BIODIVERSITY INFORMATION AVAILABILITY AND USAGE IN MOROGORO, TANZANIA

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A THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN BIOLOGY IN THE OPEN UNIVERSITY OF TANZANIA.

2010

SUPERVISORS CERTIFICATION

I have read the thesis and found it to be in a form acceptable for submission.

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DECLARATION

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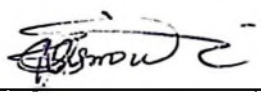

08/07/2010

Philbert Simon Nyinondi — Date

(MSc. Candidate)

DEDICATION

To God, my loving wife Dorice Lutatenekwa and my son Nyinondi Philbert who have been my companion and very trustful friends. To my beloved father Simon Nyinondi and Mother Allodia Nyinondi who laid the foundation of my education.

ABSTRACT

This study was designed to find out and assess available biodiversity information and usage in Morogoro region. Specifically the study was to identify biodiversity data location and information holders; classify identified biodiversity information according to their technological structure and geographical area of coverage; determine the extent to which the available biodiversity information is used; and recommend the best ways in which Biodiversity Information Facility can be established in Morogoro and other Tanzanian regions. The study was implemented in two phases. The first phase involved in depth literature review. The outputs of first phase were used to choose eight institutions for comprehensive study in the second phase. The second phase involved questionnaire survey, interview and participants observations. Collected quantitative data was analysed using Microsoft Office Excel as spreadsheet, while qualitative data were analysed by using the content and structural functional analysis techniques. The results revealed that Morogoro region has at least 25 datasets, of which large proportion of datasets (44%) is held by research institutions. Based on studied institutions the findings show that mammals and birds classes have been studied more than other classes. The results further show that an average of 72% datasets has been totally or partially digitalised and 80% of datasets are freely accessible. These findings provide baseline evidence that regional biodiversity information facility units can be established and function, despite the fact that potential amount of biodiversity information is still scattered, unreported and inaccessible.

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LIST OF ABBREVIATIONS

BIF	- Information Facility Units
CD-ROM	- Compact Disc Read Only Memory
EAMCP	- Eastern Arc Mountains Conservation Programme
FAO	- United Nations Food and Agriculture Organization agency
GBIF	- Global Biodiversity Information Facility
GIS	- Geographic information systems
ICT	- Information and Communication Technology
MINAPA	- Mikumi National Park
NGO	- Non Governmental organisation
SUA	- Sokoine University of Agriculture
TAFORI	- Tanzania forest Research Institute
TanBIF	- Tanzania Biodiversity Information Facility unit
TANSEED	- Tanzania Seed Company
UNAPA	- Udzugwa National Park
UN-CBD	-United Nations Convention on Biological Diversity
UNEP	- United Nations Environmental Programme
UNMEA	- United Nations Millennium Ecosystem Assessment
URT	- United Republic of Tanzania
WCMC	- World Conservation Monitoring Centre
URL	- Universal Resource Locator

CHAPTER ONE

1.0 INTRODUCTION AND LITERATURE REVIEW

1.1 Background information

1.1.1 Biodiversity

Biodiversity is short term of biological diversity, which describes the variety and variability of life on Earth (Chauvet and Oliver 1993). The 1992 United Nations Earth Summit in Rio de Janeiro defined biodiversity as "the variability among living organisms from all sources, including, *'inter alia'*, terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems". This definition was adopted by the United Nations Convention on Biological Diversity (UN-CBD) ratified by most nations in the world including Tanzania.

The Rio Declaration on Environment and Development set a milestone for biodiversity conservation through Agenda 21. The objectives and activities of Agenda 21 were and are to improve the conservation of biological diversity and the sustainable use of biological resources, as well as to support the Convention on Biological Diversity.

Biodiversity is vital to human beings for their sustenance, health, well-being and recreation. In 2005, the final report of the United Nations Millennium Ecosystem

Assessment (UNMEA) warned that if current patterns of biodiversity loss continue to increase, the future generations of humanity may be at risk. It is estimated that current species extinction rates may be a thousand times greater than normal in nature, and that 12% of bird species and 23% of mammalian species are threatened with extinction (UNMEA 2005). Some evolutionary and ecological processes may also be endangered. Accordingly, the extinction crisis is one of the most critical challenges for the 21st century.

1.1.2 Biodiversity information and usage

Biodiversity information is mainly found in published scientific books and journals, in the minds of the biodiversity specialists, in museum and research institutions. Along with the increasing importance of biodiversity issues in international policies, information has become increasingly relevant for many interested groups other than scientists (Laihonem 2003). Biodiversity information is used in complex and controversial political, economic and environmental issues, discussions and decision-making (Agenda 21 1992). However, limited access to current timely and relevant biodiversity information can be impairing to decision making, planning, and environmental education and in many other similar tasks (GBIF 2000, Momodu 2002).

Scholars in all biological sectors appreciate contribution of information in making rational biological decisions (UNEP 1993). In their studies, Rutatora and Mattee (2001) and Kasolupa (2005) acknowledge the role played by information in decision making. Informed decisions are always rational ones and usually help in minimizing the extent of biodiversity extinction risks.

1.1.3 Biodiversity information and technologies

Information and communication technologies (ICTs) are advancing rapidly and provide capabilities required to implement Agenda 21 and UN-CBD objectives of making biodiversity information timely available and accessible. The ICTs are important in improving biodiversity information accessibility and usage. Lutz (2003) describes ICTs as effective information processing and dissemination tools. According to Lutz (2003), through ICTs, users can access internet and use computers which facilitate information dissemination.

The ICTs provide tools to digitize information and store it in accessible systems; discover and retrieve data pertinent to the issue at hand; analyze data from diverse, distributed databases; input the data to decision-support, modelling or other management systems; and promote interaction among colleagues through forums, Internet-based communication facilities which enable discussion, document development and revision, and decision making in right time (Chailla *et al.* 2009).

Studies by Annam (2006), Jonathan and Matambalya (2004) reveal that ICTs play a key role in information dissemination, act as facilitators to decision making. ICTs enable communication, a process that links individuals and communities, governments and citizens in participation and shared decision making (Yonah and Cons 2005).

The evolution of ICTs has changed the techniques of communicating biodiversity information globally. Unfortunately such technologies are not on equal distribution among developed and less developed countries (Chailla *et al.* 2009). Most of those which are found in less developed countries are in urban areas (Harris 2001; Chailla *et al.* 2007). Unequal distributions of information processing technologies have negative effects on biodiversity information availability and usage (Chailla *et al.* 2009).

Various initiatives like Rio summit declaration, Millennium Development Goals, and United Nation agreement of making information as one of human rights, have been made to close information gap globally. Establishment of Biodiversity Information Facility units (BIF) and telecentres are among the efforts toward making biodiversity information available and accessible to all. Harris (1999) advocated for telecentres, due to their potentials in providing access to information for communities in rural areas, and solution to information dissemination problems in less developed countries. The Rio summit in 1992 through the United Nations Convention on Biological Diversity (UN-CBD) agreed to establish the protocol for clearing-house mechanism for biodiversity information. Global Biodiversity Information Facility (GBIF) is an output of that agreement and uses ICTs in management of biodiversity information for greater accessibility to all stakeholders.

In most African countries, biodiversity information centres and telecentres were developed in 1990s to improve access to biodiversity information and ICT services. The information centres have been described as tools for creating, accessing, and sharing information

(Hudson 2000). The expected major benefit of BIF and telecentres in Africa is the promotion of ICT use for sustainable development (Ojo 2005).

Tanzania has progressively implemented the global ICT development agreements. The national ICT development goals conform to Agenda 21 and Millennium Development Goals, which among other things promote the conservation of biodiversity and protection of environment for sustainable development. Furthermore, Tanzania is implementing ICT Policy with two broad objectives, which are to:

"1. Provide a national framework that will enable ICT, to contribute towards achieving national development goals; and

2. Transform Tanzania into a knowledge-based society through the application of ICT" (URT 2003).

Telecentres in Tanzania address the National ICT policy. The first official telecentre in Tanzania was launched in 2001 and by 2008 Tanzania had over twelve telecentres (Mtega and Malekani 2009). This implies telecentres were among other tools earmarked to facilitate biodiversity information management, dissemination and usage.

Unfortunately, Tanzania has not established mechanisms through which research institutions, government offices, NGOs and individuals holding biodiversity information can disseminate bio-information to rural communities through telecentres. The situation has been largely attributed to the fact that a good number of biodiversity information which exists, is in the form of unpublished reports, files and studies of limited distribution. In most cases even the information holders are not known.

1.2 Literature Review

1.2.1 Biodiversity historical background and definitions

Biodiversity is a concept twisted from biology and diversity, originating from and used interchangeably with biological diversity. Dasmann (1968) was the first wildlife scientist and conservationist to describe this term in advocating nature conservation. The term biodiversity became common in science and environmental policy in 1980s (Soulé and Wilcox 1980, Wilson and Peter 1988). Since that period biodiversity has achieved widespread use among biologists, environmentalists, political leaders, and all stakeholders. The use has coincided with the expansion of concern over species extinction observed in the last decades of the 20th century. Biodiversity is associated with a concern for the environment and nature conservation.

An explicit definition was first given in a Wilcox paper presented at World National Parks Conference in Bali 1982 (Wilcox 1984). The definition Wilcox gave is "Biological diversity is the variety of life forms...at all levels of biological systems (i.e., molecular, organism, population, species and ecosystem)..." afterwards, the 1992 United Nations Earth Summit in Rio de Janeiro defined "biological diversity" as "the variability among living organisms from all sources, including, 'inter alia', terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems". This is, in fact, the closest acceptable definition of biodiversity, since it is the definition adopted by the United Nations Convention on Biological Diversity (UN-CBD).

The current textbook definition of biodiversity is "variation of life at all levels of biological organization" (Gaston and Spicer 2004). Consistent with this definition the Wilcox paper stated "genes are the ultimate source of biological organization at all levels of biological systems..."

However, biologists most often define "biological diversity" or "biodiversity" as the "totality of genes, species, and ecosystems of a region". An advantage of this definition is that it describes most circumstances and presents a unified view of the following traditional three levels at which biological variety has been identified:

i. Genetic diversity; refers to the variation of genes within species. This covers distinct populations of the same species or genetic variation within a population.

ii. Species diversity; refers to the variety of species within a region. Such diversity can be measured in many ways, and scientists have not settled on a single best method. The number of species in a region -- its species "richness" -- is one often-used measure, but a more precise measurement, "taxonomic diversity", also considers the relationship of species to each other.

iii. Ecosystem diversity; is harder to measure than species or genetic diversity because the "boundaries" of communities associations of species and ecosystems are elusive. Nevertheless, as long as a consistent set of criteria is used to define communities and ecosystems, their numbers and distribution can be measured.

This study adopted UN-CBD definition of biodiversity due to its general acceptance among biodiversity information specialists, applied by GBIF.

1.2.2 Measurement of biodiversity

Biodiversity is usually plotted as taxonomic richness of a geographic area, with some reference to a temporal scale. Whittaker (1972) described the three most common metrics used to measure species-level biodiversity. The Whittaker's metrics are i) Species richness, ii) Simpson index, and iii) Shannon-Wiener index. All metrics focus on measuring species richness or species evenness. Additionally, Shannon-Wiener index measures diversity.

There are three other indices which are used by ecologists. These are i) Alpha diversity; which refers to diversity within a particular area, community or ecosystem, and is measured by counting the number of taxa within the ecosystem; ii) Beta diversity; which is species diversity between ecosystems, this involves comparing the number of taxa that are unique to each of the ecosystems; and iii) Gamma diversity; which is a measurement of the overall diversity for different ecosystems within a region.

Therefore the measurements of biodiversity depend on biome and nature of studies, and are not uniform.

