_1=1000, hence P_1=1000/2000

National Mapping Organizations (NMOs) or N_2=800, hence P_2=800/2000

Academic institutions or N_3= 200, hence P_3 =200/2000

Using proportional allocation, n_1=n. P_1, or 50*1000/2000=25 respondents from PMOs

n_2=n. P_2 or 50*800/2000=20 respondents from NMOs,

while n_3=n.P_3 or 50*200/2000=5 respondents from academic institutions. And since two academic institutions were to be surveyed, the number was rounded off to 6 in order to have three respondents per institution. The target number of respondents was 51 per country and 306 for the six EAC member states but non-response from south Sudan reduced this to 255. In addition to the questionnaire, desk study of various documents and unstructured interviews were used to give any information that was not captured using the questionnaire.

2.4.3 Data collection and analysis

The main data collection instrument was the questionnaire (Appendix A) that was administered by trained research assistants and interviews conducted by the researcher. Also desk study and focus group discussions were used in providing information that could not be got using interviews and questionnaires. For protocol reasons outside Kenya, permission was sought from the relevant authorities before the data collection commenced. The questionnaires were administered to the target respondents in the study area except in South Sudan where mail questionnaires were used. Data was collected to enable the comparative evaluation of the following eleven study elements of a cartographic service: Fundamental datasets, Metadata, SDI status, Policy and laws, Hardware and software (technology), National atlas, Geographical names gazetteer, Funding, Professional associations, Training institutions and Personnel.

The collected data was captured electronically for ease of processing and analysis; which involved inspecting, cleaning and transforming. Data cleaning is vital for error detection and corrections such as duplications or wrong entry. In case of inconsistencies, field verification may be necessary to avoid invalid conclusions. Other activities in data preparation included coding, tabulations, classifications and adjustments.

2.4.4 Definition of the study variables

The variables or elements of a cartographic service were defined to understand what the assessment was based on. They are as follows:

1. Fundamental datasets

   Fundamental data sets are the minimum primary sets of data that cannot be derived from other data sets, and that are required to spatially represent phenomena, objects, or themes important for the realisation of economic, social, and environmental benefits consistently across Africa at the local, national, sub-regional and regional levels (Schwabe *et al*, 2007).

The datasets represent a location which links different spatial data. They can be represented using addresses, postal zip codes, geo-reference systems etc. For this study, the following was being assessed:

- Availability as defined by the presence or otherwise of all ECA recommended themes for fundamental geo-spatial datasets for Africa which was either available or lacking.
- Coverage as defined by the spatial extent of a dataset for the country in question. This was essential to enable data availability from every part of a country.
- Up-to-datedness or currency determines the resolution of a dataset in terms of time. In this study, 5 years was taken as the standard.
- Spatial reference systems are defined by the datum, ellipsoid and projections. The full implementation of the AFREF recommendations got an excellent rating.
- Pricing refers to the average cost of a copy of a map sheet. Maps that cost above 5 USD were considered expensive while those that were free or cost less than 5 USD scored highly.
- Format is the form of presentation of data which in this case was considered as either digital or analogue. In order to achieve harmonization at EAC level, digital data format is desirable.
- Discoverability refers to the ease of data finding and ability to assess its usefulness. A web portal was envisaged plus other form of advertisement such as websites, brochures etc.
- Standards in this context refer to the guidelines and specifications applied to cartographic data collection, processing, production and exchange.

2. Metadata

   Metadata is defined as information that describes data or data contents. Its availability is important to specify which datasets are available, their source, resolution, quality and authorship among others.

3. Funding

   Funding is a critical aspect of any organization. It is essential to finance cartographic activities such as data collection and processing, purchase equipment and personnel

hiring and training. It was difficult to obtain the actual amount apart from the source of funding.

4. Policy and legal environment

   Maps whether for emergency response or environmental monitoring are subject to legal issues that include copyright, privacy and liability, hence it was necessary to find out the cartographic laws and regulations in use, their applicability and date of publication.

5. Personnel

   A skilled and innovative workforce is fundamental in any service industry, hence personnel level of education was sought out and the areas of specialisation. Personnel availability, qualifications, capacity building and areas of specialization were assessed.

6. A professional association

   This is a non-profit organisation whose objective is to advance the interests of a particular profession, its members and those of the general public. They were identified as key stakeholders in the harmonisation of the EAC cartographic services. Their presence, enrolment, inclusivity and proactivity were evaluated.

7. Hardware and software (technology)

   A functioning cartographic service requires basic equipment for data collection, processing and archival. The assessment was based on availability and their condition. They included GNSS receivers, computers, plotters, printers, wide format scanners to name just a few plus their supporting software.

8. Academic institutions

   The research is geared towards a global EAC market devoid of any obstacles among member states, hence the academic institutions were surveyed. Data was collected on the educational programmes offered and included the availability and type of training institution, courses and duration, level and specialization, content and mode of delivery, staffing and teaching resources, curricula update etc.

9. SDI status as an important element in cartography, the status was sought.

10. National atlas

    This is an important national document, as it summarises comprehensively a country's physical and human geography. Comparable to other national symbols, it is seen as a symbol of national unity, scientific accomplishment, and political freedom. The

question was if each country had a national atlas, status in terms of format and up-to-datedness.

11. Geographical names gazetteer

    This is a list of geographic names with geographic locations and other descriptive information. The importance of standardization of geographical names to support the needs of geo-information community by providing correct names along with up to date highly accurate maps cannot be overstated. As an essential national document, it was necessary to find out whether each country had a gazetteer of geographical names, its format and up-to-datedness.

2.4.5 Indicator development

It is important to note that different approaches were used to summarize the collected and analyzed data and included a scale indicator, a qualitative summary and a rating scale. To give a quantitative position of the cartographic services, an indicator was developed based on the results obtained from the various data collection methods. This was necessary to enable;

- A quantitative status
- A comparison amongst the EAC states
- Construction of the desired harmonised EAC model

A five tier scale was used where all the variables were listed down and their attributes evaluated from the questionnaire results, general observations and literature review. The following weights were assigned using a scale of 4 to 0 as follows:

- An attribute considered as excellent was awarded a score of 4
- An attribute considered as good was awarded a score of 3
- An attribute considered as average was awarded a score of 2
- An attribute considered as poor was awarded a score of 1
- An attribute that was generally lacking /absent was awarded a 0 score

An excellent score was awarded where the attribute had all the desired characteristics, good meant that most of the attributes were inherent, average was given where half the desired attributes were present while poor implied that the attributes were largely lacking in most of the characteristics. Worth mentioning is that the number of attributes describing a variable ranged from one to many. These were summed up and a mean taken to give a single value for each variable. A summation of the values from each country was done to give a single value

for each state (Table 1). This is the value that roughly indicates the status of each country and facilitates the comparison between states.

Table 1: Status indicators per country

Country/ variable		Country Scores(out of 5)					
	Status Indicators	**Kenya**	**Uganda**	**Tanzania**	**Rwanda**	**Burundi**	**EAC Mean**
Fundamental Datasets	Availability, update, format	2	2	2	3	2	2.2
Metadata	Availability	1	1	1	3	1	1.4
Policy and laws	Availability , update and published	3	2	2	2	2	2.2
Equipment	Hardware and software	3	2	2	2	2	2.2
National atlas	Availability, update and format	3	2	2	1	1	1.8
Geographical names gazetteers	Availability, update and format	2	1	1	1	0	1
Professional associations	Availability , inclusivity, enrolment etc.	2	1	1	0	0	1
Training institutions	Availability, courses, staffing and resources	2	2	3	2	1	2
Funding	Availability, source and adequacy	2	2	2	3	1	2
Status of SDI	Status	2	1	1	3	1	1.6
Personnel	Availability, qualifications, specialization and diversity	4	3	3	3	1	2.8
Average status		**2.3**	**1.9**	**1.8**	**2.1**	**1.1**	**1.9**

2.4.6 Rating approach

This was directly obtained from the responses of the questionnaire to give a general perspective of the services from the respondent's point of view.

Table 2: Status using the rating approach

Country/Cartographic services	**Burundi**	**Tanzania**	**Uganda**	**Kenya**	**Rwanda**	**EAC**
	Per country Mean					**Mean**
Trainees have increased	4.82	4.21	4.34	6.15	5.38	**4.98**
Technology is modern	3.82	4.93	5.49	5.15	5.43	**4.96**
Procedures are mostly manual	4.00	4.67	5.15	4.66	5.76	**4.85**
Personnel are well trained	2.73	3.88	3.79	3.93	5.71	**4.01**
Training curricula are up-to-date	4.82	5.46	5.24	5.41	6.52	**5.49**
Training Institutions are adequate	4.36	5.74	5.91	6.32	6.52	**5.77**
Personnel are adequate	4.18	6.00	5.69	5.98	6.24	**5.62**
Professional associations are available	3.82	4.93	5.26	5.15	6.52	**5.14**
Training institutions are well-staffed	4.73	4.78	7.51	5.39	6.24	**5.73**
Level of awareness is good	5.18	7.15	7.26	6.78	7.33	**6.74**
Policies are available and relevant	3.82	5.37	6.03	6.23	8.44	**5.98**
Relevant laws are well known	5.55	7.00	6.03	6.85	7.29	**6.54**
Standards are flexible and interoperable	2.82	5.15	6.18	6.12	4.1	**4.87**
Professional associations are proactive	4.27	4.19	5.59	5.44	3.95	**4.69**
Funding is adequate	3.8	4.67	5.18	5.32	6.05	**5.00**
Overall mean	**4.2**	**5.2**	**5.6**	**5.7**	**6.1**	**5.4**

2.4.7 Qualitative summary assessment

Table 3: Qualitative summary status

Variable	Qualitative status
Fundamental datasets (based on ECA recommended datasets for Africa)	Custodian is the NMOs and mostly out of date (up to 30 years of age) Not complete and most have inconsistencies with a mix of hard copy and digital records Largely no metadata, poor accessibility and expensive Most maps of Burundi and Rwanda in French Not standardized (technical[datum, format, scales e.t.c] and language) Basic topographical mapping at 1:50,000 and 1:100,000 scales Generally poor record storage and retrieval
Metadata	Rwanda has metadata (Rwanda Geoportal) Largely incomplete metadata for the rest which is not standardized and out of date Map catalogues available but analogue, outdated and incomplete Rwanda and Burundi analogue catalogues in French
Policy and legal environment	Mandate of NMOs who do not monitor adherence to laws Some laws available although outdated Mapping regulations outdated and inconsistent with modern mapping equipment Varies from country to country Most PMO's staff unaware of mapping laws and regulations Most PMOs unregulated Some professionals do not follow existing laws
Equipment and software	Generally modern with traces of traditional in some countries Broken down in some countries Expensive, inadequate and incomplete Commercial software expensive, hence too much plagiarised software; Little application of FOSS
National atlases	Available with custodian as the NMO Largely out dated and all analogue in form except Kenya In English but for Rwanda and Burundi in French
Geographical names gazetteers	Available except in Burundi with custodian as the NMO except in Rwanda Largely out dated and analogue in format Unfamiliar to most GI personnel Mostly in English, some (countries) in French
Professional associations	Available only in Kenya, Uganda and Tanzania Most Geo-information professionals do not belong as they register only surveyors except in Kenya Dormant membership and not proactive hence unknown to many professionals Few members due to stringent minimum entry requirements; High and prohibitive registration costs
Training institutions	Mostly public and a few private , 26 in total Mostly BSc. (Geomatics/Geo-spatial) apart from Burundi; Diploma available in Kenya, Uganda and Tanzania Curricula largely outdated except in Tanzania Course duration varies; course from 2 to 3 years for Diploma and 4 to 5 years B.Sc. Specializations largely similar; traditional specializations e.g. Cartographer, Surveyor, Photogrammetrist etc. fast disappearing Mode of instruction by theory, labs and industrial attachment Few foreign students in most countries Exchange programs in-country based Poor staffing levels and training opportunities in some universities especially Rwanda and Burundi Increased demands for GI training amidst scarce resources and low funding No GI specialization in some countries such as Burundi and to some extent Rwanda Overcrowded classrooms (50-80 students), poor internet access, poorly equipped labs e.g. computers not enough (or broken down)

	Poorly maintained buildings with scarce resources (furniture, hardware and software) Mostly partner with software vendors e.g. Esri East Africa
Funding	Mostly from national government, generally low and inadequate Project based and irregular with limited donor funding
State of SDI	Lack of policy and legal frameworks; No regional Policy SDI awareness levels low with little political commitment and limited SDI funding Poor data (many datasets missing, since what exists is largely analogue) with no metadata Inadequate relevant staff , low levels of technology and generally poor SDI status
Personnel(staffing)	Majority in public sector and many are bachelor's degree holders Rwanda cartographers possess B.Sc.(Geography) others; Diploma in cartography and B.Sc. Geomatics/Geo-information/Geo-informatics Mainly not adequate; majority under 40 years and well trained Some job descriptions missing e.g. land surveying, cartography and photogrammetry Generally lack motivation due to low remuneration, poorly equipped in poor working conditions Little capacity building and poor professional regulation

2.5 Results and discussion

2.5.1 Results

Table 4 **:** Reliability Test

Items	**Cronbach's Alpha**
Training institutions	.852
Funding	.781
Laws	.802
Policies	.774
Standards	.887
Mapping Technology	.910
Professional associations	.874
Personnel	.942

The study conducted a reliability test to determine the internal consistency of the data obtained. Internal consistency method was preferred as it measures whether several items that propose to measure the same general concept produce similar scores. In this study, Cronbach Alpha tests was conducted as shown in Table 4 which shows that the scales were reliable as they all surpassed a Cronbach Alpha threshold of 0.7. Marczyk *et al* (2017) states that Cronbach Alpha value of 0.7 is the threshold for determining reliability; while Nunnaly (1978) has indicated 0.7 to be an acceptable reliability coefficient.

Table 5: Respondents' Job Description by country

Job Description	**Burundi**	**Tanzania**	**Uganda**	**Kenya**	**Rwanda**
Cartographer	54.5%	46.9%	30.0%	15.2%	18.2%
Surveyor	0.0%	37.5%	45.0%	30.2%	27.3%
Photogrammetrist	18.2%	6.3%	0.0%	14.0%	4.5%
Academic Staff	9.1%	3.1%	15.0%	15.0%	18.2%
GIS Professional	9.1%	6.3%	7.5%	20.9%	27.3%
Senior Manager	9.1%	0.0%	2.5%	4.7%	4.5%
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

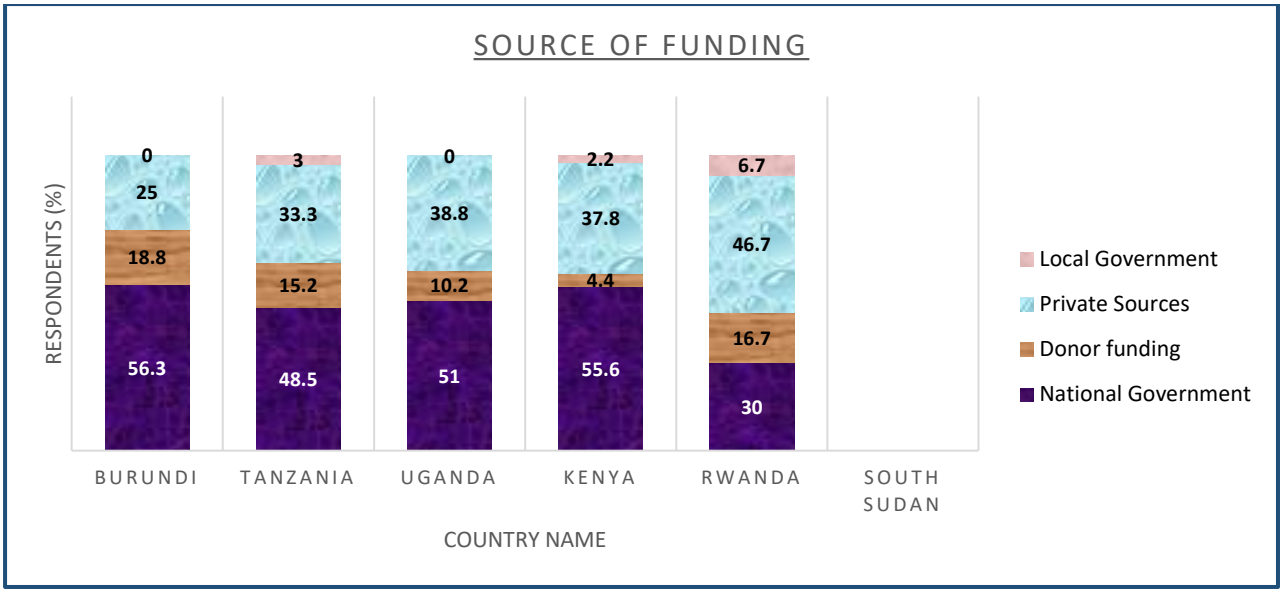

Figure 4: Sources of funding for mapping

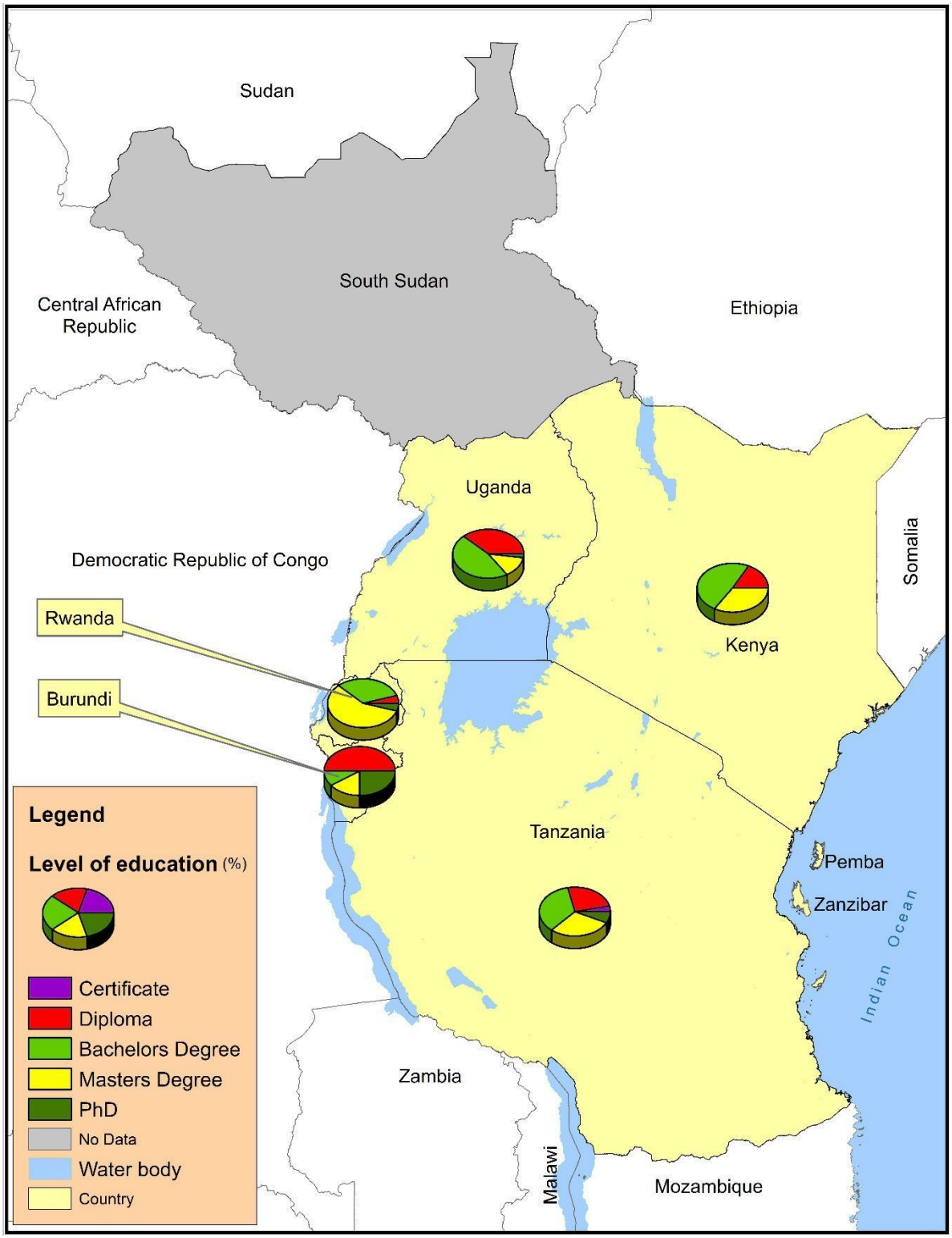

Figure 5: Levels of Education

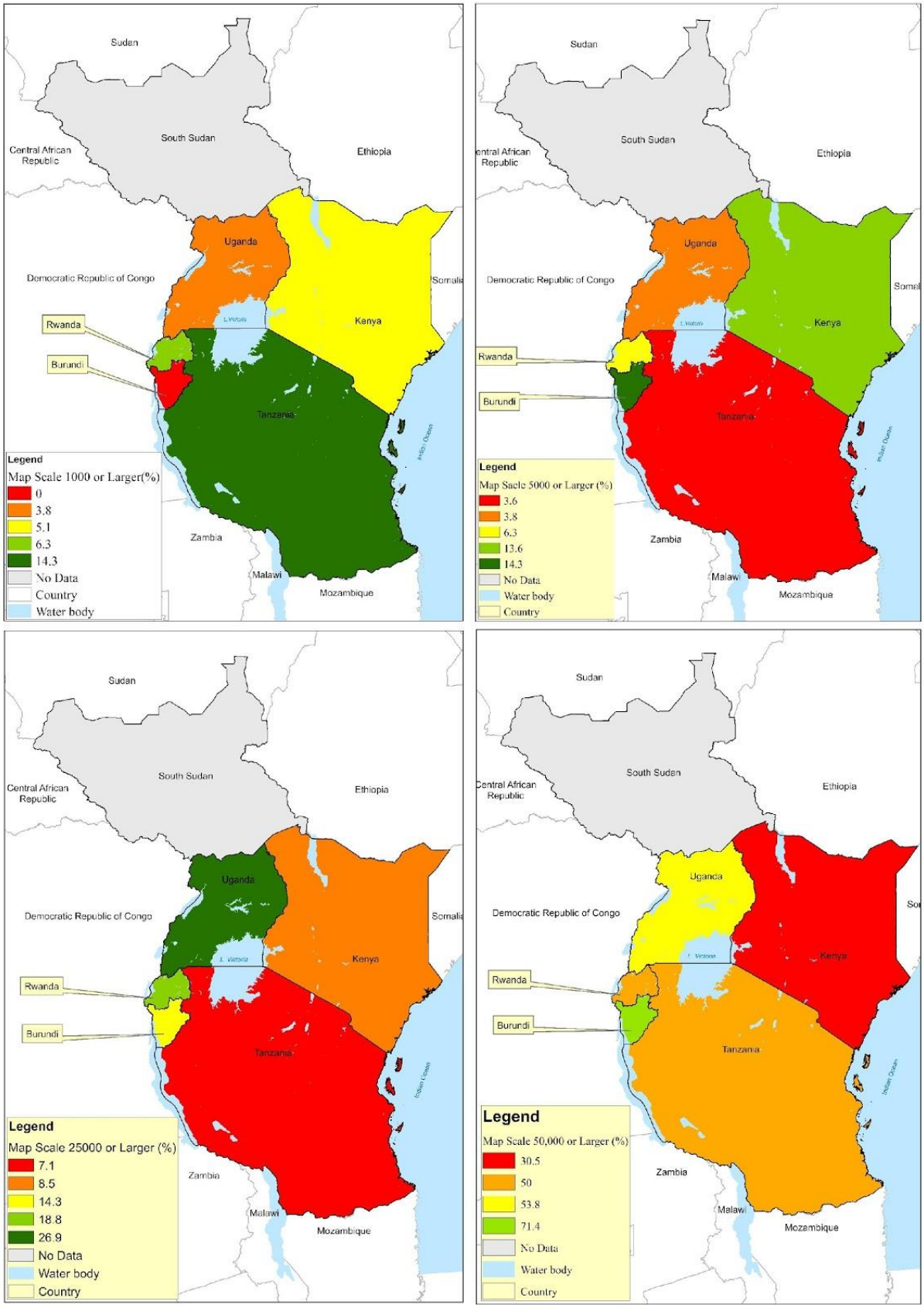

Figure 6: Map scales

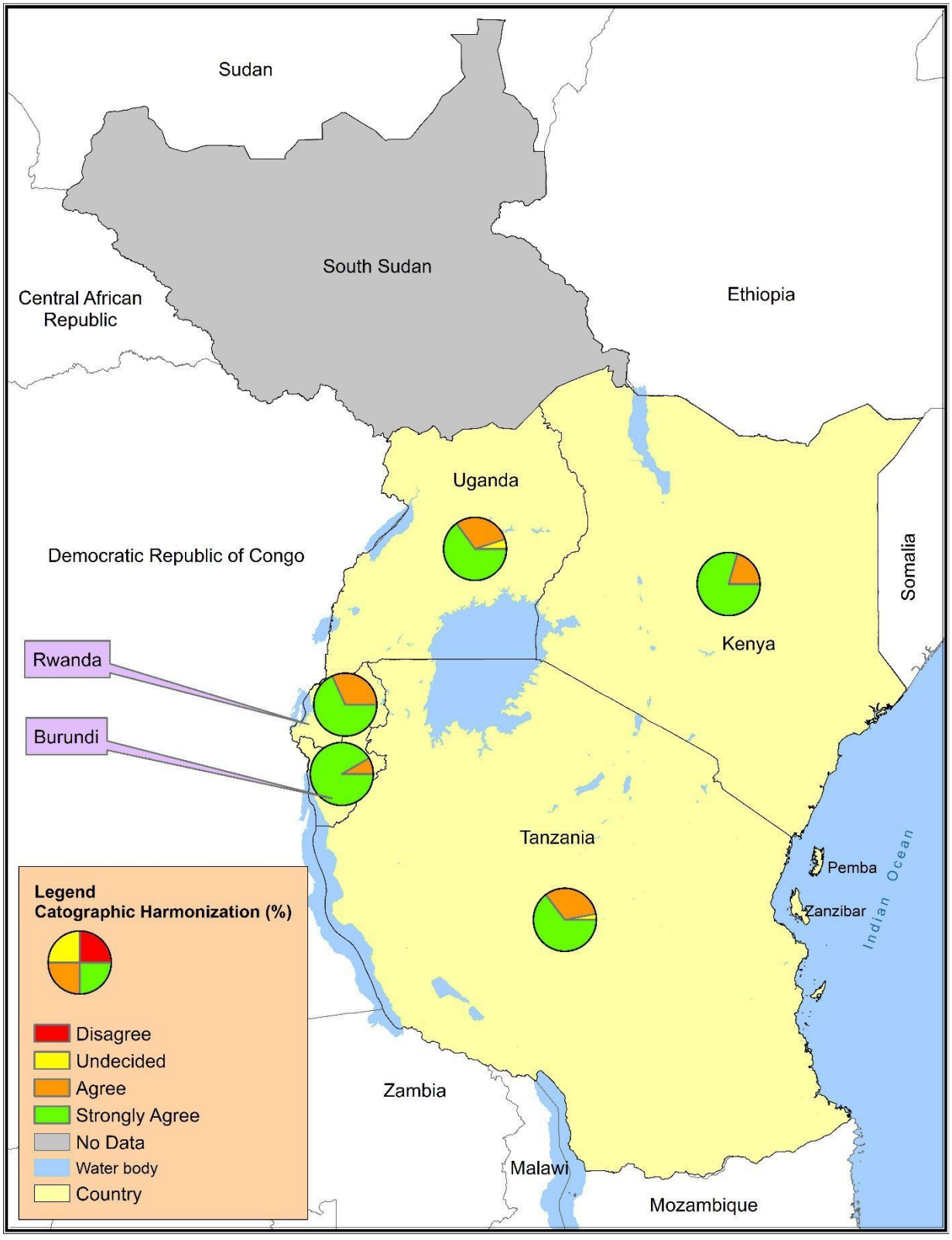

Figure 7: Responses on cartographic harmonisation

Table 6: Summary Status per member state

Variable	Burundi	Kenya	Rwanda	Tanzania	Uganda
Relevant Laws	Decree No. 100/241 of 29 October 2014	Survey Act Cap 299 of 1961, currently under review	Organic Law, 2005	Land survey and surveyors ordinance Cap 390,Professional Surveyors Act,1977	Survey Act of 1939, Cap. 232 (2000 edition)
Spatial reference systems	WGS84; Gauss Kruger projection, UTM projection; Clarke 1880 modified ellipsoid	Arc 1960, local datum; UTM & Cassini projections; Clarke 1858 and 1880 ellipsoids; KENREF- WGS84/ITRF 2008	Arc1960;WGS84, ITRF 2005; Gauss-Kruger and UTM projections; modified Clarke 1880 ellipsoid	Arc1960;WGS84, various local systems; UTM and TTM projections; Clarke 1880 ellipsoid	Arc 1960; WGS84; UTM projection; Clarke 1880 ellipsoid
Key geo-spatial datasets available	Geodetic framework, administrative and watershed boundaries, transportation network, hydrography, Ortho-photography for Gitega and Bujumbura cities, Aerial photography, Topographic maps and DEM for the whole country *(further details available in the map catalogue available at IGEBU)-Gitega*	Geodetic framework, Hydrography, Vegetation, Utilities, Administrative boundaries, Transportation network, Parcel boundaries, DEM, Digital imagery, Topographic maps and Geographical names *(further details available in the maps catalogue available at SoK)-Nairobi*	Geodetic network, Cadastral data, Geographical names, Ortho-imagery, Elevations, Transportation network, Hydrography, Government land boundaries and Administrative boundaries *(further details available in the map catalogue available at RNRA-Kigali*	Geodetic network, Topographic maps, hydrography, Cadastral data, aerial photography, Geographical names *(further details available in the map catalogue available at survey and mapping department)- Dar es Salaam*	Geodetic network, Hydrography, Administrative boundaries, Cadastral data, DEM, Aerial photography, Geographic names and Topographic maps. *(further details available in the map catalogue available at the department of survey and mapping)-Entebbe*
Basic mapping scales	1:50,000 In 42 sheets	Y731 series 1:50,000 in 512 sheets and Y633 series 1:100,000 in 89 sheets	1:50,000 in 52 sheets	Y742 series 1:50,000 in 1294 sheets	Y732 series 1:50,000 in 325 sheets
Map making standards and specifications	Burundi specifications for 1:5000, 1:25 000 No published national standards	EA specifications for topographical maps ,unpublished digital symbol specifications for 1:2,500 and 1:5,000 by SoK	Metadata standards by Esri, No published national mapping standards.	EA specifications for topographical maps , No published national standards	EA specifications for topographical maps, No published national standards

National Atlas	Available in French, analogue	Available 5th ed. 2003, in English, analogue and digital formats; 6th ed. compilation ongoing	Available in French, analogue	Available in English, of 1976 and analogue	Available, digital (PDF) in English, of 1967.
National Gazetteer of geographic names	Not available	Available, analogue, 2nd edition of 1977; revision ongoing	Available, analogue	Available, analogue, publication date unknown	Available, analogue, of 1971
Mapping Technology: **Hardware** **Software**	Computers, scanners, plotters, DPWs, Wild B8S stereo plotter, digitizing tables and GNSS sets ArcGIS and Micro station (license based) MapSource, QGIS (FOSS), AutoCAD, ILWIS and Arc view 3.2	Computers, GNSS sets, digital, cameras, scanners, plotters, light tables, printers, technical pens and scale rulers, DPWs, Total stations and map filing cabinets ArcGIS10.0 ;Adobe C55;Global Mapper; Mercator 7.2, QGIS, Erdas Imagine and AutoCAD	Computers, GNSS sets, Total stations, plotters, printers and scanners ArcGIS 10.1, 10.0, and 9.3 , Arc view 3.2 and AutoCAD	Computers, Total stations, GNSS sets, digital levels, printing machines(analogue) and stereo plotters (dysfunctional) ArcGIS, Erdas, Info system, Arc Info, Arc view- (license based) and QGIS (FOSS)	Computers, GNSS sets, scanner, plotter, technical pens, scale rulers and rubbers, DPWs, Total stations QGIS (FOSS) and ArcGIS (without license)
Professional human resource– Cartography and Geo-information	Largely Bachelor's degree level urban planners who attempt to double up as cartographers and geo-information managers.	Cartographers available at Diploma and Higher Diploma levels. Geo-information management also involves surveyors and photogrammetrists who are available at all levels up to doctoral.	GIS professionals are available, mainly at Bachelor's level; they manage geo-information and double up as cartographers	Cartographers available at Diploma and Higher Diploma levels. GI management also involves surveyors & photogrammetrists who are available at all levels up to doctoral.	Cartographers available at Diploma and Higher Diploma levels. GI management also involves surveyors & Photogrammetrists; available at all levels up to doctoral.
Available cartographic training	None	Diploma and Higher Diploma	None	Certificate and Diploma	Diploma
Relevant Professional associations and affiliations	None	ISK; for surveyors, cartographers and photogrammetrists Affiliated to FIG and ICA	None	IST; for only surveyors. Affiliated to FIG and ICA	ISU for only surveyors. Affiliated to FIG and ICA
Funding for mapping	Available from government and donors but inadequate	Available from government and donors but inadequate	Available from government and donors but inadequate	Available from government and donors but inadequate	Available from government and donors but inadequate

2.5.2 Discussion

On the history of mapping in the EAC states, historical commonalities amongst the original member states i.e. Kenya, Uganda and Tanzania are evident as illustrated by the topographical maps that are based on the EA topographical map specifications developed by the DOS (See Appendices G1, G4 and G5). The spatial reference parameters are also uniform in the older maps. Although some countries stopped using the EA specifications long before the break up, the adoption of various local datums and projections introduced the problems seen today due to non-comparability and shareability of data, such as the Tanzania Transverse Mercator (TTM). On the other hand, Rwanda and Burundi have similarities attributed to their German and Belgian history, mapping by the IGN France and prevalence of French maps and documentation. Rwanda is fast changing and adopting English since joining the EAC and RCMRD. Although the RCMRD is contributing significantly in capacity building, provision of technical expertise and data, they should put more emphasis on helping Burundi which is very low in personnel availability and specialization; GI training institutions and academic staff, lack of funds and modern equipment.

These sentiments are echoed by Ntumigomba, Director of Cartography and Topography-IGEBU in an undated Burundi report where he reports that ‘‘Awareness of the importance and place of geo-information in Burundi is a reality, implementation of a national GIS is underway, but there is a lack of human capacity’’. The same commonalities are seen in the GI education in the original members whose past personnel were trained in the same institutions such as Nairobi University (Kenya) for B.Sc. degree in Surveying and the Institute of Survey and Land Management (Uganda) for survey technicians and cartographers for the East Africans.

On the general status, the results depict a picture of great variance in the cartographic services provided by the various EAC states as discussed in the following sub headings for each variable:

Fundamental datasets

In 2008, the UN Economic Commission for Africa defined a set of recommended fundamental datasets for African countries *(geodetic control, imagery, elevations, hydrography, boundaries, geographical names, land management units, transportation, utilities and services, and natural environments).* As per the list, all the countries that were studied have a large percentage of them. The key challenges include the fact that most of the

datasets are analogue in form, while some of them are in French for Rwanda and Burundi. The data sets could also have gaps and overlaps in the border areas (Baariu *et al,* 2019). The datasets are characterised by various spatial reference systems in the different countries which is a hindrance to regional data sharing, and in some cases, even to national data sharing. These challenges, which would be fixed through implementation of the AFREF recommendations represent a very strong case for regional integration in terms of these frames.

Metadata

Although an important aspect of cartographic services, the metadata concept has not taken root in East Africa hence, only Rwanda had some metadata that was not standardized. Woldai (2002) concurs with this and notes that implementation of proper metadata in Africa requires political will at the highest echelon of governments; a solid infrastructure based on policy, guidelines and administrative arrangements, technical standards, fundamental datasets, and a means by which spatial data is made accessible to the community.

Policy and laws

Even though each country has a legal mandate for mapping and geo-information administration, some of the approved procedures and standards for the different countries are different. Many of the laws and regulations are also very old, and may have been overtaken by technological developments, hence the need for review (Baariu *et al*, 2019). This contrasts with results of a related study in the EU that indicated that GI policies and relevant technologies had crucial roles to play in regional accession (Craglia and Messer, 2002), which relates to the need to develop the infrastructure necessary to support modernization and public administration.

Hardware and software (technology)

While there are indications in all countries of efforts to advancement to modern technology, the technological facilities are not available in adequate amounts, and in terms of software, acquisition and / or upgrading remains a challenge. According to IT News Africa (2017), only Kenya and Uganda were, as of 2017, among the top 7 internet using countries in Africa.

National atlas

The national atlas is present in each country, and the two limitations that stand out are the need for revision and also the fact that the atlas in Burundi is in French.

Geographical names gazetteer

It clear that this requires much effort, so as to address its non-existence in Burundi and its availability in analogue and out-of-date form in the other countries. The digital gazetteer data collection has begun in Kenya though at a slow pace.

Funding

The findings show that mapping in all the countries studied is largely underfunded, with finance mostly coming from governments and donors, which almost always is still channelled via the same governments. The role of the private sector in funding public mapping is still very small.

Professional associations

The results demonstrate this to be an area of great scarcity, as no dedicated cartographic associations exist in any country, and only in Kenya do cartographers have any professional affiliation to the institution of surveyors of Kenya. Such state of affairs cannot enhance or sustain cartographic professionalism in the region.

Training institutions

This is only available in Kenya, Uganda and Tanzania, the highest level being Higher Diploma for cartography but up to Doctoral level for allied disciplines. It suggests the need for intra EAC cooperation in order to make this training available to Rwanda and Burundi, and to improve it where it exists. An important observation is the narrowing of gaps among the traditional GI professions resulting in a merger where a surveyor will double up as a cartographer and vice versa. Although this is positive, the danger lies in the lack of specialization. There should therefore be some form of specialization during the final years of training to allow students pick their preferences which they should learn before graduation. This actuality is expressed by Gachari (2001) when he noted that the advent and rapid advancement in Computing, Space and Instrumentation technologies has had a tremendous impact on the practice of the GI profession thus blurring the distinctions between the traditional disciplines. He goes on to differentiate the different roles as the collection, storage, management, processing, analysis, modelling and dissemination of geo-spatial information (Gachari, 2001). It is highly believed that such diverse roles require specialisation at an early stage in the learning trajectory to avoid having one ‘specialist’ being a jack of all trades.

Personnel

Although there are significant levels of geo-information human resource in all countries, individuals specifically trained in cartography are available only at Higher Diploma level and below, and only in the original partner states of Kenya, Uganda and Tanzania (Baariu *et al*, 2019). It has been observed that maps made by people without specific training in cartography often lack critical elements of cartographic design, which impacts negatively on their cartographic quality (Baariu, 2017; Laygo, 2010). The employees are nonetheless well trained and satisfactory in some countries such as Kenya.

Basic mapping scales

The basic mapping scale is uniform at 1:50,000 for all countries except for Kenya, which has used a smaller scale for some parts of the country that are less productive agriculturally. However, such parts have now assumed increased economic importance due to livestock production (e.g. Marsabit) or mining (e.g. Oil in Turkana) and this justifies their re-mapping at a larger scale.

Map making standards and specifications

It was observed that there were no published standards for most of the countries, with any specifications being ad-hoc at best. This would make it very difficult to design and publish any regional maps.

