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Review of policies, legislations and institutions for biodiversity information in sub - Saharan Africa

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Over the past three decades, most sub-Saharan African (SSA) countries have developed national policies, legislations, plans, and institutions that are geared towards biodiversity conservation and management. However, evidently lacking in these instruments is the mechanisms for the generation, processing and sharing of biodiversity information. This study reviews the current biodiversity policy and institutional landscapes, and their impacts on the generation, processing, sharing, and use of biodiversity information for decision-making in SSA. We employed an integrated approach for data collection including literature review, telephone interviews and questionnaire administration. Findings show that biodiversity information has primarily been mobilized in an *ad hoc* manner through project surveys and academic research endeavours. Currently, majority of SSA countries still do not have standalone biodiversity policies that could prioritize biodiversity information and provide specific mechanisms and structures for the mobilization, processing and sharing of biodiversity information. Rather, efforts have focused on mainstreaming strategies and action plans into related sector policies and planning activities with potential impacts on biodiversity information. This move has not been entirely successful in sustaining efforts on biodiversity data and information generation, utilization and sharing. While the relevance of biodiversity information for national development is acknowledged by stakeholders, there are still major obstacles including: the lack of funding for data mobilization, weak institutional capacity, lack of individual competencies, and inadequate training on techniques for mobilizing biodiversity data and information. Advocating for value-added and demand-driven biodiversity information has the potential to garner policy support and legitimacy to reach the level of importance required for investment, capacity development and specialised institutions for biodiversity conservation in SSA.

Key words: Biodiversity, information, policies, institutions, sub-Saharan Africa.

INTRODUCTION

Biodiversity provides a fundamental basis for economic livelihood and societal wellbeing in Africa (Cadman et al., 2010). It is vital for the health of the earth's ecosystem that survives the current and future generation. However, biodiversity worldwide is in danger with the predicted loss of species and genetic diversity as great as past mass

extinction events (Jenkins, 2003; Loreau et al., 2006). The current rate of biodiversity loss is a major concern due to its negative implication for human survival on earth. The loss of each species comes with the loss of potential economic benefits as well as the reduction in efficiency and capacity of ecosystems to produce

biomass, decompose, and recycle biologically essential nutrients (Attuquayefio and Fobil, 2005; Cardinale et al., 2012).

The growing concern for biodiversity loss and its adverse implications on humanity has attracted global attention leading to the proliferation of conventions, protocols and declarations which are aimed at encouraging countries to take serious actions to curb the imminent threat of biodiversity decline. It has also led to the establishment of global institutions, regional institutions and research institutions who are working together with donor agencies to highlight the gravity of biodiversity decline and to devise sustainable policy strategies and interventions to address the situation. However, the impact of these strategies and interventions on curtailing biodiversity loss remains elusive as the state of the world's biodiversity continues to change rapidly (Convention on Biological Diversity (CBD), 2010; Butchart et al., 2010).

Africa boasts of quite a sizeable proportion of the world's natural resources and biodiversity (African Development Bank (AfDB), 2015), yet this fundamental natural asset upon which survival depends is under severe threat. With increasing raw materials extraction for economic growth, land use changes, urbanization, and weak institutional arrangements, countries in Africa are experiencing unprecedented rate of resource exploitation in recent time. In addition, climate change phenomenon presents a new development threat to biodiversity and the future of majority of African rural population whose livelihoods are directly dependent on the biological resources.

Most African countries are signatories to several of international conventions, agreements and protocols regarding the conservation and protection of biological diversity. At the regional level, countries have also committed to initiatives and declaration in an attempt to safeguard biodiversity. As required by these commitments, countries are tasked to develop and implement national strategies, plans, or programmes for promoting the conservation and sustainable use of biological diversity. A major challenge for countries has been the translation of these international and regional regimes into practices at the local and national levels through well-defined policies, legal frameworks, and institutional structures (Kameri-Mbote and Cullet, 2002). Existing policies and institutional frameworks in African countries do not effectively incorporate biodiversity values into national development and planning agenda.