1.2.3 Evolution

Biodiversity found on Earth today is the result of 4 billion years of evolution (Cavalier-Smith 2006, Schopf 2000). The origin of life has not been definitely established by science, however some evidences suggest that life may already have been well-established a few hundred million years after the formation of the Earth (Schopf 1994). Until approximately 600 million years ago, all life consisted of archaea, bacteria, protozoans and similar single-celled organisms (DeLong 2001).

The history of biodiversity during the Phanerozoic, about 540 million years ago, started with rapid growth during the Cambrian explosion, a period during which nearly every phylum of multi-cellular organisms first appeared. Over the next 400 million years or so, global diversity showed little overall trend, but was marked by periodic, massive losses of diversity classified as mass extinction events (Schloss and Handelsman 2004, Figure 1).

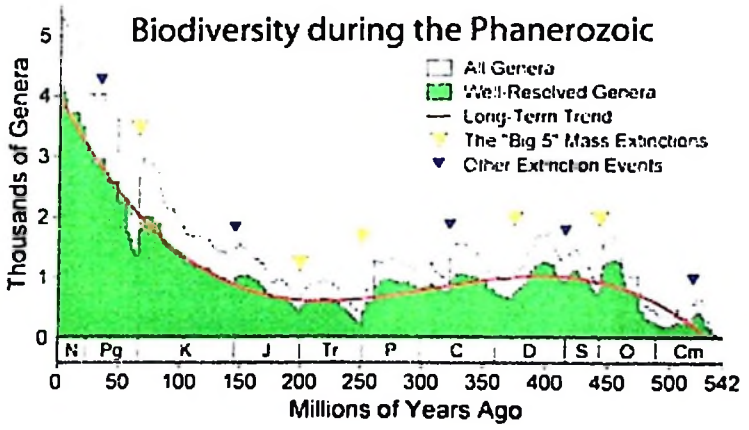

Figure 1: Biodiversity trend during the Phanerozoic period (Schopf 2000)

The apparent biodiversity shown in the fossil record suggests that the last few million years include the period of greatest biodiversity in the Earth's history (Valentine *et al.* 1999). However, not all scientists support this view, since there is considerable uncertainty as to how strongly the fossil record is biased by the greater availability and preservation of recent geologic sections. Some scholars like Alroy *et al.* (2001) argue that, corrected for sampling artifacts, modern biodiversity is not much different from biodiversity 300 million years ago.

Estimates of the present global macroscopic species diversity vary from 2 million to 100 million species, with a best estimate of between 13 to 14 million, the vast majority of them arthropods (WCMC 1992). Most biologists agree however that the period since the emergence of humans is part of a new mass extinction, the Holocene extinction event, caused primarily by the impact humans are having on the environment (Pimm *et al.* 1995, Novacek and Cleland 2001). It has been argued that the present rate of extinction is sufficient to eliminate most species on the planet Earth within 100 years (Wilson 2002, Lewis 2006).

1.2.4 Importance of biodiversity

There are a multitude of direct anthropocentric benefits of biodiversity in the areas of agriculture, science and medicine, industrial materials, ecological services, leisure, cultural, aesthetic and intellectual value. However, biodiversity also includes pest species and organisms of no known interest or direct use to human at least for the present.

Biodiversity also supports a number of natural ecosystem processes and services. Some ecosystem services that benefit society are air quality, climate (both global Carbon dioxide sequestration and local), water purification, disease control, biological pest control, pollination and prevention of erosion (Fjeldsaå and Lovett 1997). Non-material benefits that are obtained from ecosystems include spiritual and aesthetic values, knowledge systems and the value of education.

1.2.5 Distribution and threat to biodiversity

The global geographical distribution of biodiversity is relevant to conservation and is believed to be greatest near the equator, and declines towards higher latitudes (Soule and Wilcox 1980). Tropical rain forests are known for their exceptional diversity. Some locations known as "hotspots'" which are 25 in number worldwide harbour an unusually rich local diversity, perhaps because conditions favour evolutionary diversification (Madoffe 2005).

Approximately 1.8 millions species are known to scientists, but because many species are not yet described, an estimated 10-30 million species exist at present (Madoffe 2005). New species are regularly discovered on an average of between 5 and 10,000 new species each year, most of them insects and many, though discovered, are not yet classified. It is estimated that nearly 90% of all arthropods are not yet classified (WCMC 1992).

Biodiversity is threatened by human activities (Pimm *et al.*1995, Wilson 2002, Lewis 2006). It is useful to group the threats into categories namely, over hunting, habitat destruction, invasion of non-native species, domino effects, pollution, and climate change (Madoffe 2005). Habitat destruction presents the single greatest threat to the world biodiversity. The magnitude of this threat can be deduced from species-area curves and rates of habitat loss. The spread of non-native species threatens many local species with extinction, and pushes the world's biota toward a more homogeneous and widely distributed sub-set of survivors. Climate change threatens to force species and ecosystems to migrate toward higher latitudes, with no guarantee of suitable habitat or access routes. These three factors thus are of special concern (Madoffe 2005).

1.2.6 Biodiversity information

The important step in biodiversity protection and management is making biodiversity information available and more accessible to users. One has to find out what data and information are already available and incorporate them into the knowledge base. As the integrated knowledge base grows, gaps in the information required to support biodiversity activities will become apparent. These gaps are a challenge to the research community and may help individuals and institutions direct their research initiatives to areas of potential high return on research investment. Knowing where our knowledge or understanding falls short may also suggest areas where multi-institutional collaborations on a particular biodiversity issue might be most appropriate.

In spite of the facts that relatively few biological species are described, the accumulated volume of biological information and data collected over the past 250 years is massive (Blackmore 2002). Approximately three billion specimens of organisms are held in the world's natural history collections (Edwards *et al.* 2000, Schnase *et al.* 2003). Improving methods for organising, storing and retrieving the collection records is extremely critical. This alleviates the problem of users having to travel physically to the place where a specimen is housed for borrowing purposes (Edwards *et al.* 2000).

Biodiversity information must not be restricted or conditioned for scientific advancement. Conservation of biodiversity must also be linked to sound policy, which in turn, requires solid scientific foundations to which biodiversity information and data networks significantly contribute.

1.2.7 Biodiversity information sources

1.2.7.1 Human mind

People who have life- long experience in biological groups have great accumulation of biodiversity information. The human mind, however, makes errors when it comes to remembering precise details. The human mind also has a limited storage capacity and bias. A further weakness of the human mind as :. storage system is that people eventually die and their accumulated information is lost.

1.2.7.2 Paper-based systems

These systems have the advantage that they can hold information that is not standardised and thus cannot easily be entered into computer. For example, paper based file on particular species could contain lists of localities, references on the species, and distribution maps at different scales. If organised they can provide a good way of holding data, which can later be computerised. However, paper based systems are a disadvantage to other storage systems because of their static data feature.

1.2.7.3 Point locality computer databases

The main advantage of such systems is their capacity to hold precise locality details for a very large number of biological specimens. Point locality computer databases are used in Tanzania to hold a lot of data on the species, though the coverage is not comprehensive and software used cannot transfer data to newer systems.

1.2.7.4 Geographic information systems and related programmes

Geographic information systems (GIS) are computerised tools designed to assemble and analyse spatial data. The systems can be linked to point locality databases, and thus data from other sources can be imported and analysed. GIS has been useful tool in studying biodiversity, even in remote areas. However, the system requires highly trained personnel in computer science and GIS to use it.

1.2.7.5 Museum collections

There are about 10 million biological specimens in museum collections around the world. These collections are potential source of distributional data. However, the data contained in museum collections are generally difficult to access. Collections in the museums are largely or even totally non-computerised.

1.2.7.6 Database systems

Data refers to information or facts usually collected as the result of experience, observation or experiment, or processes within a computer system, or premises. Data may consist of number, words, or images, particularly as measurements or observations of a set of variables. Data are often viewed as a lowest level of abstraction from which information and knowledge are derived. Biological data is data or measurements collected from biological sources, which is commonly stored in files or databases.

A collection of related data is known as dataset, while a collection of datasets forms a metadata. The term dataset can refer to a collection of different themes that belong to the same geographic area, sometimes to a collection of similar themes that belong to different geographical areas. There is no unique definition of dataset, because there are many different schemes to construct a dataset.

Database is a term describing systems that hold information in an organised and retrievable form. Database is synonymous to databank but not metadata, which means structured data. Thus, metadata is a component of database. In biodiversity context,

metadata include bibliographic data, specimen data from museums, taxonomies developed by systematic biologists and the products of research and geospatial surveying.

However, most of biodiversity databases hold data either on species or specimens such as a) nomenclature, geographical data and status scale; b) descriptive data- morphology, anatomy, chemistry, and ecology; c) economic value of biodiversity; d) conservation status; e) images; and f) bibliography sources of data used in the database.

A number of non-computerised database systems have existed for decades. Collectively these systems hold a lot of data, but typically the data cannot be easily retrieved or manipulated. In recent years, there has been advancement in database systems. These have the same general function as the tradition databases, but can hold more data, and can be manipulated accordingly to suit the situation such access.

1.2.8 Accessibility to biodiversity information

Biological scientists normally access biodiversity information from published scientific books, journals, proceedings, research institutes, universities, archives and from other repositories. However, recent development in digitization and ICTs has brought significant changes in the way information is generated, distributed, accessed and used (Chailla *et al.* 2007, Chailla *et al.* 2009). These changes facilitate biological scientists in less developed countries to access electronic resources created by their counterparts in developed countries. In their studies Chailla (2001) and Dulle *et al.* (2001) reported limited accessibility of information generated in less developed countries due to poor

dissemination channels and technologies. The situation in Tanzania is not different to that in other less developed countries where an individual can hardly access information generated by a fellow scientist at the same institution (Chailla *et al.* 2009).

The survival of biodiversity is the responsibility of all people. Unfortunately, most people access information from magazine, television, radio, newspapers, brochure, and cell phones, where biodiversity information is inadequately communicated (Sturges and Chimseu 1996, Johnson 2004).

The preference of one information channel over the other depends on different criteria. Stephano *et al.* (2005) described the criteria for choosing information dissemination channels to include credibility and accessibility of the channel, awareness of the existence of the information channel and language used in presenting information.

Therefore, biodiversity stakeholders continue to be inadequately informed on what actions biologists are proposing for sustainable biodiversity resource use and management.

1.2.9 Access limitation to biodiversity information

There are numerous factors contributing to problems in accessing and disseminating biodiversity information. The most mentioned factors are: poor storage of biodiversity data, issues of copyright, and information search skills. Chailla *et al.* (2007) and Chailla *et al.* (2009) used the case of "digital library" and "grey literature" in institutions to show that underdeveloped ICT infrastructure is the single most important set back for information

access and dissemination in the East African countries. Kapange (2004) mentioned poor research funding and low staff morale as the major factors. However, Lwoga *et al.* (2006) supported Seneviratne and Gunawardena (2004), that information literacy among specific information consumers is low due to geographical, structural, and technological barriers. Rural people thus face digital divide due to information illiteracy.

1.2.10 Biodiversity of Tanzania

1.2.11 Global Biodiversity Information Facility (GBIF)

This subsection summary what is GBIF and its vision, mission, aim and functions based on information available on GBIF master plain and website (www.gbif.org).

The Global Biodiversity Information Facility (GBIF) is an international organisation that focuses on making scientific data on biodiversity available via the Internet using web services. The data are provided by many institutions from around the world; GBIF's information architecture makes these data accessible and searchable through a single portal. Data available through the GBIF portal are primarily distribution data on plants, animals, fungi, and microbes for the world, and scientific names data.

GBIF's vision is to make scientific biodiversity data the common property of everyone, in service to science, the Convention on Biological Diversity among other international conventions, and the public good. Through its participants and partners, GBIF will stimulate innovations in information technologies and scientific research that benefit both biodiversity and the economy.