Using the scale (Tables 1 and 2), the EAC score was 1.9 indicating a slightly below average status which differs with 5.4 out of 10 obtained using the rating scores. The per-country status shows Kenya to be leading at 2.4 and Burundi last at 1.2, which agrees with the summary results. Variables that require more work are the SDI status, professional associations, geographical names, the national atlas and metadata with below average scores. The Atlas and Geographical names low score could be because they were missing in most countries and where available, they were in French, analogue or very old. When looking at individual countries, Rwanda topped followed by Kenya, Uganda, Tanzania then Burundi which is attributed to contradictory responses from Rwanda on the availability of professional associations, attributable to misinterpretation of the questionnaires.

2.5.3 Conclusions

The results show many commonalities as well as differences. The original EAC members have much in common (spatial reference systems, personnel, GI associations, training, etc.) which should be built upon and fast tracked for cartographic services harmonisation e.g. use

of the original EA specifications for mapping. On the other hand, the newcomers like Rwanda and Burundi being small states should adapt easily with support from the original states. Furthermore, the trend is towards a modern geodetic reference network espoused in the AFREF initiative where the EAC states are members. The member states' cartographic services are characterized by inadequate basic datasets whose level of computerization remains low. The datasets are largely out of date, lack metadata, have non-uniform spatial reference systems; use of mapping standards is generally low, mapping activities are underfunded, laws and regulations are also very old and there is inadequate cartographic human resources in some countries plus the associated training facilities. These findings point to an urgent need for improvement; including digital conversion and harmonization to facilitate seamless geo-spatial data sharing across the EAC region that is needed for regional operations and development.

CHAPTER 3: THE EAC CARTOGRAPHIC SERVICES HARMONIZATION FRAMEWORK

Chapter summary

‘‘Foremost aim of international standardization is to facilitate the exchange of goods and services through the elimination of technical barriers to trade’’ (Convenors and Brannon, 2001). The same can be said of the EAC which was founded with the ultimate goal of a political federation whose implication is huge. The realization of the EAC objectives requires timely access to harmonised cartographic services that transcend national borders to inform faster decisions in emergency and disaster situations. Data harmonization is necessary for creating the possibility to combine data from heterogeneous sources (e.g. regional datasets) into integrated, consistent and unambiguous information products (Čerba *et al,* 2012**)** that can be simply integrated with other harmonized data to facilitate view, query and analysis.

After the status of cartographic services in the EAC and how they compare was determined, several disparities were exposed that hinder comparability. The gaps were addressed by adopting an approach that identified the highest ranked country for each variable as the standard and harmonising the others to this standard. The other states were supposed to achieve this best practice standard which was applied to all the variables. For instance on fundamental datasets, Rwanda was the standard as it had attained the modernization of the geodetic reference network, launched the new Rwanda base map at 1:50,000 scale, launched the National Land Use Planning Portal and implemented the land information system (RCMRD, 2014).

To estimate the resources needed for the harmonization, data was collected from the researcher’s home country and generalised for all the other states. The harmonised EAC model indicated an above average personnel availability and training, improved data, metadata, relevant laws, modern equipment, better remunerated personnel, increased training opportunities plus well equipped training institutions. The harmonisation cost was estimated as $44,309,437, to be implemented in about 36 months. This is a substantial amount but achievable with the governments’ support and partnerships.

3.1 Introduction

3.1.1 Background

While the political and economic integration process has made good progress, the topic of geo-information has traditionally been scattered and fragmented, even within single countries (Villa *et al*, 2007). The need for harmonised data is a fundamental point in building a Spatial Data Infrastructure which comprises different data sources and foresees different services and applications for retrieved geo-data (Annoni and Smits 2003; Bernard and Craglia 2005; Toth and De Lima 2005). Harmonisation refers to the standardization of data so that they can be matched with other data and information regardless of the format (Villa *et al*, 2008). Thus, while harmonisation towards economic and political integration matures in EA, cartographic harmonisation lacks a framework setting common unifying procedures nationally (between organisations) and regionally (between nations).

Spatial data heterogeneity according to Villa *et al*, (2007) is for example caused by differences in:

- data format and data collection procedures
- spatial reference system
- data/conceptual model: structure and constraints – metadata model
- nomenclature, classification, taxonomy, terminology/vocabulary, thesaurus, ontology
- scale, degree/amount of detail, extent (spatial, thematic, temporal)
- portrayal (legend/classification, style)
- processing functions: their parameters and formulas/algorithms

Although spatial data heterogeneity makes spatial harmonization complex, the significance of global mapping overrides the challenges necessitated by the need for public access to information. Some reasons for this include: trans-national events which do not respect national boundaries yet require real-time monitoring or the needs of international Aid organizations for consistent data to access (at the macro level) relative needs of different countries of large areas and, at the mesoscale (of smaller areas within any one country or region) (Rhind, 2000). This eliminates barriers to timely decision making and enhances the actions required for a better, more alert world.

3.1.2 Statement of the problem

Following the EAC's implementation of the Common Markets Protocol (CMP), shared infrastructure, natural resources, telecommunications, and institutions became a common phenomenon leading to increased and *ad hoc* cross border geo-information exchange. It is recognized that good governance at each of local, national, continental and global level requires relevant, harmonised and quality geographic information (GI) to underpin sustainable development (Hopfstock and Grünreich, 2009). Furthermore, users are emerging who are more business oriented; require accurate geographical information that is easily sharable for analyses and instantly available to resolve some emerging issues like emergency response, early warning, navigation, risk management, land and boundary dispute resolutions, site analysis, route planning and many others.

Lack of comparable systems e.g., data structures (formats, resolution, coordinate systems etc.), different laws and lack of web access delays decision making especially in a regional context which is contrary to the spirit of regional integration. Other factors that are evidently critical for a harmonised service are personnel availability and specialisation, training and capacity building and professional GI associations which should be comparable to enhance movement and employability in a global economy.

The highlighted factors point to data structures, national legislation, personnel capacities and training as the critical aspects in an attempt to achieve cartographic harmonisation within the EAC. In addressing these challenges, the question: *What needs to be done to harmonize the EAC cartographic services* arises.

3.1.3 Objectives and research questions

The objective of this chapter was to determine what needs to be done to harmonize the EAC cartographic services including the timeframe and cost. To realise this objective, the following research questions were formulated;

i. What should be done to harmonize the EAC cartographic services?
ii. What would be the estimated cost, and
iii. How much time would it take to achieve this?

3.2 Literature review

Several researches have been done in a bid to define cartographic harmonisation processes which are diverse. Some concern the harmonisation of map symbols, others the spatial

reference systems while others describe the harmonisation of the mapping applications on specific thematic data, for example, for environmental studies (Fabbro and Haselsberger, 2009). It is generally known that cartographic harmonisation is a complex undertaking with no distinctive approach as there are many facets of cartography to harmonise. In the context of this study, for example, each element of the cartographic services would require a different harmonization methodology, which is beyond the scope of this study. Spatial data harmonisation is however not new in the EAC region as illustrated in FAO's AFRICOVER project, which is an initiative on the request of twelve African countries to provide accurate and reliable land cover information, based on a systematic and harmonized land cover classification system and on uniform cartographic and mapping specifications for the whole continent of Africa (Di Gregorio and Latham, 2009).

Cross-border mapping mostly depends on the ability to find and use geo-information due to its heterogeneity found in a regional context. This arises due to multilingual maps, geodetic and semantic characteristics, data quality aspects etc. Aspects determining success and efficiency of cross-border mapping have been put across by Witchas (2004) as shown in Figure 8 and which require more than the basic cartographic skills. Thus, cross-border mapping requires facts about the specifics of the included information, the legitimacy of pertinent multinational and national guidelines and the usage of suitable tools. The awareness of spatial diversity has provoked various initiatives in an attempt to achieve national and international interoperability. Standards and recommendations, rules and laws resulting from such coordination determine the availability and usability of geodata (e. g. OGC, ISO, CEN, Freedom of Information laws), but also the usage of geonames e. g. UNGEGN (Witchas, 2005).

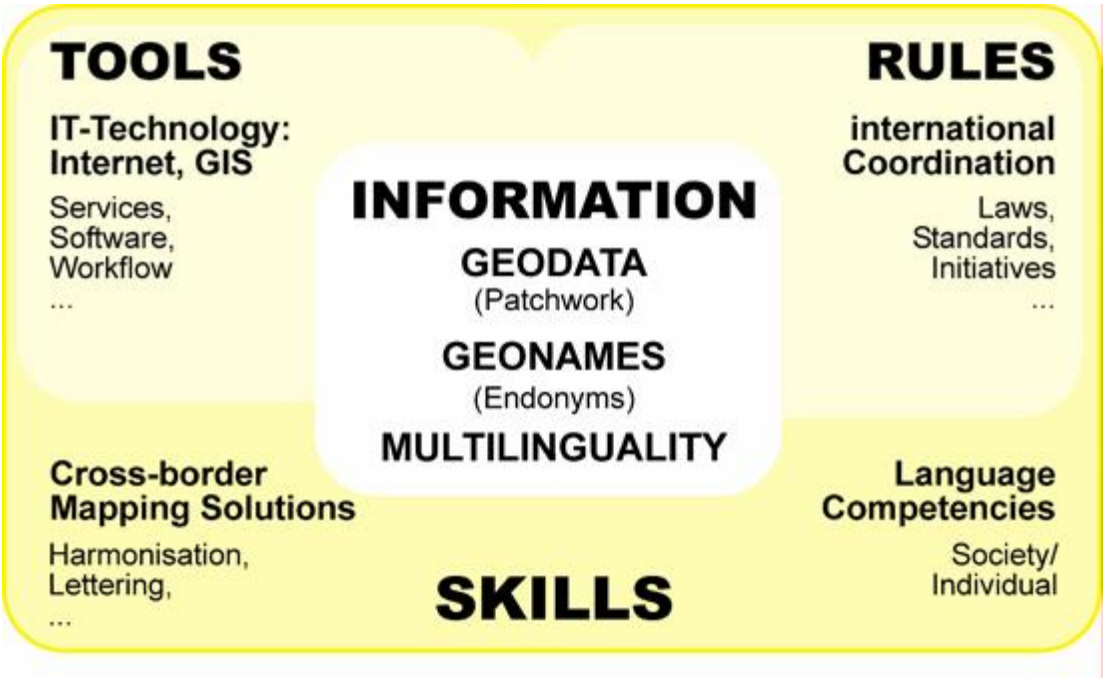

Figure 8: Aspects determining success and efficiency of cross-border mapping

Source: Witchas (2005)

3.3 Methodology

3.3.1 Assumptions

In order to answer the research questions, several assumptions and generalizations were made. This is because being a cross-border study, inherent differences were inevitable and had to be dispensed with accordingly. The assumptions include:

- That movement in-country and fuel costs were the same across the region,
- average monthly gross pay and per diems in every country per person were similar,
- a day conference facility in-country per person and full board cost per person were uniform in all the countries and
- Equipment and mapping software costs were the same across the region.

It was also noted that most member state's NMOs did not fund training for first degree courses locally and that most professional short courses were free or part of equipment procurement packages hence attracted low costs.

3.3.2 Research design

The aim of this section was to determine what needed to be done to harmonize the EAC cartographic services. As a collection of activities in which cartographers plan, design,

produce, reproduce, store, disseminate and provide services associated with maps and other cartographic materials, the definition points to a system comprising of many elements and involving various procedures. The elements are fundamental datasets, metadata, policies and laws, equipment, national atlas, geographical names gazetteer, personnel, professional associations, training institutions, funding and spatial data infrastructure (SDI) status that required a framework to facilitate interoperability thus attain mutually compatible EAC cartographic services.

This was done by adoption of best practices approach where the highest ranked variables' standard set the bar against which the others would be harmonised. This ensured that all the states were advanced to the level of their 'neighbours' gradually. Good practices often incorporated into case studies are actions, approaches and methods that are most successful or have proven most successful in the past in achieving or contributing to an objective, and that are shared with peers in order to contribute to collective learning (Fortes and Araujo, 2013). For instance, the INSPIRE implementation follows a step-wise approach, starting with unlocking the potential of existing spatial data and spatial data infrastructures and then gradually harmonising data and information services allowing eventually the seamless integration of systems and datasets at different levels into a coherent European spatial data infrastructure (Land, 2003). An advantage of this method is the ability to benchmark and learn from each other through joint projects, staff secondments, knowledge sharing and lessons learnt. Furthermore, the status results indicated very low margins of dissimilarity, hence it was reasoned that it would act as a motivating factor. Based on best practices, what was required was to use the status summary and the evaluation criterion was the highest variable; and the other states would have to look for a budget to achieve the best practice standard for the variable.

Secondly, it was reasoned that once the EAC states were harmonised to the same level, the upgrade proposal would be a lot easier as it would be a regional as opposed to a national initiative in terms of policy, funds, personnel expertize and equipment mobilization.

3.3.3 Gap analysis and what should be done to close them

i. Fundamental datasets (Rwanda is the standard)

   Based on the ECA definition of fundamental data themes, Rwanda had accomplished the modernization of the geodetic network by establishment of the CORS network, digitization and launch of the new Rwanda base map 1:50,000, launch of the National Land Use Planning Portal and the demarcation and

adjudication of all lands with issuance of titles on going. No other state had done these, hence using Rwanda as the standard; others were supposed to attain this standard.

(See Appendix E1)

ii. Metadata and Geoportal (Rwanda is the standard)

The Rwanda Metadata Portal (RMP) is a metadata directory that allows data users and producers to discover and assess geo-spatial data. It is based on the GeoNetwork Opensource, which is a standard-based, free and open source web catalogue application. Although the Geonetwork has data access function to enable users access or download data (Akinyemi and Kagoyire, 2010), this function is currently deactivated due to lack of a data sharing policy. The RMP is hosted at http://www.cgis.nur.ac.rw with varying levels of metadata record visibility.

(See Appendix E2)

iii. Policy and laws (Kenya is the standard)

Maps and data no matter the themes are subject to legal issues that include copyright, privacy and liability hence, it was necessary to find out the cartographic laws in place, their applicability and date of publication. Kenya was the standard because the Survey Act was under review while most of the others had laws that were outdated.

(See Appendix E3)

iv. Equipment (Kenya is the standard)

Kenya was found to have the most and most modern GI equipment and high use of the commercial off the shelf software (COTS). The other states were supposed to achieve the Kenyan standard by purchasing modern equipment and appropriate software.

(See Appendix E4)

v. Training Institutions (Tanzania is the standard)

Tanzania was the best standard because the GI curriculum was up-to-date (2011), had a high number of tutors and the cartography specialization was good. In

addition, Tanzania in collaboration with ITC Netherlands was offering a Diploma program, GeoInfoModule4 (GFM4) which attracts many foreign students from across the region. The students enjoy joint supervision by ITC and Ardhi University lecturers.

(See Appendix E5)

vi. Funding (Rwanda is the standard)

Funding was assessed for availability and diversity of sources and Rwanda had the most diverse sources in addition to government disbursements.

(See Appendix E6)

vii. National Atlas (Kenya is the standard)

Kenya had revised the national atlas severally and was currently working on the 6^{th} edition. In addition, there was a digital copy of the 5^{th} edition.

(See Appendix E7)

viii. Professional associations (Kenya is the standard)

Kenya was the only country with a professional association (ISK) that had a chapter for other geo-related cadres such as cartographers and photogrammetrists.

(See Appendix E8)

ix. Geographical names gazetteer (Kenya is the standard)

Kenya had accomplished some revision by collecting data of several sheets for the gazetteers. The time and cost differed depending on the number of topographical sheets. This was calculated based on the number of topographical sheets in the country of interest and the rate of data collection and updating.

(See Appendix E9)

x. Personnel (Kenya is the standard)

Kenya had well trained personnel of diverse GI backgrounds and specialization.

(See Appendix E10)

xi. SDI status (Rwanda is the standard)

Rwanda qualified because of the higher SDI readiness Index of 0.65 (Mwange *et al*, 2017), availability of digital datasets and metadata, awareness levels and regulations, all important SDI components. Kenya and Uganda required fast tracking as their draft policies were already done.

(See Appendix E11)

3.3.4 The EAC cartographic services harmonization matrix

Table 7: EAC member states' harmonisation time and cost matrix

Variable	**Country**				
	Kenya	**Rwanda**	**Uganda**	**Tanzania**	**Burundi**
1.Fundamental datasets	$10,612,000; 36 months	Standard	$;4,322,046; 36 months	$15,823,657; 36 months	$812,114; 36 months
2.Metadata and Geoportal	$57,000 12 months	Standard	$57,000 12months	$57,000 12months	$57,000 12 months
3.Policy and laws	Standard	$218,500; 24 months	$229,550; 24 months	$229,550; 24 months	$220,500; 24 months
4.Equipment	Standard	$226,670 24 months	$680,000; 24months	$680,000; 24months	$226,670; 24months
5. National atlas	Standard	$78,200; 12 months	$156,400; 12 months	$156,400; 12 months	$78,200; 12 months
6. Geographical names Gazetteer	Standard	$201,500; 6.5 months	$1,129,800; 20.4months	$5,015,250; 32.4months	$162,750; 7 months
7.Professional associations	Standard	$17,950; 12 months	$25,550; 12 months	$25,550; 12 months	$17,950; 12 months
8.Training institution	$730,200; 24 months	$344,100; 24 months	$344,100; 24 months	Standard	$266,880; 24 months
9.Funding	$6,250; 6 months	Standard	$6,250; 6 months	$6,250; 6 months	$6,250; 6 months
10. Status of SDI	$14,750; 12 months	Standard	$14,750; 12 months	$113,500; 24 months	$99,800; 24months
11.Personnel	Standard	$221,400; 12 months	$221,400; 12 months	$221,400; 12 months	$221,400; 12 months
Total Time (months)	36	36	36	36	36
Total cost per country	11,394,200	1,308,320	7,160,846	22,302, 557	2,143,514
Total cost EAC(USD)					**44,309,437**

Table 7 shows the overall total cost of attaining harmonised EAC cartographic services at approximately $44,309,437 to be implemented in about 36 months, assuming that all harmonization operations will happen concurrently.

3.4 Results and discussion

3.4.1 Results

Table 8: Harmonisation recommendations for Kenya

Variable	Gaps based on Kenya's assessment against the highest ranked country	What should be done	Approx. Time (months)	Approx. Total Cost (USD)
Fundamental datasets	• Not implemented AFREF requirements fully (Some progress noted) • No new base map • LIS not fully implemented	• RCMRD should continue to promote AFREF • Kenya should buy-in the proposal by RCMRD to manage the data while it purchases the CORS management software, license and internet • Prepare a new base map and implement LIS • Public private partnerships should be encouraged for CORS implementation • Implement the CORS	36	10,612,000
Policy and laws	Kenya was ranked the highest	Nothing		
Metadata	• Some metadata based on Kenya metadata profile • Old and analogue • No Geoportal	• Develop complete metadata for all data holdings based on a standard profile • Revise and publish metadata • Develop a Geoportal	6	31, 000
Hardware and software	Kenya ranked the highest	Nothing		
Training institutions	• Outdated curricula • Poor staffing • Constrained resources	• The university and middle level curricula should be reviewed and revised • Respective institutions should involve respective HR departments on optimal personnel requirements (results in comprehensive budgets and estimates for human resource engagement). • Enhance planning mechanisms in training institutions	24	730,200
Funding	• Poor funding from government • Low funding from elsewhere	• Increased funds from the government should be justified • More efforts should be put in sourcing for donor funds in terms of awareness creation and justification reports	6	6,250
National Atlas	Kenya was ranked the highest	Nothing		
Professional associations	Kenya was ranked the highest	Nothing		
Geographical names Gazetteer	Kenya was ranked the highest	Nothing		
Personnel	Kenya was ranked the highest	Nothing		
SDI status	Average SDI readiness index	The KNSDI policy should be fast tracked	12	14,750

Table 9 : Harmonisation recommendations for Rwanda

Variable	**Gaps based on Rwanda's assessment against the highest ranked country**	**What should be done**	**Approx. Time (Months)**	**Approx. Cost(USD)**
Fundamental Datasets	Rwanda was ranked the highest	Nothing		
Metadata	Rwanda was ranked the highest	Nothing		
Policy and laws	• Outdatedness • Incomplete • Unknown	• The laws should be reviewed and revised • The initial EAC laws from DOS, harmonised for Kenya, Uganda and Tanzania should be adopted • Awareness programs by stakeholders should be frequently carried out	24	218,500
Equipment	• Expensive and inadequate • Commercial software expensive • Plagiarised software • Little application of FOSS	• More digital equipment should be purchased • There should be increased awareness of FOSS usage	12	226,670
Training institutions	• Few GI training institutions and few GI courses • Poor staffing levels • Non specialised tutors • Insufficient learning resources	• More GI courses should be introduced in existing institutions e.g., cartography, surveying and remote sensing • Specialist tutors should be hired • More learning resources should be provided	24	344,100
Funding	Rwanda was ranked the highest	Nothing		
National Atlas	• Old and analogue	• The national atlas should be updated • A multi stakeholder approach should be adopted to provide datasets based on various organization's mandates	12	80,200
Professional associations	• No professional GI body	• A GI professional body should be established in accordance with state laws • There should be consensus and a unified approach towards geo-spatial related issues • Innovations, open days, exhibitions and symposiums should be encouraged	12	17,950
Geographical names Gazetteer	• Out of date • Analogue	• Data should be collected to update the geographical names gazetteer • A geographical names gazetteer database should be developed • A Standardization of Geographical Names Committee should be constituted	6.5	201,500
Personnel	• Insufficient • Not specialised	• More trained and Geo-specialized personnel should be hired • Rwanda should take advantage of technical assistance, technology transfer and short term skills development to impart professional skills	12	221,400
SDI status	Rwanda was ranked the highest	Nothing		

Table 10: Harmonisation recommendations for Uganda

Variable	Gaps based on Uganda's assessment against the highest ranked country	What should be done	Approx. Time (months)	Approx. Cost (USD)
Fundamental Datasets	• Not implemented AFREF requirements fully (Some progress noted) • No new base map • LIS not implemented • No web portal • Some maps analogue • Most maps out-dated	• RCMRD should continue to promote AFREF • Uganda should buy-in the proposal by RCMRD to manage the data while it purchases the CORS management software, license and internet • More PPPs on CORS establishment should be encouraged • The basic topographical maps should be revised • Fast track the development of a cadastral database (LIS) and new base map • Should take advantage of technical assisted projects to update basic maps using satellite imagery from donors	24 36	4,322,046 50,000
Metadata	• Largely no metadata • Analogue, outdated map catalogues • No Geoportal	• Formulate metadata based on a standard profile • Revise and publish metadata • Create a Geoportal	6	31, 000
Policy and laws	• Outdated and incomplete • Not published • Unknown	• The laws should be reviewed and revised • The initial EAC laws from DOS, harmonised for Kenya, Uganda and Tanzania should be adopted • Existing laws should be published • Awareness programs should be encouraged	24	229,550
Equipment	• Analogue, inadequate and broken down • Crack software rampant	• More digital equipment should be purchased • An effective and efficient sustainable maintenance program should be put in place • There should be increased awareness of FOSS usage	24	680,000
Training institutions	• Outdated curricula • Poor internet access • Inadequate resources • Low budgetary allocation • Inadequate institutions	• The university and Diploma level GI curricula should be reviewed and revised • More tutors should be hired • Internet access should be improved • Learning materials should be provided • The current budget should be reviewed as it is inadequate	24	344,100
Funding	• Poor funding from government and low funding from elsewhere	• Increased funds from the government should be justified • More efforts should be put in sourcing for donor funds	6	6,250

National Atlas	• Out dated • Analogue	• The national atlas should be updated • A multi stakeholder approach to provide datasets based on various organization's mandates should be adopted	12	156,400
Professional associations	• Low enrolment • Not active • Non-inclusivity	• Innovations, open days, exhibitions and symposiums should be encouraged • There should be consensus and a unified approach towards geo-spatial related issues • Chapters should be created for all geo-spatial cadres	12	25,500
Geographical names Gazetteer	• Out dated • Analogue	• Data should be collected to update the geographical names • A geographical names gazetteer database should be developed • A Standardization of Geographical Names Committee should be constituted	20.4	505,920
Personnel	• Inadequate and incomplete • Low capacity building	• More geo-spatial personnel should be hired in all cadres • Various approaches such as technology transfer, workshops and seminars, short term skills development courses and staff exchange programs should be explored	12	221,400
SDI status	• Low SDI readiness index	• There should be increased awareness among GI producers and users • The NSDI policy should be fast tracked	12	14,750

Table 11: Harmonisation recommendations for Tanzania

	Gaps based on Tanzania's assessment against the highest ranked country	What should be done	Approx. Time (months)	Approx. Cost(USD)
Fundamental Datasets	• Non implementation of AFREF requirements • No new base map • LIS not fully implemented • No web portal • Some maps analogue • Out dated basic maps	• RCMRD should continue to promote AFREF • Tanzania should buy-in the proposal by RCMRD to manage the data while it purchases the CORS management software, license and internet • Public private partnerships should be encouraged • A cadastral database should be fast tracked • Tanzania to take advantage of technical assisted projects to update basic maps using satellite imagery provided by donors and development partners • Implement a new base map	36	15,823,657
Metadata	• Largely no metadata • Not standardized • Analogue map catalogues	• Develop metadata based on a standard profile • Revise and publish metadata • Develop a web portal	6	31, 000
Policy and laws	• Outdatedness • Incomplete • Not published and unknown	• The laws should be reviewed and revised • The initial EAC laws from DOS, harmonised for Kenya, Uganda and Tanzania should be adopted • Existing laws should be published • Awareness programs by stakeholders should be frequently carried out	24	229,550
Equipment	• Analogue and inadequate • Broken down • Crack software rampant	• Digital equipment should be purchased • An effective and efficient sustainable maintenance program should be put in place • There should be increased awareness of FOSS	24	680,000
Training institutions	Tanzania was ranked highest	Nothing		
Funding	• Poor funding from government and low funding from elsewhere	• Increased funds from the government should be justified • More efforts should be put in sourcing for funds	6	6,250
National Atlas	• Out dated • Analogue	• The national atlas should be updated • A multi stakeholder approach to provide datasets based on various organization's mandates should be adopted	12	156,400

Professional associations	• Low enrolment • Non-inclusivity	• Innovations, open days, exhibitions and symposiums should be organized • There should be consensus and a unified approach towards geo-spatial related issues • Chapters should be created for all geo-spatial cadres	12	25,500
Geographical names Gazetteer	• Out dated • Analogue	• Data should be collected to update the geographical names gazetteer • A geographical names gazetteer database should be developed • A Standardization of Geographical Names Committee should be constituted	32.4	2,006,100
Personnel	• Inadequate • Incomplete (key cadres missing) • Low capacity building • Aged	• More geo-spatial personnel of should be hired • Various approaches such as technology transfer, workshops and seminars, short term skills development courses and staff exchange programs should be explored • Young professionals should be hired	12	221,400
SDI status	• Low SDI readiness index	• There should be increased awareness among GI producers and users • A NSDI framework and work groups should be developed with the aim of drafting a policy	24	113,500

Table 12: Harmonisation recommendations for Burundi

	Gaps based on Burundi's assessment against the highest ranked country	What should be done	Approx. time (months)	Approx. Cost(USD)
Fundamental Datasets	• Non implementation of AFREF requirements • No LIS	• RCMRD should continue to promote AFREF • Burundi should buy-in the proposal by RCMRD to manage the data while it purchases the CORS management software, license and internet • Public private partnerships should been encouraged • A cadastral database should be developed • Should take advantage of technical assisted projects to update maps using satellite imagery provided by donors and development partners	36	812,114
Metadata	• Largely no metadata • Analogue map catalogues and outdated, no Geoportal	• Develop metadata based on a standard profile • Revise and publish metadata • BCG should Fast track the creation of a Geoportal	6	31, 000
Policy and laws	• Outdated • No mapping standards • Many in French	• The laws should be reviewed and revised • BCG should ensure compliance with the laws • Plan on translation of the laws and policy documents into English	24	220,500
Equipment	• Inadequate • Crack software rampant	• Digital equipment should be purchased • There should be increased awareness of FOSS usage	24	226,670
Training institutions	• No GI specialised training institutions • Poor internet access • Poor staffing • Inadequate resources • Low budgetary allocation • Learning mostly in French	• More GI courses should be introduced in existing institutions • Specialist tutors should be hired • More learning resources should be provided • Increase budgetary allocation for GI courses • English speaking should be stimulated to attract lecturers from around the region	24	266,880
Funding	• Poor funding from government, no donor funding	• Increased funds from the government should be justified • More efforts should be put in sourcing for donor funds	6	6,250
National Atlas	• Old and analogue • In French	• The national atlas should be updated • A multi stakeholder approach to provide datasets based on various organization's mandates should be adopted • Translation to English should be done	12	80,200

Professional associations	• No professional GI body	• A GI professional body should be established • There should be consensus and a unified approach towards geo-spatial related issues • Innovations, open days, exhibitions and symposiums should be encouraged	12	17,950
Geographical names Gazetteer	• Lacking	• Coordinator of geographical names Gazetteer required • NMO should take lead as they are members of UNGEGN • Data should be collected to update the geographical names • Geographical names database should be developed • A Standardization of Geographical Names Committee should be constituted	7	65,100
Personnel	• Inadequate and incomplete • Not specialized , low capacity • Low education attainment • French speaking which deters visits to English speaking states	• More specialized geo-spatial personnel should be hired • Increase investment in various approaches such as technology transfer, workshops and seminars, short term skills development courses and staff exchange programs • Trainees should be sent to regional institutions • English should be introduced at basic levels	12	221,400
SDI status	• Very Low SDI readiness index	• Increased awareness among GI producers and users • A NSDI framework and work groups should be developed with the aim of drafting a policy	24	99,800

In estimating time, it was assumed that funds are available for the activities to run concurrently hence the activity that lasted longest was used as the approximate time. The financial implications in US Dollars was computed from the cost of each activity and summed up.

3.4.2 Discussion

In the design of a framework to harmonise the EAC cartographic services, the following key issues stood out:

- Awareness! Awareness! Awareness! And yes, Awareness is key to inform the policy makers, to educate the public, the stakeholders themselves and the partners. This resonates with Fortes and de Araújo (2013) that stakeholder engagement through outreach and awareness and capacity building is essential for the successful planning, development and implementation of SDI initiatives.
- International and technical cooperation to get funds for projects implementation
- Public private partnerships to assist in implementation then to benefit from the returns on investment.
- Stakeholders inclusiveness to ensure that they own the framework in order to support the proposed initiatives
- Personnel capacity building and recruitment of employees. This is key as technology has advanced to such high levels that the whole process of map making can be completed digitally by eliminating all manual procedures of analogue map making, hence the need for personnel retraining.
- Innovation, open days, symposiums and conferences as a way of networking and sharing knowledge and experience.

The framework for the harmonisation of the EAC cartographic services based on best practices show that 44,309,437 USD would be required for implementation in approximately 36 months. Of the total sum, an entire 31,569,817 USD would go to the modernization of geodetic networks, development of the topographical and cadastral databases and creation of geoportals. This represents 71% of the total cost of harmonisation and 18.6% of the combined EAC gross domestic product (GDP). The figure is substantial for a region in which the combined GDP is US$ 172 billion according to the EAC Statistics (2017).

The community has also been experiencing cash flow challenges as implicit from the sentiments of the East African legislative assembly (EALA) speaker in a local Kenyan daily and reported by the Daily Nation correspondent Igadwah (2016, June 22) ‘‘I know generally that there is pressure on our economies, but the point of concern here is that partner states committed to contribute money equally to the integration process’’. Things are expected to change however with the approval of a resolution for implementation of sustainable funding

mechanisms. The implementation period could be phased out to for instance five years to allow for funds mobilisation and donor support. It is believed that, this is enough time to carry out sensitization and awareness campaigns that would appeal to more stakeholders to support the initiative.

3.5 Conclusion

i. The question: 'What should be done to harmonize the EAC cartographic services including cost and time' have been answered.

ii. The harmonised EAC has indicated an above average personnel availability and training, improved data, metadata, relevant laws, modern equipment, better remunerated personnel, increased training opportunities plus well equipped training institutions.

iii. The estimated harmonisation cost was $44,309,437 to be implemented in about 36 months. This is a substantial amount but achievable with the right partnerships and governments' support.

CHAPTER 4: EUROGEOGRAPHICS EVALUATION AND COMPARISON WITH THE HARMONISED EAC MODEL

Chapter Summary

The harmonisation of the EAC cartographic services was accomplished based on best practices. The objective of this chapter is to evaluate the Eurogeographics so as to compare it with the harmonised EAC cartographic services. The first step towards any comparison would be to assess the current status in order to establish a benchmark against which to carry out the comparison. This was achieved through literature review to comprehend the EuroGeographics' history, objectives, strategy, organizational structure, membership, current activities, projects and key achievements. After the evaluation, comparison of the EuroGeographics with the harmonised EAC model was performed. Results indicated EuroGeographics to be advanced in cartographic services; thus, the Eurogeographics' members boast of European-wide products from authoritative national sources, well-coordinated production processes using international standards, up-to-date products of good positional accuracy and presence of metadata with search, view and download services. The products had a common European coordinate system, were INSPIRE and OGC compliant and largely complemented each other. The observed disparities meant that the EAC cartographic services required further upgrade and harmonisation to the state of the art in order to realise not only interoperability but also comply with international standards.

4.1 Introduction

4.1.1 Background

About EuroGeographics

Established in 2001, EuroGeographics is the membership association of the European National Mapping, Cadastre and Land Registry Authorities (NMCAs). It is composed of 63 organizations from 46 countries hence, a good example of a functional regional cartographic service. The main task of EuroGeographics is to advance NMCAs, national and pan-European products and services and to play a key role in the development of the European Spatial Data Infrastructure (ESDI), which gives a universal structure for generating reference spatial data collected and maintained by the members for the needs of state administration, economy and citizens (EuroGeographics, 2001).

EuroGeographics history and mission

EuroGeographics dates back to over 20 years ago when the *Comitée Européen des Responsables de la Cartographie Officielle (*CERCO) was formed as a forum for sharing, discussing and resolving common problems. In 1993 a subsidiary, the Multi-purpose European Ground Related Information Network (MEGRIN) was also established to manage pan-European projects including the development of web-based metadata services and integrated geographic databases (Sokacova, 2015). The merging of MEGRIN and CERCO to increase communications, team work and efficacy contributed to the formation of EuroGeographics in 2000 with 37 countries as members. Today, the membership has risen to 63 members from 46 countries. EuroGeographics later changed its legal form to a non-profit kind of organization (AISBL) under Belgian law and shifted its Headquarters from Marne-la-Valée in France to Brussels, Belgium in 2011.

According to Sokacova (2015), the primary mission was to maintain a network to help each member to improve their capabilities and role; to facilitate access to members' data, services and expertise; and to provide them with a strong voice. To this end, the EuroGeographics developed objectives that included the following:

- To contribute to the development of GI in Europe, primarily by working to make databases of European NMAs interoperable, and widely available,
- to influence decision-making by the European Commission (EC) on the development of GI policy and to lobby for the establishment of best use of GI throughout Europe,
- to assist in the creation of information needed but not currently available to our customers and
- to promote and facilitate cooperation between members, and between members and their European partners including those in the private sector (EuroGeographics, 2001)

To achieve the objectives, the Eurogeographics had clearly defined strategies that included: the growth of a strong business identity, awareness creation of GI benefits, products and services, user needs assessment, backing for best practices in GI, advancement of role of GI in EU, enhancement of cooperation between members to increase competence and efficacy and encouragement for joint visits and staff secondments amongst EuroGeographics members.

4.1.2 Statement of the problem

As many NMAs re-engineer their data by migrating from "digital mapping" to "geographic information" to support maturing customer needs, the opportunity to harmonise concepts, data models and approaches (Luzet, 2003) presents itself. The provisions of the EAC common market protocol leading to many cross border activities and *ad hoc* GI exchange brings a perfect opportunity for migration to digital mapping and centralised access of regional GI. In the East African region for instance, cartographic services have largely remained disparate and uncoordinated due to lack of regional GI organizational structures. Various mapping engagements spearheaded by the RCMRD and NMOs of contracting member states have not achieved much in terms of development of a regional GI policy and organizational structures to support cartographic harmonisation.

After the harmonisation model of the EAC cartographic services was developed in chapter 3, the harmonised EAC cartographic services that would result were found to be in need of improvement as they applied only national or no standards, lacked harmonised organizational and legislative frameworks plus web access to the harmonised services. To facilitate GI standardization in a regional and global context, the move towards international standardisation is inevitable. The first step towards the state of the art would be to assess the current situation so as to establish a benchmark against which to transform to. This was achieved by the evaluation of a state of the art model, in this study the EuroGeographics.

4.1.3 Objectives and research questions

The overall objective was to compare the harmonized EAC cartographic services with the state of the art services (EuroGeographics). In order to achieve this, the following research questions were formulated:

- What is the current status of the EuroGeographics?
- How does the EuroGeographics compare with the model of harmonised EAC cartographic services?

Scope and limitations

The EuroGeographics, comprised of 63 members drawn from 46 countries (See Appendix L) was compared with the harmonised EAC services from 5 of 6 member states. A limitation in the comparison is the non-equivalence of the two scenarios because while the EuroGeographics members are numerous with diverse cultures, languages, technology and

organizations, the EAC members are few with many commonalities such as their colonial history among others.

4.2 Literature review

For successful harmonisation of spatial data, several obstacles must be overcome. Land, Executive Director EuroGeographics (2003) recognised the obstacles as the ‘‘availability of pan-European products harmonized to agreed standards and access to better metadata about available products’’. He observed that INSPIRE implementation was challenged by ‘institutional as opposed to ‘technical’ obstacles, which would be opened by adoption and implementation of the INSPIRE Policy Principles. Consequently, the requirements for implementing the EuroGeographics core mission (achieve interoperability of mapping and other GI data within 10 years) and the initial steps envisaged by INSPIRE (the European Commission initiative for developing the ESDI) converged in recognising the need for common specifications for reference data (Luzet *et al,* 2004).

The adoption of the INSPIRE proposal for a Directive (EC 2004) by the European Commission in July 2004 marked an important step on the way forward to a European-wide legislative framework that helped in achieving an European Spatial Data Infrastructure (ESDI) (Bernard *et al,* 2005). The proposal set out common rules for the formation of an ESDI to support environmental policies and actions with a direct or indirect effect on the environment. To ensure the success of the initiative, a legal basis was necessary hence, the agreement on a Directive.

The INPIRE implementation in the EU member states is coordinated by the EuroGeographics as the coordinator of the National Mapping Organisations (NMAs). The NMAs, through EuroGeographics are active in a number of areas including the development of new metadata services, creation of European specifications for harmonization of reference datasets, harmonization of licensing terms and improving organizational cooperation (Land, 2003). The EuroGeographics efforts to implement the INSPIRE policy vision have also contributed to the European spatial data infrastructure (ESDI). The INSPIRE policy vision is, ‘‘to make harmonised and high quality geographic information readily available for formulating, implementing, monitoring and evaluating Community policy and for the citizen to access spatial information, whether local, regional, national or international” (Land, 2003). The vision is shown in Figure 9.