At a regional consultation dialogue, governments from African countries reported their inability to achieve the Africa biodiversity targets for 2010 citing the challenges

of insufficient integration and prioritization of biodiversity into broader sector of the economy (UNEP, 2010). They also noted that greater attention on climate change issues at the national level had overshadowed biodiversity conservation efforts. Concerns were raised by governments on the failure of the scientific community to effectively articulate biodiversity issues to policymakers in ways that adequately make biodiversity a priority in the political and development agenda (UNEP, 2010). Following the disappointment of not achieving the 2010 biodiversity targets, governments launched an ambitious and elaborate Strategic Plan for Biodiversity 2011-2020, which targets the sustainability of resilient ecosystems and provision of essential services by halting biodiversity loss by 2020. In order to achieve this plan, the significant gap between science and policy required a serious attention. Policymakers must formulate the appropriate policies that would slow and end the rapid rate of biodiversity loss. Improving, sharing and applying biodiversity data and information (as set by the Aichi Target 19) will be essential for policy makers to monitor the status and patterns of biological resources and to model impact of changes.

While the availability and access to high quality information on biodiversity influences effective policy making for biodiversity and ecosystem services, the same is true when it comes to how effective policies can facilitate the generation and access to high quality data on biodiversity. Given the crucial role of biodiversity in the development of Africa's economy and the importance of high quality data to inform effective decision-making, it has become necessary to examine the current policies, legislations, and institutional landscapes necessary for capturing, digitalizing and processing of biodiversity data and information in SSA countries to enable them achieve biodiversity conservation targets. Specifically, the study set out to (i) analyse existing policy and institutional landscapes that influence the generation, maintenance and access to biodiversity information in SSA; (ii) assess the potential impacts of biodiversity information on biodiversity conservation and management; and (iii) assess the factors that affect biodiversity information management in SSA.

Theoretical underpinnings on biodiversity information

In an increasingly globalised and digitised era, the relevance of environmental information including biodiversity information to nature and society has never been more pronounced than before in the development of strategies and policies (Mol, 2006). There is a growing

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interest in exploring the role of digital technology in nature conservations as highlighted by van der Wal and Arts (2015) in the *Ambio Special Issue*. In this Issue, van der Wal and Arts (2015:1) introduced the idea of 'digital conservation', which capture 'developments at the interface of digital technology and nature conservation that influence conservation-related goals'. Such emerging area raises optimism among scientists and conservationists about the potential of digital conservation in providing high quality data and information, improved surveillance, and efficiency in managing biotic resources (van der Wal and Arts, 2015).

Information and associated networks and infrastructures are increasingly regarded as critical for understanding social issues as society enters the information age (Castells, 1997a, b). The capacity of information to create transformative environmental reforms does not principally rest on the substance of the information but rather on the ability to collect, process, transmit and use information, making information available and accessible to the mass of people and institutions, as well as globalising information flow (Mol, 2006). There is considerable evidence about the role of information in defining strategies, policies and decisions on sustainable development of biotic resources and ecosystem (Ariño et al., 2011). However, the impact and relevance of information on biodiversity and the progress made in driving policies and strategies have not been uniform globally. Biodiversity information in many SSA countries are limited, non-existent or scattered in varied format in national labs, museum, survey, and project reports. This situation hinders the exchange and the creation of a cohesive data and information on biodiversity. At a scientific workshop of a group of biodiversity informaticians in the region, participants highlighted a common challenge of aggregating and synthesising existing data and information on biological resources to form a structured, unified and meaningful biodiversity information system that can adequately inform strategies and actions for biodiversity conservation (Guralnick and Hill, 2009).

To harness the potential benefits of biodiversity information in an increasingly digitised economy, there is need to look at the policies, legislations and institutional arrangements, and examine how they can effectively embrace the values of biodiversity as integral part of development at the national and local levels. Biodiversity relevant policies hold the prospects of enhancing institutional and human capacity to promote the application and utilisation of biodiversity information for conservation decisions, biodiversity data exchange and sharing, regional cooperation, and biodiversity data capture in order to meet consumer needs.