The mission of the Global Biodiversity information Facility (GBIF) is to facilitate free and open access to biodiversity data worldwide to underpin sustainable development. Priorities, with an emphasis on promoting participation and working through partners, include mobilising biodiversity data, developing protocols and standards to ensure scientific integrity and interoperability, building an informatics architecture to allow the interlinking of diverse data types from disparate sources, promoting capacity building and catalysing development of analytical tools for improved decision-making.

GBIF aims to be the preferred gateway, worldwide, to a comprehensive, distributed array of primary species-occurrence data. Membership in GBIF is open to all countries, as well as international organisations.

GBIF strives to form informatics linkages among digital data resources from across the spectrum of biological organisation - from genes to ecosystems, and to connect these to issues important to science, society and sustainability by using georeferencing and GIS tools. It works in partnership with other international organisations such as the Catalogue of Life partnership, Taxonomic Database Working Group (the international biodiversity information standards organisation), the Consortium for the Barcode of Life (CBOL), the Encyclopedia of Life (EOL), and the International Long-Term Ecological Research (ILTER), Network and the Global Earth Observing System of Systems (GEOSS), as well as GenBank and other molecular sequence data.

Achieving the GBIF vision of biodiversity data that is freely and openly available to anyone, anywhere, the following have been operationalised:

GBIF makes available primary scientific data that were recorded directly from nature. Primary data can be used and reused in different analyses without diminishing their value. GBIF places a strong emphasis on the digitisation of natural history and other biological collections in order to make accessible a temporal as well as spatial record of the occurrence of species on Earth.

GBIF also encourages the sharing of taxonomic names, data, and concepts. GBIF uses an informatics system that presents all available classifications of species and allows users to work with their preferred classifications.

Data that are made available via the GBIF network belong to the data owners. GBIF continue encouraging and helping data owners to become data sharers. This assistance takes the form of freely distributed software that meets community standards, helpdesk services, "how-to" manuals, and training workshops.

Standards for data and metadata will continue to be developed in order to facilitate linking together molecular, species and ecosystem data, as well as digital libraries, images and other resources. This will increase the data resources available for decision-making and scientific purposes, therefore maximising return on investment in data gathering.

The needs of data users, such as the biodiversity related conventions, is utilised to prioritise among digitisation projects. Funders and users works with GBIF in coordinated efforts to build robust datasets that are suitable for addressing specific pressing questions.

Connecting biodiversity databases from around the world. This is being achieved through a network of Nodes in participating countries. Standards for data sharing are being developed in partnership with Biodiversity Information Standards (TDWG), as well as free software applications, support and helpdesk for data providers.

Building a complete electronic catalogue of scientific names in partnership with other organisations. This catalogue is useful in creating an information retrieval tool that facilitates searching, enables browsing, and can contribute to the Global Taxonomy Initiative.

Providing web services that catalyse further biodiversity informatics applications by GBIF's Participants, partners and others. GBIF data are shared, dynamic, interactive and ever evolving resource, its web services allows anyone to build applications based on GBIF-mediated data. The GBIF Data Portal interface is user-friendly, the search engine robust, and the data export and visualisation services unique among global database networks.

1.2.12 Available optional solutions

Several biodiversity information scholars around the world support the UN-CBD and creation of GBIF. Today, one can access the digitized and stored information from GBIF through internet. However, people in rural areas could get access to biodiversity

information from GBIF through telecentres. Establishment of a local, national and regional biodiversity facility unit will therefore increase the likelihood of making biodiversity information on a specific taxon or on taxa from any defined location accessible. This will positively influence rational decisions making towards biodiversity resource use and management.

CHAPTER TWO

2.0 RESEARCH PROBLEM AND OBJECTIVES

2.1 Statement of research problem

Scattered biodiversity information clusters, many times unreported or inaccessible are a historical problem for those who seek to understand the intricate relationships of life and its surroundings, and are, therefore, a setback for integrating environmental management and conciliated human actions to preserve biological heritage.

Increasing concern on biodiversity loss and information access has demanded for world's attention to inventory and monitor the wealth of biodiversity. Agenda 21 and the United Nation Convention on Biological Diversity insist on collaboration in the production and dissemination of information needed for the conservation and sustainable use of biodiversity. Globally, the Global Biodiversity Information Facility unit (GBIF) has been established (GBIF, 2000). Several countries have already established their national biodiversity information infrastructures to meet the international obligations and their own conservation and development objectives. Tanzania has just established GBIF node known as Tanzania Biodiversity Information Facility unit (TanBIF). However, the status of biodiversity information in the country is partially known, and little is known on kind of biodiversity information available, the format of information management and usage in Tanzania administrative regions.

Biodiversity information is available at various centres and archives in Tanzania. The information can be gathered, organised, digitalised and disseminated through regional biodiversity information centre, which in turn will act as TanBIF nodes. The procedure involves establishing, systematic classification and documentation of available biodiversity information.

The study aimed at finding out biodiversity information available in Morogoro region, the extent to which it is being used and suggest possible ways of establishing a regional biodiversity facility unit for improved access and usage.

2.2 Research objectives

2.2.1 Main objective

The overall objective of this study was to investigate availability and accessibility of biodiversity information and usage in Morogoro region.

2.2.2 Specific objectives

i. Identify sources of biodiversity data, location and information holders
ii. Classify identified biodiversity information according to their technological structure and geographical area of coverage
iii. Determine the extent to which the available biodiversity information is used

2.3 Research questions

The key research questions were:

i. What are sources of biodiversity data?

ii. Where are the biodiversity data located in Morogoro region?

iii. What kind of biodiversity information is available?

iv. How is biodiversity information classified?

v. To which extent and for what purpose is the available biodiversity information used?

2.4 Conceptual framework

The conceptual framework describes how an organized Biodiversity Information Facility unit can bring about sustainable and improved livelihood, through enhanced access to ICT by making biodiversity information available to users (Figure 2).

According to Benjamin (2001) and Macome and Cumbana (2002), information from BIF can be accessed in telecentres through use of computers, emails, internet, CD-ROMs, hard copy and training.

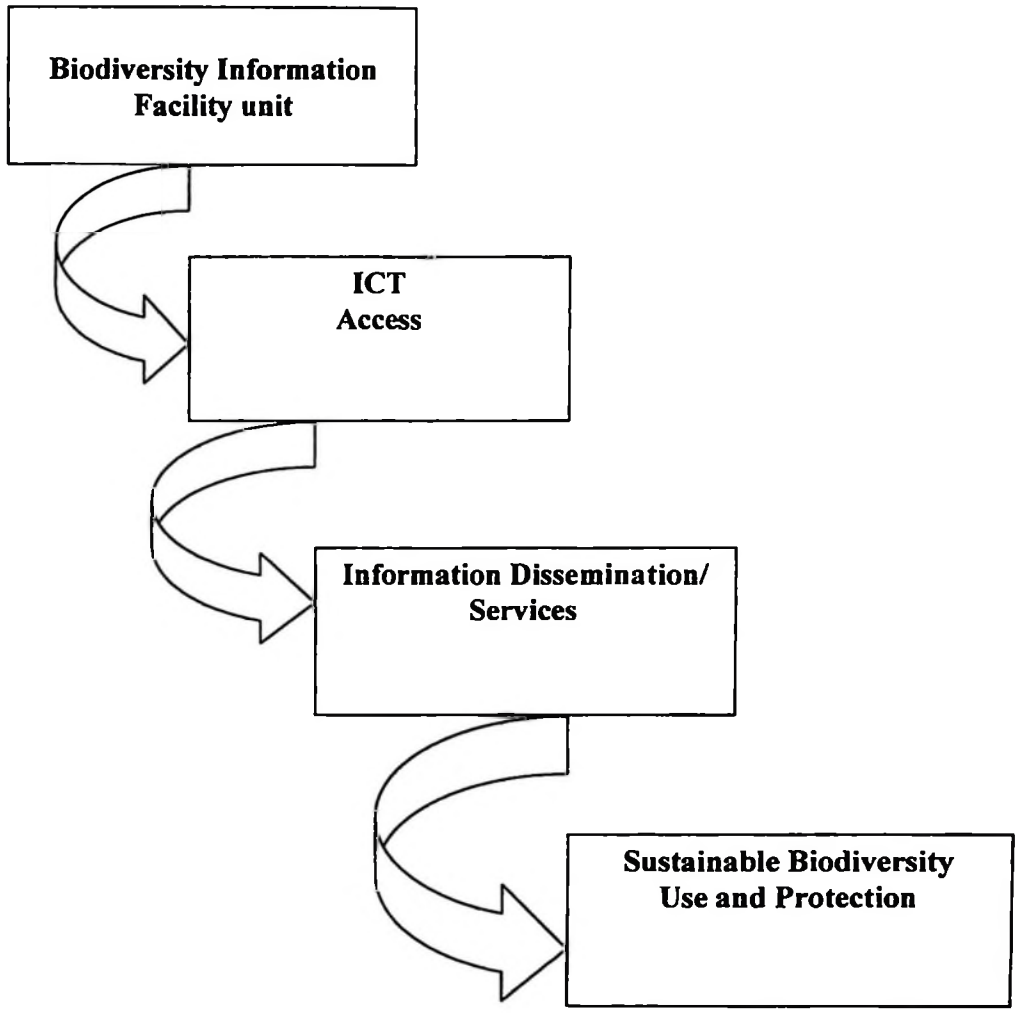

Figure 2: Conceptual framework on biodiversity information

Source: Literature review, 2008

CHAPTER THREE

3.0 METHODS AND MATERIALS

This chapter presents the methodology and procedures used in conducting the study. It covers the description of the study area, research design, data collection methods, and sampling techniques, research instruments, validation, and data analysis procedures.

3.1 Study area description

3.1.1 Geographical Location

Morogoro Region is one of the 21 Tanzania mainland regions. The Region lies between latitude 5^0 58" and 10^0 0" South of the Equator and longitude 35^0 25" and 35^0 30" East (Figure 3). It is bordered by seven other Regions. Arusha and Tanga regions to the North, Coast Region to the East, Dodoma and Iringa to the West, and Ruvuma and Lindi to the South.

3.1.3 Population

Morogoro region had a population of 1.75 million people and a population density of 24 people per square kilometre, which is below the average of 38 people per square kilometre for the mainland Tanzania as a whole (URT 2005). Two thirds of the population live in the northern districts of Mvomero, Kilosa, and Morogoro while the southern districts of Kilombero and Ulanga are less densely populated (Table 1). Despite the relatively low population density, the large proportion of protected areas and the small proportion of

arable land of the total result in significant pressure on land. Population densities can be high in settled areas. For example, the Mgeta division on the eastern side of the Uluguru Mountain has a population density of 160 people per square kilometre (Jones 2002).

Slightly over a quarter of the region's population lives in urban areas. Morogoro town is the region's administrative centre and largest city with it's over 200 000 inhabitants. Its population has grown by an average of 6.5 percent in a year for the past 35 years while the average population growth for the whole region has been 2.7 percent, close to the national average.