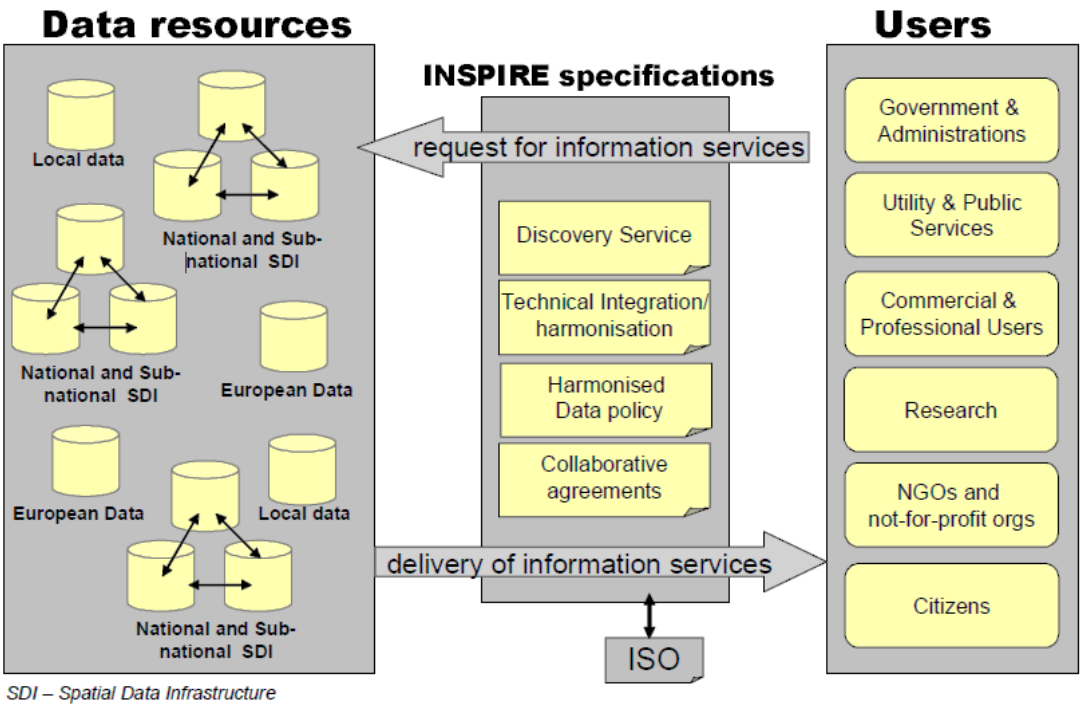

Figure 9: The INSPIRE Vision

Source: Land (2003)

The INSPIRE vision has been realised through NMAs using a step by step methodology that specifies a component of reference datasets and works on it individually. Thus, metadata service, reference data (reference system and pan-European products), policies, specifications etc.

The growth of the internet has also greatly influenced the manner in which NMAs function, thus, most of them currently have operational geoportals. Moreover, many NMAs are exploring the use of Web 2.0 to expand their operations by means of crowdsourcing methodologies. Some examples include: The US Geological Survey's VGI project that encourages citizens to collect and edit data using the National Geospatial Portal about man-made structures to advance the USGS authoritative spatial database; The Dutch Cadastre in the Netherlands and the Finnish Geospatial Research Institute are studying the use of crowdsourcing approaches to supplement their topographic databases; the Vicmap Editing Service encourages registered public users to notify the Australian state of Victoria of changes required to the Vicmap core spatial data products; the Survey of Israel is using its national geospatial portal to get citizens' feedback on its national map, as well as explores crowdsourcing techniques to map defibrillators (Cetl *et al*, 2019). An important observation

is that most NMOs are hesitant about incorporating crowdsourced data with authoritative data because it may diminish the quality and reliability of their national datasets.

4.2.1 Case studies

The European Location Framework (ELF)

The European Location Framework (ELF) means a technical infrastructure which will deliver authoritative, interoperable geo-spatial reference data from all over Europe for analyzing and understanding information connected to places and features (Pauknerova *et al*, 2016). The project is supported by a group of partners (public, private and academic organizations) and co-funded by the European Commission's Competitiveness and Innovation Framework Programme (CIP) with the aim of delivering an authoritative reference GI to the European community.

To attain the project objectives, an organizational structure was put in place and key roles clearly defined. The project team was divided into 9 sub-projects also known as Work Packages (WP) with specific deliverables being handled by different organizations (See http://www.elfproject.eu/content/structure for more details on the WPs). The ELF is unique originating from national level GI data services to develop one harmonised dataset for Europe that seamlessly crosses country borders and addresses the dual need for simple, easy-to-use web maps to integrate into a website or an application and providing access to datasets to download for those wishing to work with the data (Pauknerova *et al*, 2016). The results are a series of deliverables defined in the Description of Work document.

The GiMoDIG Project

Funded by the European Union, the objective of the GiMoDig project (Geo-spatial Info-Mobility Service by Real-Time Data-Integration and Generalisation) was to develop and test methods for delivering harmonised, European, large-scale geo-spatial data to a mobile user by means of real-time data-integration and generalisation (Afflerbach *et al*, 2004). The Project involved Sweden, Denmark, Finland and Germany to demonstrate Location Based Services (LBS). The result was the development and implementation of a prototype of a cross border spatial data service which provides access through a common interface that conforms to International Web standards into primary national topographic databases. It also led to the development of efficient use of a large amount of resources invested in the creation of nation-wide topographic databases while facilitating the use of multimedia-capabilities available in the technically advanced telecommunications networks in Europe (Sarjakoski *et al*, 2002).

For the mobile users who require timely and up-to-date information, real-time generalisation of spatial data was achieved, a critical issue for mobile users.

4.2.2 Pan-European products and services

EuroBoundaryMap (EBM) is a European reference dataset of administrative units at the scale of 1:100 000, which contains geometry, names and national codes of administrative and statistical units provided by the European National Mapping and Cadastral Agencies. Currently, EuroBoundaryMap ver. 5.0 (EBM v5.0) contains data on administrative units for 41 European countries. Products are produced in ArcGIS Geodatabase ver. 9.3 format, using WGS84 spatial reference system. The key benefits of EuroBoundaryMap product are:

- Data are being collected from the official national sources and updated accordingly;
- Harmonized and GIS oriented database;
- Link to NUTS codes published and maintained by the Eurostat;
- Metadata are available for all national providers;
- Maintenance and technical support provided;
- Common framework and licensing of products for all key countries (EuroGeographics, 2001).

EuroGlobalMap (EGM) is a European topographic dataset at a scale of 1:1 000 000. The data set has been developed with cooperation from NMCAs of the member countries using official national databases. EuroGeographics has distinct technical specifications describing the contents, accuracy and data formats thus ensuring a unique standard in the creation of topographic data sets. EuroGlobalMap Ver. 4.0 (EGM v4.0) has national data from 45 countries included. It is produced in ArcGIS Geodatabase Ver. 9.3 format, in ETRS89 spatial reference system (EuroGeographics, 2001). It has six primary themes in vector format specifically: administrative boundaries, hydrography, transportation, settlements, altitudes and geographic names and available as “open data”.

4.3 Methodology

4.3.1 Research design and justification

Research design

A descriptive case study methodology was adopted which requires that the investigator present a descriptive theory, which creates the general context for the investigator to follow during the study. The theoretical orientation adopted is articulated in the National

Cartographic Service (NCS) conceptual framework (Figure 1) which was used to assess the EAC cartographic services, the dependent variable in the study. This framework identified EuroGeographics as the dependent variable (unit of analysis) whose status was determined by the following independent variables: Fundamental datasets, metadata, SDI status, policy and laws, hardware and software, national atlas, geographical names, professional GI associations, funding, training and personnel. The elements were evaluated and then compared against the harmonised EAC cartographic services to determine if there were any differences or similarities between them, and in particular, any gaps that would need to be filled in upgrading the EAC harmonised services.

Justification

The EuroGeographics, a European initiative was picked to serve as state of the art for the EAC cartographic services upgrade because Europe and Africa share many similarities. E.g. both regions have many different countries which are heterogeneous in terms of legal and organizational aspects, attributable to the colonial history of the region. The EAC mapping history and education are also characterised by a great deal of early European influence.

4.3.2 Data collection

Data collection was realized through literature review of relevant materials from EuroGeographics' websites, NMCAs official portals, member country reports, projects, case studies, survey reports, conference proceedings, EuroGeographics guidelines and technical documents among others. Examples of the reviewed documents include: *EuroGeoNames: the vision of integrated geographical names data within a European SDI* (Sievers and Zaccheddu, 2005); *Final Version of the EuroGeographics Technical Architecture* (Christl and WP5 partners, 2011); *EuroSpec – Providing the foundations to maximize the use of GI* (Luzet, 2003); *Challenges in Geo-spatial Data Harmonisation: Examples and Approaches from the HUMBOLDT project* (Fichtinger, *et al,* 2009); and *EuroGlobalMap Pan-European Database at Small Scale Specification and Data Catalogue for Data Production - User version for EGM release v10.0* (EuroGeoGraphics, 2017) among others.

The literature review represents a method as the literature reviewer chooses from an array of strategies and procedures for identifying, recording, understanding, meaning-making, and transmitting information pertinent to a topic of interest (Onwuegbuzie, *et al.,* 2010). The search technique entailed the use of the key word of the variable in question. After finding the relevant literature material, the criteria of assessing the variables for the EAC member

states was applied. For example, the fundamental dataset was evaluated for thematic availability, custodianship, update, format, spatial coverage, datum, level of digitization and cost among others.

The population of the study comprised of all EuroGeographics members with random sampling. The search technique entailed looking out for projects or pilots being implemented towards the attainment of the EuroGeographics objectives. In some instances, deductions were made based on the state of the art projects and prototypes. For instance, the presence of a national geoportal with search, view and download services was a pointer to digital data with metadata. While EAC assessment was based on both primary and secondary data, the Eurogeographics relied entirely on secondary data sources although an email was exchanged with a Eurogeographics official, P. Sokacova (personal communication, December 18, 2018). The authenticity of the sources was presumed coming from Eurogeographics' official websites, refereed journals and conference proceedings. The procedure involved evaluating the specific variables at the EU level (including projects using EuroGeographics specifications) and where not available, at the EuroGeographic's member states' national level. The point was to gather as much information as possible from the harmonised and state of the art interoperability projects and initiatives.

4.3.3 Comparative evaluation and data analysis

1. Fundamental/Reference datasets

It was observed that similar to their EAC counterparts, European NMCAs are the custodians of the fundamental datasets. Each national producer being responsible for conversion and upgrade of the database of its territory including the update and maintenance of this national part of the dataset as per the agreed update plan (Pammer *et al*, 2009). The datasets are initially harmonised to EuroGeographics specifications and data model. At Europe/regional level, national datasets 1:50,000 and 1:100,000 are available but less (vector) coverage than larger scales, however raster data is available (EuroGeographics, 2017). Also available are harmonised pan-European datasets based on national data with a bi-annual update scheme: EuroBoundaryMap (1:100,000) containing administrative units, EuroRegionalMap (1:250,000), EuroGlobalMap (1:1,000,000), EuroDEM (60 m) and also producing EuroDEM 25/30m resolution by demand (EuroGeographics, 2017). SABE project is the Seamless Administrative Boundaries of Europe, a harmonised dataset assembled from the official data

provided by member countries and permanently maintained by the EuroGeographics (Luzet, 2003).

EuroGeographics has several interoperability projects all geared towards the realisation of its objectives and the implementation of the INSPIRE Directive such as the European Reference Frame (EUREF), whose main goal is the creation and maintenance of the European Reference Frame. As such, the ETRS89 (European Terrestrial Reference System 1989) has been adopted by numerous European countries and organisations as the official system for geo-referencing. The EU uses ETRS89 as a conventional reference system as well (Adam *et al.,* 2002). The European Location Framework (ELF) is a project realized through a consortium of partners (public, private and academic organisations) to deliver up-to-date, authoritative, interoperable, cross-border, and reference geo-information for usage by the public and private sectors through an online ELF web service. Co-funded by the European Commission's Competitiveness and Innovation Framework Programme (CIP) (Pauknerova *et al.,* 2016), ELF is responsible for the development of standards, specifications, tools and technical infrastructure. A follow-up on the ELF is the Open European Location Services (ELS) whose emphasis is to enhance access to, and boost the take up and use of geo-information; there is no equivalent in the EAC.

It was observed that the Eurogeographics' mission and the INSPIRE aspirations played a key role in commissioning of the Eurospec project, whose goal was to define reference data specifications. Consequently, the interoperability intention supported by development of data specifications was achieved through research (the ETeMII White Paper: chapter on interoperability) whose findings were endorsed by INSPIRE. In Europe, national level geoportals are available in most countries and at different levels of operation, at EU level the Coordinate Reference System_European Union (CRS_EU) online portal provides services such as search and view, such a portal is lacking in the EAC countries. Specifically France, Germany, Spain and Norway were found to have Geoportals with tools for search, view and in some cases download in compliance with Article 11(1) of the INSPIRE Directive. The Geoportals were however limited by the number of GI organizations that offered GI for sharing and re-use.

In East Africa, implementation of the AFREF is on-going to comply with the AFREF recommendations for the member states. The objective of the AFREF initiative being to unify and modernize the geodetic reference frame in Africa by encouraging African governments

through their NMAs to improve their geodetic networks using modern GNSS technologies including establishments of a network of CORS providing a variety of services including DGPS/RTK corrections and supporting a variety of applications such as mapping, engineering, cadastral, weather, geodynamics and so on (Kamamia, 2017). According to the Director General (DG) of RCMRD, at continental level, countries are supposed to launch at least one CORS to contribute GNSS data to enable the computation of a uniform continental reference framework, which many countries have done. Static data from these CORS is being used to compute initial AFREF computations and static data is easily accessible from websites and the AFREF data centre hosted by the NMA of South Africa.

At national level, member states are expected to establish Real Time Networks (RTN) through a network of CORS. Generally, implementation of the AFREF/RTN has been very slow with a few countries such as South Africa, Botswana, Rwanda and Namibia having complied. This is attributed to the high cost of the equipment, software, supporting IT infrastructure and inadequate technological GNSS capacity. To fast track on the AFREF implementation, RCMRD is offering to take the role of data centre/secretariat of the CORS within her member states while the member states provide a location with basic amenities including internet, GNSS hardware and Leica Spider CORS network management software site licenses. It remains to be seen how many will consider this offer. RCMRD is currently running 2 CORS in Kenya; RCMN in Nairobi and DKUT at Dedan Kimathi University, Nyeri. Rwanda has completed the CORS stations installation as illustrated in Figure 10.

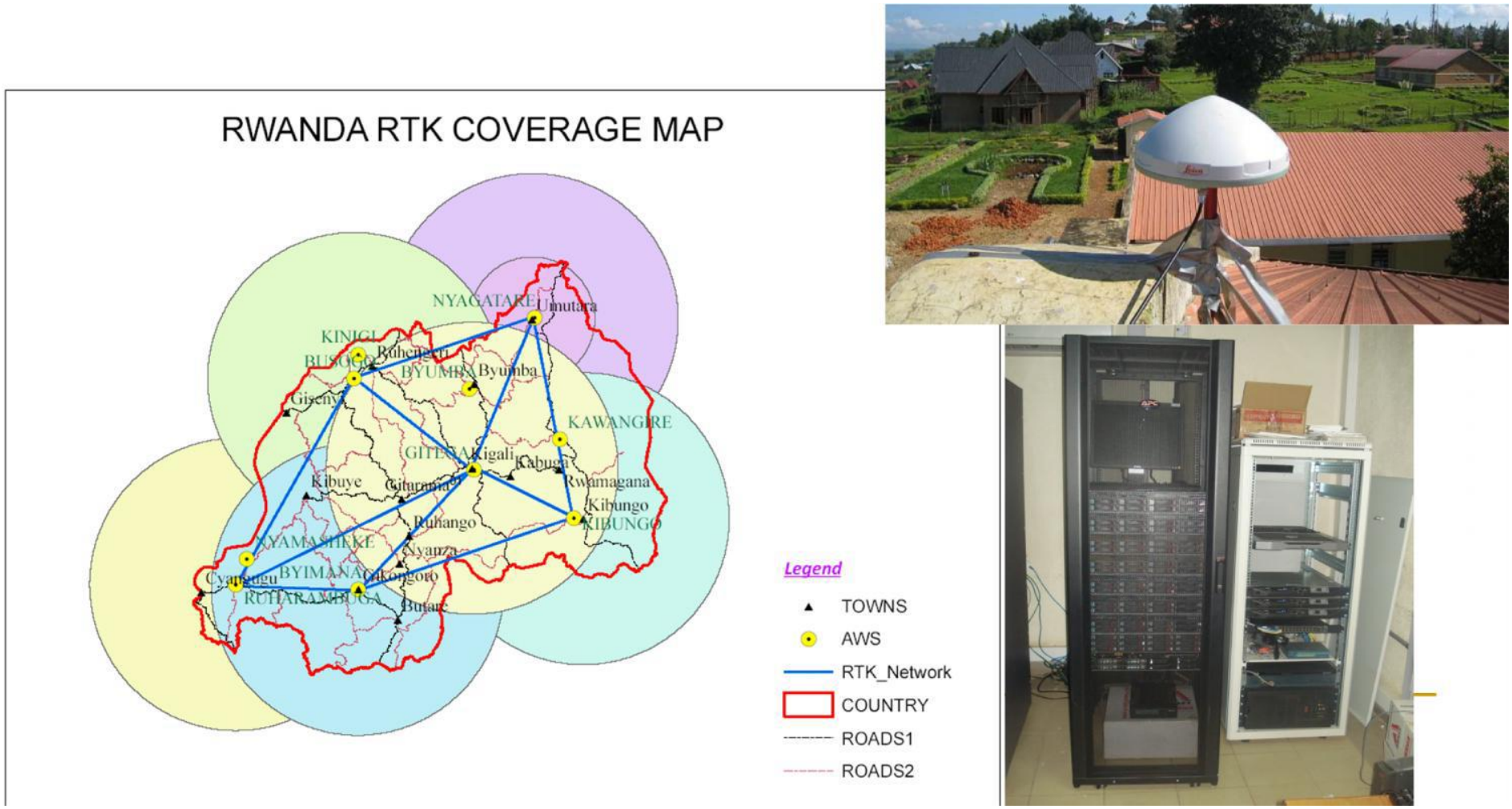

Figure 10: Rwanda Modern Geodetic Reference Network completed with 8 stations

Source: RCMRD (2014)

2. Metadata

A brief overview of current status of European spatial data infrastructures − relevant developments and perspectives for Bulgaria by Pashova and Bandrova (2017) indicate considerable improvements in the availability and conformity of the metadata and the spatial datasets in most of the EU countries, although some metadata records for spatial datasets for 12 member states were still not fully compliant with the metadata regulation. However, EuroGeographics boasts of a new metadata service for discovery level service, decentralised system allowing local maintenance of the data, profile based on ISO 19115 and multilingual ''gateway'' (*https://www.gim-international.com/content/news/plan-to-deliver-authoritative-pan-european-open-data-services-unveiled)*. The decentralised model ensures that NMAS provide and update their own information. Although the EAC members currently have harmonised metadata, it is limited in terms of data holdings (incomplete) and also cannot be shared due to lack of a data sharing policy.

3. SDI status

EuroGeographics has continually promoted and defined the European Spatial Data Infrastructure (ESDI) by its participation in the INSPIRE Expert and Working groups, directly through its Head Office, and through the active contribution of many of its member NMAs (Luzet, 2003). The EU Directive 2007/2/EC to establish an Infrastructure for Spatial Information in the European Community (INSPIRE) applies to all member states (De Vries, 2011). This Directive is being implemented in most of the EU member states using different approaches and in complex environments thereby affecting compliance with recommendations, technical specifications, and timeframes of the roadmap from each member state. The SDI statuses also differ from country to country while political willingness and awareness are high in the EU member states. Generally, INSPIRE implementation in the EU is half way with encouraging indicators. The SDI readiness is however much higher compared to the EAC member states where, according to Mwange *et al* (2017), only Rwanda and Kenya recorded indices greater than 0.5. Currently in EA after the harmonization, SDI awareness levels are higher, metadata and relevant staff are available, technology and political willingness have improved. These developments should drive the SDI readiness index higher although the region lacks a champion to lead in SDI implementation.

4. Policy and legal environment

Similar to the EAC member states, the EuroGeographics' members are run by national laws and international treaties and, for EU members the European policy and legal framework. The NMAs in both blocs are in charge of defining National Policies and legal frameworks. The EuroGeographics offers the central point for coordination of NMCA activity to implement INSPIRE in policy areas e.g., reference data, metadata, and data quality, a role that is lacking within the EAC. The NMCAs through EuroGeographics are active in a number of areas including the development of new metadata services, making of European specifications for harmonization of reference datasets, harmonization of licensing terms and improving organizational cooperation (Land, 2003). In the EAC the relevant GI laws are available and up-to-date but they vary from country to country thus impeding interoperability.

EuroGeographics members are required to conform to harmonised licensing frameworks by submitting data to the EU that complies with public private partnerships, access to public sector information, legal protection of GI by the intellectual property rights, restricted access and data licensing. EuroGeographics specifications and guidelines are ISO and OGC compliant. Although awareness of mapping laws and regulations improved, most private mapping companies in the EAC are unregulated which can be attributed to lack of enough manpower to enforce and ensure the compliance with the available laws. EAC lacks regional initiatives to organise GI policy, hence lack of a common policy. It is apparent that harmonized policies and laws that span EAC borders are required to address emergency situations, environmental management and security concerns among others.

5. Hardware and software (Technology)

Modern equipment were deduced from the state of the art projects being implemented in member countries under EuroGeographics guidance. These include the pan-European and interoperability projects being coordinated and implemented by various member states but in compliance with EuroGeographics specifications. For instance, Ukraine was the first country in the world to establish a legal framework for land relations monitoring following the adoption of a Government Resolution (EGAR, 2017) by completing the transfer of the State Land Cadastre system to Block chain technology in September 2017. Other successful collaborations and technology are evidenced by projects such as the GiMoDig Project involving Sweden, Denmark, Finland and Germany to demonstrate Location Based Services (LBS) (www.gimodig.fgi.fi); the Ordnance Survey Ireland, Ordnance Survey of Northern

Ireland and Ordnance Survey Great Britain collaboration (www.osmaps.org) and the harmonisation the Länder datasets in Germany by BKG (www.bkg.bund.de) (Luzet, 2003).

These projects are based on a distinct technical framework (data type, data model, and delivery formats etc.) and proprietary software, mainly Esri. On the other hand, although modern equipment coupled with clear maintenance strategies are in place, there are currently neither interoperability nor pan-East African projects. The approval of open data policy which supports free data access, has encouraged several governments to release data for public use including spatial data from some European NMAs. For instance the NMAs of Finland and the Netherlands have offered their datasets under open access licences to be incorporated into the OpenStreetMap. The Netherlands Kadaster is running successful VGI activities, e.g., 'terugmelding BRT' (alert on the Dutch Topographic Registry) and 'terug-melding BGT' (alert on the 'large scale' Topographic Registry), to report new changes and errors (Olteanu-Raimond *et al,* 2017). Other successful VGI projects include the maintenance of the markers that define the borders between the Netherlands and Germany (it helped Kadaster to make a decision as to whether it needed to maintain a particular marker or not) and the forest paths project (whose objective was to use VGI to update the National Dutch Forest Organization's datasets). In the EAC, a few countries have implemented the open data initiatives such as Kenya and Rwanda while the rest are in the initial stages. This study too revealed that there were no considerations for VGI in most NMAs for topographic map revision due to difficulties with authenticating such data.

6. National Atlas

The EuroGeographics currently does not have a strategy for harmonization of the national atlases, hence member states have national/regional atlases with up to date reference maps. In some countries, web based access of the atlas was available. Similarly, the EAC member states have the National Atlas under the custodianship of the NMAs which is updated regularly and harmonised in terms of language and format. However, atlases are largely analogue and hence web access is not possible.

7. Geographical names gazetteers

EuroGeonames (EGN) is a system of the European geographic names infrastructure, a pan-European service of the geographic names register that has been developed in line with the INSPIRE application schema of the geographical names register (D2.5 Generic Conceptual

Model, V3.1) under the authority of the EuroGeographics (Hećimović *et al*, 2010). The EGN was completed through the detailed survey/inventory on geographical names data (SI-EGN). The SI-EGN is a consortium consisting of the BKG, as project coordinator, together with the NMCAs from Austria and Slovenia as well as with the EuroGeographics Head Office (EGHO) and Esri Germany (Sievers and Zaccheddu, 2005).

EGN implementation throughout the EU started in 2006 forward. A web service with authoritative place names linked to geographical names of official sources across Europe, the EGN is ISO and OGC compliant thus, the service can publish, find and deliver, use and study geographical names data through the Internet across Europe. While all the EAC member states have a geographical names gazetteer under custodianship of individual NMOs, the Geographical names registers are still country specific, not up-to-date and full digital coverage has not been achieved. In addition, there were no known efforts to develop a pan-East African Geographical names gazetteer.

8. Professional Associations

These are national associations for individuals working in the GI field. Most EuroGeographics member states have a national GI association or organization under the European umbrella Organisation for Geographic Information (EUROGI) coordination. This implies that at national level there are various types of membership ranging from sponsor, corporate, individual to student membership that vary from country to country. At European level, there are national professional GI association or pan-European organization type of membership, for instance:

Austria

The Austrian Umbrella Organisation for Geographic Information (AGEO) has a mission of stimulating the efficient use of GI by providing information to the public, management and use of GI, supply of information on the availability of GI and promotion of education and Continuous Professional Development (CPD). AGEO attracts various membership categories from institutions such as companies, University Institutes, Associations, Public Institutions, Licensed surveyors, Energy supply companies. It does not register individual members.

United Kingdom

The United Kingdom's Association for Geographic Information (AGI) mission (to maximise the use of geographic information for the benefit of the citizen, good governance and

commerce), is a membership organisation, attracting members from all sectors including users, software suppliers and vendors, consultants, government departments, local authorities, emergency services, educational establishments and individuals (Probert, 2003).

Similar to the EUROGI's mission, the national GI associations' mission is the advancement of practise and awareness creation of GI for the welfare of society through good governance. Most associations are independent of government and offer a platform to share best practices and expertize through knowledge exchange networks (KENs) - expert working Groups. The national GI associations exhibit similar key roles of awareness creation, raising of GI standards, facilitator of professional development and training (short courses) and research and in some instances GI policy makers. These are achieved through various action plans such as workshop, seminars, conferences, publications, lobbying and projects. They communicate to members through bulletins, reports, magazines, newsletters, Email and websites. Majority of them have partnerships with different stakeholders with common interests such as developers, standards groups and GI organisations among others. The EAC GI associations are available in each country with no umbrella organization at regional level. Although majority of Geo-information professionals are members of professional associations, it is mostly at various individual membership categories which still remains low due to inadequate public relations and awareness and high registration fees.

9. Funding

EuroGeographics activities are funded through member countries' subscriptions and a working budget of over 3 billion Euros per year, although further cash may be availed for specific project work. Most the NMAs are self-funding (central government). Due to greater awareness on the value of GI, there is greater political support for GI activities. Funding models include central government, specific taxes, registration fees, fee-based data and public private partnerships. Although there is a shift from licensed to open data necessitated by the digital agenda for Europe since 2010, this has not impacted the funding models significantly. Member states are required to put in place sustainable funding, investment and charging mechanisms while availing the data for free access, view and download to citizens. The dominant funding model in the EAC is equally the central government with little donor support and lack of a data policy to stimulate the GI market.

10. Training and education

In spite of the importance the EU places on education, the structures of education systems in European countries differs significantly, both within and amongst countries. Fortunately, the trend towards greater compatibility and mutual recognition was enhanced by the Bologna Declaration in 1999. The main goal of the Bologna Declaration was to create a European space for higher education in order to enhance the employability and mobility of citizens and increase the international competitiveness of European higher education (Lisec and Ruiz Fernández, 2008). In the EAC, the Common Markets Protocol (CMP) provides for "Four Freedoms": the free movement of goods; labour; services; and capital. Annex VI of the CMP has regulations that guide mutual Recognition of Academic and Professional Qualifications; which was adopted by the 22nd Council of Ministers to implement the provisions of Article 11.1(a) (Okiror, 2014). Thus, the MRA for EAC Engineers was signed on 7th December 2012 at Arusha, in achievement of the CMP Art. 11: Annex VI. Conversely, negotiations of MRAs for Land Surveyors were concluded but documents had not been signed as of July 2018. The Open European area of education and training was formed to afford students and instructors free movement by recognition of their study programmes and diplomas which were achieved through the European Credit Transfer System (ECTS).

Another project relating to higher education in the GI sciences and supported by the European Commission, is the thematic network EEGECS (European Education in Geodetic Engineering, Cartography and Surveying). The purpose was to support networking in order to provide information on international educational programmes, research, scientific projects – not only for higher educational level but also life-long learning (Lisec *et al,* 2008). The EEGECS is a project originally created by Geodetic Engineering, Cartography and Surveying institutions with the objective of enhancing collaboration and co-operation between the higher education institutions which offer such studies and those from related fields (Steinkellner and Heine, 2005). The network is composed of different types of partners and institutions; universities, public institutions, private companies and associations (Ruiz Fernández and Estellés, 2008) with over 100 institutions from 27 different European countries. The general aim of the project was to make the achievements and essential results obtained by EEGECS available to the students, teachers and researchers, faculty managers, public and private sectors that are involved in professional activities related to Geomatics, through a number of permanently active and open Working Groups who use the results on

everyday basis (EEGECS, 2005). The work has been allocated to six working groups as shown in Table 13.

Table 13 : The EEGECS organizing structure

EEGECS WG	Objectives
WG1	Undergraduate education
WG2	Research
WG3	Continuous education, e-learning and the European dimension of studies
WG4	Enterprises-Private sector
WG5	Mobility, Language, Culture, Citizenship, Social cohesion
WG6	Quality Assurance

Source: EEGECS (2005).

An equivalent to the European EEGECS is the East African Qualifications Framework for Higher Education (EAQFHE) that dates back to 2006 when the Inter-University Council for East Africa (IUCEA) formed a regional quality assurance structure for East Africa. The EAQFHE process began in 2012 through IUCEA in collaboration with the national commissions and councils for higher education and higher education institutions in the EAC states and the East African Business Council (EABC) (IUCEA, 2015). The aim was to support regional quality assurance with a tool to enhance harmonisation of education and training systems plus the acquired testimonials. The framework will enable the operationalization of Article 11 of the CMP as a guiding mechanism for mutual recognition of qualifications among the Partner States. An important observation is that the GI curricula throughout Europe have typically advanced in the framework of the higher education programmes of geodesy, surveying and cartography. This explains why the new methodology and technology for spatial data acquisition and analysis, such as photogrammetry, remote sensing and GIS, has been usually included in the higher education curricula of geodesy, surveying and cartography (Lisec *et al*, 2008).

EduMapping is an AGILE (Association of Geographic Information Laboratories Europe) initiative conceived in Hanover, Germany in 2009 at the pre-Conference workshop on the European Qualification Framework (EQF) and its application in the GI field (Rip, 2008). The aim of EQF was to compare different countries' national qualifications systems to a joint European reference framework. The objective of the workshop was to analyse if GI education in Europe was ready for EQF, and if the Geographic Information Science and Technology

Body of Knowledge (GI-BoK) (DiBiase *et al*, 2006) could be used for that purpose. After it became clear that no proper overview of GI-teaching existed in Europe, several proposals were put forward including the proposal to use the Body of Knowledge (BoK) as a standard reference. This bore the first version of EduMapping using the BoK as reference. If acknowledged, EduMapping could be used nationally for comparing GIS know how for students that have been taught at different educational institutions and also locally, for instance within a University, for comparing different courses (Rip, 2008) but much better when used internationally to compare GI-related disciplines.

‘‘Geographic Information –Need to Know’’ (GI-N2K) is a European Union commissioned project comprising of 31 partners from 25 countries in Europe, led by the University of Leuven, Belgium from 2013. The project intention was to improve the previous version of GIS&T BoK. The results of the project indicated that most GI-related organizations in Europe were unaware of the GIS&T BoK hence, its applicability as a knowledge domain reference remains very low. It was consequently concluded that the GI-N2K project would elevate the GIS&T BoK project to a better position if a more attractive version (with regard to content, tools and user interface) could be constructed, that might stimulate awareness in Europe on both the Demand and the Supply side (Rip *et al,* 2014). Donert, (2007) gives an overview of higher GI education in Europe as characterised by: few universities that offer undergraduate degree programmes based on GIS, GIScience or geo-spatial technologies; growth in university GIS modules; perceived as specialities or highly ‘technical’; rarely used as a teaching technology; rarely used in teacher training (of new teachers or in professional development of existing teachers). This observation agrees with what is happening in the EAC region.

11. Personnel

More than 100,000 people across Europe are employed by EuroGeographics members, who owe the people responsibility for implementing the mission and mandate of the EuroGeographics. In addition, an open forum for members and invited experts ensures that there is a common vision for pan-European GI that through exchange of knowledge and experience gives members the opportunity to increase their skills and capabilities, a key objective for EuroGeographics. This guarantees members benefit from open and easy access to distinguished professionals via seven Knowledge Exchange Networks (KENs) that

individually target a specific area of interest for National Mapping, Land Registry and Cadastral Authorities.

In addition to cadastral and land registry experts, Sokacova (2015) identifies the EuroGeographics' KENs as:

a) Specialists in spatial data infrastructure development and INSPIRE implementation –INSPIRE KEN;
b) Recognized leaders in geo-information quality management – Quality KEN;
c) Authorities on providing mapping for emergencies – Emergency Mapping KEN;
d) Key players in the development of national geo-information initiatives such as Open Data and e-government – Business Interoperability KEN;
e) GNSS experts including those from the European Position Determination System (EUPOS), the IAG Reference Frame Sub Commission for Europe (EUREF) and the Council of European Geodetic Surveyors (CLGE) – Positioning KEN;
f) Expert commentators and contributors to European policy through coordinated communications with the President of the EU, Council of Ministers, MEPs and the European Commission – Policy KEN and its Task Forces on the Digital Agenda and Copernicus.
g) In addition to examining the role of cadastre (documenting the property objects) and land registry (documenting legal rights in properties), the Cadastre and Land Registry KEN also follows the development of relevant technologies and practices. Through the KENs, members are able to exchange ideas, knowledge and best practice, thus enabling them to develop their skills and expertise in an economical approach. Availability of webinars guarantees that everyone takes part in meetings and workshops that are also available through a dedicated YouTube channel.

EuroSDR (http://www.eurosdr.net/) is a non-profit organisation that provides a pan-European network that brings together mapping/cadastre agencies and academia for the purpose of applied research, and securing timely, research-based knowledge that allows the agencies to play their role as content providers and government competence centres for geographic information and spatial data infrastructures (Streilein *et al,* 2016). Its research activities

covers the entire GI management cycle and works through six commissions, the 6th of which is the knowledge transfer commission. The main purpose of this commission is to support the transfer of knowledge from EuroSDR research projects to NMCAs, academia and industry and to fulfil specific NMCAs demands for knowledge update (Streilein *et al*, 2016). EuroSDR provides a network where research organisations meet with the public and private sector, to share and exchange knowledge and ideas about current trends thus, knowledge and research results are translated into real world applications.

4.4 Results and discussion

4.4.1 Results

Table 14 is a summary of the comparison plus the identified gaps that will guide the design of the upgraded East African Community cartographic services.

Table 14: EuroGeographics and the harmonized EAC services comparison and Gaps

Variable	EAC harmonized model status	EuroGeographics status	Gaps
Fundamental datasets	• NMOs mandate • Mostly up-to-date • Consistent • Easy accessibility(mapping portals) • Not expensive • Incomplete metadata • Not standardized • Basic topographical mapping at 1:50000 • Mostly digital • Improved records storage and retrieval (digital storage)	• NMCAs mandate • Bi-annual update and maintenance plan • Datasets harmonised to EuroGeographics specs and data model • National datasets 1:50,000/1:100,000 less (vector) coverage; raster data available • Harmonised national data, bi-annual update scheme include: EuroBoundaryMap (1:100,000) admin units; EuroRegionalMap (1:250,000); EuroGlobalMap (1:1,000,000);EuroDEM (60 m) ; National names gazetteers accessible through service infrastructure (EuroGeoNames) • EuroDEM 25/30m production by demand • EUREF defines European reference system: horizontal (ETRS89) & vertical (EVRF2000). • Open ELS Europe's gateway • ELF project for standards, specifications, tools and technical infrastructure • National level and EU online web portals • Promote and define ESDI by Expert groups • Research on EuroSpec project prior to European Reference data specifications creation	• EAC lacks: Organizational structure; harmonised data model and specifications and pan-EAC products • Interoperability scheme • Open location based services, • EAC Geoportals • Research on GI harmonization • Key GI stakeholders, • Harmony in production and exchange of GI
Metadata	• Metadata available • Revised catalogues • Harmonised in language (English)	• New metadata services [discovery level service] • EuroGeographics decentralized system for local maintenance • Profile based on ISO 19115-Multilingual) ''gateway''	• Metadata not harmonised to international standards(ISO and OGC) • Not decentralized
Policy and legal environment	• Mandate of NMAs • Relevant laws available • Mapping regulations up-to-date and consistent with modern mapping equipment • Varies per country • Awareness of mapping laws and regulations • Most PMOs unregulated	• Mandate of National Mapping agencies • EuroGeographics' members run by national laws, international treaties and, for EU members, the European policy and legal framework • EuroGeographics provides the focal point for coordination of NMA activity to implement INSPIRE in policy areas e.g., reference data, metadata, data quality etc. • Relevant and modern policy e.g., Open data and PSI, collaborative mapping • Standardized, transparent licensing and pricing agreements	• Lack of regional initiatives to structure GI • No standards in policy issues such as PSI, Open data access, licensing, restricted access, IPR, pricing agreements etc. • Harmonized policies and laws that span EAC borders

Hardware and software (Technology)	• Modern equipment • Maintenance mechanism in place • Adequate and complete • Commercial software blended with extensive adoption of FOSS • Plagiarized software minimal	• Modern equipment as presumed from the state of art the projects being implemented • High technology uptake evidenced by several projects done under EuroGeographics e.g. the block chain technology for property registration by Sweden • Projects have well-defined technical framework (data type, data model, delivery formats etc.) • Based on COTS e.g. Esri suite • ISO and OGC compliant specifications	• No defined technical frameworks • Existing specifications country specific and not ISO and OGC compliant • No consensus on what EAC needs
National atlases	• Available • Custodian is the NMO • Up to date • Digital in all states • In English in all states	• No European regional atlas • Member states with National/regional atlases • Have up to date reference maps • Web based access • Digital	• Web access to National atlases lacking
Geographical names gazetteers	• Available in all EAC member states • Custodian is NMO; English • Up to date and digital (50%)	• Pan EuroGeoNames (EGN) • Implemented throughout the EU • Available as a web service • The service is ISO/OGC compliant	• Lacks complete digital and up-to-date Geonames coverage • Not harmonised • No web service
Professional GI associations	• Available in all member states • Majority of Geo-information professionals are members • Registering all GI professionals • Active individual membership	• Available in most countries under EUROGI coordination • At national level, either corporate or individual membership • More than 1 GI association in member states • International level; national professional GI association or pan-European organization type of membership • High awareness levels and participation in GI issues • Platform to share best practices and expertize through KENs- expert working Groups • Independent of government • Engages governments on GI matters e.g., policy • Attracts many sponsors hence more funding	• No umbrella GI body • No more than one GI association for EAC members • Few membership types • Few partnerships • Poor communication with members and stakeholders
Training institutions	• Increased institutions • Mostly public and private • More GI cadres at all levels • Up-to-date curricula • Specializations similar • Traditional specializations e.g. Cartographer, Surveyor, Photogrammetrist improved	• Bologna Declaration, 1999 enabled compatibility and mutual recognition of academic qualifications • Open European Area of Education & Training facilitated students/teachers movement across states(recognition of study programs and diplomas) • European Credit Transfer System supports movement • Traditional GI programs of geodesy, surveying and cartography well entrenched in the higher education curriculum	• No GI education harmonization framework • No EAC GI website for news and information • No networking, collaboration and exchange programs • No research on GI in education and training

	• Mode of instruction: theory, labs and industrial attachment • Improved staffing at all levels • Improved training opportunities • GI specialization in Burundi • Improved resources , hence no overcrowded classrooms • Moderately equipped labs	• EEGECS project supports networking (provide info on international education programs, research, scientific projects) • EduMapping test if GI education in Europe is ready for EQF by use of GI-BoK • GI-N2K an EC project to improve the GIS&T BoK; results indicate that it was unknown in Europe thus not fit as a knowledge domain reference • GI education in Europe characterized by: • Few universities offering undergraduate degree programs in GIS, GIScience or geo-spatial technologies; rapid growth in university GIS modules; GI courses perceived as highly 'technical' and rarely used to teach technology	• No publications for GI in education • EAC GI Mutual Recognition Agreement not signed yet(July, 2018)
Funding	• Increased national government allocation • NMAs mostly self-funding • More donor funding	• EC for European-wide projects and member states • NMAs self-funding (central government) • Awareness on GI value, greater political support • Partners with organizations e.g., PPP,OGC • Sustainable funding, investment and charging mechanisms put in place by Member States and maintained in accordance with Policy Principle No. 8. of INSPIRE	• GI activities not funded by EAC • Few funding models • Poor political awareness and support • No EAC-level Open data policy to stimulate GI uptake
SDI status	• Policy and legal frameworks available • Digital up-to-date datasets • SDI awareness higher • Metadata not standardized • Relevant staff available • Improved technology • Political awareness higher • Improved SDI readiness	• The EU Directive 2007/2/EC to establish an Infrastructure for Spatial Information in the EU (INSPIRE) applies for all member states • Directive being implemented in most of the EU member states • SDI status not uniform • Political, legal, organizational, and cultural differences amid member states significantly impact on GI harmonization • Overall implementation status half-way	• Lacks an INSPIRE type of Directive • No legal framework • Data non-interoperable • Political, legal, organizational, and cultural variances
Personnel (staffing)	• Majority in public sector • Bachelor's degree holders • Majority under 40 years • Well trained • Most job cadres available • Improved remuneration • Well equipped • Good working conditions • Improved capacity building	• EuroGeographics employs over 66,000 people • Modern equipment and technology • Well trained and continuous capacity development • Open forum for members and invited experts ensures a common vision for pan-European GI • Employees in various sectors affiliated to GI • Members can easily access experts via seven Knowledge Exchange Networks (KENs) • Cooperation between EuroSDR, NMCAs and academia ensures research results translate into real world applications	• Poor knowledge of modern techniques • No forum to exchange ideas, knowledge and expertise • A disconnect between academic research and policy formulation

4.4.2 Discussion

Acting as the hub for NMCAs, the EuroGeographics has succeeded in the management of NMCA's activities towards INSPIRE implementation in policy areas e.g., reference data, metadata, data quality etc. EuroGeographics boasts of a well-defined reference framework for Europe, courtesy of projects like the ELF, EUREF, EuroSpec and the ETeMII White paper whose results were instrumental in defining specifications for an interoperable Europe. For instance, EUREF defines European reference system; the horizontal (ETRS89) and vertical (EVRF2000); Open ELS provides Europe's gateway to location based services, while the ELF project developed the standards, specifications, tools and technical infrastructure for Europe. These are attributed to the INSPIRE objectives and the vision of EuroGeographics and captured in the words of Luzet (2003) *the requirements for implementing the EuroGeographics core mission (achieve interoperability of mapping and other GI data within 10 years) and the initial steps envisaged by INSPIRE for developing the ESDI converge in recognising the need for common specifications for reference data.*

These two initiatives have produced several other interoperability projects, pan-European products and research that have propelled the EU countries to the advanced state witnessed in the evaluation. The EuroGeographics has also developed human resource capacity through open forums for members and invited experts which ensure a common vision for pan-European GI. These facilitate knowledge exchange and building networks, particularly the knowledge expert networks (KENs) help members acquire expert knowledge on various geo-information matters.