Conceptual framework

Policies, legislations and institutions are complex with

varied interpretations in literature. Several narratives have informed biodiversity policies and institutions for the management of biological resources across the globe. The following narratives have shaped development of national biodiversity policies, legislations and institutions: (i) the declining biological diversity and its threat on human existence, ecosystem and food security as result of continuous anthropogenic activities and the impact of environmental conditions; (ii) the rise of multiple international agreements, protocols and conventions which has influenced countries to commit themselves towards curbing biodiversity decline or loss; (iii) urgency with which actors must respond to reverse the loss of biological resources and to preserve biodiversity through policy strategies, legislations and institutions; and (iv) the critical aspect of generating biodiversity information that would effectively inform decision-making and national planning. The important question is to understand how policies, legislations and institutions function with a wide array of actors to influence the capture and processing of high quality data and information on biodiversity to inform actions and decision-making in sub-Saharan African countries. In understanding how these issues function, their impacts and implications, the paper articulates a conceptual model that guide the analysis of what and how biodiversity related policies, legislations and institutions shape biodiversity agenda as well as the generation, processing and access to vital information on biodiversity (Figure 1).

In this model, we identified two analytical lenses through which this study was carried out. The first is the policy analysis tool which would help to examine existing policies, legislations and institutions and their role in the conservation of biological resources as well as the generation, processing and use of biodiversity information for evidence-based decision-making. The second approach looks at the processes and contribution of biodiversity information to conservation and national development through the analytical lens of information economy (Castells, 1996).

Policy analysis

Under the policy analysis, various policies are examined to determine the ones with the potential to achieve a given set of goals considering the relations between the policies and the goals (Nagel 1999). Dunn (2015) defined policy analysis as "a process of multidisciplinary inquiry, designed to create, critically assess, and communicate information that is useful in understanding and improving policies". Policy analysis has become an essential tool for analysis of public policies aimed at reducing uncertainties, providing clear direction and systematic arrangements to improve public policymaking. As Walker (2000) pointed out, in the absence of analysis, important policy choices have been made based on hunches and guess work often resulting in undesirable outcomes. With