Table 1: Population of the Morogoro region, 1967-2002

Administrative area	1967	1988	2002
Morogoro Urban	24 999	117 601	227 921
Morogoro Rural	291 373	430 202	263 012
Mvomero	x	x	259 347
Kilosa	193 810	346 526	488 191
Kilombero	74 222	187 593	321 611
Ulanga	100 700	138 642	193 280
Morogoro Region	685 104	1 220 564	1 753 362

Source: United Republic of Tanzania, 2005

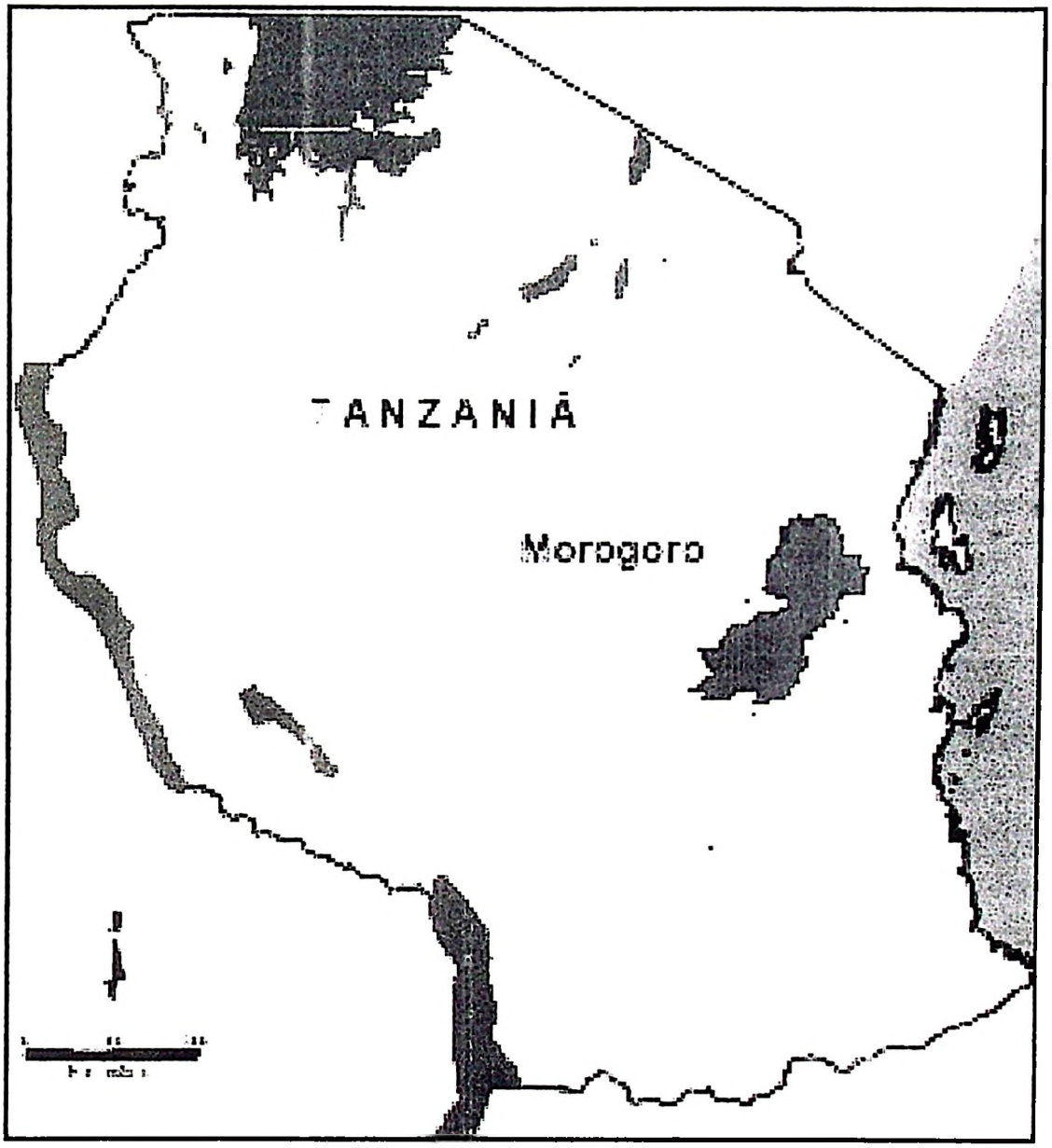

Figure 3: Map showing location of Morogoro region

Source: United Republic of Tanzania, 2005

3.1.2 Administrative Units

Morogoro Region occupies a total area of 72,939 square kilometres which is approximately 8.2% of the total area of Tanzania mainland. Administratively Morogoro region has five districts (Figure 4). The districts are divided into thirty divisions. Divisions in turn are further sub-divided into 140 wards. There are 457 villages in the region (Table 2).

Table 2: Area and administrative structure of Morogoro region

District	Area (Km^2)	Divisions (Number)	Wards (Number)	Villages (Number)
Morogoro Urban	260	1	19	-
Morogoro Rural	19,056	10	42	214
Kilosa	14,918	9	36	132
Kilombero	14,246	5	19	45
Ulanga	24,460	5	24	65
Total	72,939	30	140	457

Source: Regional Planning Department, Morogoro region, 2000

3.1.3 Ethnic Groups

The main ethnic groups in Morogoro region are the Luguru, Sagara, Kaguru, Ndamba and the Pogoro. Each tribe is dominant of atleast one distict. That is the lugulu tribe dominates Morogoro rural district, Sagara/Kaguru in Kilosa, Ndamba are the majority in Kilombero and Pogoro in Ulanga district.

Figure 4: Map showing administrative districts of Morogoro region

Source: United Republic of Tanzania, 2005

3.1.4 Climate

The annual rainfall ranges from 600mm in low lands to 1200mm in the highland plateau. However, there are areas which experience exceptional droughts, with less than 600mm of rainfall and these areas are in Gairo and Mamboya divisions in the North of Kilosa District and Ngerengere Division in the East of Morogoro Rural District. The mean annual temperatures vary with altitude from the valley bottom to the mountain top. The average annual temperature varies between 18^0 C on the mountains to 30^0 C in river valleys. In most parts of the region, the average temperatures are almost uniform at 25^0 C. In general the hot season runs from July to September.

3.1.5 Biological resources

The region's land area is classified as forest area (36,959 km^2), wildlife reserves area (31,000 km^2), and public land area (5,000 $km^{2)}$. It is estimated that 88% land of Morogoro region, which is 64,160 km^2 is covered by forest (FAO 1974). The forestlands from utilization point are classified as forest reserves, public land, and forest plantations (Table 3).

The vegetation in the forest reserves consists of closed forest, woodlands and grasslands. The exact vegetation covers of individual forest reserves is unknown, but previous estimates covering all reserves together indicate that approximately 13% is closed forest, 84% woodland and 3% is grassland. Some of the forest reserves are for protective purposes, in which case clear felling is avoided in order to protect slopes against erosion and to safeguard the water sources of towns and villages. Other reserves are for productive

purpose and protection at the same time. They protect against soil erosion and they are there for the production of timber, poles and fuelwood. The extent and classification of each Forest Reserve is given by district in Appendix 1.

The region has 47 Forest Reserves, and wildlife famous protected areas, namely, Selous Game Reserve, Wami-Mbiki Wildlife Management Area, Mikumi and Udzugwa National Parks.

Table 3: Forestlands by category and District in Morogoro region

Category of Forestlands	District					Total
	Kilosa	Morogoro Rural	Kilombero	Ulanga	Morogoro Urban	
Forest reserves	3,670	1,752	1,278	4,927	0	11,627
Public land	4,115	2,733	7,960	10,493	0	25,301
Forest plantation	16	15	0	0	0	31
Total	7,801	4,500	9,238	15,420	0	36,959

Source: Regional Planning Department, Morogoro region, 2000

3.2 Research Design

The study was done in two phases: phase one involved literature and reconnaissance survey to identify research works and biographies, and available datasets of Morogoro biodiversity. The survey was done to get a general picture of the kind of biodiversity information available.

Phase two of the study involved questionnaire survey, which was the main tool for data collection. Other tools were checklists and participants observations.

3.3 Sample and Sampling Techniques

A sample is a set of elements taken from a larger population. It is a subset of the population which is the full set of elements or people or whatever you are sampling (Johnson and Christensen, 2004). Sampling techniques are methods used in selecting a sample. According to Krishnaswami and Ritcher (2002), random and non random sampling methods are the major sampling techniques. In this study non random sampling techniques were employed.

Non-random sampling has various sampling strategies. In this study purposive sampling was used to select institutions to be included in the study area. This kind of sampling strategies depends on the judgemental decision of the researcher basing on some well known criteria (Johnson and Christensen 2004). It also ensures high representation in heterogeneous population. In this case, the results of first phase reveal that Morogoro biodiversity information was concentrate on research institutions, conservation institutions, and NGOs dealing with conservation issues. It was thus necessary to use purposive sampling to ensure high degree of representation and also selecting the institutions which have relatively large collections of biodiversity information. The sources of information available on the selected institution among other were collected directly from the field or indirectly from local people, local institutions, and government institutions.

Institutions selected for study are: National parks (Mikumi and Udzugwa), game reserves (Selous), research institutes (Sokoine University, Tanzania Forests Research Institutes, Tanzania National Seeds Company, and Ilonga Agricultural Research institute) and NGOs (Eastern Arc Mountains Conservation Programme).

3.4 Research Instruments

Research instruments are tools used by researchers to collect information for a study (Ary *et al.* 1996). The observations and structured interviews were the main research instruments of this study. All these instruments aimed at cross checking the authenticity and accuracy of data collected.

3.4.1 Participants observations

Participants Observations provides the opportunity for researchers to gain the confidence of the persons being studied, to reduce interference with the natural cause of events. The techniques require one to keep eyes open when visiting a study area and check what you are told against what you see (Mettrick, 1993). Much information was obtained by observing what is going on. The method of participants' observations was used to tie together the more discrete elements of the data collected by other methods and permitted these elements to be examined within the context of social systems (Kajembe, 1994). This help in more complete understanding of both the individual elements and the whole.

3.4.2 Structured Interviews

A structured interview was used in collecting data from selected institutions. This tool for data collection was chosen because of its ability to gain additional information (Johnson and Christensen, 2004). Questionnaire surveys are also familiar to most people, reduce biasness and are easy to analyze in comparison to other designs. The major limitation of written questionnaires survey is the possibiiity of low response rates. Response rates vary widely from one questionnaire to another (10% - 90%); however, well-designed studies consistently produce high response rates. Another drawback of questionnaires is the inability to probe responses. They allow little flexibility to the respondent with respect to response format. By allowing frequent space for comments, the researcher can partially overcome this disadvantage. A questionnaire requesting factual information will probably not be affected by the lack of personal contact. A questionnaire probing sensitive issues or attitudes may be severely affected. For a variety of reasons, the questionnaires respondent may not be who you think it is which causes a confounding error (Johnson and Christensen, 2004).

The study adopted standardized English language questionnaire designed by World Conservation Monitoring Centre (WCMC) in 1994, for East Africa (Appendix 3).

3.4.3 Literature review

Literature review was done to compliment other tools for data collection. This method captured secondary data from libraries, offices and laboratories. Generally, secondary data supplemented the primary data collected.

3.6 Data Analysis

Different data analysis approaches were used depending on the type of information and data collected. Quantitative data were analysed using Microsoft Office Excel. The program was used to perform descriptive statistics such as summation, mean, and percentage. Qualitative data were analysed by using the content and structural functional analysis techniques.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

Results presented in this chapter are based on the data collected between Febuary and August in 2008. Conservation and research institutions surveyed are Mikumi National Park (MINAPA), Udzugwa National Park (UNAPA), Selous Game Reserve, Sokoine University of Agriculture (SUA), Tanzania Forests Research Institutes (TAFORI), Tanzania National Seeds Company (TANSEED), Ilonga Agricultural Research institute and Eastern Arc Mountains Conservation Programme (EAMCP). The results revealed that Morogoro region has at least 25 datasets, of which large proportion of datasets (44%) is held by research institutions. The results further showed that an average of 72% datasets has been totally or partially digitalised and 80% of datasets are freely accessible.

The chapter is organised in four sections, which are:

i. Biodiversity data location and information holders in Morogoro region
ii. Classification of identified biodiversity information; based on technological structure and geographical area of coverage
iii. Use of the available biodiversity information
iv. Conceptual model for establishing Biodiversity Information Facility Unit in Morogoro region

4.1 Biodiversity data location and information holders in Morogoro region

The results presented in Table 3 show that Morogoro region has at least 25 datasets. Twenty five datasets are considered to be the least and justifiable figure because only few institutions were selected for this study. It is also worthwhile to note that biodiversity information reported in surveyed institutions is not exhaustive. This is because there is biodiversity information which is held by individual researchers and filed reports that are unknown and forgotten in those institutions. Hence this biodiversity information which is not accessible to users can be referred to as "grey literature" because it is hidden and not easily visible.