A key observation contributing to the European success story is stakeholder involvement. This is in line with Land (2003)'s observation that, ''Experience within EuroGeographics has shown that new and innovative organizational models and leadership styles are required to successfully coordinate European activities. A 'network' model in which all stakeholders share a common vision and have real ownership of the activities designed to achieve the vision is more likely to succeed than a more traditional 'centralised' or 'hierarchical' model.

The comparative evaluation and analysis shows that the EuroGeographics and the harmonised EAC cartographic services have a lot of gaps to be filled in order to attain the state of the art model. They arose due to advanced GI organisational structures and legal frameworks in the EuroGeographics that are lacking in the EAC. There are also

commonalities between the two blocs that include the development and maintenance of fundamental datasets and the definition and implementation of national GI policies by the respective NMAs. Thus, the EuroGeographics' members are run by national laws and international treaties and, for EU members the European policy and legal framework.

4.5 Conclusion

The research questions:

- What is the current status of the EuroGeographics has been answered and it is concluded that an INPIRE-type of Directive is needed for the East African community, to be implemented by all the member states. This will require a new administrative structure and leadership approach for successful coordination of the EAC GI activities.
- How does the EuroGeographics compare with the harmonised EAC cartographic services? This too has been answered and it is concluded that the observed disparities between the EuroGeographics and the EAC cartographic services call for further upgrade and harmonisation to the state of the art in order to realise not only interoperability but also comply with international standards.

CHAPTER 5: ROADMAP FOR UPGRADING THE HARMONIZED EAC CARTOGRAPHIC SERVICE MODEL TO THE STATE OF THE ART

Chapter summary

Poor access to relevant information suppresses the growth of the information society. Fortunately today, the concept of regional integration has minimized this by opening up country borders for trade and investments. In the EAC for instance, article 5(1) of the common market protocol gives the scope of cooperation as: *"The provisions of this Protocol shall apply to any activity undertaken in cooperation by the Partner States to achieve the free movement of goods, persons, labour, services and capital and to ensure the enjoyment of the rights of establishment and residence of their nationals within the Community*" (EAC, 2009). Similarly, barriers to full exploitation of cartographic services within the EAC and beyond ought to be removed. The study fulfils this need by recommending a roadmap for a harmonized state of the art EAC cartographic service.

To reveal the gaps/barriers to cartographic harmonization, a comparison of the harmonized EAC cartographic service was carried out using the variables consistently used in this study, i.e. fundamental datasets, metadata, SDI status, policy and laws, hardware and software (technology), national atlas, geographical names gazetteer, funding, professional associations, training institutions and personnel. The results revealed many disparities that required further upgrade and harmonization to the state of the art in order to realize not only interoperability but also comply with international standards. Thus, the main objective of the chapter is to propose a roadmap for realization of the state of the art EAC cartographic service, including time frame and cost. This has been achieved and the roadmap is estimated to cost 22,402,800 USD and to be achievable within 60 Months. The geographical names gazetteers, fundamental datasets, technology and personnel are seen as critical factors in the attainment of the state of the art because they are both capital and time intensive. For this reason, they may require further break down into short and long term goals.

5.1 Introduction

5.1.1 Background

The state of the art in a field or discipline is "the highest level of general development achieved at a particular time" (Buckley and Gartner, 2013). In this context, it means the

highest level achievable by the EAC cartographic service in terms of all the study variables' upgrade and persistence to comply with international standards.

Study objectives linkages

The overall objective of this study was to determine the status of cartographic services in the EAC member states and to subsequently derive a roadmap for a harmonised, state of the art EAC cartographic service. Figure 11 shows the specific objectives plus their interlinkages.

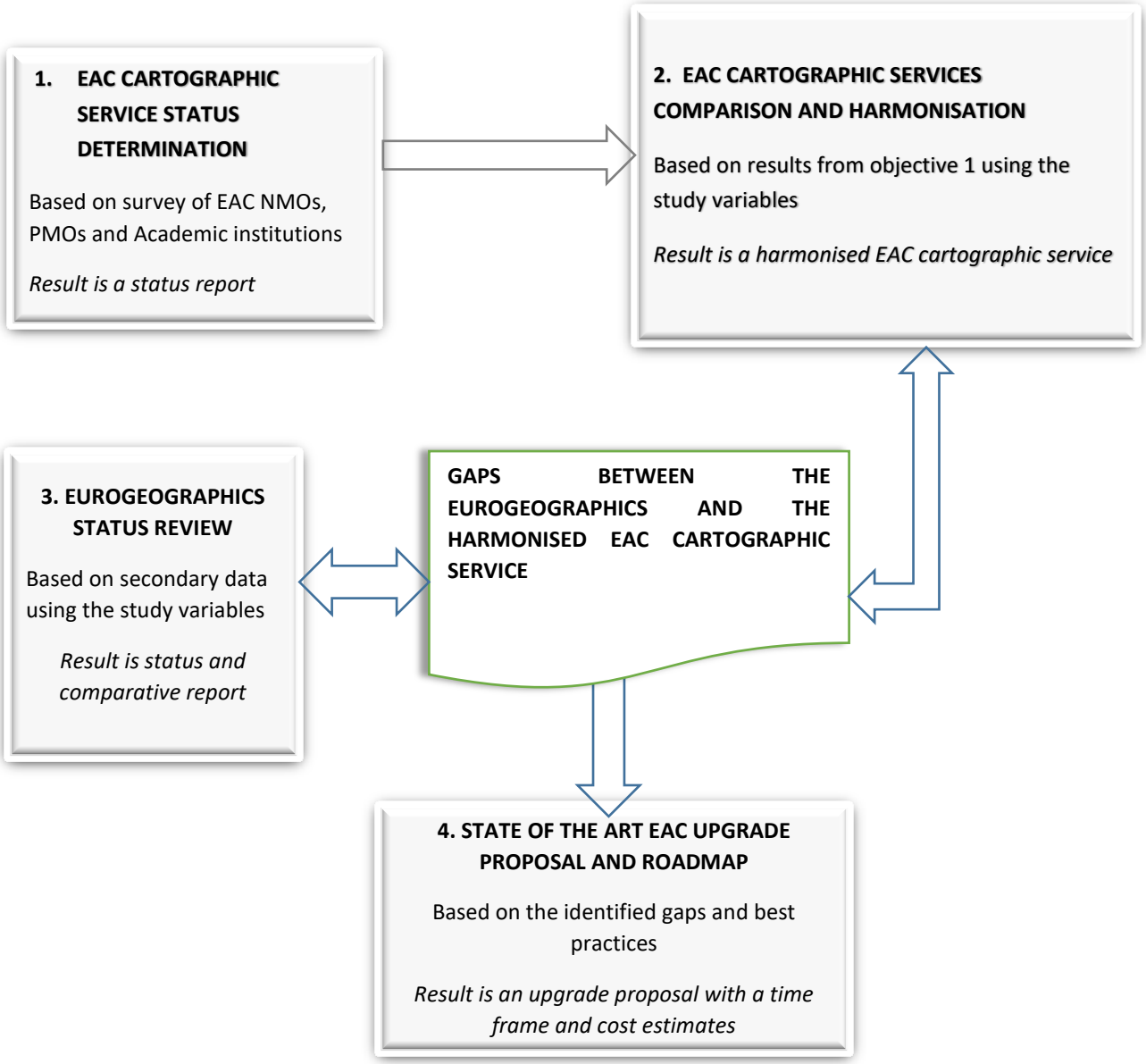

Figure 11: Study objectives linkages

Impact of technology on geo-information

Mapping has undergone a technological renaissance, new opportunities have opened and the renaissance continues. Today many organisations collect all kinds of data and information using GPS, aerial and satellite imagery, new sources of data from LIDAR to SAR and the Internet and low cost desk top systems have brought capability to the reach of many (Heipke *et al*, 2003). Likewise Cartography, the art, science and technology of map making has not been spared; hence we come across terms such as the ‘‘paradigm shift’’ while others call it ‘‘democratization’’. And truthfully ‘‘democratization’’ it is as it has enabled anyone equipped with a desktop computer and software to make a map, any map for that matter. Never mind that the accuracy and quality of such maps are never guaranteed. The downside is that prized information is worthless if it is not fit for purpose. This applies to maps as well which are understood as tools to support decision making and whose accuracy should not be compromised. Cartographers are important to check the quality and accuracy of these maps plus other GI products.

Geographic information framework

Today, the adoption of GI in various applications backed by technological advancements has motivated the need for information with simple to display, process and use services. Thus, GI has moved from Desktop computers to the smartphones, and even more to the mainstream information society. Consequently, experts are required to collect, assemble and integrate GI into applications, whereas data suppliers should implement common standards and steady methods that are consistent with Information Systems industry. This means that in order to satisfy the current needs of society, standardization is an inevitability. Heipke *et al* (2003) summarised the basic characteristics of a framework for geographic information as: high quality geographic information, fit for purpose reference information that is georeferenced to this base by a wide variety of users; maintained information to a level of currency to meet user’s needs; richer attribution of features; connected information and is easy to geo reference, link and is effectively plug and play increasingly meeting the needs of mainstream information systems integrators; adheres to practical standards and principles; is inclusive to all those who collect information and need to link it to or analyse their environment and supported by a rigorous systems infrastructure with clear and consistent licensing and business models to sustain all of this.

5.1.2 Statement of the problem

Economic and political integration of East Africa have been expanding since its second founding in 2000, and more with the accession of Rwanda and Burundi in 2007 and South Sudan in 2016. Recently, the Democratic Republic of Congo has also expressed interest to join the East African Community as the 7th member (Mutambo, 2019, para. 1). Driven by the provisions of the common markets protocol article 5[1]; *the free movement of goods, persons, labour, services and capital* (EAC, 2009), greater regional assimilation is foreseen and this is expected to stimulate the demands for harmonised spatial data to support regional decision making. Meanwhile, the question of how or what it would take the EAC to achieve a harmonised and state of the art cartographic service or information infrastructure must have escaped the minds of many regional GI scientists in the EAC. This is because the NMOs and RCMRD have done nothing towards the development of a regional GI policy. Further information shows that the EAC secretariat in Arusha does not have in its strategic plan a program concerning GI (J. Kivuva, personal communication, April 16, 2019).

The findings of a similar study carried out in the European Union showed that GI policies and relevant technologies such as geographic information systems have key roles to play in regional accession (Craglia and Messer, 2002). A comparison of the harmonised EAC cartographic services with the state of the art showed the EAC to be in need of improvement as they applied only national or no standards, lacked harmonised legislative frameworks and web access to the harmonised services, lacked technical specifications etc. Once implemented, the harmonised and state of the art EAC cartographic service will promote interoperable, effective and efficient problem solving tools across the EAC countries and organizations, thereby reducing cost associated with country-specific GI capacities while providing effective and timely information to decision makers.

5.1.3 Objectives and research questions

The main objective was to propose a roadmap for realization of the state of the art EAC cartographic services, including time frame and cost. To realise the objectives the following research questions were framed:

i. What should be done to close the gaps between the harmonised EAC model and the EuroGeographics?
ii. How much would it cost? and
iii. How long would it take?

5.2 Literature review

The roadmap

A roadmap is a path towards the attainment of an organization's vision. A well designed roadmap should be based on best practices while concentrating on the organisation's mission, goal and objectives. Roadmaps require financial and political support in order to be successful hence, their development should align well with the organization's priorities, in this case, the EAC. Funding is specifically a critical element because governments often change while sustainable funding and support should be maintained. Roadmaps chart the path necessary for the attainment of the organisation's vision by stating the goals, objectives and initiatives necessary for its success.

Fortes and de Araújo (2013) gives a graphic illustration of these factors as in Figure 12.

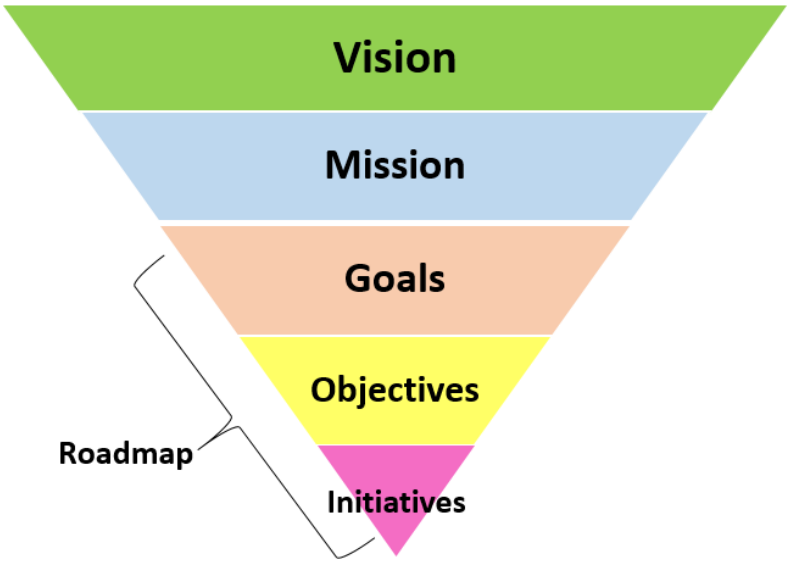

Figure 12: Key Strategic Plan or Roadmap Elements

Source: Fortes and de Araújo (2013)

It should be noted that there are currently no established local services to validate the EAC cartographic service roadmap. However, efforts that are closely related to cartographic services are the SDI development and specific projects (such as MAFA and AFREF) which could offer valuable insights.

The United Nation Economic Commission for Africa (UNECA) in collaboration with the International Cartographic Association (ICA) launched the Mapping Africa for Africa (MAFA) initiative (Economic Commission for Africa, 2007) with the aim of harmonising the

fundamental geo-spatial data in Africa. Several resolutions were made that targeted individual member states. They include the inventory of existing geo-spatial data sets and related metadata, improvement of mapping standards to international level and institutions working on topics related to mapping should avail the booklets in key official languages, such as English and French to mention a few. According to Clarke (2018), the determination of fundamental geo-spatial datasets for Africa, catalogue of available fundamental geo-spatial datasets (in-country and foreign), and the determination of gaps in available fundamental geo-spatial datasets have been completed. However, compliance with international standards and language harmonisation especially in the EAC still remains a challenge that must be addressed.

The Africa Reference Framework project (AFREF) is designed to unify the co-ordinate reference systems in Africa using Global Navigation Satellite Systems (GNSS) and, in particular, the Global Positioning System (GPS) as the primary positioning tool (Wonnacott, 2005). Designed to support the goals of NEPAD, the AFREF project plans to achieve a standardized and reliable coordinate system all over Africa. Largely, implementation of the AFREF/RTN has been very slow with a few countries such as South Africa, Botswana, Rwanda and Namibia having complied. Successful cartographic data harmonization has been demonstrated in the AFRICOVER-EA project that has availed timely and location-specific land cover data for ten African countries.

Pertaining to higher education in the EAC, the Inter University Council of East Africa (IUCEA) is authorised to coordinate the advancement of higher education and research in the Community. Hence, the IUCEA is being enhanced during the period of Vision 2050 to encourage educational institutions to harmoniously consider adopting good practices in the management of the institutions of higher learning to respond to the needs of the development agenda of the region (EAC, 2015).

Scope

The study proposes a roadmap that begins with the:

- Identification of the gaps arising from the review and comparative evaluation of the EuroGeographics and the harmonised EAC cartographic service model,
- Suggestion or proposal of solutions to close the identified gaps and
- Estimation of the cost and time needed to address the said gaps.

In proposing what should be done to upgrade the EAC cartographic service to the state of the art, issues such as the general architecture, specifications and organisational structure are addressed as well.

5.3 Methodology

5.3.1 Assumptions and generalizations

To accomplish this objective, assumptions and generalizations were made that include:

- The existence of a EuroGeographics-type of organization to coordinate the stakeholders from all the EAC member states and availability of support from the EAC secretariat in Arusha.
- Guarantee of political support in all member states.
- Uniformity in the cost of travelling, fuel, per diem and remuneration across the region.
- Availability of implementation funds.
- Apart from per diems and travelling allowances, monthly emoluments were not included in the perks as it was assumed that the participants had full time jobs in their countries.
- Availability of adequate personnel to carry out the upgrade proposal.
- All other costs applied in the region.

5.3.2 Research design

The objective was achieved by analysing the gaps arising from the comparison between the harmonised EAC cartographic services with the EuroGeographics. The gaps were analysed based on the variables consistently used in this study. These are: fundamental datasets, metadata, SDI status, policy and laws, hardware and software (technology), national atlas, geographical names gazetteer, funding, professional associations, training institutions and personnel.

The gaps were analysed and interventions generated to close them, as follows: Since every gap required an action or more to address, the possible interventions were gathered from relevant literature, knowledge and best practices to define a suitable intervention for each gap. For instance, what actions were needed for the fundamental datasets to become available, accessible and interoperable across the EAC? The interventions ranged from awareness creation workshops, capacity building activities to equipment purchase to mention

but a few. As each intervention required resources in terms of personnel, capital and time, this too was costed and a time span allocated to it. Overall, each variable had several activities with a total cost and timeframe. The adopted approach is shown in Figure 13.

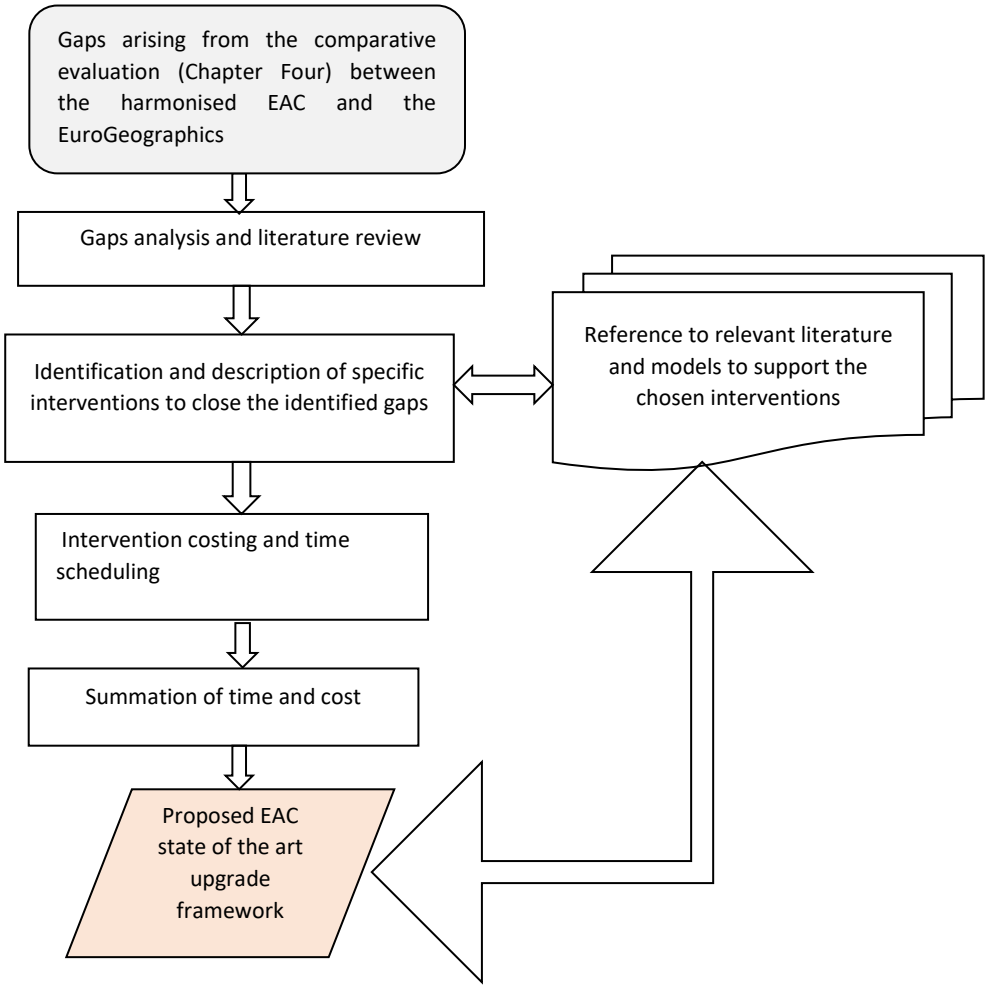

Figure 13 : Proposed state of the art upgrade flowchart

5.3.3 Analysis of gaps and roadmap design

Fundamental datasets and metadata

The upgrading of fundamental datasets and metadata will be founded on the European Location Framework (ELF) and the INSPIRE guidelines. The ELF is a technical infrastructure with the aim of providing an authoritative, interoperable geo-spatial reference data from all over Europe. Realization of the framework was via the ELF project that delivered a unique gateway to the authoritative reference geo-spatial information for Europe (harmonised pan-European maps, geographic and land information) sourced from the NMCAs around Europe and including transparent licensing (Pauknerova *et al*, 2016). This

resulted into a single harmonised European cross border service that delivered web maps through a website as well as applications for view and download services. The EAC upgrade roadmap desires a platform similar to the ELF's with the ability to integrate all national level reference geo-spatial datasets to be delivered to users and application developers through either open source or proprietary cloud platforms.

Gaps and what should be done to close them

a) Lack of harmonised cartographic specifications and data models, standardized metadata profiles, EAC level Geoportals and pan-EAC cartographic products. These gaps will be closed through the following:

   i) The project, Mapping Africa for Africa (MAFA) helped in the determination of the fundamental geo-spatial datasets for Africa plus a catalogue of their national and foreign availability (Schwabe *et al*, 2007). Thus, while the themes were determined, they lack interoperability in terms of data model, language, and coordinate systems among others.

   ii) A strategy to attain the harmonised fundamental data themes for East Africa should be developed and implemented based on the ELF and INSPIRE as the ELF realisation empowers the implementation of INSPIRE in Europe (Pauknerova *et al*, 2016) by complementing activities associated with European NMCAs. For the EAC to attain the state of the art standard, key pillars of data interoperability as described in INSPIRE Conceptual Framework documents will be applied. The key pillars are Conceptual Models, Encoding, Harmonised vocabularies and Registers and they are described by D2.5: Generic Conceptual Model; D2.6: Methodology for Specification Development; D2.7: Guidelines for Encoding; D2.9: O&M Guidelines and D2.10.3: Common Data Models (Tomas, 2013) documents.

   iii) The prevalent use of fundamental datasets necessitate that they are broadly accessible to many users without abstract doubts and with a means in place to ease discovery, which demands metadata description. Schwabe *et al (*2007) suggests that the following elements as essential when capturing metadata for fundamental datasets: originator of the dataset, publication date, title of the dataset, format of the dataset, description of the dataset, purpose of the dataset, date of completion, status of dataset (e.g. completeness), contact details of custodian, accuracy of attributes, accuracy of spatial data, scale of maps,

projection/coordinate system, datum, ellipsoid, access constraints, use constraints and distribution information and spatial boundary extent. These factors should be considered by the metadata working group.

iv) Design and launch of spatial data repositories that accommodate OGC compliant Web Map Services (WMS), Web Feature Services (WFS) and Web Tile Services (WTS) requirements for discovery, access and download.

v) Harmonised pan-EAC products will be achieved through specific pilot projects commissioned in member states that serve to test different themes such as topographic maps, geographical names gazetteers etc. for interoperability.

vi) Lack of research on cartographic harmonization approaches can be achieved by commissioning of research to define areas that require harmonisation including modern mapping approaches that utilize Volunteered Geographic Information (VGI).

vii) Promotion of the adoption and implementation of the developed framework among all the stakeholders and the general public. This is important as people can only embrace what they are aware of. The awareness should articulate the key benefits of the new harmonised cartographic service particularly to the citizenry which can be achieved via conferences, workshops, seminars, brochures, fliers, print, electronic, social media etc.

Total estimated implementation cost is $2,818,500 in approximately 60 months
(See Appendix F1)

SDI status

A report back by member states at the UNECA's Committee on Development Information Science and Technology (CODIST) in May 2009 further confirmed that SDI had limited impact in ensuring that geo-spatial information was being used to address the development needs of the continent (Schwabe and Govender, 2009). Sub-regional organisations e.g. RCMRD were not able to help due to financial constraints despite having adequate expertise. This necessitated the African institutions to engage with EUROGI and agreed to the concept of the Africa-European Spatial Infrastructure Alignment (AESI-Align) initiative, with the hope that lessons learnt through INSPIRE would be transferred to African institutions and also lessons learnt in Africa would be communicated to institutions in Europe (Schwabe and Govender, 2009).

Gaps and what should be done to close them

a) Building partnerships and raising awareness amongst all geo-information stakeholders from public, private, non-governmental organizations, academic institutions, policy makers and politicians should be the starting point in addressing the lack of a harmonised regional policy and subsequently a RSDI. This should be preceded by a meeting of regional GI leaders to deliberate on the need followed by formation of an SDI organizational structure to spearhead the process.
b) With an SDI organizational structure in place, the political, legal, organizational, and cultural variances between member states should be determined and addressed. This can be done through the relevant working groups which should evaluate the variances in order to find a solution.
c) The low SDI status of the EAC members can be addressed through legislation of an INSPIRE-like Directive of the European council. This can be done by rallying all GI stakeholders to come up with a memorandum of understanding and subsequent formation of relevant working groups to prepare the draft of the proposed Directive. If approved by the EALA, the Directive would set the pace and the time lines for NSDI implementation in all the member states.
d) Convening of a delegate's workshop of all stakeholders in the region. This should help to publicise the policy/Directive and seek support from the data users and suppliers; public, private and academic sectors and other participant organisations. It should be multi-stakeholder based.
e) To be acceptable, the defined RSDI policy strategy must align with national as well as regional policies.

Total estimated cost = $1,056,000 in approximately 42months

(See Appendix F2)

Policy and laws

Gaps and what should be done to close them

While successful spatial data infrastructure initiatives are closely linked to the overall policy environment in the jurisdiction in which they are implemented, the INSPIRE's primary alignment is with EU environmental policy (Fortes and de Araújo, 2013). Policy requirements can be achieved in many ways for instance, a policy may be drafted that safeguards stakeholder needs, or focuses on the user needs, or that satisfy both. In the EAC, policy issues of concern include: cartographic production process, data sharing,

sensitive/confidential information, privacy concerns, intellectual property rights (IPR), licensing agreements, volunteered Geographic Information (VGI), data storage, cloud computing and location based services across borders.

a) Although lead agencies already exist at national levels, a regional level coordinating organ is assumed, consisting of representatives from NMOs who are already in charge of GI policies in their respective countries. It must begin with the creation of awareness on the need for relevant cartographic policies and standards and the benefits accruing from them. This can be achieved through seminars, workshops, conferences, publications, brochures, fliers and social media (twitter, Facebook, etc.).
b) Prior to policy formulation, a needs assessment should be done to ensure that key GI policy issues are identified and deliberated upon.
c) Policy formulation and development should be through a multi-stakeholder approach to addresses their needs. The list of stakeholders should comprise the NMOs, academia, industry, legal experts, cartographic associations, standards bodies, ICT, security and NGOs. Sometimes it is unclear which agency has the mandate to take the lead for the topic covered by the policy, so it is important to identify who owns the issue and what the respective roles of the key stakeholders will be (Fortes and de Araújo, 2013). After the initial deliberations, working groups should be formed based on expertise to come up with a draft proposal.
d) Adoption of the draft proposal by the stakeholders and the public, which calls for public participation at the formulation and development phase. After going through the East African Legislative Assembly (EALA) and if adopted it is ready for implementation. The drafters should agree on an implementation period which should give everyone ample time and resources to attain. The result will be harmonized policies and laws spanning the East African borders.
e) Development of a new Web portal devoted to GI issues and projects within the services of the East African community.
f) Continuous monitoring, documenting, and publicizing of data policy changes occurring at national/regional level in East Africa and in the international arena.

Total estimated cost is $1,227,500 in approximately 48 months

(See Appendix F3)

Hardware and software (Technology)

In the context of this study, technology refers to the hardware and software needed to support cartographic data collection, processing, production, analysis, reproduction, archiving and dissemination and also includes the network infrastructure necessary to support data exchange, visualization, view and download services. This makes the state of the art technology attainment both capital and time intensive.

Gaps and what should be done to close them

a) On the lack of consensus of what the EAC requires in terms of technical architecture and specifications; consensus should be built through a multi-stakeholder approach and bench-marking. This should be followed by the appointment of an all-inclusive team to deliberate on the desired technical frameworks and specifications for the EAC that are ISO and OGC compliant to support discovery, exchange, view and download services. The EuroGeographics technical architecture should be a useful guide.

b) Definition of an EAC state of the art cartographic services architecture and the technologies required for its implementation. This is followed by the development of a high capacity, secure and scalable network connectivity enabling real-time access to combined spatial data services (NSW Government, 2016). This ensures that spatial data and services are made available to a large number of relevant stakeholders.

Note: After the harmonisation of the EAC cartographic services, equipment and software would have been acquired, hence there was no equipment budget in this section.

Total estimated cost is $ 1,452,500 in approximately 60 months
(See Appendix F4)

National Atlas

Gaps and what should be done to close them

a) Since web access to National atlases is lacking in the EAC, a web portal should be designed to facilitate web access of EAC national atlases preceded by a harmonization framework. This is because it would be an effort in futility to provide disparate atlases that are not comparable. It will be accomplished through the formation of an Atlas coordination committee for initial deliberations who should be appointed from different organizations from each country. Other Atlas coordination and compilation activities would include:

- A one-day workshop for all stakeholders to create awareness among data suppliers from every organization that will be involved.
- A three-day workshop where the atlas compilation committee will meet half-yearly six times to design the atlas specifications and data model. This would give member states ample time to comply with requirements.
- A one-day workshop where all stakeholders review and adopt the proposals presented to them.
- A workshop for the final compilation and publishing
- Design and launch of the EAC Atlas geoportal

Total estimated cost= $946,250 in approximately 48 months
(See Appendix F5)

Geographical names gazetteer

The International standardization of Geographical names encourages the development of standards in order to ease the international exchange of goods, services and improve co-operation in the field of intellectual, scientific and economic activities.

Gaps and what should be done to close them

The harmonised EAC gazetteers lacked a full digital coverage and up-to-datedness. Likewise, member states' gazetteers were not available as web services hindering discovery and use. These gaps would be addressed concurrently by:

a) Organisation of the first Geographical Names meeting with key stakeholders mostly from NMOs as the custodians and members of the Geographical Names Authority in their respective countries. Other important stakeholders include: the UN Group of Experts on Geographical Names (UNGEGN), private organizations and academia. Expert services of surveyors, cartographers, geographers, linguists should be exploited as required. It is assumed that the policy issues have already been addressed.
b) The formation of a committee to formulate, adopt and define the guiding principles and practices that it will apply during operation. The deployed standards should be ISO and OGC compliant to help publish, discover, and send, use and study the Geographical names data through the internet across EA. This will extend the usage of country names beyond national borders. The scale of representation should be agreed upon.

c) As the intention is to achieve the EuroGeographics standard, the EA Geographical Names specifications, architecture and implementation should follow the guidelines for data harmonisation and specifications developed by INSPIRE and the EuroSpec initiative of the EuroGeographics (Sievers and Zaccheddu, 2005). Modifications may be done to fit the EAC framework where possible.

d) Awareness creation among all stakeholders and the public. This should be accomplished through one day workshop involving around 100 people from all countries.

e) Development of an implementation strategy within an agreed timeframe by setting targets and schedules. This should be done in four phases (thus, initiation, development, first implementation and testing and second implementation and sustainability) because it requires a substantial amount of money and time.

Total estimated cost= $9, 199,750 in approximately 60 months
(See Appendix F6)

Funding
Gaps and what should be done to close them

Compared with the EuroGeographics, the EAC is characterised by low funding and few funding options/models other than the national governments. This dual gap will be addressed by application of several approaches namely;

i. Creation of awareness especially among the EAC secretariat staff to make them buy-in the value of GI in order to allocate funds for its development.
ii. Seeking more beneficial partnerships in order to expand funding options and attain sustainable funding mechanisms
iii. Promotion of the benefits of GI to attract more support by involving citizens in GI activities such as demonstrations and corporate social responsibilities.
iv. Pursuing greater political awareness and support through intense awareness campaigns on the value of GI in critical cross-border activities such as environmental conservation, security monitoring, disaster risk mitigation and infrastructure development among others.
v. Investing in research and reports for more funding justification
vi. Promotion of the information market at regional level which should stimulate more demand for spatial data and services.

Total estimated cost is $600,750 in approximately 30 Months

(See Appendix F7)

Professional associations

Gaps and what should be done to close them

a) Although there exists a bit of cooperation among national GI associations in EA (specifically ISK, IST and ISU), there are no clear legal and organizational structures on which to base these previous engagements. Hence, the first thing should be the establishment of an umbrella EAC-wide professional association similar to EUROGI to provide coordination and leadership, thus resolving the lack of coordination on GI matters. This must be different from the Association of Professionals Societies in East Africa (APSEA) that brings together professional bodies of various disciplines in Kenya after the collapse of the initial EAC in 1977.

b) Awareness creation through a one-day workshop with delegates from all the member states to draw up more partnerships. This should converge all the potential players in both the demand and supply side of the GI sector irrespective of whether they are in the public or private sectors as they play a fundamental role in developing the GI capacity within each nation (Wolfkamp, 2003).

c) Develop an organizational structure to define the Articles of constitution, regulations and objectives of the association. This can be achieved by adopting the European Umbrella Organisation for Geographic Information (EUROGI) vision, whose founders envisioned a European-wide organisation to advance the interests of the GI community. They also presented EUROGI as an organisation that would not "*replace existing organisations but …catalyse effective cooperation between existing national, international, and discipline oriented bodies to bring added value in the areas of Strategy, Coordination, and Services*" (Burrough *et al,* 1993). This should be emphasized so that existing GI associations do not feel threatened.

d) The need to expand membership to include other geo-related professionals, marketers and developers should be highlighted as well as registration of more than one GI body per country. This is critical because in most developing countries, only one GI body is registered with rigid laws that exclude most of the other professionals such as Geographers, Cartographers, GIS specialists, ICT and GI software vendors among others who are viewed as ‘‘outsiders’’ by the mainstream GI associations.

e) Election of office bearers led by the president, executive committee and the secretariat. The General Board is also formed consisting of all participating countries. A constitution is made that will guide the operations of the organization followed by registration of the organization as a legal entity in the country of operation.

f) With office bearers, office and registration, work can begin. At this point, research would be encouraged to identify and recruit more GI players and possible partners in EA who will assist in funds mobilization to finance GI activities. Also an awareness campaign should be done so as to attract as much support as possible from all sectors.

Total estimated cost =$769,250 in approximately 48 months
(See Appendix F8)

Training institutions

Gaps and what should be done to close them

a) Due to the free movement of persons and labour provided for in the Common Market Protocol (CMP) articles 76 and 104, there is need to improve collaboration in higher education institutions so as to harmonise and continuously update the GI curriculum to match the technological advances and international standards. This will enhance the employability and international mobility of students, researchers and teachers in the geo-spatial profession.

b) Through the Inter-University Council for East Africa (IUCEA), a Geo-spatial organization should be formed and tasked with:
    - The promotion of collaboration and networking in GI training and education to promote joint educational projects and e-learning activities;
    - The development of links between the universities and professionals so as to standardize University and Diploma curricula. This will enable the mobility and employability of the holders of these qualifications.
    - The resolution of the disconnect between academic research and policy formulation and research on GI in education and training.
    - Promotion and the development of a harmonized policy framework that would provide for the establishment of a Research and Innovation Coordination Unit (RICU). RICU would be responsible for planning and coordination of regional research, innovation and capacity building programmes as developed by IUCEA in partnership with higher education institutions and other stakeholder institutions and with international strategic partners (EAC, 2015).

c) On the lack of mutual recognition of GI professionals, the East African Qualifications Framework for Higher Education (EAQFHE) should be fast tracked to ensure that its recommendations are implemented in the operationalization of Article 11 of the CMP

which is the guiding mechanism for mutual recognition of qualifications among the Partner States.

d) An EAC website for news and information on higher education programs and requirements, job opportunities etc. is lacking. A website for news and information on higher education programs and requirements, job opportunities among others should be designed and launched.

e) An East African GI magazine should be launched with contributions from all member countries to address the lack of publications on GI education.