Table 4: Distribution and location of Datasets holding

Location	Number of Datasets	% of Datasets
MINAPA	2	8
UNAPA	3	12
Selous	1	4
SUA	8	32
TAFORI	1	4
TANSEED	1	4
Ilonga	1	4
EAMCP	6	24
Others (UA, WCST)	2	8
Total	25	100

Source: Survey 2008

Table 3 further indicates proportions of the datasets holding of the surveyed institutes. The datasets at MINAPA, UNAPA, EAMCP and Selous Game reserve covers specific areas in Morogoro region (Figure 5, Table 4 and Appendix 2a). A relatively equal percentage of the datasets extends beyond Morogoro region (Table 4). Overall, results indicate that datasets at national research centres like SUA, TAFORI and TANSEED tend to cross regional boundaries (Appendix 2a). This is worth noting when planning for regional and national biodiversity information facility unit.

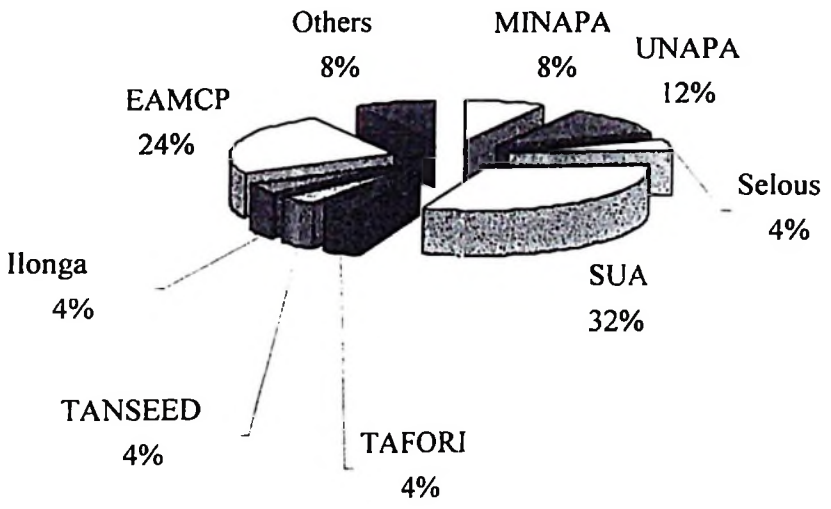

Figure 5: Location of data holdings (source: Survey 2008)

According to the World Conservation Monitoring Centre (1994), Tanzania mainland has 243 datasets. This implies Morogoro region constitutes over 10.3% of the country datasets. The explanation of high percentage may be due to high biodiversity richness, and/or presence of many conservation and research institutions. The explanation could be true, because SUA, TANSEED, TAFORI and Ilonga are national centres for research and training and have potential biodiversity data holdings. Table 4 show that research institutions hold large proportion of datasets as expected (Edwards *et al.* 2000, Schnase *et al.* 2003). Non-governmental Organisations also contribute to biodiversity research and conservation. Morogoro region has many conservation NGOs which have contributed to availability and accessibility of biodiversity information e.g. EAMCP (Table 4) and others (Appendix 2a, b and c).

Table 5: Data coverage by sector

Sector	Number of Datasets	% of Dataset
Protected Areas	6	24
Research Institutes	11	44
EAMCP	6	24
Others (UA, WCST)	2	8

Source: Survey 2008

4.2 Classification of identified biodiversity information

The number of living organism is very large, which necessitates arranging them into taxonomical categories. The generally, accepted hierarchy of taxonomic categories are Kingdom, Phylum, Class, Order, Family, Genus, and Species. Taxonomic coverage of Morogoro region, as presented in Table 5, revealed that there are a small number of datasets (20%) that is sorted to Class level on the hierarchy. Most datasets on vertebrates (34%) contain information at phylum level. Furthermore, all invertebrates which form five phyla are treated as one group in the available datasets (Figure 6). Plant Kingdom constitutes 33% of available datasets, again not taxonomically ranked (Figure 6).

The global total of existing species proportions are 0.4% for vertebrates, 2.4% plants, 64.3% of arthropods, 14.4% other invertebrates, 1.6% algae, 1.6% protozoan, 8% fungi, 3.2% bacteria, and 4% viruses (WCMC 1992). The datasets coverage of arthropods and other invertebrates in Morogoro region is very weak, i.e. 34% against 78.7% global total share (Figure 6). Furthermore, the studies of lower organisms such as algae, fungi, protozoan, bacteria and viruses that make up about 18.2% of global total species are almost non-existing in Morogoro regions. In addition, the results revealed that plants with global total proportion of 2.4%, in Morogoro region were predominant with a total proportion of 33%. Similarly, vertebrates which accounts for 0.4% of the global total species, represent a total of 20% of Morogoro region biodiversity datasets.

Table 6: Taxonomic classification of datasets * of Morogoro region

Location	Vertebrates (Datasets)							Invertebrates (Datasets)	Plants (Datasets)
	Mammalia	Aves	Reptilia	Amphibia	Fish	Non-Specified vert.	Total vertebrates		
MINAPA						1(400	1(400)		1(200)
UNAPA						2(300)	2(300)		
Selous		1(450)				1(57)	2(507)		
SUA	1(45)				1(30)	2(56)	4(131)	2(104)	2(189)
TAFORI									2(1300)
TANSEED									1(500)
Ilonga									1(200)
EAMCP	1 (76)	1(140)	1(47)	1(44)			4(307)	1(107)	1(381)
Other (WCST)						1 (400)	1 (400)		
Total	2	2	1	1	1	8	13	3	8

Source: Survey 2008

** Dataset is a collection of related data*

Taxonomic coverage in Morogoro region may not be representing the actual proportions of biodiversity richness or evenness. According to Kapange (2004) poor research funding and low staff morale has influence to the significant different on species survey coverage. Kapange (2004) argument attests that vertebrates and plants have been more surveyed than other categories of living organisms in Morogoro region.

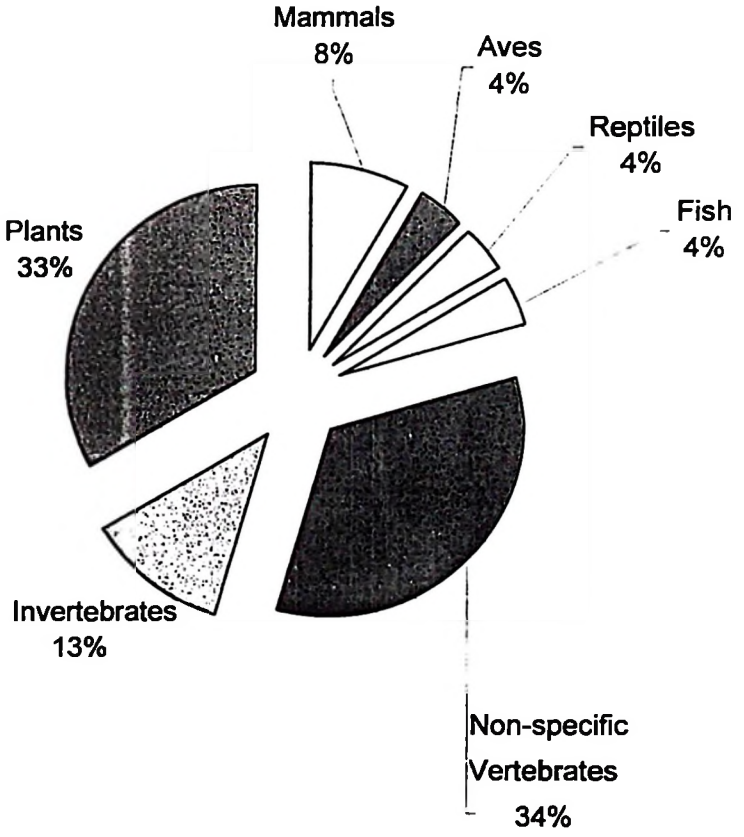

Figure 6: Taxonomic classification of Species by group coverage
Source: Survey 2008

During the survey, respondents were given a set of list of biomes to classify their data holdings. In that context a biome was defined as a group of ecosystems that have a similar climate and are therefore inhabited by particular plant and animal species. The findings suggest that many datasets (48%) cover more than one biome (Table 6 and figure 7). These findings point to the need for checking the details of the datasets, which has cross biomes data, due to their potential for biodiversity monitoring and conservation.

Table 7: Classification of datasets based on biome coverage

Biome	Number of Datasets	% of Dataset
Tropical dry woodlands	2	8
Savanna	1	4
Deserts and semi-deserts	-	-
Mountains and highland	10	40
Wetlands	-	-
Unspecific	12	48

Source: Survey 2008

The mountains and highlands biome has higher ratio of datasets compared to tropical dry woodlands and savannah (Table 6 and Figure 7). The datasets proportions do not reflect Morogoro region biomes instead it implies that mountains and highlands have been studied more than other biomes. The major reason for poor coverage of other biomes is poor research funding due to lack of interest of donors (Kapange 2004).

The findings summarised in Table 7 show that 76% of the holdings are actively maintained and updated. This reflects the relative importance of maintaining a biodiversity dataset once it has been established. However, the rest 24% of datasets which are not maintained may be poorly accessed and used due to structural and technological barriers (Lwoga *et al.* 2006).

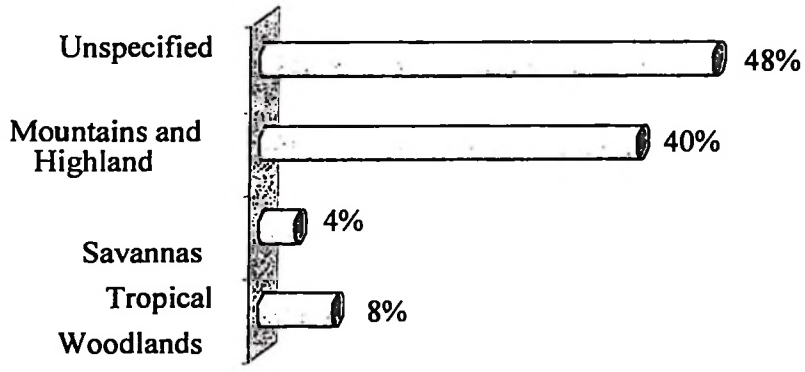

Figure 7: Classification of datasets based biome coverage
Source: Survey 2008

Table 8 and Figure 8 reveal that the majority of datasets for the region have been documented in a structured fashion, through the use of datasets or some other types of catalogue system.

Table 8: Classification of datasets based on maintenance status

Data maintenance	Number of Datasets	% of Dataset
Active (Frequently maintained)	19	76
Passive (Rarely maintained)	2	8
Not sure	4	16

Source: Survey 2008

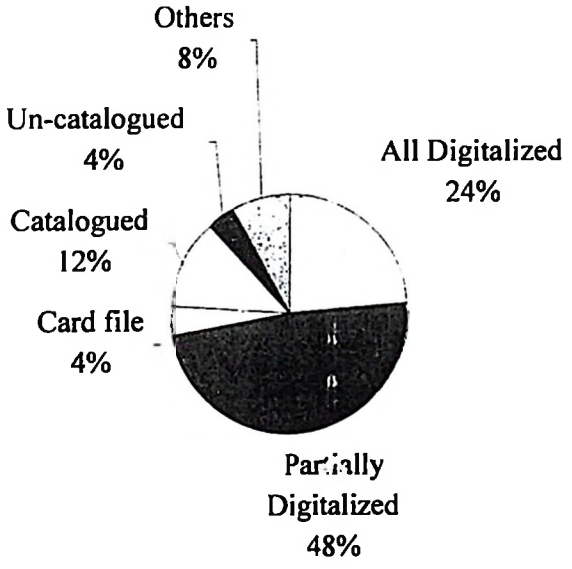

Figure 8: Datasets e-classification (Source: Survey 2008)

Averages of 72% datasets have been totally or partially digitalised. Datasets in the form of specimens, field records, maps, bibliography or mixture of all are prevalent (Figure 9).

Table 9: Classification of datasets based on Management and format of data holdings

How Data is Managed	Form of dataset							
	Maps	GIS	Data base	Field records	specimens	Biblio graphy	other	Total
All Digitalised	1	1	1	2	1	-	-	6
Partially Digitalised	2		1	5	2	1	1	12
Card file	-	-	-	-	-	1		1
catalogued	-	-	-	-	-	-	3	3
Un-catalogued	-	-	-	-	-	-	1	1
Others	-	-	-	-	-	-	2	2
Total	**3**	**1**	**2**	**7**	**3**	**2**	**7**	**25**

Source: Survey 2008

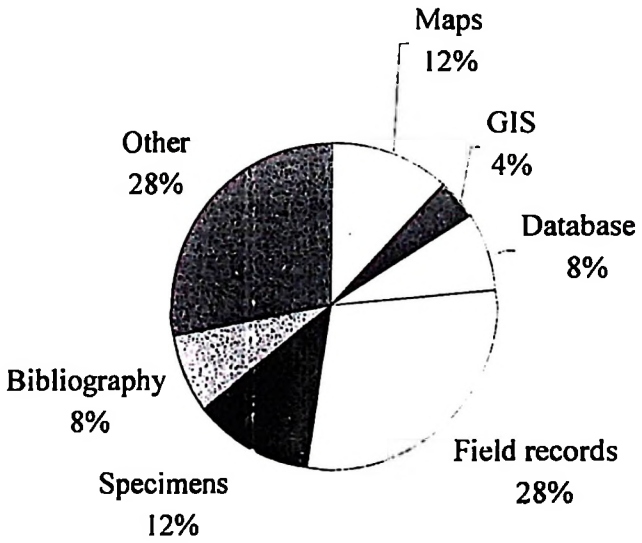

Figure 9: Datasets management format (Source: Survey 2008)

According to Lutz (2003) and Chailla *et al.* (2009) digitalised information is stored in accessible systems, which promote interaction among colleagues through forums, internet-based communication discussion, and decision making in real time. Digitalised datasets are also argued to be cost effective to users because of reduced costs for travelling physically (how is it networked for others to access?) to the place where a specimen is housed for the purpose of borrowing (Edwards *et al.* 2000). On that ground Morogoro region biodiversity information may seem to be easily accessible. Unfortunately, this is not the case as described in section 4.3.

4.3 Use of the available biodiversity information

The datasets available in Morogoro region were developed for different reasons. The survey revealed that different institutions (Table 3) have different biodiversity dataset usage objectives (Appendix 2a). Overall, the usage of biodiversity information depends on the role of specific unit in the organization and/or organization mission. Furthermore, outsiders have access to most of datasets. Table 9 presents important consideration regarding access to the dataset information in the region.

Most of biodiversity information (80%) held by surveyed organizations is freely available and few has limited access conditions (Appendix 2a). The access to information is predominantly through print out publications and online (Table 10 and Appendix 2c). Publications are associated with costs that many cannot afford. Similarly, onsite access often involves more costs in terms of time and fund. The use of online access may be more

cost effective and convenient, while the use of storage devices such as flash disks and CD-ROMs have limited storage capacity, and may require sensitive handling on postage.

Table 10: Outsiders access conditions to the data holdings

Access Conditions	Number of datasets	% of datasets
Freely available	20	80
On payment	-	-
Limited Access	2	8
No outsiders Access	-	-
Others or unknown (No guidelines for access)	3	12

Table 11: Outsiders access means to the data holdings

Access means	Number of datasets	% of datasets
Published scientific materials	10	40
Storage devices	1	4
On-site	3	12
On-line	9	36
Others	2	8

Hence, biodiversity information in Morogoro region is accessible for elite scholars. Studies on information access channels show that most people access information from magazine, television, radio, newspapers, brochure, and cell phones (Sturges and Chimseu 1996, Johnson 2004). Based on Sturges and Chimseu (1996) and Johnson (2004) arguments it is inferred that biodiversity information in Morogoro region is not accessible to most people, and thus, not used in socio-economic and environmental planning, discussions and decision-making in the region (Momodu, 2002).

Morogoro region to some extent has tried to utilize ICTs in terms of biodiversity information management and dissemination (Figure 8 and Table 10). According to Chailla *et al.* (2009) digitalization of the available datasets could enhance information dissemination and sharing, although Stephano *et al.* (2005) revealed that information dissemination depends on the awareness of the existence of the information channel and language used in presenting information. All Morogoro region biodiversity datasets are presented in English language. The datasets which are online cannot be easily accessible because their URL is unknown to most users.

There have been various alternatives sought to minimize the information gap, telecentres being one of them. Gómez and Hunt (1999) in Latchem and Walker (2001) point out that telecentres have been hailed as the solution to development problems around the world because of their ability to provide desperately needed access to information and communication technologies. Hudson (2000) describes telecentres as a means of providing access to tools to create, access, and share information. According to Ojo (2005), the

expected benefits of telecentres in Africa includes; to promote the use of ICTs for community development

According to Mtega and Malekani (2009) Tanzania has over twelve telecentres which were introduced to ensure that Tanzanians especially those in rural areas access information. These telecentres include Kilosa, Sengerema, Ngara, Mtwara, Kasulu, Dakawa and Lugoba to mention few. Kilosa telecentres is located in Morogoro region. Surprisingly, the results showed that Kilosa telecentre is not among the channels for Morogoro region biodiversity information dissemination. This can be attributed to the fact Tanzania has not established mechanisms through which research institutions, government offices, NGOs and individuals holding biodiversity information can disseminate them through telecentres.

4.4 Institutions capacity of managing biodiversity information

The results show that there are few computers and related hardware in most institutions. There is a general lack of ICT computer hardware and software for management of biodiversity data and information. SUA departments of forest biology, faculty of veterinary, pest management centre and Herbarium sections have reported having ICT facilities but these are few. TAFORI on the other hand reports of having very few and very basic ICT facilities. MINAPA and UNAPA have computers for administrative operations and not specific for biodiversity data. With NGOs, EAMCP indicated to have relatively modern and sufficient computers and other ICT facilities. The study further reveal that two institutions, SUA and EAMCP have a GIS laboratory, this facility is being shared

intensely because GIS and Maps feature as the most commonly used tools in biodiversity data generation, analysis and presentation. The biodiversity data are managed in analogue, spreadsheet particularly Microsoft Excel and Access packages, word-processing like Microsoft Words and images. Generally ICT facilities are few and where they exist they are obsolete and incompatible with latest technology.

The study institutions have shortage of manpower resources. However, due to some database work going on, there appears to be some professional manpower some institutions such as SUA (department of biology, and less at pest management centre), and EAMCP. Other institutions seem to lack ICT manpower, however, respondents did not categorically admitted it. Inline with shortage of professional manpower, there are no established programmes for generating biodiversity data. Thus, most biodiversity information collected is from student studies, research projects, biodiversity inventories and consultancies. Generally the specimen collection is done opportunistically, and donor supported. Programmes for generating biodiversity data are generally not sustainable.

4.5 Conceptual model for regional Biodiversity Information Facility Unit

The main purpose of BIF is to enable a global distributed network of interoperable databases that contain primary biodiversity data. The data are normalized into a common data exchange format, and thereafter, shared with the world using internet protocols that recognize and handle the data exchange formats. GBIF recommends the adoption of either

Darwin Core 1.4 with the DiGIR protocol package or the ABCD and the BIOCASe protocol package.

The custodians of biodiversity database(s) may follow the following steps to share information through GBIF.

i. Acquire a normal PC and place it safely outside institution firewall.
ii. Should choose and download a data provider package i.e. Darwin Core 1.4 with the DiGIR protocol package, or the ABCD and the BIOCASe protocol package.
iii. Install the chosen data provider package e.g. ABCD
iv. Define the contact details in the metadata.
v. Link the database(s) to the provider.
vi. Register the new provider.
vii. Adhere to the GBIF data sharing agreement.

A GBIF participant node is a mechanism by which a Participant coordinates and supports its GBIF data-sharing activities. A Participant Node includes both physical infrastructure and human resources. GBIF encourages Participant Node to support Participant's data providers in terms of information technology (IT) infrastructure and expertise. Each Participant signing the Memorandum of Understanding seek to form a Participant Node or Nodes, accessible via GBIF, that will organise and/or provide access to biodiversity data, or to data and metadata standardized, software tools or other services to enhance the GBIF network. Tanzania has signed the Memorandum of Understanding and formed GBIF node known as TanBIF. However, Tanzania can form regional nodes or facilitate regions to become data providers.

The study results presented in section 4.1, 4.2 and 4.3 provide the basis for Morogoro region to form GBIF node or data providers through TanBIF. Morogoro region has many biodiversity holders and holdings (Appendix 2). The biodiversity holdings are in different formats that can be standards and deposited at one selected repository "region data repository". In turn, the region data repository may act as GBIF node or data provider.

Morogoro Biodiversity Information Facility Unit (MoroBIF) can be designed and established as shown in Figure 10. Biodiversity primary data generated in field surveys and from government and non-government institutions could be deposited at the agreed regional depository (MoroBIF). In this case the data provider retains the right of information access control.