Total estimated cost =$799,000 in approximately 48 months

(See Appendix F9)

Personnel

Gaps and what should be done to close them

a) Formation and launch of an EA-GI resource hub with a common vision for the region to address the lack of a forum to exchange ideas, knowledge and expertise. Personnel should be allowed to join international professional organizations to be acquainted with what is happening elsewhere.

b) Lack of knowledge of modern mapping techniques such as the latest VGI and UAVs should be accomplished through retraining of personnel to improve their capabilities.

c) Low capacity building should also be enhanced through proper technology transfer to local staff so that when the donor funded projects are over, there is continuity even after the project closure. In addition, those lucky to attend international training programs should also transfer the acquired skills to the staff at the working place.

Total estimated cost is $3,532,800 in approximately 60 months

(See Appendix F10)

5.4 Results and discussion

5.4.1 Results

The results, which are detailed in the preceding section 5.3.3, and are summarized in Table 15.

Table 15 : The proposed roadmap for the state of the art EAC cartographic service

DATA	ACTIVITY	PERIOD IN MONTHS/ COST IN US DOLLARS											
		0	6	12	18	24	30	36	42	48	54	60	TOTAL(USD)
Fundamental datasets	Stakeholder conference	223,750											
	Design data model and specifications.		1,560,000										
	Geo portal development						19,000						
	Metadata profiles						72,000						
	Research on inventory						180,000						
	Interoperability research								150,000				
	Framework adoption										223,750		
	Final report										390,000		
													2,818,500
SDI status	Meeting to deliberate status	9,750											
	Awareness and building of consensus		223,750										
	Draft proposal writing			195,000									
	Draft proposal						223,750						
	Draft proposal comments							180,000					
	Draft adoption								223,750				
													1,056,000
Policy and laws	Consensus building	223,750											
	Follow up workshops		97,500										
	Draft			390,000									
	Public participation.						180,000						
	Draft adoption							223,750					
	Web portal design and launch							15,000					
	Draft to EALA for adoption								97,500				
													1,227,500

Hardware and software	Awareness and consensus building	223,750											
	Bench-marking by technical team		750,000										
	Definition of technical requirements			255,000									
	Workshop							223,750					
													1,452,500
National Atlas	Atlas committee	33,750											
	Awareness workshop		223,750										
	Atlas compilation		382,500										
	Review of the proposals							223,750					
	Final compilations								67,500				
	Web portal design								15,000				
													946,250
Geographical names	Awareness workshop	110,000											
	Formation of working groups		28,750										
	Data collection			8,874,500									
	Progress inventory							28,750					
	Design of geoportal							19,000					
	Review workshop								110,000				
	Final report									28,750			
													9,199,750
Funding	Awareness workshops	360,000											
	1-day workshop			223,750									
	Report writing				15,000								
	Publication and newsletter					2,000							
													600,750
Professional associations	Initial deliberations	19,500											
	Delegates workshop		102,250										

	Executive members meeting			39,000									
	Annual general meeting						223,750						
	2 research studies							60,000					
	Awareness campaigns								102,000				
	Conference								223,750				
													769,250
Training Institutions	Deliberations	19,500											
	Draft harmonised curriculum			255,000									
	Research			60,000									
	Web portal design and launch.							15,000					
	Publication launch							2,000					
	Adoption of proposed curriculum								223,750				
													799,000
Personnel	Retraining											1,080,000	
	Capacity building											1,800,000	
	Exchange programs											652,800	
													3,532,800
GRAND TOTAL		**1,223,750**	**3,592,250**	**10,292,250**	**15,000**	**2,000**	**898,500**	**991,000**	**1,213,250**	**28,750**	**613,750**	**3,532,800**	**22,402,300**

5.4.2 Discussion

The proposed roadmap gives the path that should be followed for the attainment of the state of the art EAC cartographic services. It contains the activities, time schedules and priority areas to begin with. It is clear that awareness creation, initial deliberations and stakeholder identification dominate the first year activities as they are prerequisites for further engagements. A summation of all the necessary interventions shows the upgrading of the harmonised EAC cartographic service to the state of the art would cost approximately 22,402,300 US Dollars. The implementation period is estimated to be 60 months (5 years) if all the activities run concurrently because 60 months is the time taken by the longest running activity. Out of this, 9,199,750 USDs goes to the data collection and development for the geographical names gazetteers. The high cost is due to the current status of the EAC gazetteers which have been completely abandoned. It is noted that the first year requires less than 5,000,000 USD to begin, or 25% of the total budget.

Of all the ten elements due for upgrading, it should be noted that collaboration in higher education has been on-going through the IUCEA, hence this study recommends that they should factor all training including technician level. This way, a framework for advancing from technician to professional will be clearly spelt out.

The roadmap indicates that the geographical names gazetteers, fundamental datasets, technology and personnel are critical to the attainment of the state of the art because they are both capital and time intensive. For this reason, they may require further break down as short and long term goals to give ample time for resource mobilization and possible partnerships. Conversely, awareness campaigns, organizational structures and building partnerships are seen as the short term goals because they do not require a lot of resources.

5.5 Conclusions

The research questions for this chapter were:

i. What should be done to close the gaps between the harmonised EAC and the EuroGeographics?
ii. How much would it cost? and
iii. How long would it take?

These have been answered and it is estimated that the said gaps can be closed at an approximate total cost of 22,402,800 US Dollars and achievable within 60 Months. Geographical names gazetteers, fundamental datasets, technology and personnel are seen as

critical factors in the attainment of the state of the art because they are both capital and time demanding. This is justified as fundamental datasets are necessary to achieve socio-development goals of any country and through development of a well-structured and comprehensive data foundation that would be accurate, consistent and compatible not only on local level but as well as national level (Rautenbach, 2015).

CHAPTER 6: IMPLEMENTATION FRAMEWORK FOR THE STATE OF THE ART EAC CARTOGRAPHIC SERVICES

Chapter Summary

The chapter gives a summary of tools to support the state of the art cartographic implementation. These are arrangements to aid the roadmap implementation process. For instance, the operational structure shows how the model will be anchored within the other EAC organs, the proposed EAC cartographic specifications showing the elements being harmonised and the technical architecture for spatial data discovery, access, view and download services. An overview of the different sectors that this service will support are given as a cost benefit case. An overview of the roadmap risks and potential benefits are also highlighted.

6.1 The EAC cartographic service operational structure

The roadmap for an upgraded Cartographic service has been completed but requires a structure to support its operationalization. The designed framework comprises all the six participating member states headquartered in Arusha, Tanzania with the summit at the top. The service should function in line with the other organs of the community. For example, the service should be under the council of ministers responsible for Surveying and Mapping in the member states which is the policy organ of the community. The service would be under a team of experts (the Cartographic Service Technical Advisory Committee) who make recommendations to the sectoral committee of Surveying and mapping which are then passed to the coordination committee (Permanent secretaries of Surveying and Mapping in respective member states).

The main function of the coordination committee is to receive and consider reports of the sectoral committees and submit reports and recommendations to the council of Ministers (Ogalo, 2012). It should be noted that the sectoral committee of Surveying and Mapping does not currently exist but it will be created for the purpose of overseeing Surveying and mapping issues of regional importance. A management board, reporting to the technical advisory committee would ensure that the working groups and project teams are run smoothly by providing funds and other logistics. This operational structure is shown in Figure 14.

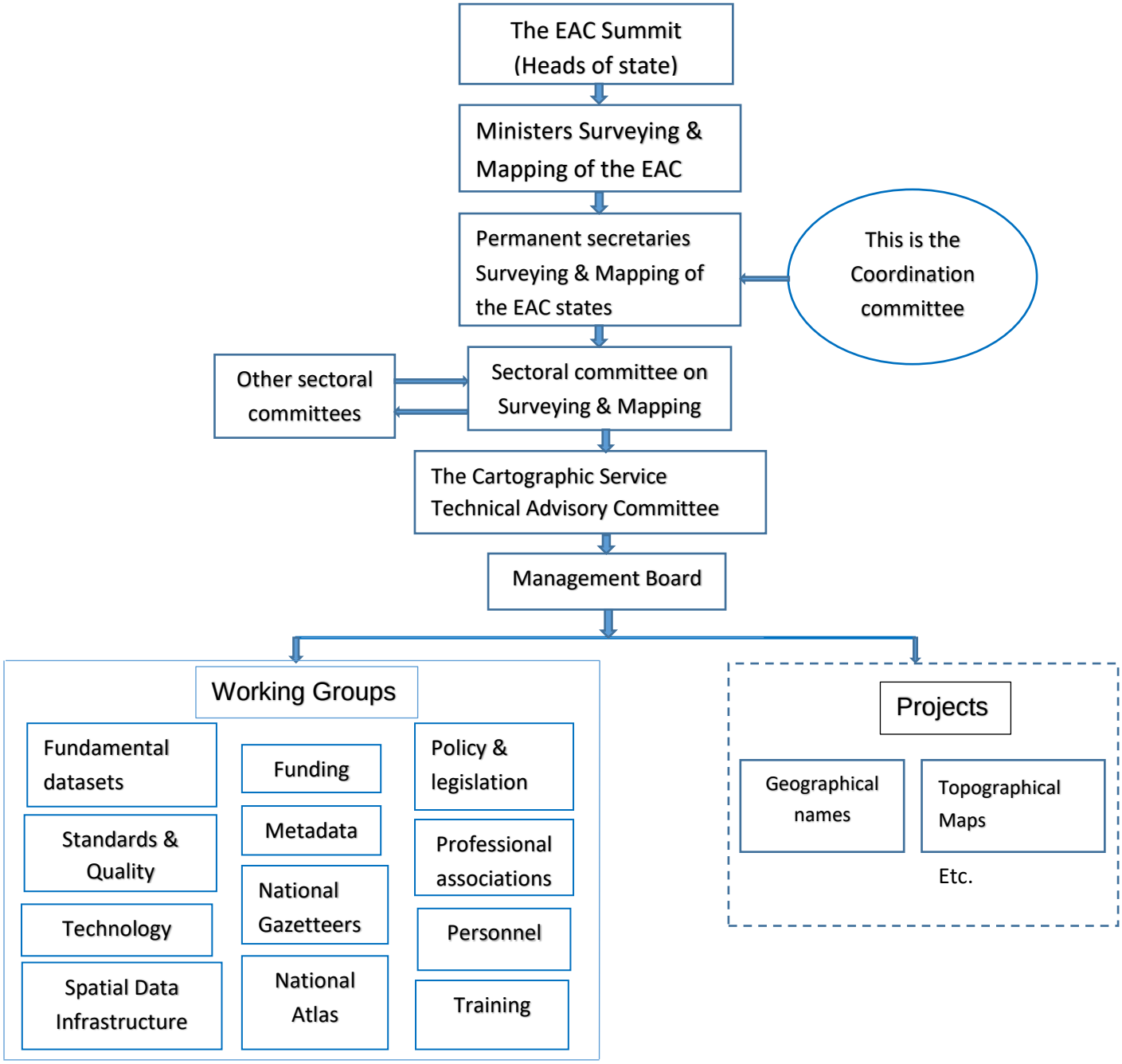

Figure 14 : Proposed EAC cartographic service operational structure

6.1.1 Working Groups (WGs)

These are specialists and technical experts responsible for designing the upgrade in various areas in order to achieve full cartographic services interoperability. The study variables used in this study have been used to create the working groups ensuring that every variable was taken into consideration.

a) Fundamental/Core datasets WG

It will be responsible for all interoperability aspects of fundamental datasets including thematic definition, dataset custodianship, update cycle, data model definition, specifications and quality.

b) Metadata WG

It will be responsible for metadata research and development.

c) Funding WG

The WG will be responsible for resources mobilization and will work closely with the management board. While project budgets are expected to come entirely from the Board, WGs are facilitated at member state level with little support from the Board. Thus, WG members are individual experts from different countries who have a common goal but working in their respective countries.

d) Policy and legislation WG

This group must ensure that relevant policy and legislation are in place to facilitate cartographic services upgrade. The policies must also support the objectives of the EAC in the integration process. They must address fully pertinent questions such as public sector information (PSI), confidentiality, restricted access, licensing agreements, pricing, intellectual property rights (IPR), copyrights, open data access among others.

e) Standards and quality WG

Standards are a powerful tool to drive both political and technological implementations, they help to refine the different choices to organisations and help information to be used and interpreted in the same way (UNGGIM, 2014). Working in conjunction with international and national standardization organisations, the WG will define and recommend the adoption of relevant standards to facilitate cartographic services discovery, download, exchange, publishing and visualization based on international standards. The WG will also be responsible for designing quality standards into processes and products and later monitoring and evaluation to

ensure compliance with those processes. Its deliverables will be quality assessment reports.

f) Technology WG

This working group will be responsible for the technical architecture that will entirely support proposed upgrade consequently, facilitating distributed and networked cartographic data access. A fully functioning spatial data infrastructure architecture for instance provides users with the functionality to discover the type of data they are seeking, to visualize the data online to confirm that it will meet their needs and, if so, to access the data directly (Fortes and de Araújo, 2013). The WG must thus order research into the appropriate architecture and supporting technology to help in its implementation. Other areas to consider facilitating technological implementation include hardware and software, Geoportals, services such as the Web Map Service, Web Feature Service and the Web Catalogue Services among others. Due to its complexity and technical demands, this WG will require expertise beyond GI such as information and communication technology (ICT) and security.

g) Training WG

The WG will be responsible for training at Diploma and University levels. It is expected to guide on curricula review, update and harmonization structure; an equalization of degree and diploma programs framework; research; a structure to support students and teachers' mobility and establishment of a training institute. It should work in liaison with the IUCEA.

h) Personnel development WG

This WG will be responsible for continuous capacity development of GI personnel through retraining, staff secondments and knowledge exchange networks among others.

i) Professional associations WG

It will be responsible for the formation of an umbrella professional GI association in the EAC with membership limited to corporate, sponsor or national GI association.

j) National geographical names gazetteers WG

The goal of this WG is to develop a pan-EAC Geonames as a web service to facilitate definitive and authoritative place names and State Boundaries of east Africa.

k) National atlas WG

This will work towards the creation of an EAC level atlas with web access and based on standard symbols and specifications.

6.1.2 Projects

This refers to specific projects and prototypes that will be used to test the implementation of the state of the art. For instance, a pilot project for fundamental datasets implementation would require a project that differs from training; These are anticipated after implementation has begun. At the beginning, the projects are not ready but they are foreseen because it is through them that the upgrading will be realised, measured and monitored.

6.2 Proposed EAC cartographic services specifications and technical architecture

6.2.1 Proposed EAC cartographic services general specifications

Figure 15 is a diagrammatic representation of the general EAC cartographic service configuration. The harmonized EAC specifications apply to the fundamental datasets, metadata, SDI, policy and laws, technology, national atlas, geographical names gazetteer, funding, professional associations, training and personnel. The services boast of EAC-wide products from authoritative national sources, referred to as data authors (Figure 15) produced using international standards and specifications by respective NMOs or other authorised organizations. The datasets are located in distributed sources across the region where users can access and assess what they need via geoprocessing services. The common specifications also imply comparability of academic qualifications, ease of labour movement and employability of EAC personnel. In this architecture users refer to the public sector, non-governmental organisations, research organisations and academia. The main role of users is consumption and utilisation of the data and information obtained from the cartographic service in their day to day activities. The services aggregated from the member states would be made discoverable and accessible to the users via an integrated geoportal (https://github.com/Esri/geoportal-server/wiki/What-is-a-geoportal-and-the-geoportal-server).

Experiences in Europe in relation to developing seamless data indicate that significant harmonization work is needed, and that for each theme a specific working group or organisation needs to be appointed with the task of undertaking this work (Heipke *et al*, 2003). The harmonised EAC model acts as a one-stop-shop for all matters related to cartographic services and for the member states, compliance is mandatory.

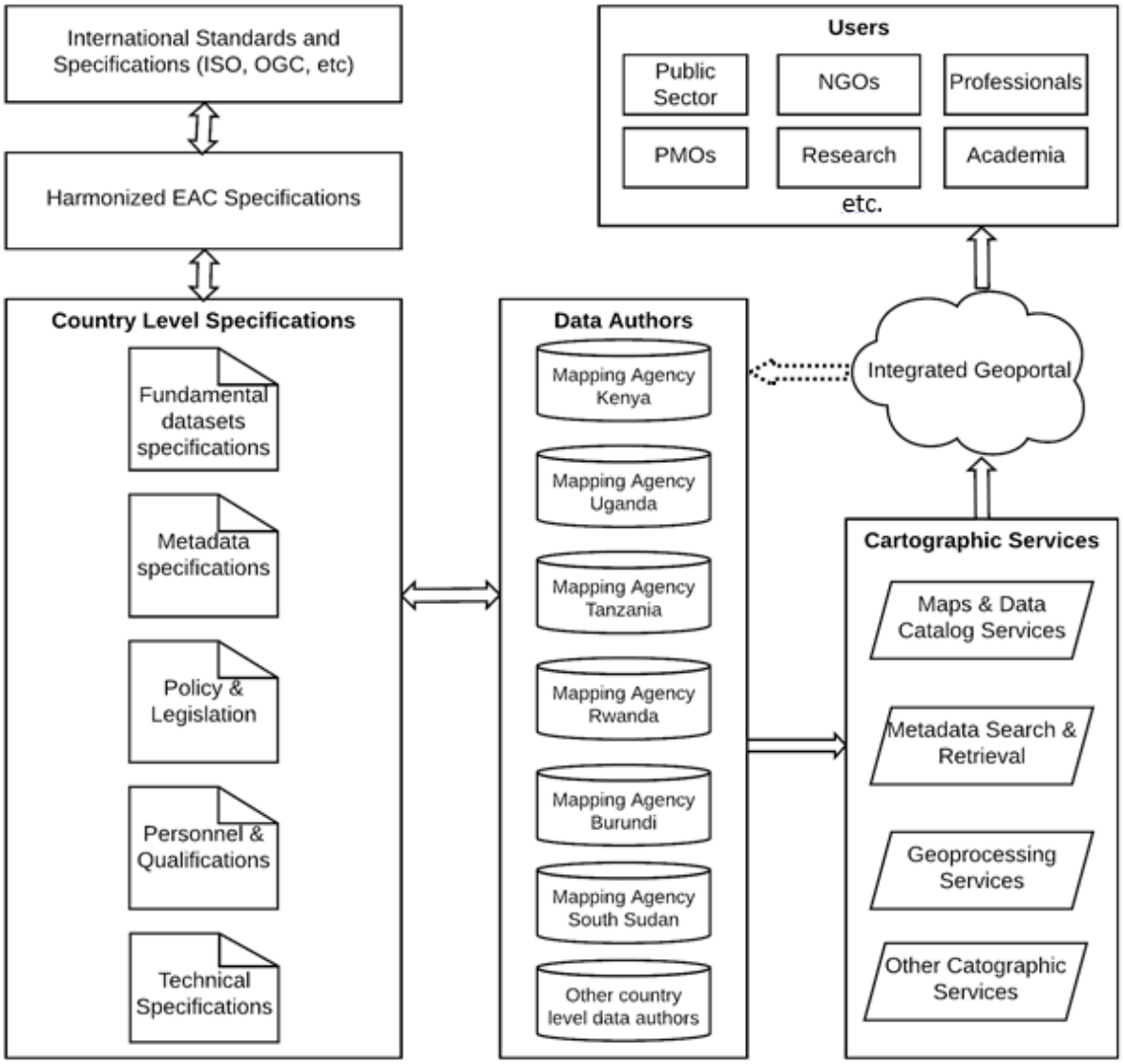

Figure 15: The proposed EAC cartographic services general architecture

6.2.2 Proposed state of the art cartographic service architecture and web services

A cartographic service is a form of web service that provides the functionality to publish, search, access, retrieve and process cartographic datasets and maps over the internet. They include:

a) Maps and Data Catalogue Service

Catalogue services support the ability to publish and search collections of descriptive information (metadata) for data, services, and related information objects. Metadata in catalogues represent resource characteristics that can be queried and presented for evaluation and further processing by both humans and software. Catalogue services

are required to support the discovery and binding to registered information resources within an information community (https://www.opengeo-spatial.org/standards/cat).

Maps and data catalogue services created primarily by the **data authors** would enable users to easily discover cartographic datasets within the integrated EAC geoportal. More importantly, the users would be able to determine the suitability of the datasets and maps for their specific needs by investigating the metadata information provided by the data authors.

b) Metadata, Search and Retrieval Service

While a catalogue service provides metadata search and retrieval capabilities, it is important to note that metadata is created according to specified standards. For example the Federal Geographic Data Committee (FGDC) is tasked to enable access to National Spatial Data Infrastructure (NSDI) resources and to support the creation, management, and maintenance of the metadata required to fuel data discovery and access (https://www.fgdc.gov/metadata). When metadata records are formatted to a common standard, it enables the location and readability of the metadata by both humans and machines.

c) Geo-processing Service

More often than not, geo-spatial data can be processed further to obtain result-sets that communicate desired information. Data authors can create and publish geo-processing services that can be used by others to process the cartographic datasets. For example, a service that provides polygon overlay functionalities can be exposed to users online to be able to return datasets that cover specified country or sub-regions from the whole region

Figure 16 illustrates the envisioned low level system architecture of the proposed EAC cartographic service. The diagram adopts a layered approach in illustrating how the different components of the services would interact with each other.

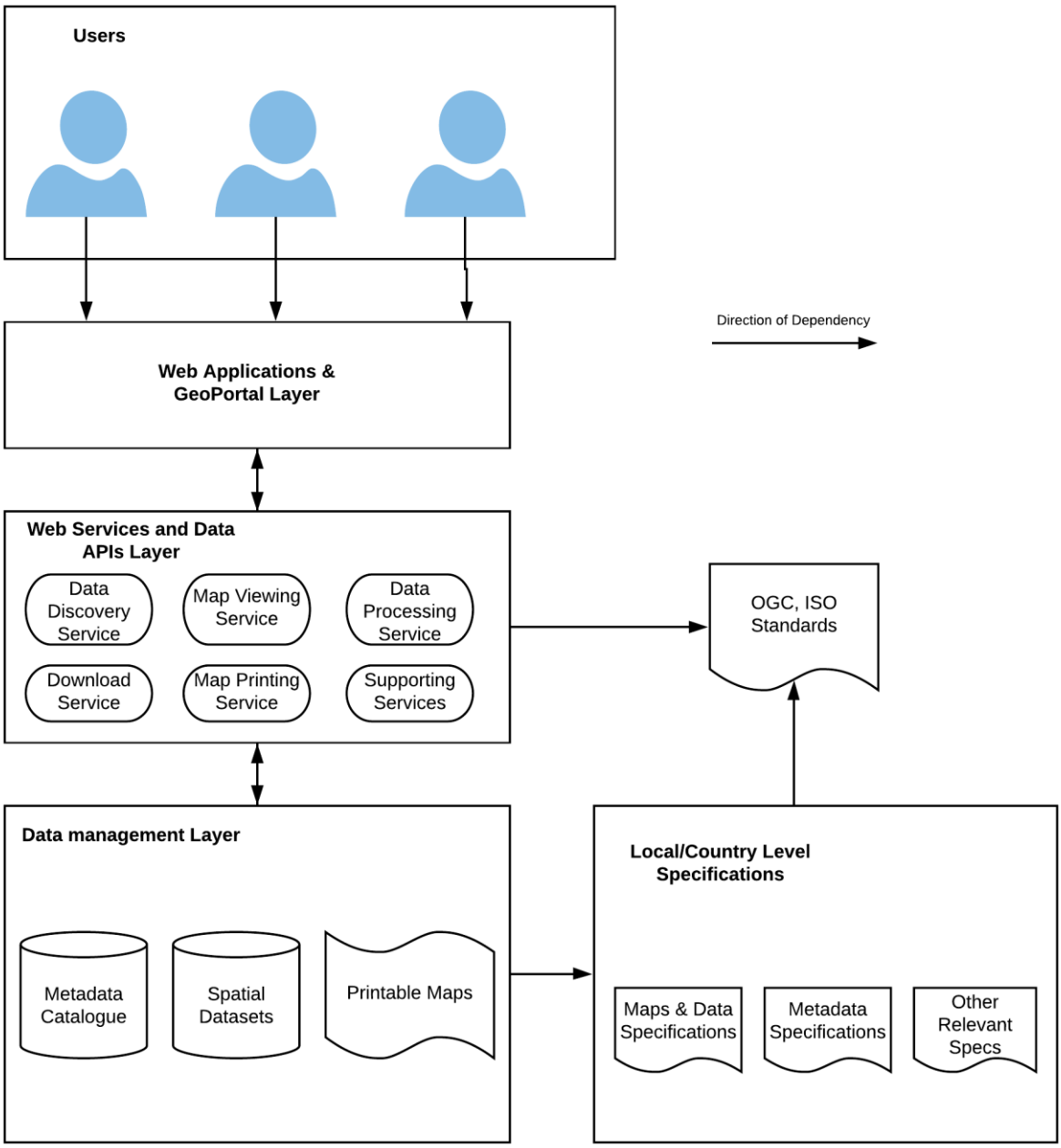

Figure 16: Proposed state of the art Cartographic Service – Low level system architecture

Data Management layer

The data management layer is concerned with the data storage mechanisms used. In most cases different data storage mechanisms would be employed depending on the nature of data. The choice of the data storage mechanism depends on a number of factors, such as: number of individuals accessing the data concurrently, frequency of data change, volumes and types of data, access control and cost of storage (http://michaelminn.net/tutorials/gis-storage/).

Web Services layer

The web services layer enables implementation of the different web service standards required to access, retrieve, analyse, download or present cartographic datasets. The web services layer enables access to the underlying datasets and geo-processing capabilities through standardized protocols and data exchange formats.

Applications layer

The application layer provides web or mobile based apps that users interact with over the internet. For example, the integrated EAC geoportal would sit in this layer abstracting away the web services layer and providing unique capabilities to the users

6.3 Key success factors

Success is the primary goal in any roadmap therefore it should be planned beforehand. For the state of the art cartographic service, the following are believed to be critical success factors of the implementation framework and include:

i) Organisational arrangements

Organizational issues that need to be addressed are coordination at both national and regional levels. In this framework, most activities will be completed at national level, therefore the national government should have a regulatory authority, preferably the NMOs as they are responsible for production, maintenance, distribution and dissemination of the fundamental datasets. The national regulator should publish specifications that the national data providers must adhere to. At the regional level, coordination will be done by the Cartographic Services Technical Advisory Committee. It is the committee that is responsible for coordination of the national regulatory authorities to ensure compliance with the common EAC specifications and implementing rules. The WGs and project teams working on the various harmonisation aspects also work in liaison with this committee for technical guidance. The member states are responsible for their own capacity building efforts. However, if a member state has inadequate human capacity, external assistance at the EAC level may be provided as the idea is to have every member up to the task and compliant.

ii) Technical specifications

These will be developed by the responsible working groups and must be prioritised as implementation cannot begin without the blue print. The EuroGeographics Technical architecture should be a useful guide.

iii) Legislation

Legislation is a critical area because without the requisite law, engagement between organisations would be a challenge because of copy rights and other data publishing issues. Issues concerning dataset pricing and copyrights must be specified in the anticipated law.

iv) Financial arrangements

It is true that funding is key in the preparation and implementation phases of the roadmap. Member states should cater for their costs while long term sustainability is key. Unless a member state is unable to, then regional intervention is an option. The regional office should be able to develop a strong business case for adequate funding.

6.4 Potential risks

The EAC cartographic service being a new concept in East Africa runs the risk of failure due to various reasons such as lack of political support. Political support is necessary for cross-sectoral and/or cross-border interoperability efforts to facilitate cooperation between public administrations (European Union, 2017). All stakeholders should also share the vision of the project in order to support it, otherwise stakeholder buy-in is a risk factor. The cartographic services are expected to benefit many stakeholders ranging from government to non-government organisations, learning and research institutions, the private sector, and the general public at all levels who should be engaged in its development. Lack of funding is a risk because all the activities require adequate and sustainable budget. Although key partnerships are targeted for resource mobilization, funding is a risk factor without which the dream of an EAC cartographic service will remain just that, a dream. Mwange *et al* (2017) suggests self-funding and cost recovery models for sustainable SDI funding, an approach considered suitable for this roadmap.

6.5 Expected benefits

According to Sokacova, (2015) the primary mission of EuroGeographics was to maintain a network to help each member state to improve their capabilities and role; to facilitate access

to members' data, services and expertise; and to provide them with a strong voice. This is what the EAC member states desire to attain:

- Enhance EAC cartographic services interoperability and accessibility
- Contribute to decision making through a strong GI policy
- Promote cooperation and networking between members
- To learn from each other which helps in growth

6.6 Discussion and conclusion

6.6.1 Discussion

The operational structure shows that the cartographic services will function in sync with the other sectoral committees of the community in support of their operations. The general configuration of the common EAC specifications has been demonstrated with harmonisation starting from local to national to regional (EAC) level, indicating both bottom-up and top-down models. This can be likened to the building of national and European SDIs where action is needed at top down (policy frameworks, coordination), and bottom up, integrating what already exists (Heipke et al, 2003). Further, experience within EuroGeographics has shown that new and innovative organizational models and leadership styles are required to successfully coordinate European activities. A 'network' model in which all stakeholders share a common vision and have real ownership of the activities designed to achieve the vision is more likely to succeed than a more traditional 'centralised' or 'hierarchical' model (Land, 2003).

6.6.2 Conclusions

The concept of the state of the art implementation framework has been articulated. This is the basis for further actions as it identifies the areas for further action and the responsible group(s) of people. It's supporting system architectures have also been illustrated using the general configuration and the low level system architecture.

CHAPTER 7: CONCLUSIONS, RECOMMENDATIONS, CONTRIBUTION AND AREAS FOR FURTHER RESEARCH

7.1 Conclusions

The Overall objective of this study was to determine the status of the cartographic services in the EAC member states and to subsequently derive a roadmap for harmonized, state of the art cartographic service in East Africa.

The following were the specific objectives:

i. To determine the status of each EAC member country's cartographic services (including its historical development) and how the services compare amongst themselves.
ii. To determine what needs to be done to harmonize them.
iii. To compare the harmonized model with the state of the art services (modelled on the European EuroGeographics)
iv. To propose a roadmap for state of the art cartographic service, including time frame and cost.

These objectives have all been achieved and the following conclusions made from the results and discussions:

- In view of their inadequate status, there is an urgent need for improvement of the EAC cartographic services including digital conversion and harmonization in order to facilitate seamless geo-spatial data sharing across the EAC region that is needed for regional operations and development.
- An INPIRE-type of Directive is needed for the East African community to be implemented by all the member states. This will require a new administrative structure and leadership approach for successful coordination of the expected EAC GI activities.
- A design for harmonizing the EAC cartographic services has been carried out and its implementation is estimated to take 36 months at a cost of USD 45 million.
- A design for upgrading the harmonised EAC cartographic services model to the state of the art (EuroGeographics) has been carried out and its implementation is estimated to take 60 months, at a cost of USD 23 million.
- An implementation framework including the relevant architectures has been set out.

- The whole operation of improving the present EAC cartographic services to the state of the art is estimated to take 96 months and to cost USD 68 million.

7.2 Recommendations

This study makes the following recommendations based on the conclusions of the study:

- Public value for the improvement initiative should be justified and the EAC governments convinced of its value before implementation.
- A new administrative structure and leadership approach is necessary for the successful coordination of the EAC GI activities.
- Sustainable funding and investments should be made to develop and manage a common fund for the EAC cartographic services.
- Awareness creation and consensus building should be done to ensure that stakeholders, the public, the EAC secretariat and policy makers buy into the idea of improving cartographic services.
- Continuous capacity building by way of relevant workshops, open forums, webinars, online learning tools and operational policy instruments should be carried out.
- The EAC Cartographic Services Technical Advisory Committee, if and when formed should adopt modern approaches in providing their services.
- The Universities in the EAC should consider introducing Cartography as a program and not a support course because 'cartographic democratization' has stimulated interest in mapping, hence the need to train more personnel and increase professional regulation.
- A regional steering committee should be formed to foresee the conception, development and implementation of the improved EAC cartographic services.

7.3 Contribution

Prior to this study, there have been very few studies focused on East African cartographic services. It could therefore be said that this study has produced a body of knowledge that will fill this gap; the authorities and residents of East Africa, and the whole world at large, will be now better aware of these services and how they compare globally. The improvement design that has been documented will be a guide to whichever authority decides, at whatever point in

time, to implement it. This design could also, with necessary adjustments, be implemented in other regions of the world. Should the upgrade proposal of this study be implemented, it will be a step towards developing the EA RSDI which remains in limbo in all the relevant countries.

7.4 Areas for further research

The study recommends that further research should be done in the following areas of concern to build on its findings:

- Maps and data use trends or habits in East Africa as this will assist the planners to estimate prior to committing the funds for the harmonisation, how East Africans use cartographic products and to what extent.
- Establishing the economic worth of Geo-information activities and business in the East African Community.
- Perform prototype or pilot projects using the EAC specifications as a way of learning from experience e.g., edge matching project at the EAC borders
- The surveyed elements in this study could all be studied and researched on individual basis. Thus, a study can be commissioned to survey the training institutions, professional associations etc. more deeply.
- A user needs study should be commissioned to understand what the users need so as to customize and factor their needs in all areas of harmonisation.
- Further research and inventory should be done to define other areas for harmonisation and upgrade.

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APPENDICES

Appendix A: Questionnaire

ANALYSIS AND MODELING OF CARTOGRAPHIC SERVICES AMONG THE EAST AFRICAN COMMUNITY MEMMBER STATES

The questionnaire is intended to determine the status of the cartographic services in the east African community member states and to subsequently propose a roadmap for a harmonized, state-of-the-art cartographic service in East Africa.

The questionnaire is divided into two (2) parts. Part one contains 15 general questions to be answered by all respondents. Part two is divided into three sections. Section 2A contains questions for national mapping organization employees only, section 2B is for employees from the private mapping organizations and section 2C is for employees from academic institutions.

SERIAL NUMBER: [____]

PART 1: DEMOGRAPHICS AND GENERAL QUESTIONNAIRE TO ASSESS THE STATUS OF CARTOGRAPHIC INFORMATION AND SERVICES AMONG THE GEO-INFORMATION COMMUNITY IN THE STUDY AREA

1. Respondent country of residence

   Burundi South Sudan Tanzania

   Uganda Kenya Rwanda

2. Respondent organisational category

   National Mapping Organization (NMO)

   Private Mapping Organization (PMO)

   Academic Institution

3. Respondent job description

   Cartographer Surveyor Photogrammetrist

   Academic staff GIS professional Senior manager

   Other (specify).....

4. Respondent highest education level

   Certificate Diploma

   Bachelors Degree Masters Degree

   Ph.D

5. Respondent age

   <30 Years 31-40 Years 41-50 Years

   51-60 Years 61+

6. The major activity of your organisation
   Please tick the activity(s) that applies to your organisation

   Geo-information data collection, processing and analysis

   Topographic Map Production

   Geodetic Network Establishment

   Cadastral and Engineering surveys

   Thematic Map Production

   Geo-Information Education /Training

   Other (Name): .....

7. In carrying out the above activity, what standards (if any) does your organization follow?
   International standards (e.g. ISO) National standards

   Organizational standards Industry standards

   Others please specify.....

8. Cartographic manpower
   How many Geo-Information professionals does this organization employ...

   Please fill in the table below the various Geo-Information professionals

Specialist	**Total no.**	**Functional title**	**Highest education level**
Cartographers			
Geo-spatial Engineers(surveyors)			
GIS professionals			
Photogrammetrists			

9. Budget and funding
   What is the source of funding for cartographic/Geo-Information services in your organization?

   National government

   Local government

   Donor/project funding

   Private sources

   Other (Specify): .....

   What is the approximate amount per annum? ..... (US Dollars)

10. Advertisement and awareness creation
    a) Does your organization periodically organise expos and exhibitions to showcase what they do and create awareness among the population?

    Yes No

    b) If yes, how often?

    Monthly Annually other (specify).....

c) How do you advertise your products and services?

Website (Internet)	Focus group discussions among users
Billboards	Public media (Newspapers, TV, Radio)
Bulletins/Brochures/flyers	Seminars and conferences
Others (specify).....	

11. Professional cartographic associations - availability

Do you belong to any professional cartographic association in your country?

Yes No

If "Yes", please list them and tick the appropriate space to indicate whether national, regional or international.

..... |(i) National; (ii) Regional; (iii) International; (iv) Multiple.

..... |(i) National; (ii) Regional; (iii) International; (iv) Multiple.

..... |(i) National; (ii) Regional; (iii) International; (iv) Multiple.

..... |(i) National; (ii) Regional; (iii) International; (iv) Multiple.

In your view, what do you think is the role of professional associations?

.....

12. Cross border cartographic services

a) Does your organization offer any products/services across the East African Community?

Yes No

If yes, name the type of services and where is the service

Services name.....

b) Does your organisation collaborate with other countries for joint mapping projects?

Yes No

13. Harmonization of cartographic services

Harmonization of cartographic services is important for the EAC member states.

Strongly Agree Agree Undecided

Disagree Strongly Disagree

Stakeholders for harmonizing cartographic services:

The following are important stakeholders in harmonizing cartographic services in the EAC member states (State whether ministries, departments, professionals, associations, etc).

.....(.....)
.....(.....)
.....(.....)
.....(.....)
.....(.....)

As a geo-information practitioner, what benefits do you expect from such an integration process?

.....

14. National spatial data infrastructure
    a) Are you aware of NSDI initiatives in your country?

    Yes No

    b) Does your country have a NSDI policy?

    Yes No

    c) Has your organization in any way participated in NSDI initiatives?

    Yes No

    d) If yes, which of the following initiatives are you aware of?

    Training of government staff in GIS

    Collaboration with GI organizations in the private and public sector

    Development of a clearing house for GI data

    Digital cadastral index map creation

    Large scale digital map creation

15. Cartographic services - rating

    In this country, being a cartographic services provider/user and/or trainer, you may have had different encounters. Based on these and your experience, kindly, rate each of the under listed using a scale 1 to 10, the lowest point being the worst and the highest being the best in terms of cartographic service status. Consider the period of your experience is to be the last 5 years.

    (Please select by circling)
    Cartographic service:

    Laws are common knowledge: [1]; [2]; [3]; [4]; [5]; [6]; [7]; [8]; [9]; [10].
    Policies are available and relevant: [1]; [2]; [3]; [4]; [5]; [6]; [7]; [8]; [9]; [10].
    Standards are flexible and interoperable: [1]; [2]; [3]; [4]; [5]; [6]; [7]; [8]; [9]; [10].

Funding is adequate:	[1]; [2]; [3]; [4]; [5]; [6]; [7]; [8]; [9]; [10].
Personnel are adequate:	[1]; [2]; [3]; [4]; [5]; [6]; [7]; [8]; [9]; [10].
Personnel are well trained :	[1]; [2]; [3]; [4]; [5]; [6]; [7]; [8]; [9]; [10].
Training Institutions are adequate:	[1]; [2]; [3]; [4]; [5]; [6]; [7]; [8]; [9]; [10].
Training Institutions are well staffed:	[1]; [2]; [3]; [4]; [5]; [6]; [7]; [8]; [9]; [10].
Training curricula are up-to-date:	[1]; [2]; [3]; [4]; [5]; [6]; [7]; [8]; [9]; [10].
Trainees have increased:	[1]; [2]; [3]; [4]; [5]; [6]; [7]; [8]; [9]; [10].
Procedures are mostly manual:	[1]; [2]; [3]; [4]; [5]; [6]; [7]; [8]; [9]; [10].
Technology is modern:	[1]; [2]; [3]; [4]; [5]; [6]; [7]; [8]; [9]; [10].
Professional associations are available:	[1]; [2]; [3]; [4]; [5]; [6]; [7]; [8]; [9]; [10].
Professional associations are proactive:	[1]; [2]; [3]; [4]; [5]; [6]; [7]; [8]; [9]; [10].
Level of awareness is good:	[1]; [2]; [3]; [4]; [5]; [6]; [7]; [8]; [9]; [10].

PART 2: CARTOGRAPHIC SERVICE ASSESSMENT

PART 2A: ASSESSING THE STATUS OF CARTOGRAPHIC INFORMATION AND SERVICES AMONG THE NATIONAL MAPPING ORGANIZATIONS (NMO)

[ONLY RESPONDENTS FROM THE NATIONAL MAPPING ORGANIZATIONS SHOULD FILL THIS SECTION]

16. **LEGAL OR REGULATORY MANDATE OF NMO**
    Please state the legal mandate of the NMO……..

    …….

17. Laws and policies
    a) Under which laws are cartographic services provided in the country?
    Law (Mention Title)..... (Year of enactment).....

    Law (Mention Title)..... (Year of enactment).....

    b) Does your organization have the following policies concerning cartographic information and are they being enforced?

No.	Policy	Availability	Enforcement
1	Copy right		
2	Intellectual property rights		
3	Pricing		

18. Maps – categories and format
    At what scales are basic topographic maps products (series) produced and maintained?

    Please choose the category closest to your scales.

    Category 1: 1:1,000 or greater

    Category 2: 1:5,000 or greater

    Category 3: 1:25,000 or greater

Category 4: 1:50,000 or greater

Category 5: 1:100,000 or greater

Category 6: 1:250,000 or greater

Category 7: 1:500,000 or greater

Category 8: 1:1,000,000 or smaller

Please state the format of the topographic maps from the selected category.

Category 1: 1:1,000 or greater | (i) Digital [ ]; (ii) Analogue [ ]; (iii) Both

Category 2: 1:5,000 or greater | (i) Digital [ ]; (ii) Analogue [ ]; (iii) Both

Category 3: 1:25,000 or greater | (i) Digital [ ]; (ii) Analogue [ ]; (iii) Both

Category 4: 1:50,000 or greater | (i) Digital [ ]; (ii) Analogue [ ]; (iii) Both

Category 5: 1:100,000 or greater | (i) Digital [ ]; (ii) Analogue [ ]; (iii) Both

Category 6: 1:250,000 or greater | (i) Digital [ ]; (ii) Analogue [ ]; (iii) Both

Category 7: 1:500,000 or greater | (i) Digital [ ]; (ii) Analogue [ ]; (iii) Both

Category 8: 1:1,000,000 or smaller | (i) Digital [ ]; (ii) Analogue [ ]; (iii) Both

19. Maps - age
Please state the age of the selected category (years).

Category 1: 1:1,000 or greater | (i) <5; (ii) 5-15; (iii) 16-30; (iv) >30

Category 2: 1:5,000 or greater | (i) <5; (ii) 5-15; (iii) 16-30; (iv) >30

Category 3: 1:25,000 or greater | (i) <5; (ii) 5-15; (iii) 16-30; (iv) >30

Category 4: 1:50,000 or greater | (i) <5; (ii) 5-15; (iii) 16-30; (iv) >30

Category 5: 1:100,000 or greater| (i) <5; (ii) 5-15; (iii) 16-30; (iv) >30

Category 6: 1:250,000 or greater | (i) <5; (ii) 5-15; (iii) 16-30; (iv) >30

Category 7: 1:500,000 or greater | (i) <5; (ii) 5-15; (iii) 16-30; (iv) >30

Category 8: 1:1,000,000 or smaller | (i) <5; (ii) 5-15; (iii) 16-30; (iv) >30

20. Please state whether the following maps are available in your country and indicate the scale, format and percent of area covered by the maps.

Map	**Availability**	**Scales**	**Format**	**% coverage**
Cadastral				
Administrative Boundaries				
Charts				
Aerial Photographs				

Satellite Imagery				
Urban/towns				
Roads				

21. Maps – cost and sales
    a) What is the approximate cost of a single copy of any map?
    <$5 $5-10 $11-20 >20 Do not know

    b) How would you rate map sales in your organization**?**
    Above average Average
    Poor Below average

22. By what method is national topographic mapping undertaken?

    Field surveys Crowd sourcing by Volunteers

    Third Party Data Sources Satellite imagery

    Other (specify)..... Photogrammetric

    Does your country have a national gazette on geographical names?

    Yes No Do not know

    If yes, what is the format and age of the national gazette?

    Analogue / Paper..... Age.....

    Digital..... Age.....

23. Does your country have a national atlas?
    Yes No Do not know

    If yes, what is the format and age of the national atlas?

    Analogue / Paper..... Age.....

    Digital..... Age.....

24. Cartographic equipment – type and software
    Please list the cartographic equipment in use. Tick in the appropriate space to state whether the equipment is analogue or digital

    ..... (1) Digital).....(2) Analogue)

    ..... (1) Digital).....(2) Analogue)

    ..... (1) Digital).....(2) Analogue)

    ..... (1) Digital)..... (2)Analogue)

Do not know

If the equipment is digital, Please state the software in **use** and if it is **free** or l**icence** is paid

.....

.....

.....

.....

Not applicable

25. Skills training - short courses
Have you attended any short courses for skills improvement in cartography?

Yes [(i) In-country; (ii) Abroad; (iii) Both]

No

If yes, how long was the training?

< 1 month 1-2 months 3-6 months

26. Threats
a) What do you think are the major threats to your organizational growth?

Competition from private mapping organizations

Lack of awareness on the importance of geo-information

Stringent government policies

Unfair competition with other public organizations

Not keeping up with technological advancements

Lack of well-trained manpower

Inadequate government funding

Other (please specify).....

b) Do you consider your organization digital?
Yes No
Give reasons for your answer.....

c) What do understand by the term volunteered Geographic Information (VGI).....?

What threat does VGI pose to your organization?
-
-
Would consider VGI for map revision in NMOs?
Yes No
Please explain your response.....

.....

27. **NETWORK CONNECTION**

Is your organisation connected to any network?

Yes No Do not know

If yes, which type?

Local Area Network World Wide Web Other (specify).....

28. **PRODUCTS ACCESS AND DISSEMINATION**

a) How do customers access your services?

Office visit Telephone Email

Website Other (specify).....

b) In what mode are GI products disseminated to customers**?**

Hard copy Digital media

Through the web Email others (specify).....

PART 2B: ASSESSING THE STATUS OF CARTOGRAPHIC INFORMATION AND SERVICES AMONG THE PRIVATE MAPPING ORGANIZATIONS IN THE AREA OF STUDY.

[ONLY RESPONDENTS FROM THE PRIVATE MAPPING ORGANIZATIONS SHOULD FILL THIS SECTION]

29. Policies and laws

a) Under which laws are cartographic services provided in the country?

Law (Mention Title)..... (Year of enactment).....

Law (Mention Title)..... (Year of enactment).....

b) Does your organization have the following policies concerning cartographic information and are they being enforced?

No.	**Policy**	**Availability**	**Enforcement**
1	Copy right		
2	Intellectual property rights		
3	Pricing		

30. Geo-information regulation and quality assurance

a) Who regulates private data/service providers?

The government Professional associations

The private sector No one

Other (specify).....

b) Who implements the quality requirements of data and/or services that you provide to the public

The government Professional associations

The private sector No one

Other (specify).....

31. Geo-information products and services

a) What Geo-Information products (digital or analogue) and services do you offer?

Land surveying

Geo-processing services

Online Geo-Information services provision

Geo-Information sales, training and consultancy

Standard map production

Customized maps production

Other (specify).....

b) List the data type, format and spatial reference of data which you get from the NMO

Data type	**Data format**	**Spatial reference system**

c) When dealing with NMO, what challenges do you encounter?

-

-

d) What is the most commonly used exchange format and the most preferred?

Method	**Current method**	**Preferred method**
Internet		
Email		
Magnetic media/CD, diskettes, tape		
Others (Specify)		

e) What challenges do you encounter during data exchange?
Incompatible data formats

Incomplete information

Poor customer service

Delays in delivery

Inaccurate data

Outdated information

Other (specify).....

32. Threats
a) What do you perceive as the major threat to your organizational growth?

Competition from other private mapping organizations

Lack of awareness on the importance of geo-information

Unfair government GI policies

Unfair competition with the public organizations

Not keeping up with technological advancements

Other (please specify).....

b) Do you think you have what it takes to compete globally?

Yes No

Give reasons for your answer.....

c) Do you consider your organization digital?

Yes No
Give reasons for your answer.....

d) What do understand by the term volunteered Geographic Information (VGI).....?

What threat does VGI pose to your organization?
-
-
Would consider VGI for map updating in your organization?

33. Network connection
Is your organisation connected to any network?

Yes No

If yes, which type?

Local Area Network World Wide Web Other (specify).....

34. Products access and dissemination
    a) How do customers access your services?

    Office visit Telephone Email

    Website Other (specify).....

    b) In what mode are GI products disseminated to customers?

    Hard copy Digital media

    Through the web Email

    Others (specify).....

PART 2C: ASSESSING THE STATUS OF CARTOGRAPHIC INFORMATION AND SERVICES AMONG THE ACADEMIC INSTITUTIONS IN THE STUDY AREA.

[ONLY RESPONDENTS FROM THE ACADEMIC INSTITUTIONS SHOULD FILL THIS SECTION]

35. Please describe your institution

    Public University Private University
    Diploma College (Public) Diploma College (Private)

36. Geo-information-related programmes
    Please fill in the table below by identifying the Geo-Information-related program, curriculum last update, course duration, examiner and the number of trainers.

Programme Name	**Curricula last update**	**Course duration**	**Examiner**	**No. of trainers**

37. Course content delivery mode
    a) How do you teach your students?
    Theory only Theory and practical
    Theory, practical & field attachment

    b) Do you participate in exchange programs with other universities/colleges outside your country?

    Yes No

    If yes, please indicate the program and country

    .....

b) How do you motivate your students.....?
.....

38. Foreign students training
    a) Do you train foreign students from the EAC member states?
    Yes No

    b) If yes, please indicate their number and country of origin for the years indicated below:

Year	Total number	Country
2013		
2014		
2015		
2016		

39. Cartography training status
    a) Do you agree that cartography training/ study has been deteriorating?
    Strongly Agree Agree Undecided
    Disagree Strongly Disagree Do not know

    Give reasons for your answer.....

    b) State some of the challenges you face while performing your teaching duties

    i.

    ii.

    iii.

    c) What benefits do you think a harmonised curriculum would bring to the EAC citizens?

40. Approximately, how many institutions are offering Geo-information Professional training at any level in your country.....?

THE END

THANK YOU FOR YOUR PATIENCE AND PARTICIPATION

For any queries or comments please contact any of the following:

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Appendix B: Equipment cost estimates

This gives a summary of equipment costs, item/activity descriptions and detailed calculations of the cost and time in the process of harmonising and upgrading the EAC cartographic services. The actual figures were obtained from various sources including survey of Kenya, Regional centre for Mapping of Resources for Development (RCMRD), equipment purchase quotations and individual expert narrations.

Cost Estimates

	Item Description	**Unit Quantity**	**Unit Estimate Cost (USD)**	**Remarks**
1	CORS equipment	1	22,000	
2	CORS management software	1	50,000	can manage 1000 CORS
3	Large format(A0) HP Designjet-Plotter	1	15,000	
4	Wide image scanner(A0)	1	15,000	
5	Digital Aerial photography	$1KM^2$	300	
6	RTK GPS		15,000	
7	A server	1	20,000	
8	Software			Inclusive of Installation &Training of the software
	- ArcGIS 10.5,	1	10,000	Unit cost per licence
	- Adobe	package	2000	
	-ArcView	package	3000	
	- MapInfo	package	2000	
9	Computer Hardware & Accessories	1	1,000	Laptops & Desktops
10	Handheld GPSs	1	300	
11	Filling cabinet	1	200	
12	Safe	1	2000	
13	External disks 1TB	1	100	
14	Photocopiers	1	3000	
15	Printers	1	600	
16	Digital cameras	1	1000	
17	Miscellaneous		500,000	

Source: Compiled by the author

Appendix C: Activity description and costs per unit item

No	**Description of the item**	**Unit**	**No.**	**Unit Cost (USD)**	**Remarks and assumptions**
1.	Day Conference Package	Persons	1	35	Conference facility
2.	Full board conference package	Persons	1	200	Conference facility
3	Internal meetings an workshops	Persons	1	10	Tea and snacks served
4	Transport by road in country to and from	Persons	1	50	Cost apply in the region
5	Transport by air in EA return ticket	Persons	1	800	
6	Fuels costs -Diesel and -petrol	Litre	1	1 and 1.1 respectively	
7	Approx. annual remuneration	Person per month	1	600	Assumed to be uniform for all
8	Per diem	Person	1	70	
9	Web design	Website	1	2000	
10	Topographical map sheet digitizing (1:50000)	Per sheet per person/per day	1		
11	Geographical names gazetteer data collection and updating	Per sheet/per team/per day	Team	517	Team is a group of five persons with one vehicle
12	Software training package	Per person/day	1	100	
13	Management training courses	Per person/month	1	1400	
14	Banners	Piece	1	150	
15	Roll-Up Adverts	Piece	1	100	
16	File Folders	Pieces		1	
17	Printing Papers	Reams	1	6	
18	Airtime (communication)		1	10	
19	Name Tags & Holders	Tags (pcs)	1	1	
20	Flash Disks	Piece (8GB)	1	10	
21	Tonners	Piece	1	150	
22	Highlighters (Yellow, Blue)	Piece	1	1.4	

Source: Compiled by the author

Appendix D: Geoportal development

	Development Task	**Duration (Days)**	**Cost (USD)**
1	Geoportal System Design -Database design -Architectural design -Module design -User interface design	15	2,000
2	Geoportal Programming -Interface customization – modifying look and feel to fit organization's preferences -Plugin development -User and integration testing	30	5,500
3	Geoportal Documentation (User and administrator manuals)	5	400
4	Geoportal Installation -Geoportal system, plugins and dependencies installation -Server, Database and Map Server configuration	5	600
5	Geoportal Training (User and administrator training)	5	1,000
	Total	**60**	**9,500**

Appendix E: EAC cartographic services harmonization framework

What should be done to close them?

1) Fundamental datasets: Rwanda is the standard

What should the other states do to close the gaps and attain the Rwanda standard?

Kenya, Uganda and Tanzania should each buy 10 CORS every year in 24 months to attain at least 20 plus the CORS management software @ $22,000 and $50,000 respectively. It is worth mentioning that the Kenya government recently purchased 20 CORS worth of equipment and software which had not been installed by the time of data collection. It also has 2 CORS owned by RCMRD and a few others by private companies, hence would require less than her peers. Uganda has established a network of 28 CORS under World Bank project christened "Updating and implementing Geodetic Reference Frame for Land Administration in Uganda", which was done in two phases (AFREF, 2017). Other private investors such as Survnet Uganda Limited and Eagle Surveys Limited established several CORS across Uganda. From the foregoing, the study recommends 20 CORS each for Kenya and Uganda respectively, 40 for Tanzania and 8 for Burundi computed as follows:

-10 CORS @$22,000 = $220,000

-CORS management software@$50,000

-Supporting infrastructure @ $120,000

-cost of 20 CORS@ $22,000=$440,000 plus $50,000+$120,000=$610,000 each for Kenya Uganda

-cost of 40 CORS@ $22,000= $880,000 plus $50,000+$120,000=$1,050,000 for Tanzania

-Burundi would need to buy 4 CORS per year in 24 months, which is 8 CORS@$22,000 = $176,000 plus the management software @$50,000 plus support Infrastructure @ $60,000

Giving $286,000.

<u>Topographical and cadastral database development</u>

All member countries have begun the digital conversion of both topographical and cadastral maps at varying levels through government efforts and project/donor funds. Since this study could not ascertain the actual level of digitization, estimates were done based on the number of topographical sheets plus the country coverage using the KNSDI projections for the

development of Cadastral and Topographical database for Kenya @ $10,000,000 achievable in 36 months. Thus,

-Kenya is covered by 520 sheets at scale 1:50,000 and 89 sheets of 1:100,000 scale. A 1:50,000 sheet has four 1:100,000 sheets. This translates into 356 sheets of 1:50,000 adding up to 876 sheets of 1:50,000sheet series. The 1:50,000 basic topographical series are; Tanzania 1294 sheets, Uganda 325, Burundi 46 and Rwanda 52, while Kenya's equivalent is 876 sheets.

Hence, if $10,000,000 is needed for 876 sheets, 1 sheet (for both topo and cadastral) would need $10,000,000/876=$11,415.525 per sheet

-Therefore, Tanzania would cost $11,415.525*1294 sheets=$14,771,657;

-Uganda would cost $11,415.525*325 sheets=$3,710,046;

-Burundi would cost $11,415.525*46 sheets =$525,114.

Web portal development @ approximately $2,000 applicable to all countries

2) Metadata and Geoportal (Rwanda is the standard)-12 months

What should the other states do to close the gaps and attain the Rwanda standard?

They should carry out an inventory of fundamental geo-spatial datasets to begin with, compile metadata and metadata creation and publication. Metadata development workflow will entail:

-Inventory at a cost of $20,000 per country

-Compilation, creation and publication

Estimates from top industry players give metadata creation at $100 per feature class per day

-Assume there are 100 feature classes/layers for fundamental and other datasets will cost 100*$100=$10,000

-Using a FOSS software such as used by Rwanda (GeoNetwork)

-Other overheads (internet, power, etc) = approximately $5000

-Human resource 1 persons in 5 months (100 days /20 working days=5) @ 600PM= $3000

-Overall cost is $10000+$5000+$3000= $18000 applicable for all countries

-Geoportal development –design for a corporate website – $19,000 per country

-Metadata geoportal total cost= $57, 000

This is achievable in 12months or 240 working Days

3) Policy and laws (Kenya is the standard)-24 months

What should the other states do to close the gaps and attain the Kenya standard?

The following tasks were recommended for Uganda and Tanzania:

-Initial stakeholders meeting to deliberate on the need (30 persons for a day workshop @ $35 per person and transport @ $50 per person; 30(35+50) = $2,550)

-Document preparation up to 10 sessions (20 people for 5 Days full board @ $200 per day; 20*5*200*10 = $200,000)

-Transport by road for 10 sessions (20 persons @ $50 per person; $20*50*10= $ 10,000)

-Final workshop (external stakeholders) and public participation from across the countries; ($35+ $50)*200 participants = $17,000

-TOTAL COST =**$229,550(Uganda and Tanzania)**

-For Burundi and Rwanda being smaller were computed with less people in mind thus:

-Initial stakeholders meeting consisting of 20 persons for a day workshop @ $35 per person and transport @ $50 per person; 20(35+50) = $1,700

-Document preparation for 10 sessions (20 people for 5 Days full board @ $200 per day; 20*5*200*10 = $200,000)

-Transport by road for 10 sessions (20 persons @ $50 per person $20*50*10= $ 10,000).

-Final workshop (external stakeholders) and public participation from across the country; ($35+ $50)*80 participants = $6,800

-Total Cost =$218,500(Rwanda and Burundi).

4) Equipment (Kenya is the standard)-24 months

What should the other states do to close the gaps and attain the

This was given an approximate figure for the states to budget based on their needs. Thus, approximate purchase of basic equipment for Uganda and Tanzania:

- Foss awareness creation workshops and seminars at least 3 sessions per year @30,000 per session =$90, 000 by 2 years= $180,000
- Purchase of equipment based on country needs @ $500,000 per year spread out over 2 years = $500,000
- TOTAL= $680,000
- Burundi and Rwanda, cost of equipment is approximated at 1/3 of the bigger countries ;1/3*$680,000=$226,670

5) Training Institutions (Tanzania is the standard)-24 months

What should the other states do to close the gaps and attain the Tanzania standard?

Training institutions had deficiencies that called for the following tasks:

-Curriculum review and development where it lacked,

-Hiring of lecturers and,

-Research into current industry needs

The number of persons to be included in the review committee were derived from the results of the study plus 2 more from outside those institutions. Thus two persons per institution.

- Curriculum

Kenya with nine (9) institutions

- This should be done concurrently for both bachelors and Diploma. The first meeting to deliberate on the need for development, review or revision is held by stakeholders with 20 participants from the various institutions @ $10 per person per day for 1 day: gives 20*$10=$200

- Then, 4 meetings of 20 persons to review and revise the curriculum consisting of various specialists; thus, [20*200*3 days] 4 sessions= $48,000

-Transport for 20 persons @$50 per person for 4 sessions= $4000

- Research

-A research into current trends and industry demands; 3 studies @$10,000 per paper equals $30,000

- Hiring

-Hiring 2 assistant lecturers per year @$1500 per month*2 persons*12 for 2 years =$72,000

-Thus, $72,000* 9 institutions =$648,000

TOTAL=$200+$48,000+$4,000+$30,000+$648,000**=$730,200**

Uganda and Rwanda as they both had four (4) institutions each

The first meeting to deliberate on the need for development, review or revision is held by stakeholders with 10 participants from the various institutions @ $10 per person per day; 10*10=$100

-4 meetings of 10 persons to review and revise the curriculum consisting of various specialists; thus, [10*200*3 days] 4 sessions= $24,000

-Transport for 10 persons @$50 pp for 4 sessions= $2000

-Uganda, research as Kenya = $30,000

-Hiring @$$72,000*4 institutions =$288,000

TOTAL=$100+$24,000+$2,000+$30,000+$288,000=**$344,100**

Burundi with three (3) institutions

The first meeting to deliberate on the need for development, review or revision is held by stakeholders with 8 participants from the various institutions @ $10 per person per day; 8*10=$80

-4 meetings of 8 persons to review and revise the curriculum consisting of various specialists; thus, [8*200*3 days] 4 sessions= $19,200

-Transport for 8 persons @$50 pp for 4 sessions= $1,600

-Burundi, research as Kenya's = $30,000

-Hiring @$72,000*3 institutions =$216,000

TOTAL=$80+$19,200+$1,600+$30,000+$216,000**=$266,880**

6) Funding (Rwanda is the standard) -6 Months

What should the other states do to close the gaps and attain the Rwanda standard?

- Required are expert reports to justify the need for increased budgetary allocation from the government and technical aid agencies
- First internal meeting to strategize consisting of 100 people @ $10 per person=$1000
- Actual reports based on consultative workshops and seminars of 5 persons @$200 for 5 days full board; thus 5*$200*5=$5000
- Transport @$50*5 persons =$250
- TOTAL: $1000+$5000+$250= $6,250 applicable to all other states.

7) National Atlas (Kenya is the standard)- 12 months

What should the other states do to close the gaps and attain the Kenya standard?

Kenya has revised the national atlas severally and currently on the 6th edition. In addition, there is availability of digital atlas copy. For Tanzania and Uganda, the following should be done so as to catch up with Kenya:

-Day conference for sensitization involving 120 stakeholders @$35 per person=$4200

-Other conference materials @$2000

-Atlas compilation team of 20 experts @$600 per month for 12 months=$144,000

-Day conference for 120 stakeholders @$35 to adopt the draft atlas =$4200

-Other conference materials @$2000

-**TOTAL: $156, 400**

Rwanda and Burundi n 12 months

-Day conference for sensitization involving 60 stakeholders @$35=$2100

-Other conference materials @$2000

-Atlas compilation team of 10 experts @$600 per month for 12 months=$72,000

-Day conference for 60 stakeholders @$35 to adopt the draft atlas=$2100

-Other conference materials @$2000

-**TOTAL: $80,200**

8) **Professional associations (Kenya is the standard) -12 months**

What should the other states do to close the gaps and attain the Kenya standard?

Kenya was the only country with a professional association (ISK) that had a chapter for other Geo-related cadres such as cartographers and photogrammetrists.

-Tanzania and Uganda: These would require at least 3 sessions of awareness creation seminars in 12 months @$35per participant for 100 participants: $35*100*3=$10,500

-Transport for 100 participants@$50 per participant times 3 sessions=$15,000

-TOTAL: **=$25,500**

- Burundi and Rwanda:

-Awareness creation 3 sessions*50 participants @$35=$5,250

-Transport for 50 participants@$50 per participant times 3 sessions=$7,500

-Election of officials'@ $3000

-Registration of association $200

-Miscellaneous costs $2000

-TOTAL: **$17,950**

9) Geographical names gazetteer (Kenya is the standard)

What should the other states do to close the gaps and attain the Kenya standard?

Kenya had accomplished some revision by collecting data of several sheets for the gazetteers. The time and cost differs depending on the number of topographical sheets. This was calculated based on the number of topographical sheets in the country of interest and the rate

of data collection and updating of 1 sheet by a team of 5 people where a team is required for the following tasks:

-Driver of the team's vehicle

-Team leader for coordination and guidance

-Data collection and recording the coordinates, names e.t.c

-Map reading

-Interviewing the local elders on the area and feature names and their history

Although Kenya is the standard, it should be noted that data collection for the digital gazetteer in still ongoing with most sheets done in some counties. Thus, an assumption was made that Kenya had completed about 50%, hence the other countries were expected to attain the same level.

It was determined that 1 team (5 persons) worked on 1 topographical sheet coverage of 1:50,000 for 15 days. Hence;

-Rwanda with 52 sheets of 1:50 000 covering the entire country would require 52*15 =26 months for 1 team to complete.

-4 teams (20 persons) will take 6.5 months, thus 20*($600+ [$70*30]) 6.5=$351,000

-4 teams require 4 vehicles @$2000PM* 6.5 months= $52,000

-TOTAL: $403, 0000 for the entire country coverage, but we need 50% coverage which is 1/2*$403,000= **$201,500**

-Burundi with 46 sheets of 1:50 000 covering the entire would require 46*15 =21 months for I team to complete.

-3 teams (15persons) will take 7 months, thus 15*($600+[$70*30])7=$283,500

-3 teams require 3 vehicles @$2000PM* 7 months= $42,000, hence; Total =$325,500

50% coverage would thus need; 1/2*$325,500= **$162,750**

-Uganda with 325 sheets of 1:50 000 covering the entire country would require 325*15 =162.5 months for I team to complete.

-8 teams (40 persons) will take 20.4 months, thus 40*($600+ [$70*30]) 20.4=$2,203,200

-8 teams require 8 vehicles @$2000PM* 20.4 months= $326,400; total = $2,259,600

-50% coverage =1/2*$2,259,600= **$1,129,800**

-Tanzania with 1294 sheets of 1:50 000 covering the entire country would require 1294*15 =647 months for I team to complete.

-20 teams (100 persons) will take 32.4 months, thus 100*($600+ [$70*30]) 32.4=$8,734,500

-20 teams require 20 vehicles @$2000PM* 32.4 months= $1,296,000; total= $10,030,500

- 50% coverage =1/2*$10,030,500= **$5,015,250**

10) Personnel (Kenya is the standard)- 12 months

What should the other states do to close the gaps and attain the Kenya standard?

Rwanda, Burundi, Uganda and Tanzania would require equal number of personnel to harmonise with Kenya. Tasks include;

-Hiring all cadres of personnel

-Short courses training professional and management training

-24 professionals will be hired representing all cadres @ $600 per month multiplied by 12 months= $172,800 p.a.

-Management training courses @ $1400*24persons (8 people every 4 months) = $33,600

-Professional courses @ $500 per person for 5 days by10 persons i.e., 10 people quarterly,

- Thus, (10*$500)3= $15,000 giving an overall total of **$221,400**

11) SDI status (Rwanda is the standard)

What should the other states do to close the gaps and attain the Rwanda Standard?

On SDI status, **Kenya and Uganda** require fast tracking as the draft policies are already in place. What is needed is a workshop to build consensus and adoption of the draft policy achievable within 12 months. What should be done include;

-A stakeholders workshop of 150 persons @ $35 per day= $5250

-Transport allowance for 150 participants@$50 per participant =$7,500

-Other conference expenses @ $2000, giving an overall total of $**14,750**

Tanzania and Burundi would require 6 workshops in 24 months

-150 persons @ $35*= $5250 for Tanzania and 75 persons @ $35*= $2625 for Burundi

-Transport allowance for 150 participants@$50 per participant =$7,500 for Tanzania and 75 participants@$50 per participant = $3750 for Burundi

-Other items @ $2000 for Tanzania and $1000 for Burundi

-.Specialists and drafters of {20 persons @ $200 full board *5 days}*4 sessions = $80 000 for both Tanzania and Burundi

-Transport for 20 persons @ $50pp*4 sessions= $4000 for both

-A final stakeholders workshop to finalise and adopt the draft before presenting it to the cabinet @150 persons @ $35*= $5250 for Tanzania and 75 persons @ $35*= $2625 for Burundi

-Transport allowance for 150 participants@$50 per participant =$7,500 for Tanzania and 75 participants@$50 per participant = $3750 for Burundi

-Other items @ $2000 for Tanzania and $1000 for Burundi

TOTAL= **$113,500 for Tanzania and $ 99,800 for Burundi**

Appendix F: EAC Cartographic services upgrade proposal

Notes:

- Accommodation applies for all participants
- Transport applies to the host country's participants only
- Air travel applies to the visiting participants from EAC states.
- Miscellaneous costs cover all participants**.**
- N/A means not applicable and pp means per person

1) Fundamental datasets and metadata

	Time	Activity	Rate per item (USD)		No. of persons	No. of days	Total cost (USD)
i.	**Month 0**	-1st stakeholder conference (delegates, experts and participants from member states, the organizational structure will be agreed on	Accommodation	200pp	200	2	80,000
			Transport	50pp	35	Return	1,750
			Miscellaneous	50pp	200	1	10,000
			Air ticket	800pp	165	Return	132,000
						Sub-total = $223,750	
ii.	**Months 6,12,18,24,30**	-Experts to meet 4 times half yearly to design data model and specifications. -5 groups comprising of 12 members from 6 countries (domain experts).	Accommodation	200pp	12	4	9,600
			Transport	50pp	2	Return	100
			Miscellaneous	50pp	12	3	1800
			Air ticket	800pp	10	Return	8000
	1 group require $78,000 ; 5 groups: $78,000*5=$390,000 ; hence the 4 workshops will cost: $390,000 *4 = $1,560,000						
iii.	**Months 30-36**	EAC-Geo portal development	19,000 (One-off)		N/A	N/A	19,000
iv.	**Months 30-42**	Metadata profiles creation and upgrade all countries	12,000 per country		N/A	N/A	72,000
v.	**Months 30-42**	Research on inventory	30,000 per country		N/A	N/A	180,000
vi.	**Months 42-54**	Interoperability research based on pilots projects	50,000*3 projects		N/A	N/A	150,000
vii.	**Month 54**	A final all-inclusive stakeholders workshop to adopt the framework prior to its implementation	Accommodation	200pp	200	2	80,000
			Transport	50pp	35	Return	1750
			Miscellaneous	50pp	200	1	10,000
			Air ticket	800pp	165	Return	132,000
						Sub-total =$223,750	
viii.	**Month 54-60**	Final report preparation and presentation by all 5 working groups. Each group comprises of 12 members.	Accommodation	200pp	12	4	9,600
			Transport	50pp	2	Return	100
			Miscellaneous	50pp	12	3	1800
			Air ticket	800pp	10	Return	8000
						1 group cost is $78,000; 5 groups = 78,000×5= $ 390,000	
						Total estimated cost =$2,818,500 in approximately 60 months	

2) SDI

	Time	Activity	Rate per item(USD)		No. of People	No. of Days	Total cost (USD)
i.	**Month 0**	1st meeting to deliberate (6 people from all states)	Accommodation	200pp	6	4	4,800
			Transport	50pp	1	Return	50
			Miscellaneous	50pp	6	3	900
			Air ticket	800pp	5	Return	4,000
						Sub-total = $9,750	
ii.	**Month 6**	2nd workshop to create awareness and build consensus(delegates from all states)	Accommodation	200pp	200	2	80,000
			Transport	50pp	35	Return	1,750
			Miscellaneous	50pp	200	1	10,000
			Air ticket	800pp	165	Return	132,000
						Sub-total = $223,750	
iii.	**Month 12-30**	3rd, 4th, 5th, 6th, workshop : Only working groups (30 members per workshop) - to meet four times (draft proposal writing)	Accommodation	200pp	30	4	24,000
			Transport	50pp	5	Return	250
			Miscellaneous	50pp	30	3	4500
			Air ticket	800pp	25	Return	20,000
	1 workshop = $48,750 per session; therefore, 4 sessions = $48,750×4=$195,000(sub-total)						
iv.	**Month 30**	7th workshop: (Delegates peruse the draft proposal)	Accommodation	200pp	200	2	80,000
			Transport	50pp	35	Return	1,750
			Miscellaneous	50pp	200	1	10,000
			Air ticket	800pp	165	Return	132,000
						Sub-total = $223,750	
v.	**Month 36**	8th meeting: Draft proposal goes for public comments locally in all the states.	30,000 per country		N/A	N/A	180,000
vi.	**Month 42**	9th meeting: Final all stakeholders to adopt the draft before being taken to the EALA	Accommodation	200pp	200	2	80,000
			Transport	50pp	35	Return	1,750
			Miscellaneous	50pp	200	1	10,000
			Air ticket	800pp	165	Return	132,000
						Sub-total = $223,750	
						Total estimated cost = $1,056, 000in approximately 42months	

3) Policy and Laws

	Time	Activity	Rate per item(USD)		No. of People	No. of Days	Total cost (USD)
i.	**Month 0**	-1st workshop (stakeholders and experts from all states) - For awareness creation and consensus building on EAC cartographic policy	Accommodation	200pp	200	2	80,000
			Transport	50pp	35	Return	1,750
			Miscellaneous	50pp	200	1	10,000
			Air ticket	800pp	165	Return	132,000
	Sub-total = $223,750						
ii.	**Month 6**	-Follow up workshop: WGs formed(10 experts per country), duties assigned	Accommodation	200pp	60	4	48,000
			Transport	50pp	10	Return	500
			Miscellaneous	50pp	60	3	9,000
			Air ticket	800pp	50	Return	40,000
	1 group Sub-total = $97,500						
iii.	**Months 12,18,24,30**	-WGs meet 4 times to collate and agree on draft, thus. - 10 members per state	Accommodation	200pp	60	4	48,000
			Transport	50pp	10	Return	500
			Miscellaneous	50pp	60	3	9,000
			Air ticket	800pp	50	Return	40,000
	1 meeting = $97,500; therefore, 4 sessions Sub-total =$97,500×4= $390,000						
iv.	**Month 30-36**	Public participation- all states.	30,000 per country		N/A	N/A	180,000
v.	**Month 36**	Final stakeholders meeting to adopt the draft proposal	Accommodation	200pp	200	2	80,000
			Transport	50pp	35	Return	1,750
			Miscellaneous	50pp	200	1	10,000
			Air ticket	800pp	165	Return	132,000
	Sub-total = $223,750						
vi.	**Month 36**	Web portal design and launch.	15,000		N/A	N/A	15,000
vii.	**Month 42-48**	Draft goes to the EALA for adoption debate May require a miscellaneous budget equal to one sitting.	97,500		N/A	N/A	97,500
	Total estimated cost = $1,227,500 in 48 months						

4) Hardware and software

	Time	Activity	Rate per item(USD)		No. of People	No. of Days	Total cost (USD)
i.	**Month 0**	1st Workshop: create awareness and build building	Accommodation	200pp	200	2	80,000
			Transport	50pp	35	Return	1,750
			Miscellaneous	50pp	200	1	10,000
			Air ticket	800pp	165	Return	132,000
	Sub-total = $223,750						
ii.	**Month 6**	Bench-marking by technical team to EuroGeographics headquarters for 10 days	Per Diem	1,000pp	30	10days	300,000
			Air travel	15,000pp	30	Return	450,000
	Sub-total = $750,000						
iii.	**Month 12-30**	Technical team of 30 persons meet 4 times. One meeting lasts 5 days. Workshop to define technical requirements.	Accommodation	200pp	30	6	36,000
			Transport	50pp	5	Return	250
			Miscellaneous	50pp	30	5	7,500
			Air ticket	800pp	25	Return	20,000
1 meeting= $63,750; Sub-total for 4 meetings = $63,750×4= $255,000							
iv.	**Month 36**	1-day workshop (200 persons to adopt the recommendations)	Accommodation	200pp	200	2	80,000
			Transport	50pp	35	Return	1,750
			Miscellaneous	50pp	200	1	10,000
			Air ticket	800pp	165	Return	132,000
Sub-total = $223,750							
Total estimated cost = $ 1,452,500 in approximately 60 months							

5) National Atlas

	Time	Activity	Rate per item (USD)		No. of People	No. of Days	Total cost (USD)
i.	**Month 0**	1st Atlas coordination committee meets to deliberate on the need (should be appointed from different organizations)	Accommodation	200pp	30	2	12,000
			Transport	50pp	5	Return	250
			Miscellaneous	50pp	30	1	1,500
			Air ticket	800pp	25	Return	20,000
	Sub-total = $33,750						
ii.	**Month 6**	2nd all stakeholders workshop: create awareness among data suppliers - Atlas compilation committee is nominated	Accommodation	200pp	200	2	80,000
			Transport	50pp	35	Return	1750
			Miscellaneous	50pp	200	1	10,000
			Air ticket	800pp	165	Return	132,000
	Sub-total = $223,750						
iii.	**Months 6-36**	5-days workshop for atlas compilation (meet half-yearly to develop the compilation specifications and data model) -Committee of 30 members from all states	Accommodation	200	30	6	36,000
			Transport	50	5	Return	250
			Miscellaneous	50	30	5	7,500
			Air ticket	800	25	Return	20,000
1 meeting = $63,750 ; therefore, 6 meetings Sub-total = 6×$63,750=$382,500							
iv.	**Month 36-42**	1-day workshop where all stakeholders review and adopt the proposals Approximately 200 persons.	Accommodation	200pp	200	2	80,000
			Transport	50pp	35	Return	1750
			Miscellaneous	50pp	200	1	10,000
			Air ticket	800pp	165	Return	132,000
Sub-total = $223,750							
v.	**Month 42-54**	2 meetings for final compilations and publishing	33,750 per meeting		N/A	N/A	67,500
vi.	**Month 42-54**	Design web portal and maintenance	15,000 per item		N/A	N/A	15,000
Total estimated cost = $946,250 in the 54 months							

6) Geographical names gazetteers

	Time	Activity	Rate per item(USD)		No. of People	No. of Days	Total cost (USD)
i.	**Month 0**	1st awareness creation workshop: 100 persons.	Accommodation	200pp	100	2	40,000
			Transport	50pp	20	Return	1,000
			Miscellaneous	50pp	100	1	5,000
			Air ticket	800pp	80	Return	64,000
		Sub-total = $110,000					
ii.	**Month 6 -12**	2nd sitting of 19 experts, formation of WGs and assign duties)	Accommodation	200pp	19	4	15,200
			Transport	50pp	6	Return	300
			Miscellaneous	50pp	19	3	2,850
			Air ticket	800pp	13	Return	10,400
		Sub-total = $28,750					
iii.	**Months 12-36**	Data collection for full country coverage estimated from the EAC harmonisation estimates as a ratio. Since 100% coverage cost was known, the 50% was computed as follows:	Kenya	50%4730400	N/A	N/A	2,365,200
			Uganda	50%2259600			1,129,800
			Tanzania	50%10,030,500			5,015,250
			Rwanda	50%403000			201,500
			Burundi	50%325500			162,750
		Sub-total =$8,874,500					
iv.	**Month 36-42**	3rd Sitting of experts to discuss the inventory progress.	Accommodation	200pp	19	4	15,200
			Transport	50pp	6	Return	300
			Miscellaneous	50pp	19	3	2,850
			Air ticket	800pp	13	Return	10,400
		Sub-total = $28,750					
v.		Design of geo portal	19,000				**19,000**
vi.	**Month 42-48**	4th progress review workshop of 100 persons.	Accommodation	200pp	100	2	40,000
			Transport	50pp	20	Return	1,000
			Miscellaneous	50pp	100	1	5,000
			Air ticket	800pp	80	Return	64,000
		Sub-total = $110,000					
vii.	**Month 48-54**	4th sitting final report	28,750		N/A	N/A	**28,750**
Total estimated cost = $9,199,750							