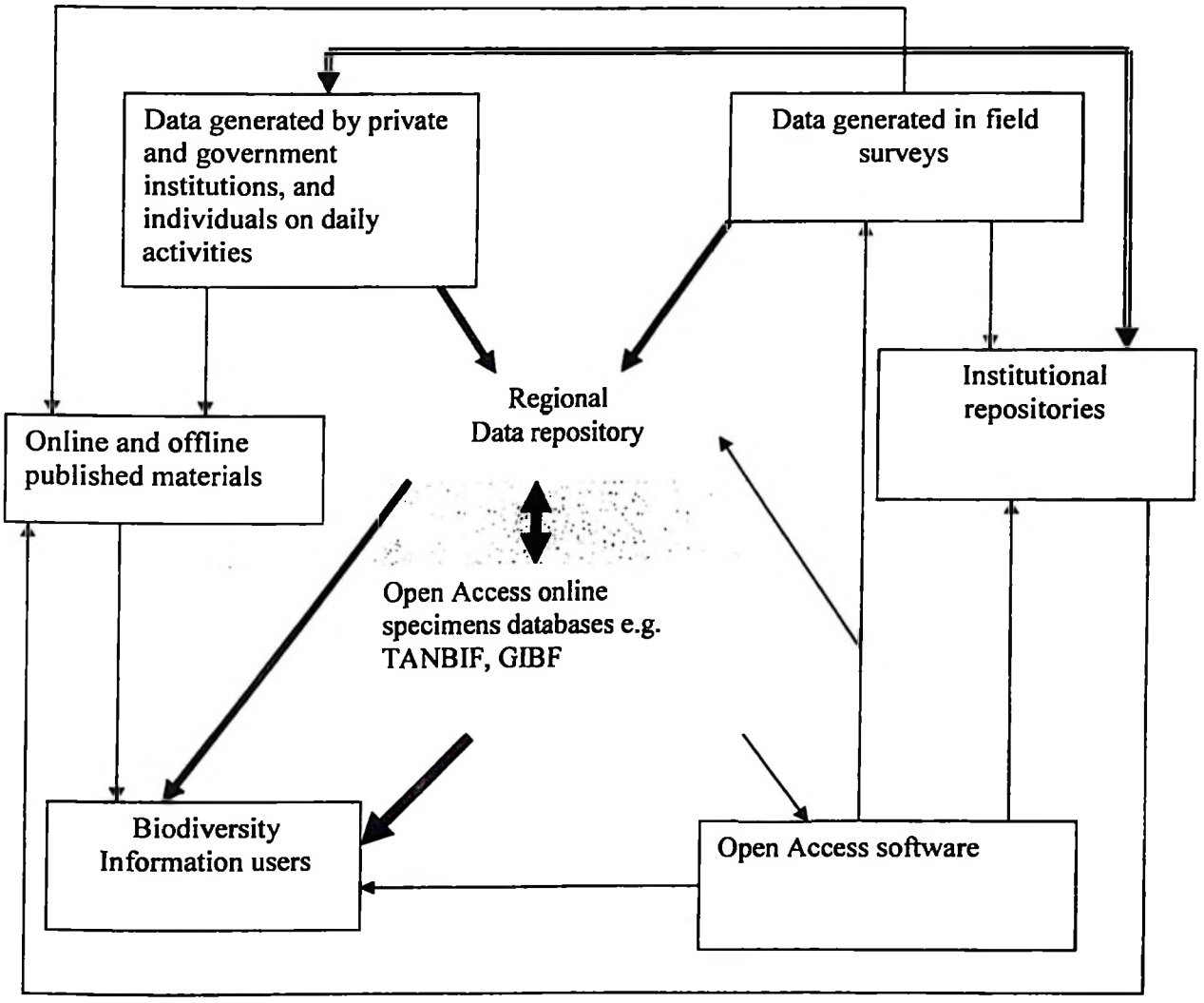

Figure 10: The model to establish region Biodiversity Information Facility Unit

The current datasets available in Morogoro region can be sorted and packed in the GBIF accessible package protocol, and through MoroBIF be connected to the TanBIF. Morogoro region biodiversity information held by institutions in other Tanzania regions can also be accessed and used in Morogoro region through information clearing mechanisms established under UN-CBD. Importantly, Morogoro region biodiversity datasets are held outside Tanzania (e.g Appendix 2b). The established MoroBIF could facilitate its accessibility in Morogoro region from GBIF. Biodiversity information will be accessible through various channels (Figure 11). Biodiversity users will be free to get information through MoroBIF, TanBIF, GBIF, online and offline publications, onsite, and from institutions repositories. Therefore, the establishment of MoroBIF will enhances biodiversity information availability and usage through information sharing and networking.

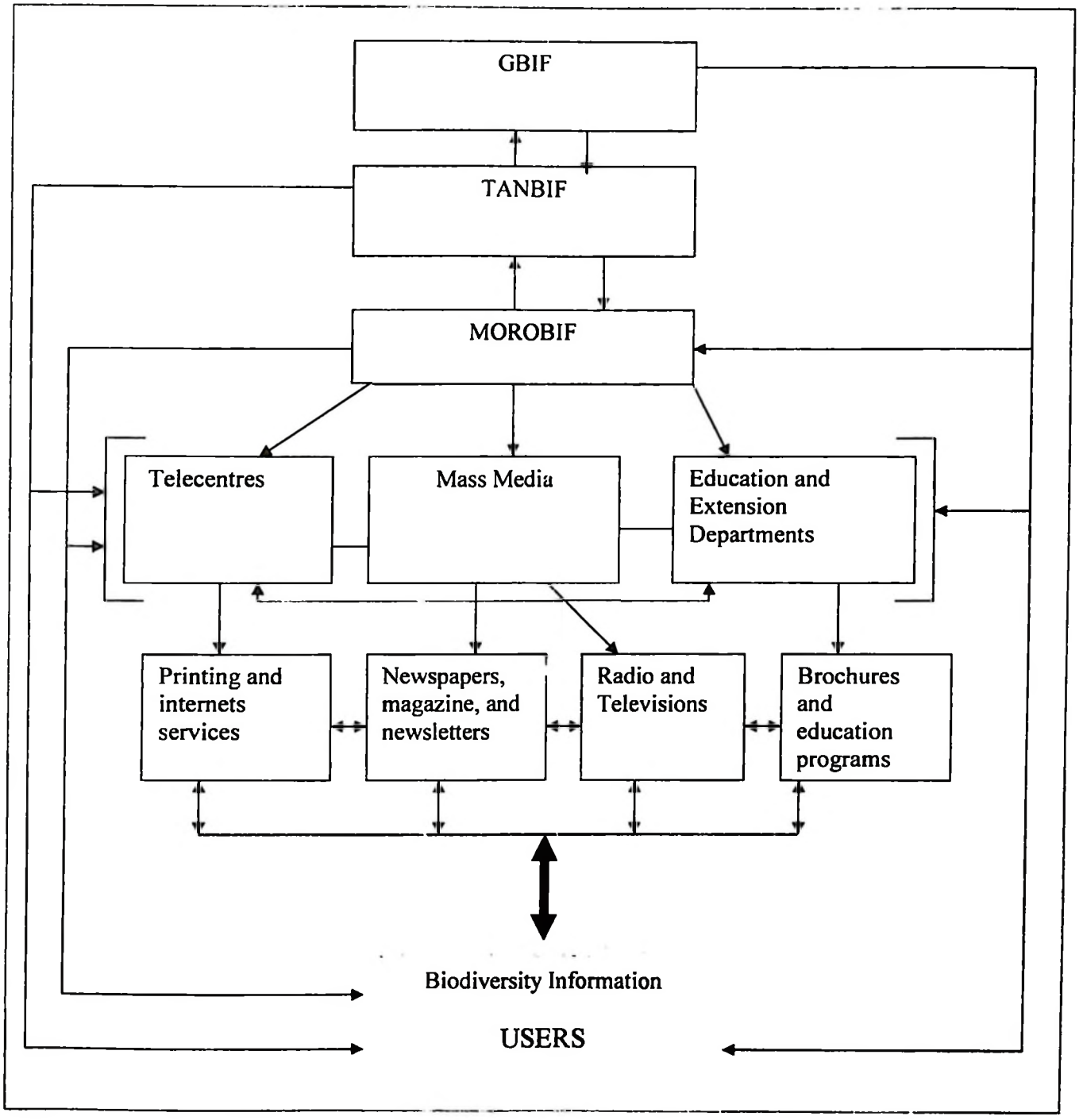

Figure 11: Biodiversity information flow

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Morogoro region is rich in biodiversity information holdings, despite the fact that potential amount of biodiversity information is still scattered, unreported and inaccessible.

Considering the biodiversity information available in Morogoro region in terms of geographic and taxonomic coverage, it appears that more data needs to be collected with respect to amphibians, reptiles, fish, arthropods and other invertebrates groups, lower plants, microbes and fungi, for the purpose of developing indicators of biodiversity conservation. More data on tropical woodlands, wetlands and semi-arid areas need to be surveyed and collected, because these biomes represents potential gaps in the knowledge base of Morogoro region. This conclusion is based on the available literature about Morogoro biodiversity and studied institutions, which are the most famous biodiversity holding institutions in the region.

Access to biodiversity information is not easy, despite the ICTs developments which could be used to facilitate dissemination and networking. Improved accessibility to biodiversity datasets information could enhance biodiversity conservation in Morogoro region.

5.2 Recommendations

5.2.1 Actions and strategies Institutions

1. Establish institution focal point of reference in biodiversity data or database.
2. Digitalise all possible biodiversity data available in the institution.
3. Establish database standards and protocols to comply with GBIF.
4. Establish small Local Area Networks to facilitate access to distributed resources (Internet, data access, data-entry, email communication) and connect to biodiversity database.
5. Develop the capacity of research scientist and paraprofessional in ICTs to handle and communicate biodiversity information.
6. Each institution should establish policy for exchange and sharing of data so as to facilitate sharing of biodiversity data within the network.

5.2.2 Actions and strategies for Morogoro region

1. Establish Regional focal point of reference in biodiversity database.
2. Coordinate the establishment of database standards and protocols.
3. Select database software systems for regional application in managing biodiversity databases.
4. Establish more efficient Internet.
5. Develop the capacity of research in region institutions to establish continuous programme for biodiversity data generation programme.
6. Establish a Regional biodiversity information office, which will be responsible for establishing and maintaining regional biodiversity information facility unit.

7. Morogoro region needs to promote and fully utilize ICTs to improve biodiversity information availability and usage. It is therefore recommended to develop a strategy for the region biodiversity information management and exchange mechanism for the region.

5.2.3 Actions and strategies for the nation

1. Nation actions through COSTECH are required to support and coordinate establishment of regional biodiversity information facility unity, and effectively be connected to TanBIF.
2. The government of Tanzania should take deliberate measures to reduce dependency on donors' money for programmes of biodiversity information generation and management. This will ensure sustainability of such programme.

5.2.4 Suggestions for future studies

A user-needs assessment is proposed to identify critical areas of biodiversity information requirements. Furthermore, there is need to review critically the types and details of biodiversity datasets available against an established set of criteria regarding minimum datasets required for effective biodiversity monitoring. In addition, further studies are required to fill gaps regarding data on amphibians, reptiles, fish, arthropods and other invertebrates groups, lower plants, microbes and fungi, and biological surveys on tropical woodlands, wetlands and semi-arid areas of the region.

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APPENDICES

Appendix 1: Forest reserves in Morogoro region

Forest Reserves in Morogoro Rural District (Area by Hectares and classification)

Name of the Forestry Reserve	Protective Mountain Catchment			Productive C
	A-1	A-2	Lowland Catchment B	
Kanga	6.664	-	-	
Lusunguru	-	-	-	2.274
Mtibwa	-	-	-	882
Maleta	-	-	-	1.026
Pamgale	-	-	-	12.950
Nguru South	18.793	-	-	-
Mkindo	-	7.542	-	217
Mbogo	-	-	-	92
Morogoro Fuel Rese.	-	-	-	12.950
Nguru ya Ndege	-	-	2.407	-
Dindili	-	-	1.107	-

Kitulangholo	-	-	4.678	-
Mindu	-	-	2.285	-
Uluguru North	8.357	-	-	-
Uluguru South	16.428	-	-	-
Pangawe E and W	-	-	775	-
Ruggles Brice	-	-	-	42
Nyandiduma	-	-	57	-
Tangeni River	-	-	231	-
Konga	-	-	-	5
Bunduki	-	-	104	-
Vigoza	-	-	26	-
Vigoregore	-	-	-	-
Mkungwe	-	-	6.640	-
Mkulazi	-	-	68.627	-

B. Forest Reserves in Kilosa District, Area by Hectares and classification

Name of Forest Reserve	Protective			Productive
	Mountain Catchment		Low Land Catchment	
	A1	A2	B	C
Talagwe			1,085	
Mamboya			204	
Ikwamba	889			
Mamboto	149			
Uponera	292			
Milindo	3,087			
North Mamiwa Kisara	6,941			

South Mamiwa Kisara	6,266			
Kihotori			208	
Ukwiva	54.635			
Pata	20.619			
Chonwa			705	
Total	82.878		2.202	

Source: Morogoro Region planning office, 2008

C. Forest Reserves in Kilosa District, Arca by Hectares and classification

Name of Forest Reserve	Productive			Productive C
	Mountain Catchment		Low Land Catchment	
	A1	A2	B	
Mwanikana	17.993			
Magombela			1.578	
Kalinga			761	
Kilombero River				158.365
Nyanganje	18.988			
Iwonde	11.749			
Ikanga			3.467	

Matundu	17.656			
Iyondo	27.960			
Uzungwe Scarp	P.M.			
Njerera	P.M.			
Masagati			6.472	
Total	97.346		12.278	158.365

Source: Morogoro Region planning office, 2008

D. Forest Reserves in Kilosa District, Area by Hectares and classification

Name of project reserve	Protective			Productive
	Mountain Catchment		Lowland catchment	
	A_1	A_2	B	C
Nambiga			1.390	
Myowe			93	
Mahenge Scarp			388	
Nawenge			169	
Kwiro			134	
Mzelezi			771	
Mahulu			987	
Sali			983	
Luhombero				296.948
Ngindo				535.531
Total			4.931	832.479