7) Funding

	Time	Activity	Rate per item (USD)		No. of People	No. of Days	Total cost (USD)
i.	**Month 0-12**	Country level awareness creation workshops of 100 persons. 2 meetings required.	30,000 per meeting		N/A	N/A	30,000
1 country =$ 30,000; 6 countries= $30,000×6 =$180,000, thus 2 meetings sub-total =$180,000×2=$ 360,000							
ii.	**Month 12-18**	1-day workshop regionally of 200 persons	Accommodation	200pp	200	2	80,000
			Transport	50pp	35	Return	1,750
			Miscellaneous	50pp	200	1	10,000
			Air ticket	800pp	165	Return	132,000
	Sub-total = $223,750						
iii.	**Months 18-24**	3 Written reports	5,000 per report		N/A	N/A	15,000
iv.	**Month 24-30**	Publication and newsletter	2,000		N/A	N/A	2,000
Total estimated cost = $600,750 in 30 months							

8) Professional associations

	Time	Activity	Rate per item (USD)		No. of People	No. of Days	Total cost (USD)
i.	**Month 0**	1st meeting 2 persons per country = 12 persons for 3 days.	Accommodation	200pp	12	4	9,600
			Transport	50pp	2	Return	100
			Miscellaneous	50pp	12	3	1,800
			Air ticket	800pp	10	Return	8,000
	Sub-total = $19,500						
ii.	**Month 6**	2nd meeting; delegates from all countries and various GI sectors; 15 per state	Accommodation	200pp	90	2	36,000
			Transport	50pp	15	Return	750
			Miscellaneous	50pp	90	1	4500
			Air ticket	800pp	75	Return	60,000
	Sub-total = $101,250						
iii.	**Months 12-30**	3rd, 4th, 5th and 6th meetings of 3 days by the secretariat, president and the executive committee members	Accommodation	200	6	4	4,800
			Transport	50	1	Return	50
			Miscellaneous	50	6	3	900
			Air ticket	800	5	Return	4,000
1 meeting will cost $9,750; therefore, 4 meetings sub-total = $9,750×4=$39,000							
iv.	**Month 30-36**	7th workshop: An annual 1 day general meeting for all delegates and guests	Accommodation	200pp	200	2	80,000
			Transport	50pp	35	Return	1750
			Miscellaneous	50pp	200	1	10,000
			Air ticket	800pp	165	Return	132,000
Sub-total = $ 223,750							
v.	**Month 36-42**	2 research procedures	30,000 per research		N/A	N/A	**60,000**
vi.	**Month 42-48**	Awareness campaigns (in each of the 6 country)	Trans	50	200	N/A	10,000
			Per diem	35	200	1day	7,000
1 country=$17,000; therefore sub-total for 6 countries= $17,000×6=$102,000							
vii.	**Month 42-48**	One conference for everyone (Regional).	Accommodation	200pp	200	2	80,000
			Transport	50pp	35	Return	1750
			Miscellaneous	50pp	200	1	10,000
			Air ticket	800pp	165	Return	132,000
Total = $223,750							
Total estimated cost= $769,250 in 48 months							

9) Training Institutions

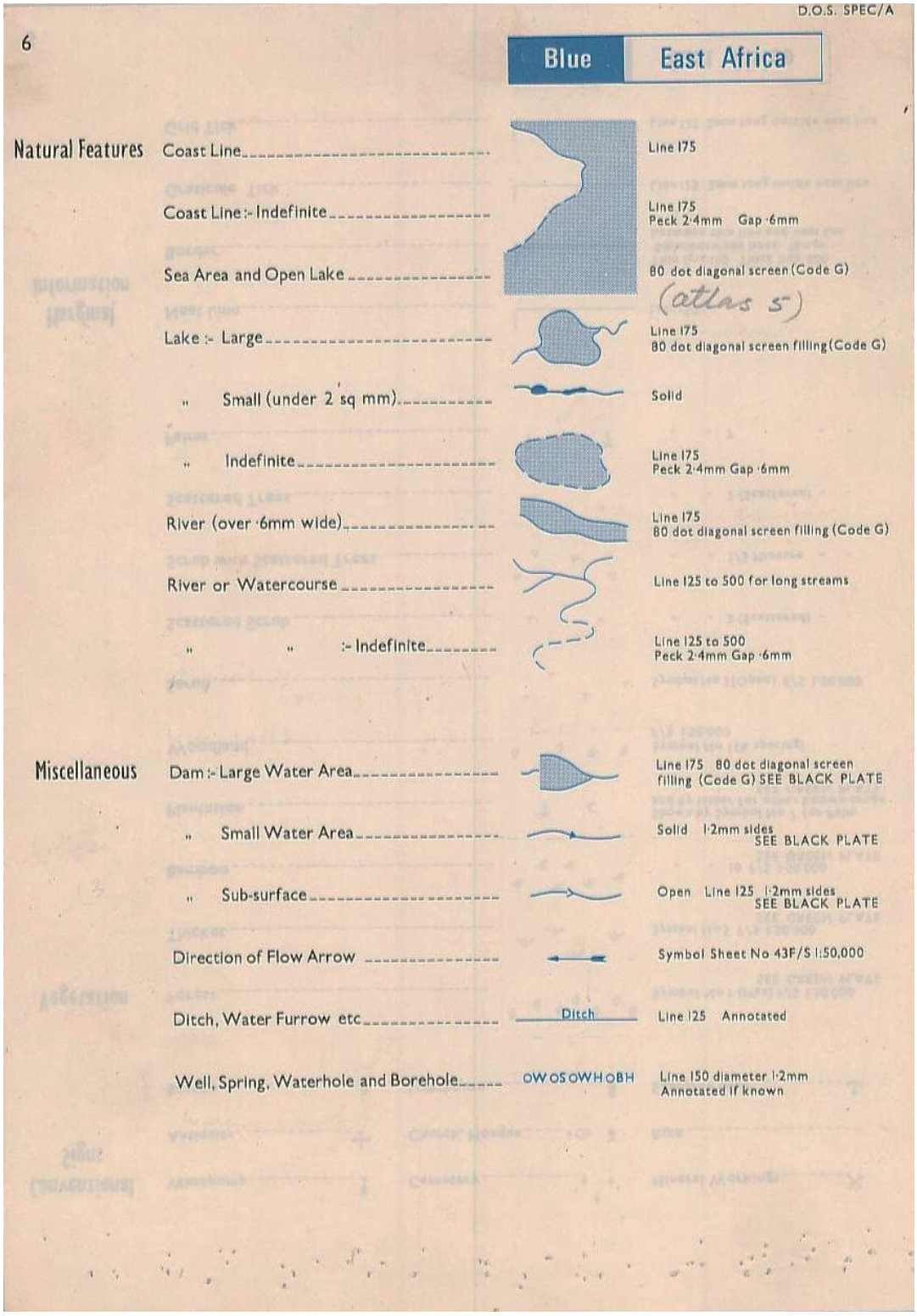
	Time	Activity	Rate per item(USD)		No. of People	No. of Days	Total cost (USD)
i.	**Month 0**	1st meeting 3 days to deliberate on the need to review and harmonise EA curricula; 2 people per country	Accommodation	200pp	12	4	9,600
			Transport	50pp	2	Return	100
			Miscellaneous	50pp	12	3	1,800
			Air ticket	800pp	10	Return	8,000
	Sub-total = $19,500						
ii.	**Month 6**	2nd sitting of 19 experts, formation of WGs and allocate duties. 6 from host country, 13 from abroad.	Accommodation	200pp	200	2	80,000
			Transport	50pp	35	Return	1750
			Miscellaneous	50pp	200	1	10,000
			Air ticket	800pp	165	Return	132,000
	Sub-total = $223,750						
iii.	**Month 12-36**	4 half-yearly sittings of professionals to review and draft a harmonised EA curriculum. 30 specialists; 5 per country.	Accommodation	200pp	30	6	36,000
			Transport	50pp	5	Return	250
			Miscellaneous	50pp	30	5	7,500
			Air ticket	800pp	25	Return	20,000
1 sitting costing $63,750; therefore, 4 sittings sub-total =$255,000							
iv.	**Month 12-36**	research and fast tracking of existing initiatives such as the EAQFHE and mutual recognition agreements among surveyors	30,000 per research		N/A	N/A	**60,000**
v.	**Month 36-42**	Web portal design and launch.	15,000 per item		N/A	N/A	**15,000**
vi.	**Month 36-48**	Launch a publication for the EAC-GI education	2000 per item		N/A	N/A	**2,000**
vii.	**Month 42-48**	Final stakeholders to adopt the proposed and harmonised EA GI curriculum	Accommodation	200pp	200	2	80,000
			Transport	50pp	35	Return	1750
			Miscellaneous	50pp	200	1	10,000
			Air ticket	800pp	165	Return	132,000
Sub-total =$ 223,750							
Total estimated cost =$799,000 in approximately 48 months							

10) Personnel

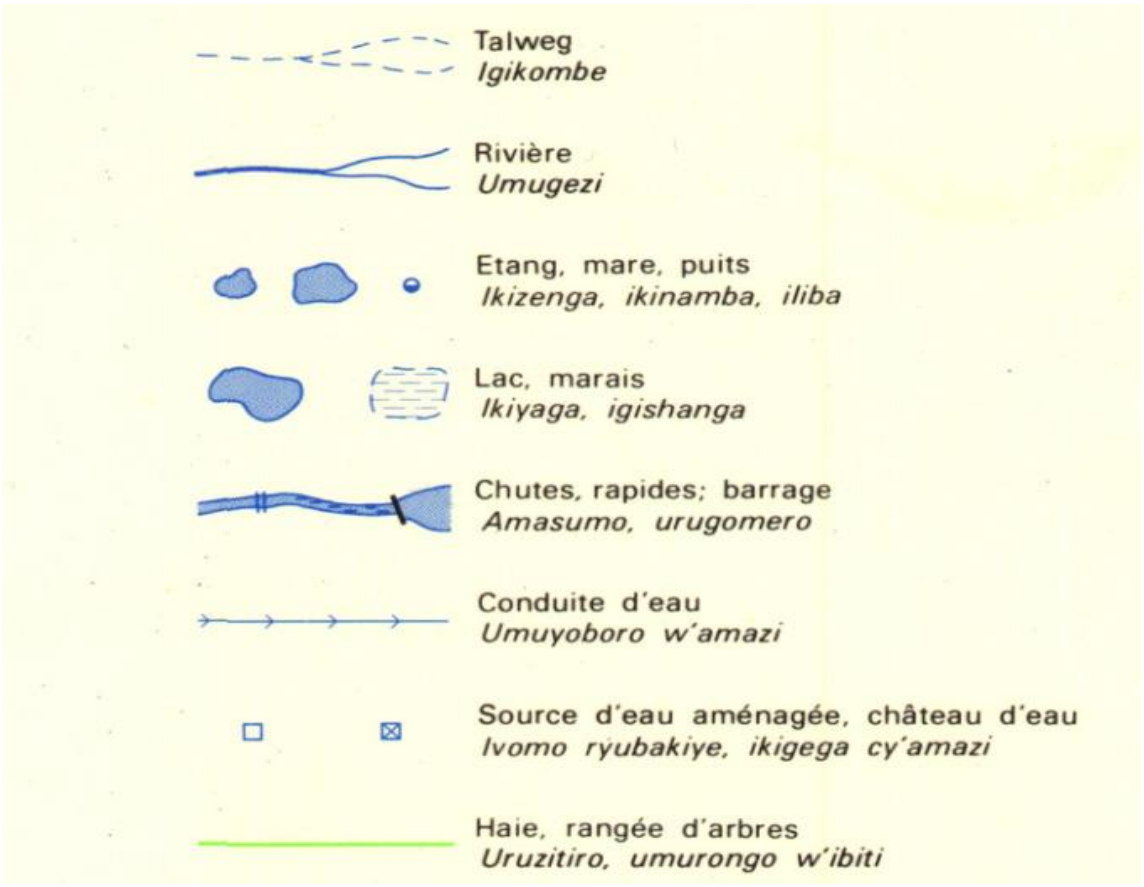
	Activity	Rate per item(USD)		No. of People	No. of Semesters per year	Total cost (USD)
i.	Retraining at least 24 personnel per country per year for five years; each course has 6 semesters.	Tuition	500 per semester	24	3 semesters	36,000
	Cost per year = $36,000 per country; 5 years will be $36,000×5=$180,000 per country Thus sub-total for 6 countries= $180,000×6=$1,080,000					
ii.	Capacity building (short courses) lasting for five days of 24 personnel per country per year for five years	Tuition	500 per semester	24	5	60,000
	1 year = $60,000 per country ; 5 years =$60,000×5= $300,000 per country Therefore, sub-total for 6 countries=$300,000 ×6= $1,800,000					
iii.	Exchange programs (within EAC) of 40 personnel per country i.e 240 personnel per year for five years.	Accommodation	200	240	4	192,000
		Air ticket	800	240	Return	192,000
		Per diem	280	240	4	268,800
	1 year = $652,800					
Total estimated cost =$3,532,800						

Appendix G: Extracts of the Map specifications used by the EAC member states

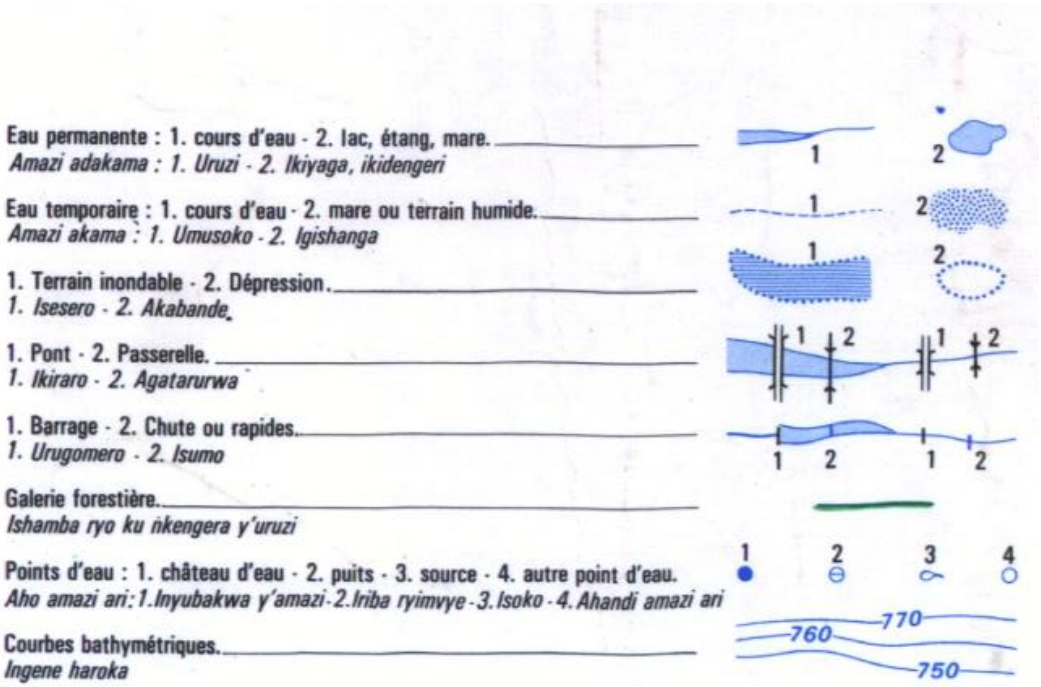
1) East Africa (Kenya, Uganda and Tanzania) topographical map symbol specifications for water features



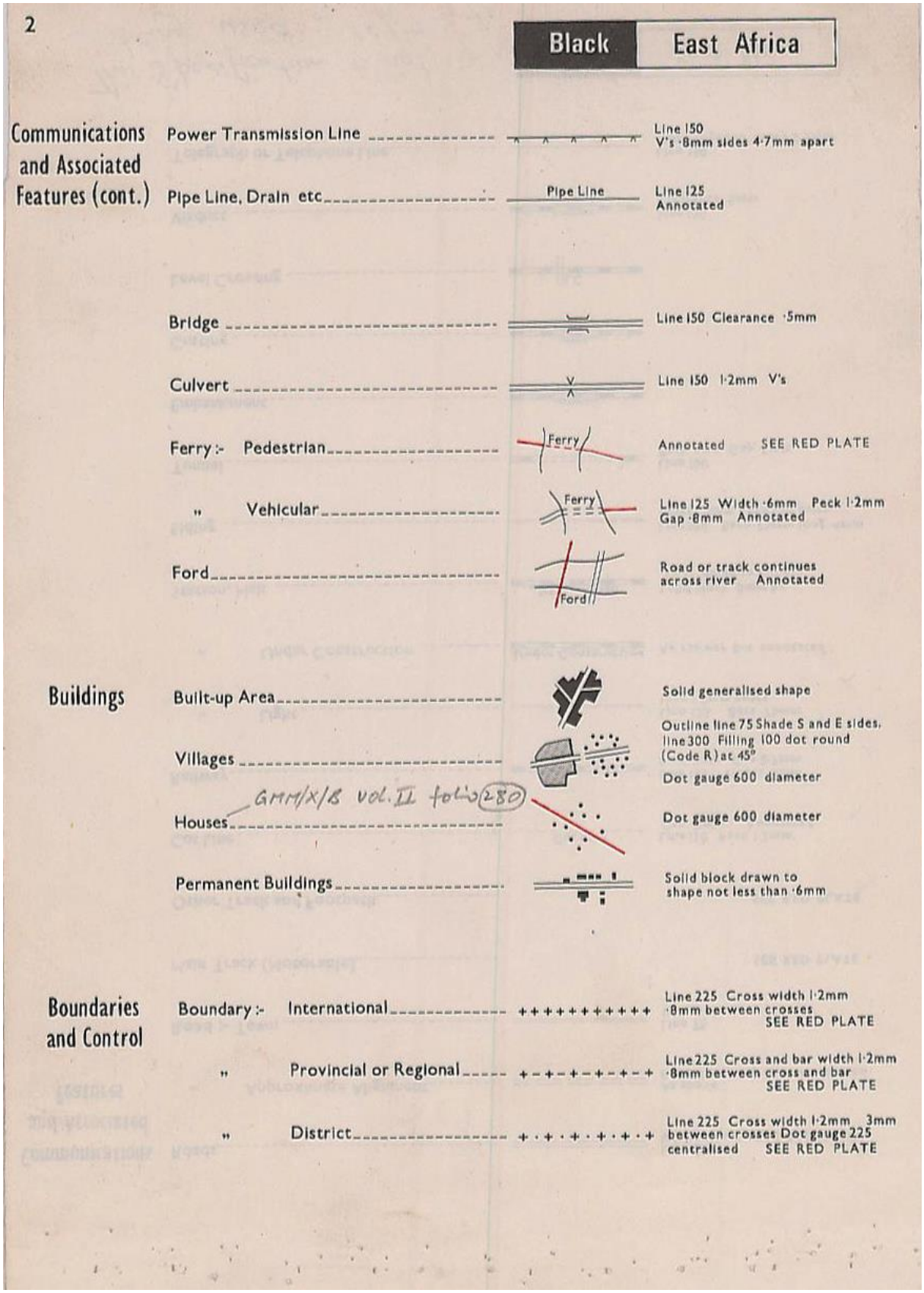
2) Rwanda topographical map scale 1:50,000 symbols for water features



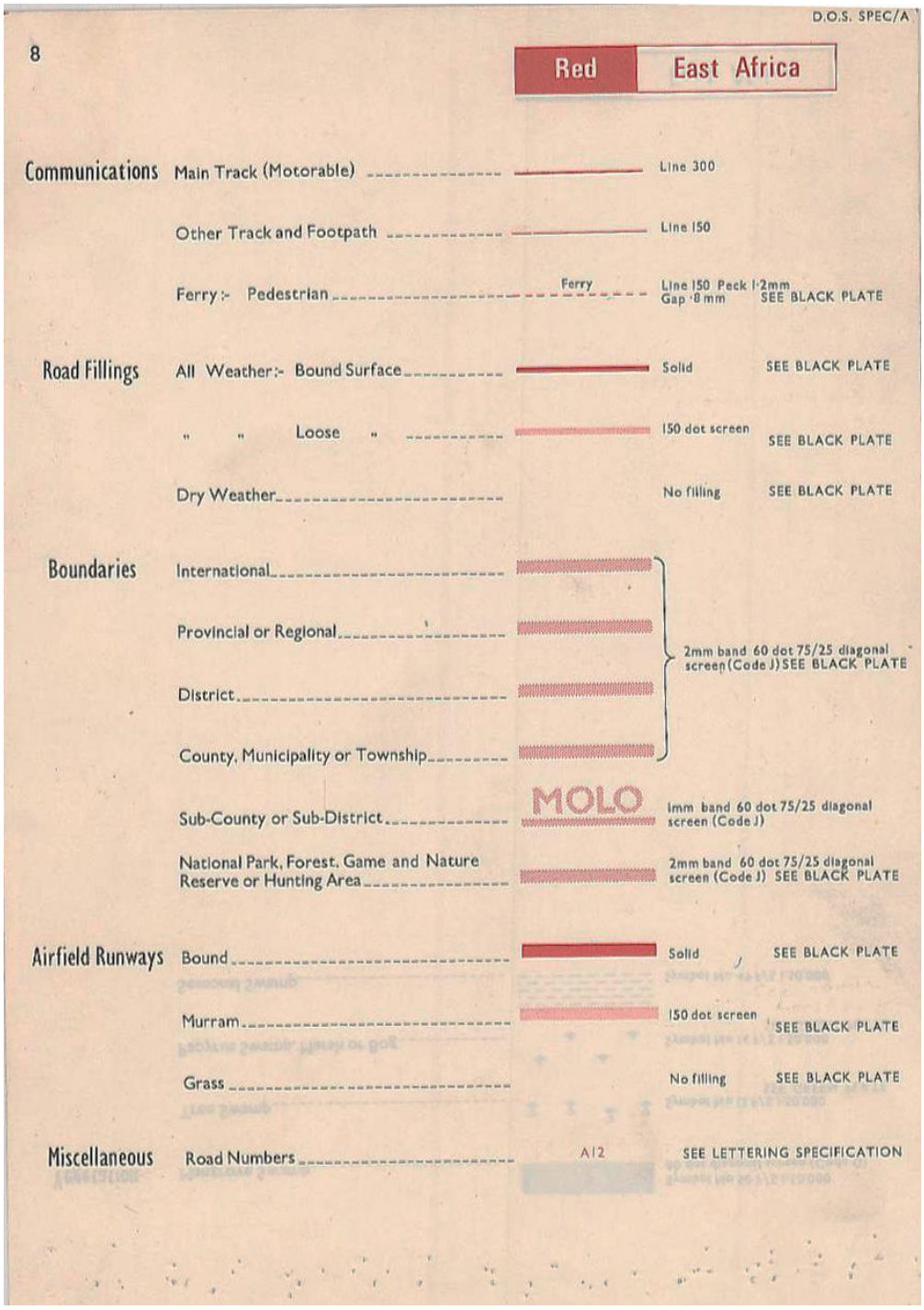
3) Burundi topographical map scale 1:50,000 symbols for water features



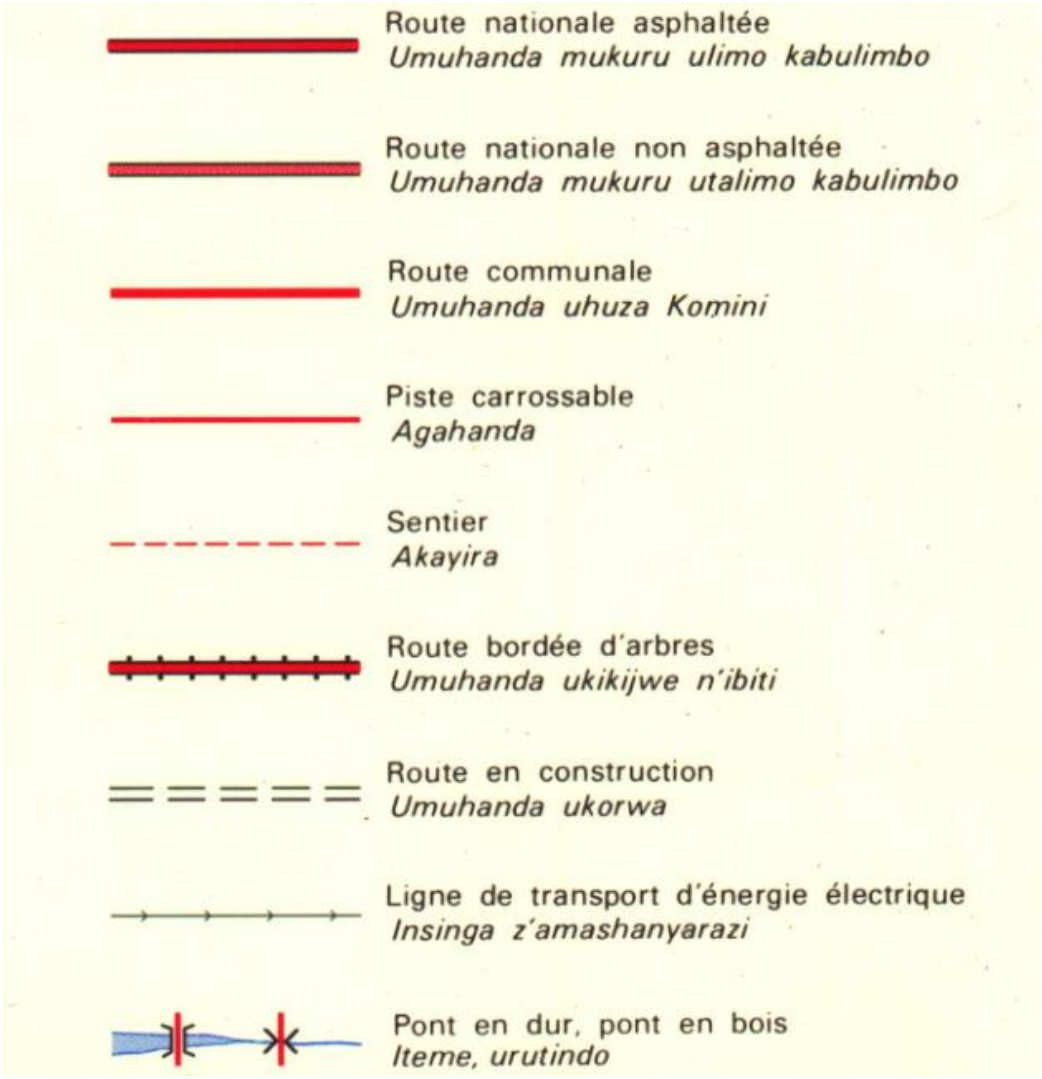
4) Boundaries, communications and associated features (black plate)



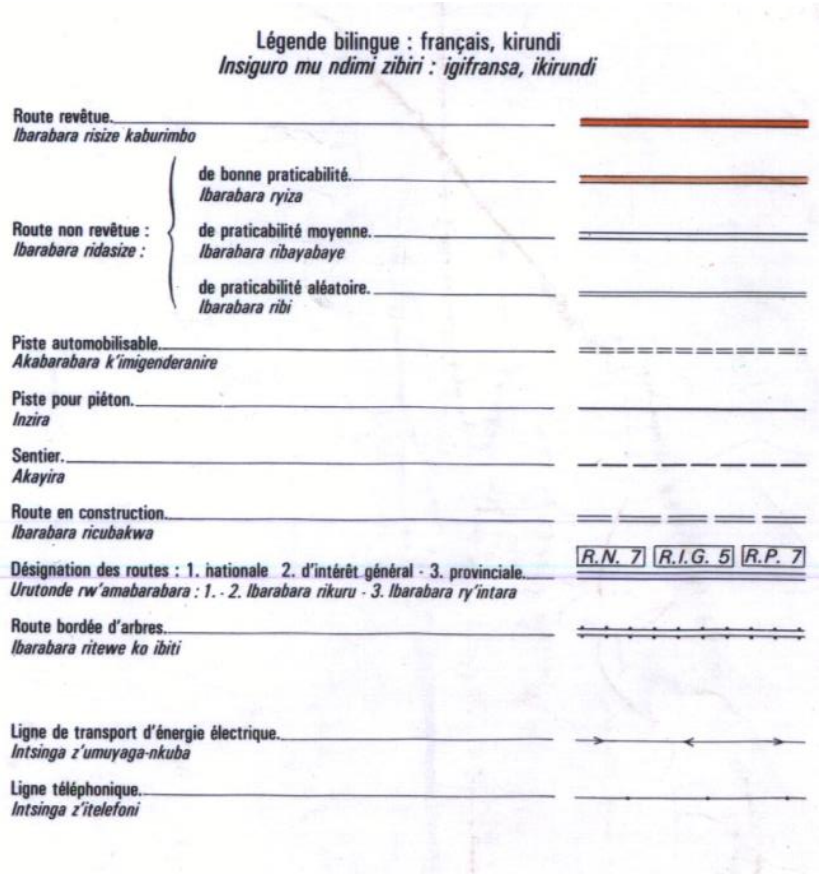
5) Boundaries, communications and associated features (red plate)