Appendix 2: Biodiversity information availability and usage in Morogoro Region

A. List of main biodiversity information holders, description of dataset, usage objective and access conditions

S/N	Datasets holders	Datasets description	Usage Objective	Access Conditions
1	**Sokoine University of Agriculture**			
	Pest Management Centre	– Covered whole Morogoro region – Collection specimen of rodents and insects species. – Dataset is 75% computerized and specimen labelled	–Study of taxonomy, ecology and economic importance	–Freely available –Outsiders request in writing
	Department of Forest Biology	–Cover the whole region –Bibliographic, physical specimens, field records –Not catalogued	– Documentation, research, and training	Freely available
	Faculty of Forest	–Cover the whole region –Research and surveys reports, publication, bibliography and images and students dissertation	– Training, advisory and developing conservation plan	Freely available upon request

		on natural resources –Not catalogued		
	Department of Crop Science	–Cover the whole region –Native non domesticated flora and fauna classified as weeds and pests –Available in reports and print out showing ecological distribution –Not catalogued	– Study economic importance and improve crop production	Freely available upon request
	Faculty of Veterinary	–Coverage –not specified –DNA materials –Specimen of animals and microorganisms	– Training and research purposes	Limited
	Department of Animal Science and Production	–Cover the whole region –Dataset on rangelands and species composition of those rangelands. –Field information	– Training and research purposes	Freely available

	Sokoine National Agricultural Library	–Cover the whole region –Collection of various electronic and grey literature on biological and social sciences	– Reference, research, repository and legal deposit	-Freely available -borrowing for members
2	**Tanzania Forestry Research Institute (TAFORI)**			
		–Cover the whole region –Physical specimen –Research report –Catalogued –10-20% computerized	– Forestry research – Policy evidence based advice	Limited
3	**Tanzania Tree Seed Agency (TTSA)**			
		–Cover the whole region –Database on tree seeds –Bibliographic , maps, tables and field records –Physical specimen –Partially catalogued and computerized	– Improve seed quality – supply of forest products and marketing tree seeds	-Online -Some datasets have limited access due to copyrights protection

4.	**Udzugwa Ecological Monitoring Centre**			
		–Udzugwa Mountains National Park –Compiled reports, bibliographies, publications and research records in the park –Partially computerized	– Ecological monitoring and management	Digitalised datasets are freely available online
5	**Mikumi National Park –under TANAPA**			
	Department of Ecology	–Official reports –Surveys and field records –Research reports –Very limited digitalised information and catalogued	– Ecological monitoring and management	-TANAPA permit -Publication and newsletter
6.	**Selous Game Reserve-under Wildlife Division**			
		–Official reports –Surveys and field records –Research reports –Hunting records –Very limited information is digitalised and catalogued	– Ecological monitoring and management	-Require written permit from Tanzania Wildlife Division

7	**Eastern Arc Mountains Conservation Endowment Fund (EAMCEF)**			
		–Cover all eastern arc mountains in Morogoro region i.e. Mahenge, Malundwe, Nguru, Rubeho, Udzungwa, Ukaguru and Uluguru –Bibliographies , publications and field records –Database of biodiversity, images and maps –Information on specimen depository –Link to other partners –Information catalogued and computerized	– Monitoring and sustainable conservation of Eastern Arc Mountains (Biodiversity hotspot)	Freely available Online (full text)
8	**Uluguru Mountains Biodiversity Conservation Project**			
	African Conservation Foundation	–Covers Uluguru mountain ranges –Bibliographies , publication and field records –Database of biodiversity, images	– Conservation management of Uluguru mountain ranges	Freely available Online (full text)

		and maps –Information on specimen depository –Link to other partners –Information catalogued and computerized		
9.	**Districts Natural Resources Offices**			
	District offices	–Cover respective districts –Not catalogued datasets of natural resources found in the District	– Administration and Management	Upon request on writing

Source: Field survey 2008

B. List of other important holders of biodiversity information of Morogoro

1.	Animal behavior research institute (University of Wisconsin, USA)
	Dataset on Behavioral ecology of Yellow and Olive baboon of Mikumi National Park
2.	College of African Wildlife Management Mweka
	Collection of wildlife specimen
3.	Institute of Resource Assesment (UDSM)
	Satellite map sheet of wood fuel
4.	Irish Aid-Kilosa District rural development program
	Bioinformation on forest reserves, maps of land use and agroforestry programme
5.	Ministry of Natural Resources and Tourism
	Dataset of all protected areas including man made Mindu Dams
6.	Ministry of Land and planning
	Morogoro region physical plans
7.	Wildlife Conservation Society in Tanzania
	Dataset of Tanzania wildlife
8.	Trento Museum of Natural History
	Dataset of Udzugwa national park
9.	Tanzania National Parks Authority (TANAPA)
	Dataset of Mikumi and udzugwa National Parks
10.	Tanzania wildlife division
	Datasets of Selous Game Reserve biological diversity
11.	Tanzania Forest Conservation Group

Nguru and Rubeho Mountains of biodiversity datasets
12. FAO Biological Diversity Homepage
Includes Biological Diversity for Food and Agriculture
13. Commission on Genetic Resources for Food and Agriculture
Dataset on genetics
14. FORESTRY Global Forest Resources Assessment 2000 (FRA 2000)
Includes two chapters related to forest biological diversity: Chapter 5, "Forest biological diversity"; and Chapter 7, "Forests in protected areas"
15. State of the World's Forests 2001
Includes a chapter entitled "Forest biological diversity conservation: protected area management"
16. Forest Genetic Resources homepage
Includes the annual bulletin on Forest Genetic Resources
17. Non-Wood Forest Products homepage
(www.fao.org/fo/FOP/FOPW/NWFP/nwfp-e.sthm)
Includes a searchable database of non-wood forest products
18. FAO Worldwide Information System on Forest Genetic Resources (REFORGEN)
Ecosystems Ecoport
19. Royal Society for the protection of birds
Dataset on forests, and birds found in Morogoro
20. University of Antwerp
-Dataset of small mammals of Morogoro

Source: Literature review

C: List of biodiversity information holders with online freely accessible database in Morogoro region

S/N	Institution	Coverage of Bioinformation	Web adders (URL)
1.	Eastern Arc Mountains Conservation Endowment Fund (EAMCEF)	–Mahenge Mt. in Ulanga district –Malundwe Mt. (Mikumi National Park) in Mvomero District –Nguru Mt. in Morogoro rural district –Rubeho Mt. in Kilosa district –Udzungwa in Kilosa and Kilombero distict –Ukaguru in Kilosa district –Uluguru in Mvomero, Morogoro rural and Urban district	http://www.easternarc.or.tz
2.	African Conservation Foundation	Uluguru Mountains Biodiversity Conservation Project- in Mvomero, Morogoro rural and Urban district	http://www.africanconservation.com/uluguru/contents.html
3.	Tanzania Forest Conservation Group	–Nguru Mt. in Morogoro rural district –Rubeho Mt. in Kilosa district	http://www.tfcg.org
4.	Udzugwa	Udzugwa Mountains Nationa Park	http://www.udzungwacentre.org

	Ecological Monitoring Centre		
5	Tanzania Tree Seed Agency	Database on tree seeds, contains seed collected in Morogoro region	http://www.ttsa.co.tz
6.	Tanzania bird atlas	Shows the Important Birds Areas (IBA) of Morogoro region	http://tanzaniabirdatlas.com/important-bird-areas/important-bird-areas-iba-tanzania/
7.	International Union for Conservation of Nature	Status of flora and fauna species	http://www.redlist.org/info
8.	Sokoine National Agricultural Library	Abstracts and catalogue of Special collection	http://www.suanet.ac.tz/lib/

Appendix 3: Questionnaire

AVAILABILITY OF BIODIVERSITY INFORMATION IN MOROGORO

QUESTIONNAIRE

This is a survey of the ***sources*** and ***types*** of information held in biodiversity for Morogoro by organizations both within and outside Morogoro region. It is collaborative venture between the Open University of Tanzania and Sokoine University of Agriculture. Primary interest is information on biology (e.g. plants, animals, habitats, ecosystems), although information on land data (e.g. land use, protected areas), physical features (e.g. soils), legal (e.g. environmental laws) and economic (e.g. wildlife trade, medicinal plants) aspects is also of use.

Numerous collections of data concerning the biodiversity of the region exist. These may range in size from the small (e.g. an individual's record of birds from one locality) to the large (e.g. the collection of Morogoro region herbarium) collections. This information may exist in many forms including papers records, maps, bibliographies, and computer records. To facilitate access to these invaluable data sources, a "data sources" database is being constructed, based on the findings of this survey. When completed, this database will be made available and accessible to institutions within and outside the region, thus, supporting biodiversity conservation initiatives.

In order to prepare this database, we would be most grateful if you could take a few minutes to fill out this questionnaire. A rapid response is important. If you have ***a number of distinct datasets,*** please fill out a copy of this questionnaire for ***each.*** Further, if you could pass a copy of this questionnaire to any other person or organization you know which hold significant information on biodiversity of Morogoro region, it would be appreciated.

1. INSTITUTIONAL DETAILS

Name of department or unit:

Name of institution:

Type of institution (e.g. government, NGO):

Postal Address:

Physical address (if different from above):

Tel No: *Fax No*:

Email: *Telex*:

Function of unit/Institution:

2. DESCRIPTION OF INFORMATION SOURCE (please complete on form for *each* dataset)

Name or subject area of dataset:

Name of information manager:

Form of dataset:		**Size of information holdings:**
☐	biographic collections:	-
☐	physical specimens (e.g. herbarium sheets)	-
☐	maps	-
☐	tables	-
☐	GIS holdings (e.g. wetlands)	-
☐	database information (electronic records)	-
☐	field records	-
☐	others- specify	-

Objective of dataset:

Where dataset is located:
Country:

How the information is being managed:

☐ all computerised

☐ percentage computerised (%)

☐ card file

☐ catalogued

☐ uncatalogued

☐ other-specify

How was the dataset acquired/built? :

If computerise: Hardware (e.g. PC compatible, SUN, VAX, Apple Macs, other, including model):

Operating system:(e.g. DOS,Sun Os, VMS, other, including Version):

Software used to maintain this dataset (e.g. dbase, FoxPro, Oracle, Arc/Info, other, including version):

3. INFORMATION COVERAGE (if applicable, please provide a map)

Area of coverage – local/regional/ national (please specify):

Biomes covered:

☐ Tropical humid forests
☐ Tropical dry woodlands
☐ Deserts and semi deserts
☐ Mountain and highlands
☐ Wetlands and river systems
☐ Lake systems

Ecosystems covered (e.g. savanna, rainforest):

Description- Summary of information held (if applicable, please specify the major groups of flora or fauna):

Time period that information covers (months/years):

Is the information:
Being actively maintained (yes/no)? :

Part of an ongoing project/contract (yes/no/which)?:

Date/period that information was/is collected (e.g. 1920-1930, 1931-1940, ...)? :

Completeness, limitations and gaps in the information

4. ACCESS

Conditions:

- ☐ no outside access/use
- ☐ limited access (please give details0
- ☐ freely available (at any time?)
- ☐ on payment of funds 9 e.g. cost of recovery; commercial sale)
- ☐ other –specify)

Outside access through:

- ☐ published material
- ☐ diskette/tape
- ☐ on-site
- ☐ online-specify network(s)
- ☐ other-specify

Documentation of information holdings (e.g. descriptions available, user guides, on-screen documentation):

Other organisations known to hold biodiversity information (names and addresses):

Name of person completing this form (title and position):

Availability of Biodiversity Information Review -please return **as quickly as possible** to:
Philbert S. Nyinondi, Sokoine University of agriculture, P.O. BOX 3022, Morogoro, Tanzania. Tel. +255-732930154/+255-786-677648; Fax: ++255-23-2604638.
Email: pnyinondi@suanet.ac.tz or pnyinondi@inbox.com