6) Rwanda transport, communications and associated features

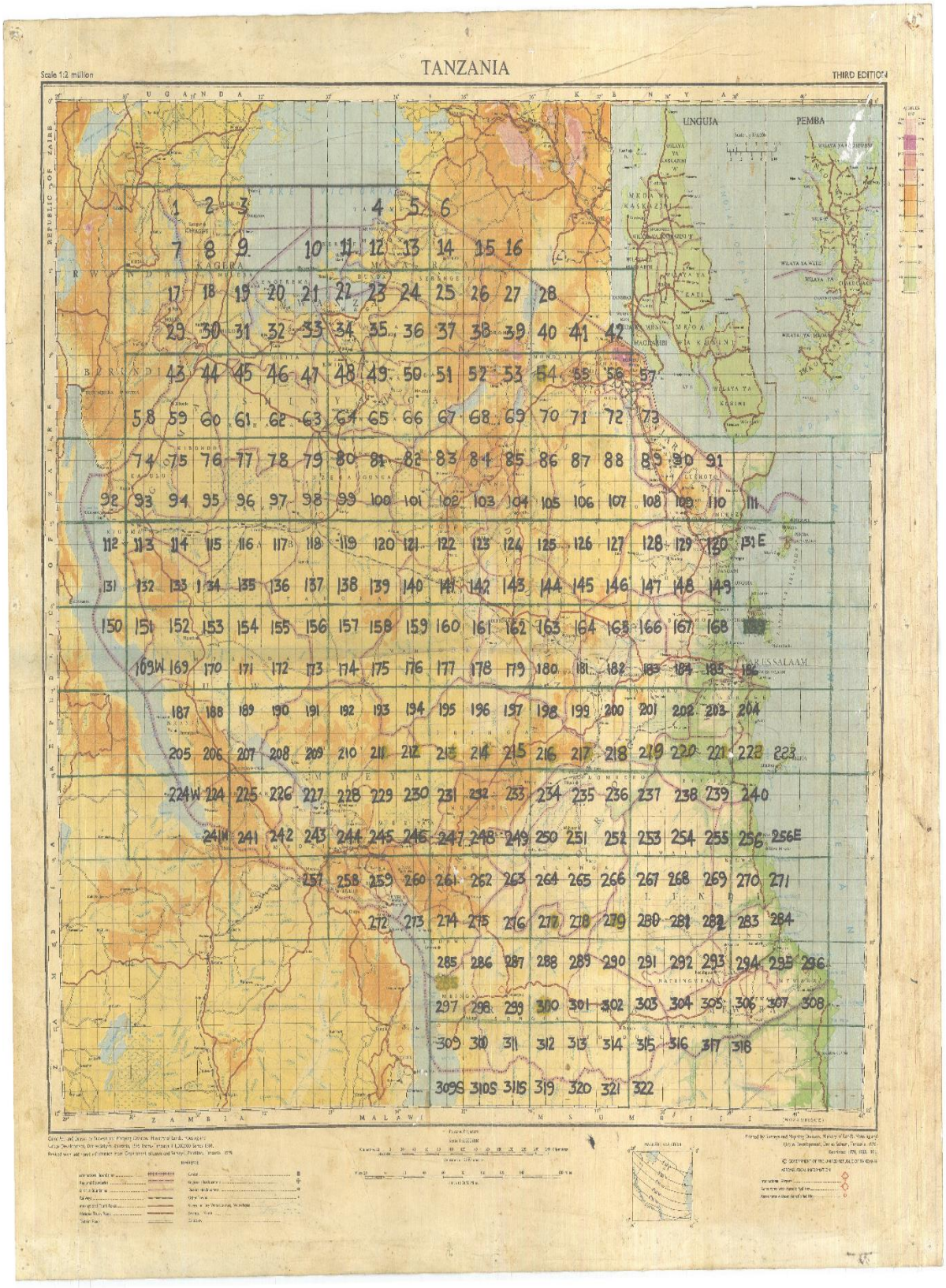


7) Burundi transport, communications and associated features

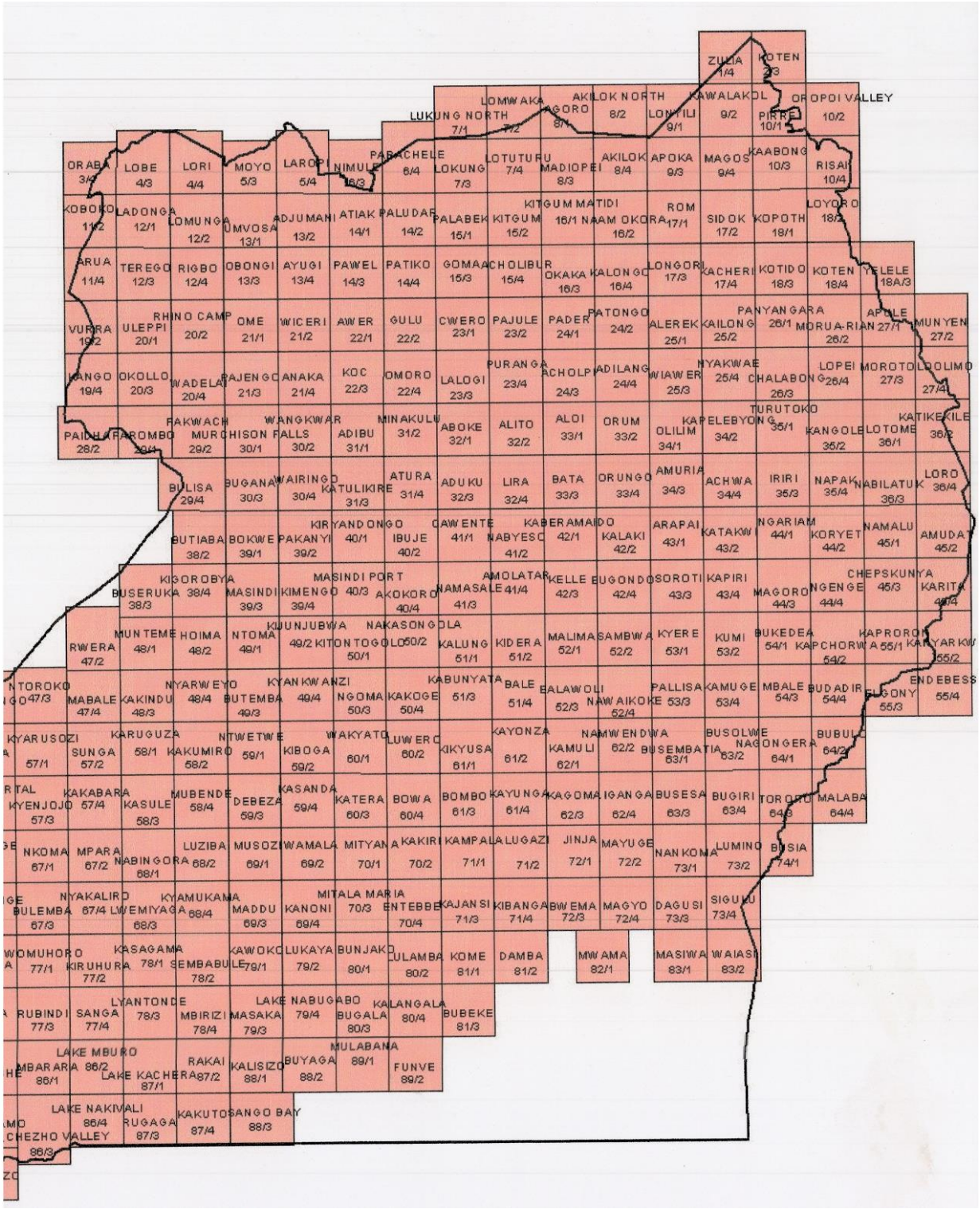


Appendix H: Standard sheet index for basic mapping

1. Tanzania



2. Uganda


ZULIA 1/4
KOTEN 2/3
LOMWAKA 7/2
AKILOK NORTH 8/2
KAWALAKOL 9/2
OROPOI VALLEY 10/2
LUKUNG NORTH 7/1
AGORO 8/1
LONTILI 9/1
PIRRE 10/1
ORABA 3/4
LOBE 4/3
LORI 4/4
MOYO 5/3
LAROPI 5/4
NIMULE 6/3
PARACHELE 6/4
LOKUNG 7/3
LOTUTURU 7/4
MADIOPEI 8/3
AKILOK 8/4
APOKA 9/3
MAGOS 9/4
KAABONG 10/3
RISAI 10/4
KOBOKO 11/2
LADONGA 12/1
LOMUNGA 12/2
UMVOSA 13/1
ADJUMANI 13/2
ATIAK 14/1
PALUDAR 14/2
PALABEK 15/1
KITGUM 15/2
KITGUM MATIDI 16/1
NAAM OKORA 16/2
ROM 17/1
SIDOK 17/2
KOPOTH 18/1
LOYORO 18/2
ARUA 11/4
TEREGO 12/3
RIGBO 12/4
OBONGI 13/3
AYUGI 13/4
PAWEL 14/3
PATIKO 14/4
GOMA 15/3
ACHOLIBUR 15/4
OKAKA 16/3
KALONGO 16/4
LONGORI 17/3
KACHERI 17/4
KOTIDO 18/3
KOTEN 18/4
YELELE 18A/3
VURRA 19/2
RHINO CAMP 20/2
ULEPPI 20/1
OME 21/1
WICERI 21/2
AWER 22/1
GULU 22/2
CWERO 23/1
PAJULE 23/2
PADER 24/1
PATONGO 24/2
ALEREK 25/1
KAILONG 25/2
PANYANGARA 26/1
MORUA-RIAN 26/2
APOLE 27/1
MUNYEN 27/2
KANGO 19/4
OKOLLO 20/3
WADELAI 20/4
PAJENGO 21/3
ANAKA 21/4
KOC 22/3
OMORO 22/4
LALOGI 23/3
PURANGA 23/4
ACHOLPI 24/3
ADILANG 24/4
WIAWER 25/3
NYAKWAE 25/4
CHALABONG 26/3
LOPEI 26/4
MOROTO 27/3
LOLIMO 27/4
PAIDHA 28/2
PAROMBO 28/3
FAKWACH MURCHISON 29/2
WANGKWAR FALLS 30/1
ADIBU 30/2
MINAKULU 31/2
ABOKE 32/1
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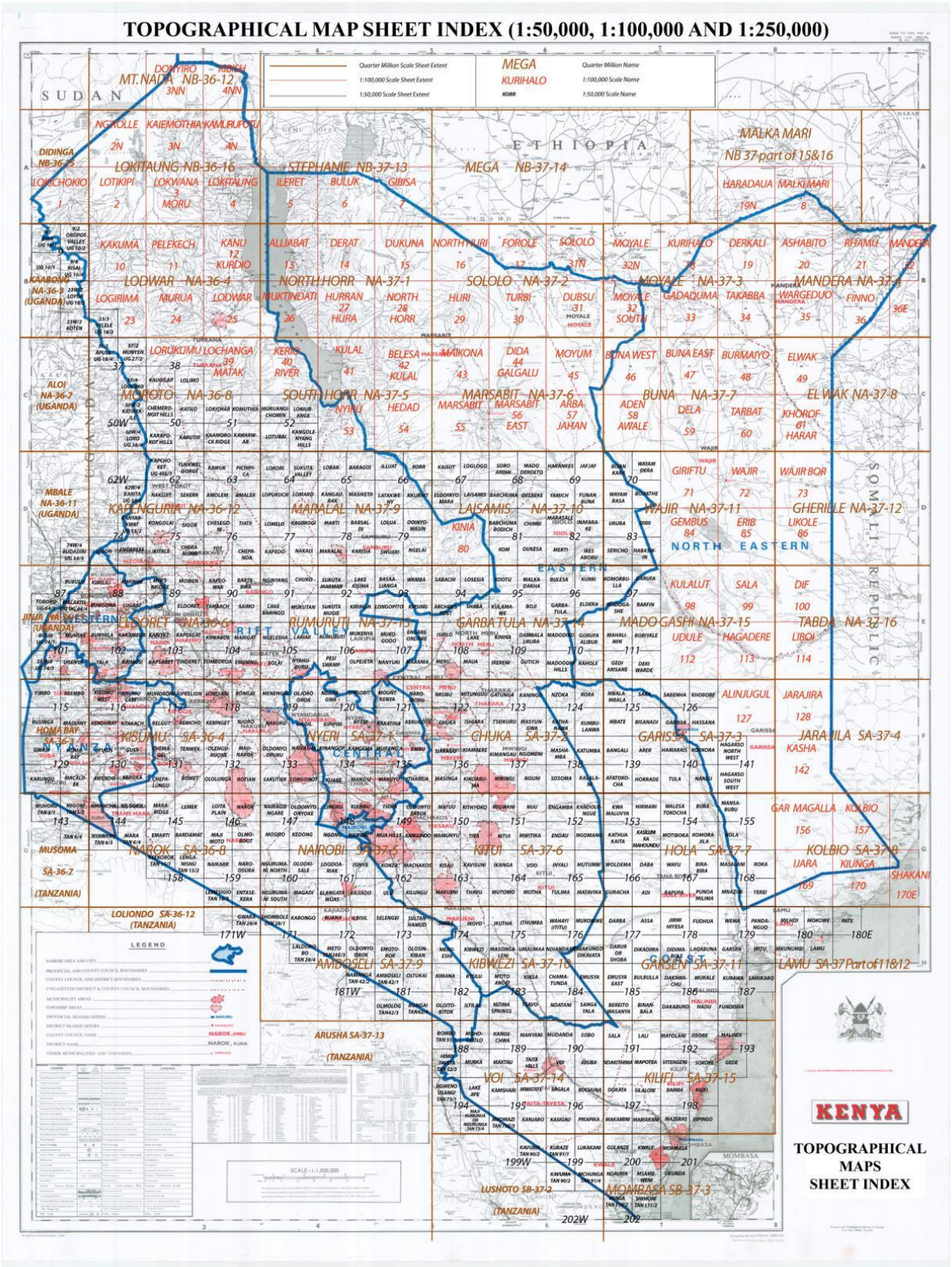
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TOPOGRAPHICAL MAPS SHEET INDEX
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ETHIOPIA
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TANZANIA
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STEPHANIE NB-37-13
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KURDIO
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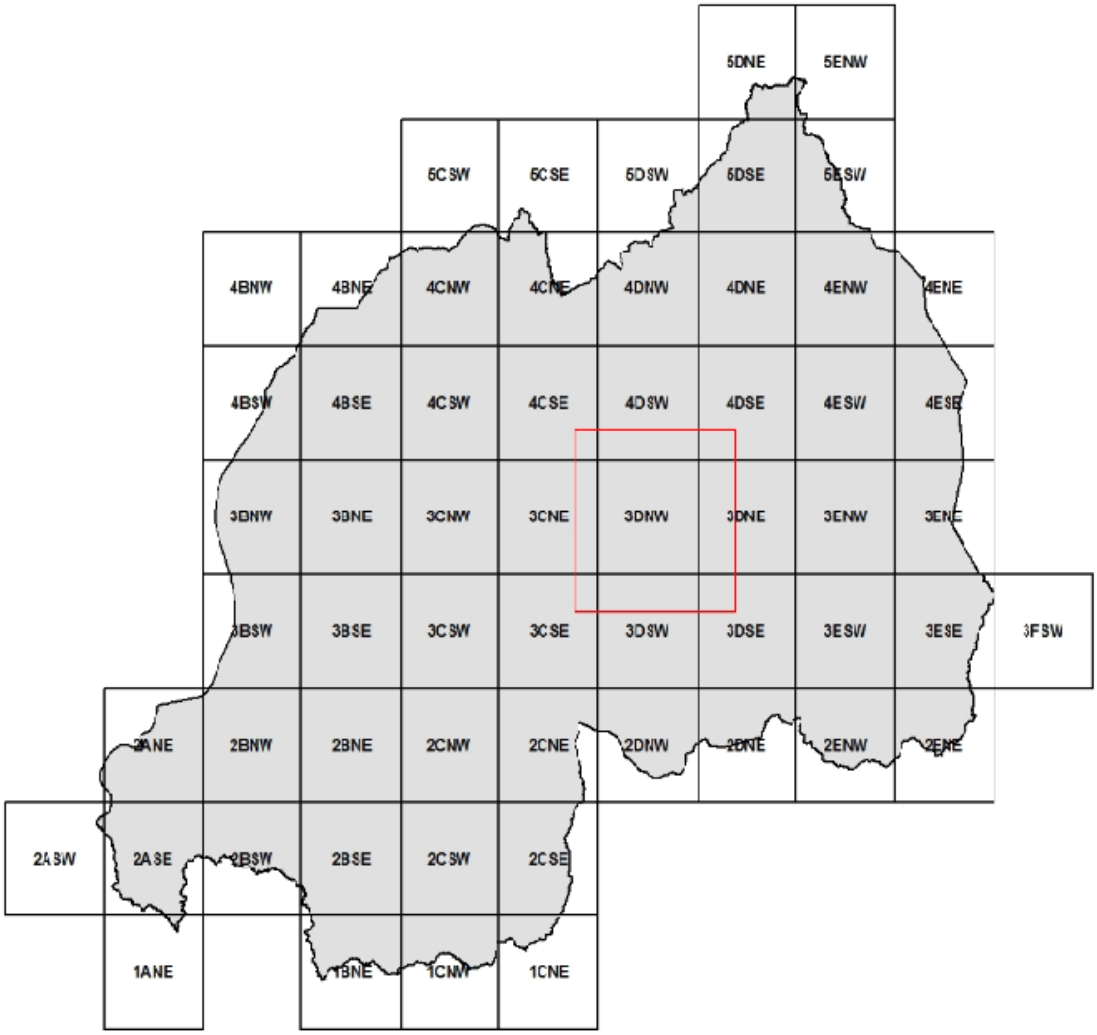
4. Rwanda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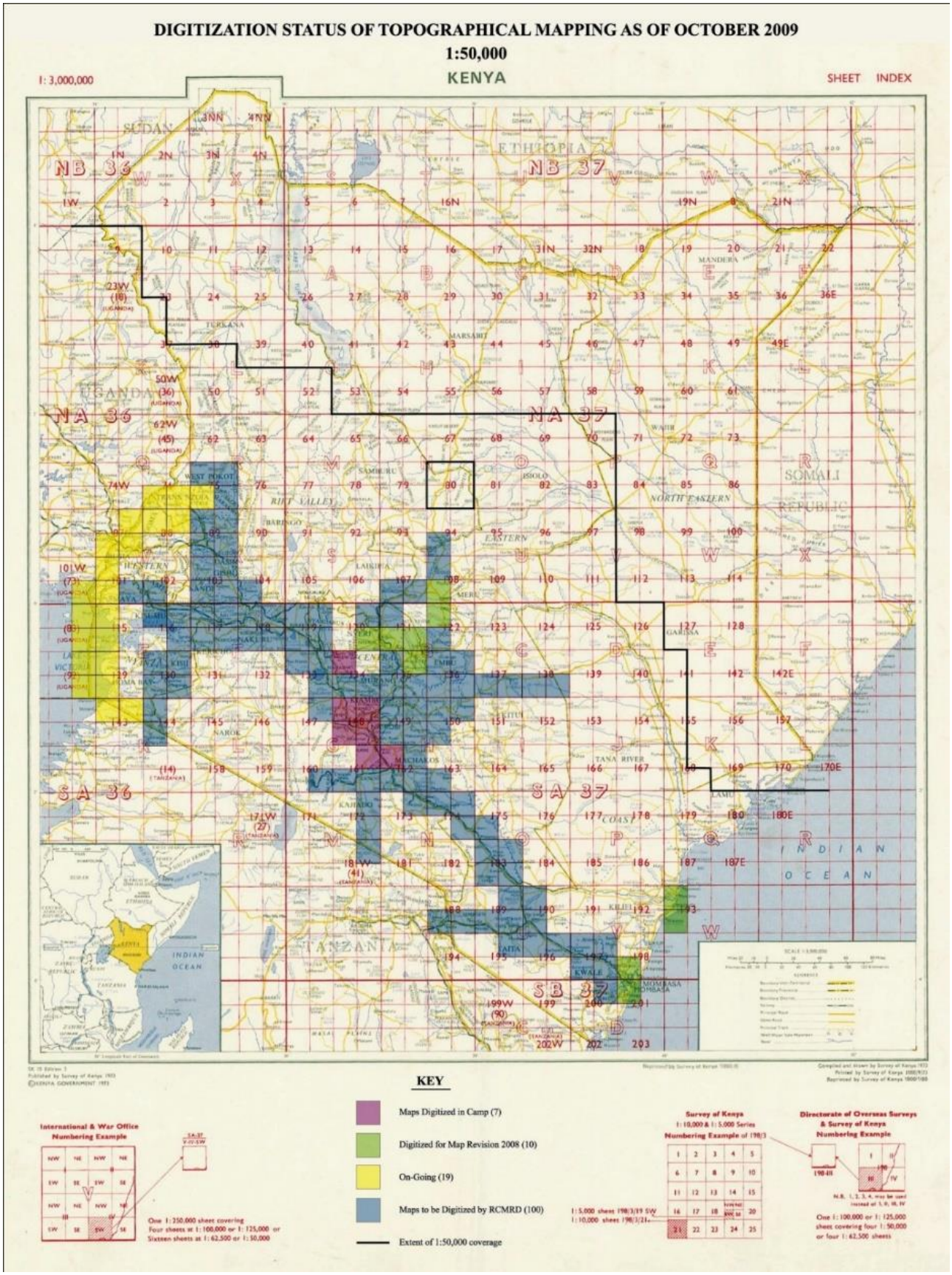
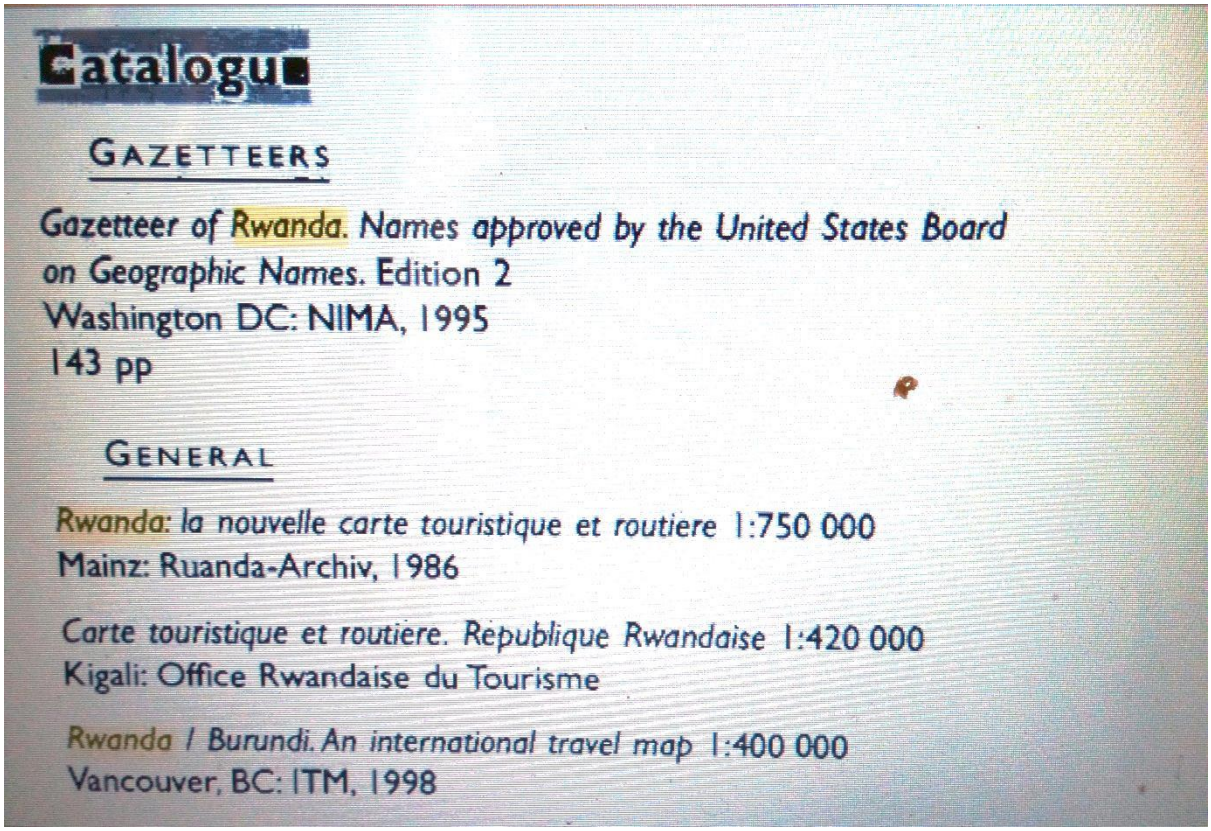
Appendix I: Kenya topographical mapping digitization status



Appendix J: Extract from Rwanda gazetteers



Catalogue

GAZETTEERS

Gazetteer of Rwanda. Names approved by the United States Board on Geographic Names. Edition 2
Washington DC: NIMA, 1995
143 pp

GENERAL

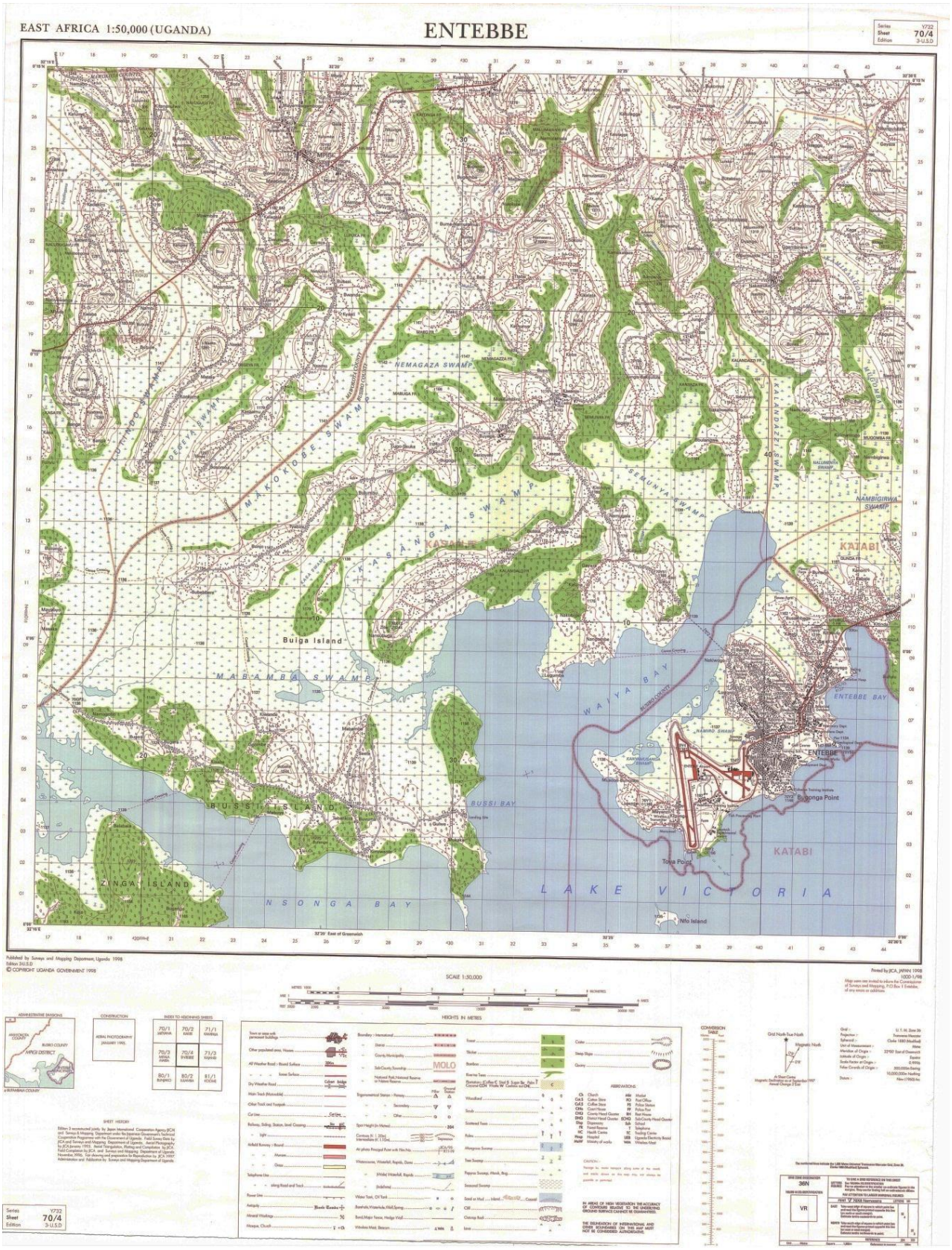
Rwanda: la nouvelle carte touristique et routiere 1:750 000
Mainz: Ruanda-Archiv, 1986

Carte touristique et routiere. Republique Rwandaise 1:420 000
Kigali: Office Rwandaise du Tourisme

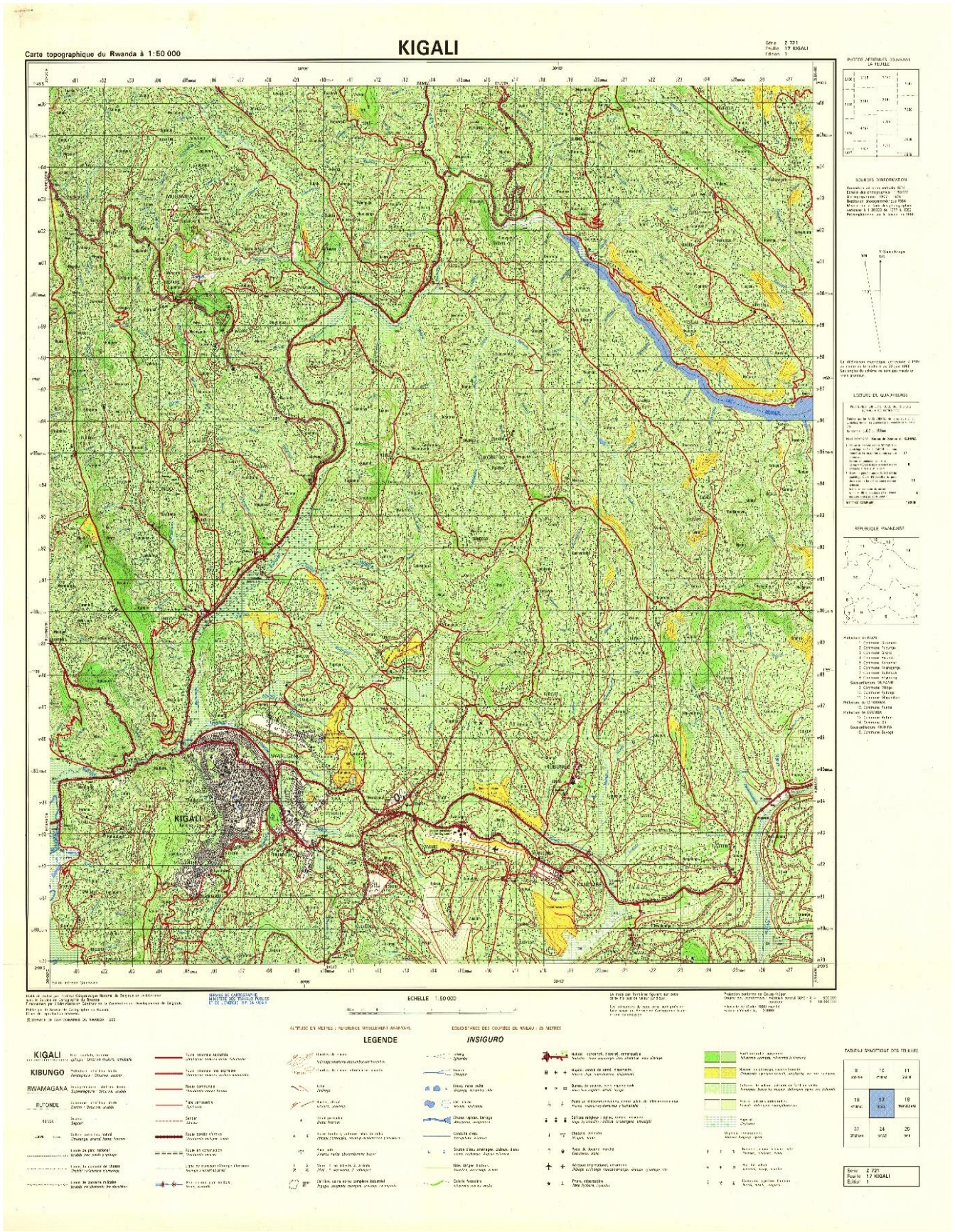
Rwanda / Burundi. An international travel map 1:400 000
Vancouver, BC: ITM, 1998

Appendix K: EAC states' topographical sheets (scale 1:50, 000)

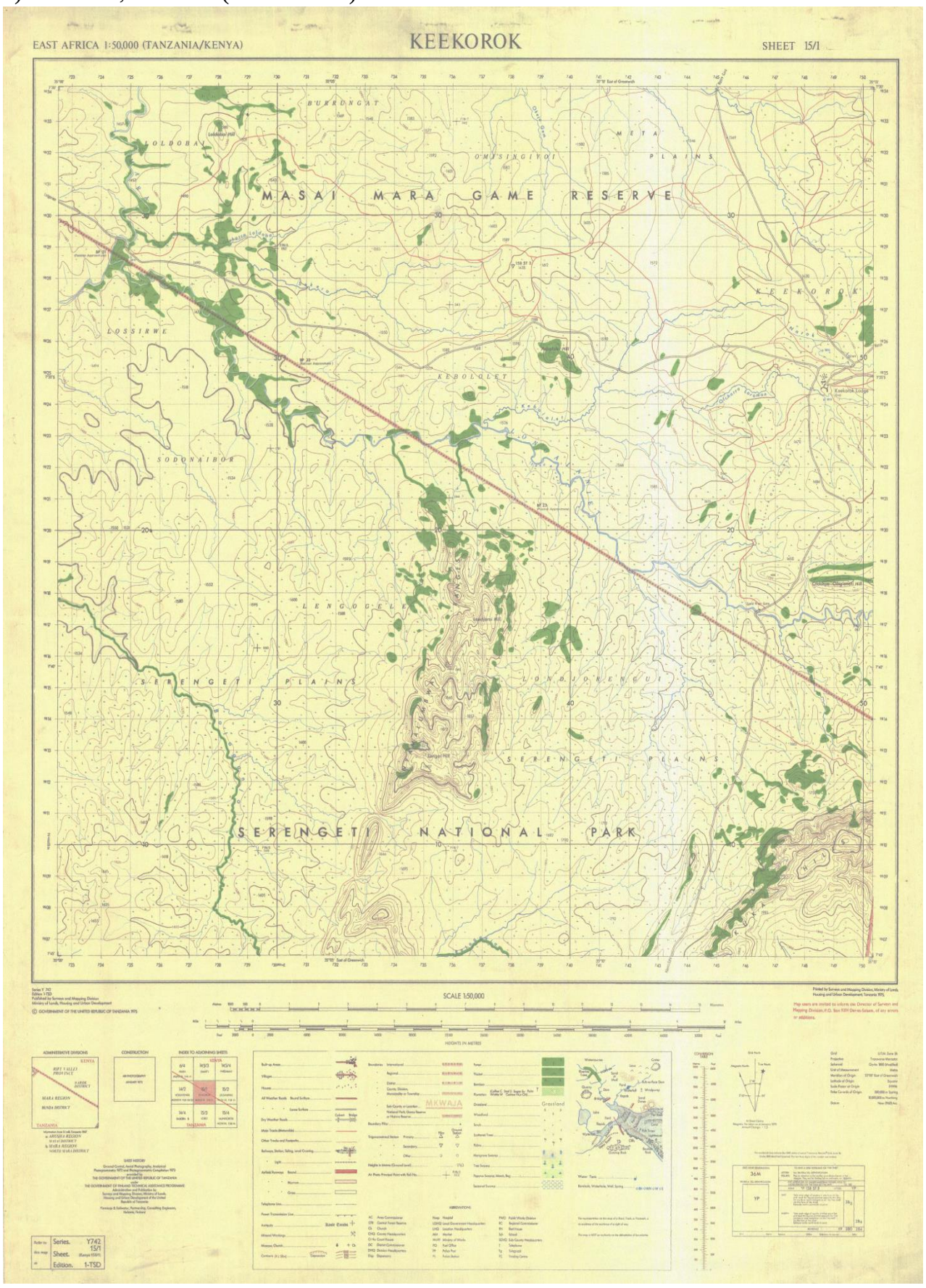
1) Entebbe, Uganda (Series Y 732)



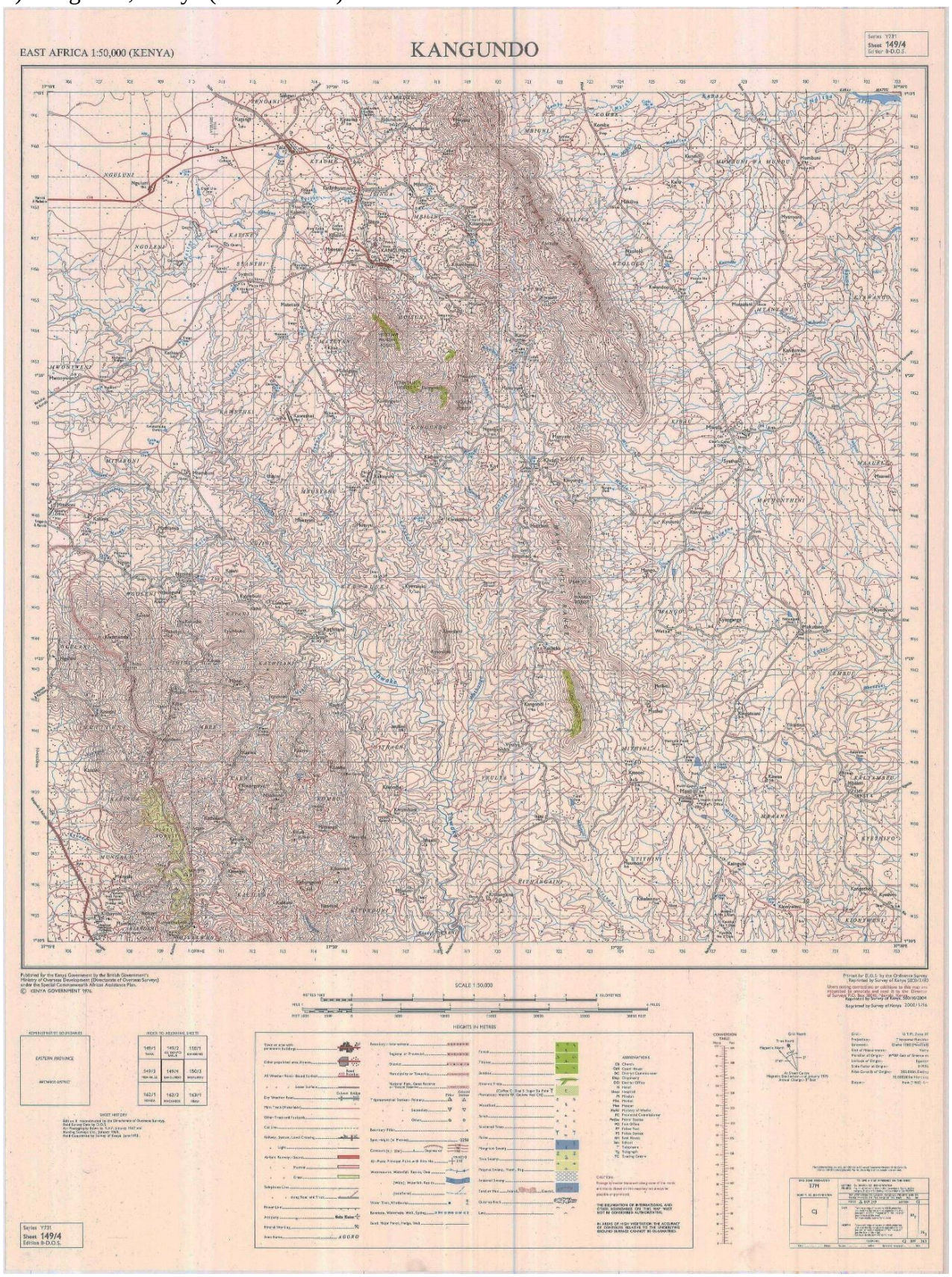
2) Kigali, Rwanda (Series Z 721)



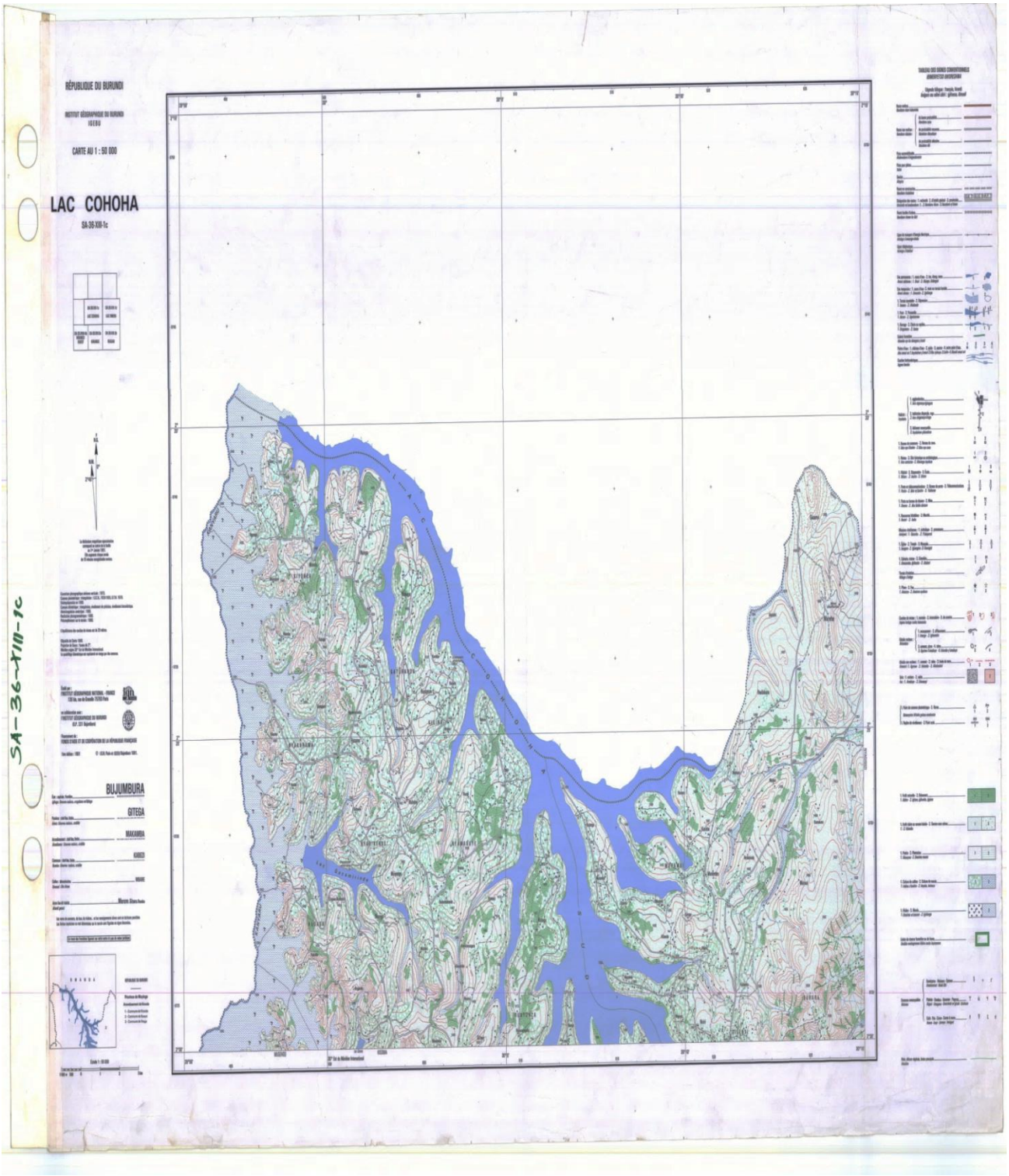
3) Keekorok, Tanzania (Series Y 742)



4) Kangundo, Kenya (series Y 732)



5) Bujumbura, Burundi (Series)



Appendix L: EuroGeographics members

No.	Country	Organization
1	ALBANIA	State Authority for Geospatial Information
		Central Office of Immovable Property Registration
2	ARMENIA	Real Estate Cadastre Committee of the Republic of Armenia
3	AUSTRIA	Federal Office of Metrology and Surveying
4	AZERBAIJAN	Real Estate Cadastre and Address Registry Service under the State Committee on Property Issues, the Republic of Azerbaijan
5	BELARUS	State Committee on Property of the Republic of Belarus
6	BELGIUM	National Geographic Institute
		General Administration of Patrimonial Documentation
7	BOSNIA and HERZEGOVINA	Federal Administration for Geodetic and Real Property Affairs
		Republic Authority for Geodetic and Property Affairs of Republic of Srpska
8	BULGARIA	Geodesy, Cartography and Cadastre Agency
9	CROATIA	State Geodetic Administration of the Republic of Croatia
10	CYPRUS	Cyprus Department of Lands and Surveys
11	CZECH REP	Czech Office for Surveying, Mapping and Cadastre
12	DENMARK	Danish Geodata Agency
		Agency for Data Supply and Efficiency
13	ESTONIA	Estonian Land Board
14	FINLAND	National Land Survey of Finland
15	FRANCE	National Institute of Geographic and Forest Information
16	GEORGIA	National Agency of Public Registry
17	GERMANY	Federal Agency for Cartography and Geodesy
	GERMANY	Working Committee of the Surveying Authorities of the Laender of the Federal Republic of Germany
18	GREAT BRITAIN	Ordnance Survey
		Her Majesty's Land Registry
		Registers of Scotland
19	GREECE	Hellenic Military Geographical Service
		Hellenic Cadastre
20	HUNGARY	Department of Geodesy, Remote Sensing and Land Offices
		Geoinformation Service of Hungarian Defence Forces
21	ICELAND	National Land Survey of Iceland
		Registers Iceland
22	IRELAND	Ordnance Survey Ireland
23	ITALY	Italian Military Geographic Institute
		Revenue Agency
24	KOSOVO	Kosovo Cadastral Agency
25	LATVIA	The State Land Service
		Latvian Geospatial Information Agency
26	LITHUANIA	National Land Service under the Ministry of Agriculture
		State Enterprise Centre of Registers
27	LUXEMBOURG	Administration of the Cadastre and Topography
28	MALTA	Malta Planning Authority
	MALTA	Malta Land Registry
29	MOLDOVA	Agency for Land Relations and Cadastre of the Republic of Moldova
30	MONTENEGRO	Real Estate Administration of Montenegro
31	NORTHERN IRELAND	Land and Property Services
32	NORWAY	Norwegian Mapping Authority
33	POLAND	Head Office of Geodesy and Cartography
34	PORTUGAL	Directorate General for Territory
35	REPUBLIC OF NORTH MACEDONIA	Agency for Real Estate Cadastre
36	ROMANIA	National Agency for Cadastre and Land Registration of Romania
37	RUSSIA	Federal Service for State Registration, Cadastre and Cartography
38	SERBIA	Republic Geodetic Authority
39	SLOVAK REPUBLIC	Geodesy, Cartography and Cadastre
40	SLOVENIA	Surveying and Mapping Authority of the Republic of Slovenia
41	SPAIN	National Geographic Institute of Spain
		General Directorate for the Cadastre
		Territorial Commission of the Geographic High Council
42	SWEDEN	The Swedish Mapping, Cadastral and Land Registration Authority
43	SWITZERLAND	Federal Office of Topography
44	THE NETHERLANDS	Cadastre, Land Registry and Mapping Agency
45	TURKEY	General Command of Mapping
		General Directorate of Land Registry and Cadastre
46	UKRAINE	State Service of Ukraine for Geodesy, Cartography and Cadastre

Appendix M: Participating organizations in East Africa

NO.	ORGANIZATION NAME	COUNTRY
1.	Geographic Institute of Burundi (NMO)	Burundi
2.	*Bureau Decentralization Des Geomatique* (BCG)	Burundi
3.	University of Burundi	Burundi
4.	Esri	Burundi
5.	Rwanda Natural Resources Authority(NMO)	Rwanda
6.	INES	Rwanda
7.	NUR	Rwanda
8.	Esri	Rwanda
9.	GIS-TECH Cadastrals	Rwanda
10.	GeoInfo Consultants	Rwanda
11.	Felix Sugi and partners	Rwanda
12.	Surveys and Mapping Division (NMO)	Tanzania
13.	Ardhi University	Tanzania
14.	Ardhi Institute_Tabora	Tanzania
15.	MUST College	Tanzania
16.	SEBA Survey Consultants	Tanzania
17.	Geodata Consultants	Tanzania
18.	Right Touch Surveys	Tanzania
19.	Geomaps	Tanzania
20.	Olipa	Tanzania
21.	Department of Surveys and Mapping (NMO)	Uganda
22.	Makerere University	Uganda
23.	Survey Training School(Entebbe)	Uganda
24.	GIC	Uganda
25.	Prime Surveys	Uganda
26.	Survey Consult Limited	Uganda
27.	GeoGecko	Uganda
28.	Terrains maps	Uganda
29.	Uganda Map	Uganda
30.	Digital mapping	Uganda
31.	Survey of Kenya (NMO)	Kenya
32.	University of Nairobi	Kenya
33.	Kenya Institute of Surveying and Mapping (KISM)	Kenya
34.	Ramani Geosystems	Kenya
35.	Tourist Maps	Kenya
36.	Geomaps	Kenya
37.	Geodev Surveys	Kenya
38.	Esri	Kenya