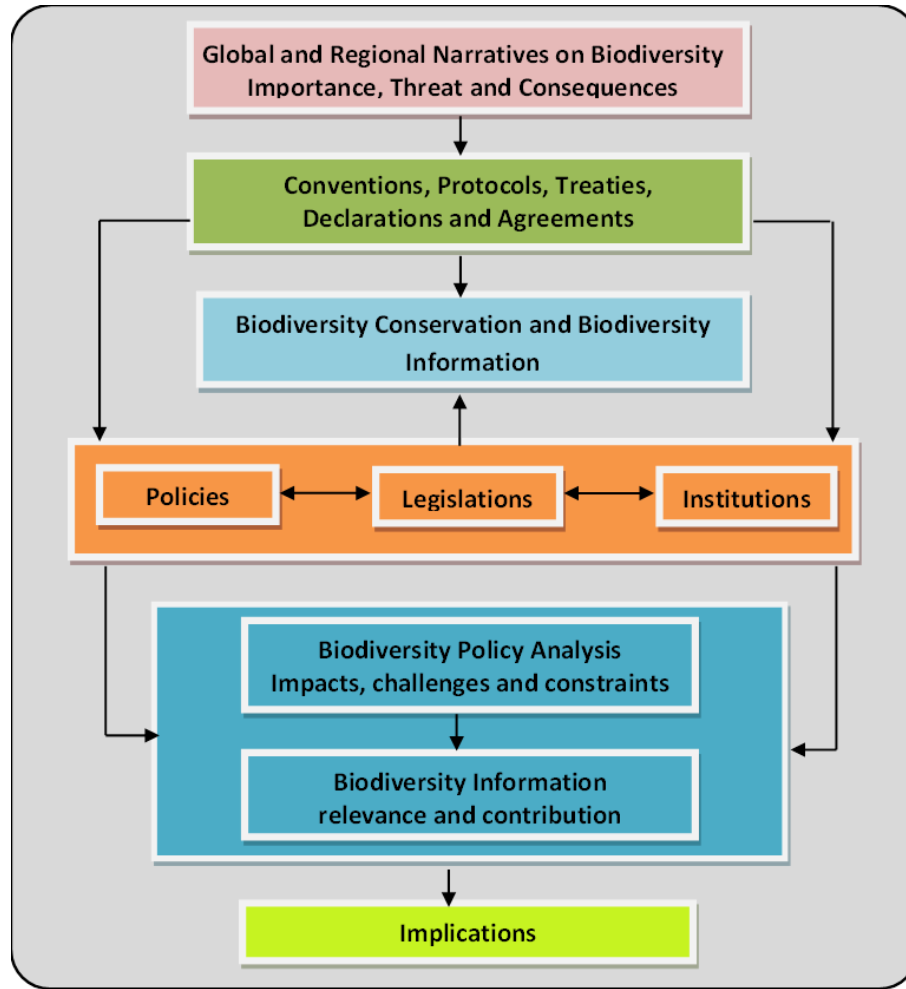


Figure 1. Conceptual model.

its root from systems analysis, policy analysis can be categorised into two main field of inquiry. The first entails analytical and descriptive analysis of existing policies with the aim to explain policies and their development. The second is prescriptive which deals with the analysis of new policy thus the formulation of policies and proposals (Bührs and Ton, 1993). The selection of policy analysis type is dependent on the area of interest and purpose of analysis. In this paper, we employ the former to analyse existing policies and institutions that are in one way or the other engaged in biodiversity conservation and management.

Several approaches to policy analysis have been identified. The four most commonly used approaches include: *Analysis 'of-for' policy*, *analycentric*, *policy process*, and *meta-policy approach*. The 'analysis 'of-for' policy' consists of two parts - analysis 'for' policy approach entails research that is commissioned by policy makers in order to actualise policy development, while the analysis 'of' policy approach is more of an academic research to understand the rational of the development of

a particular policy at a particular time and their impacts (Khorsandi, 2014). The analycentric approach target individual problems at micro-level and aims to find effective and efficient solution in technical and economic terms (e.g. the most efficient allocation of resources). With a scope at meso-level and problem interpreted in a political way, the policy process approach place emphasis on the political process, involving stakeholders. The objective is to determine the processes and means used, clarifying the role and influence of stakeholders in the policy process. One way of achieving this objective is to use a heuristic policy cycle, which demonstrates an iterative policy-making process, and policy analysis involving logical performance steps (Weible et al., 2012). For the meta-policy approach, the scope is the macro-level and its problem interpretation is structural in nature. As a systems and context approach, the meta-policy approach brings out the contextual factors such as the economic, socio-cultural and political factors that influence the policy process. This study draws from the meta-policy approach to explain how policies and

institutions emerged from global narratives on biodiversity decline and how these policies and institutions have shaped biodiversity conservations as well as the generation and use of information on biodiversity.

Information economy

According to Castells (1996, 1997), 'information economy' highlights the role played by information in economic processes. It represents a specific form of economy in which the generation, processing and transmission of information becomes a vital source of power and productivity (Kember, 2003). The idea of an information economy is not only about the importance of information in economic processes but also about the fundamental transition of the economic imperative (Mol, 2006). The rise of a new technological paradigm, powered by information and communication technologies (ICTs), and connected to globalisation processes, is creating a transformation from which a fundamentally different social and economic order has emerged. Modern economies have become information-based because the prosperity of the economy in terms of productivity and competitiveness of units fundamentally rely on their ability to generate, process and use information (Castells, 1997). With the rising relevance of biodiversity information in socio-economic development processes, there is an opportunity to articulate pragmatic policies and realign institutions to prioritise the transmission, handling, processing, and sharing of biodiversity information for national development planning and conservation management.

MATERIALS AND METHODS

Study area

Geographically, sub-Saharan Africa lies south of the Sahara desert on the continent of Africa. It comprises about 49 sovereign countries widely spread in the southern, western, central and eastern part of Africa, with some eastern islands of Africa. According to the World Bank, the population was estimated to be 974 million as at 2014 (World Bank, 2014). Sub-Saharan Africa is characterized by very rich and diverse biological resources, which represent the region's natural wealth upon which socio-economic development is based. The SSA region is home to more than 900 amphibian species, 960 mammal species and approximately 1600 bird species (International Union for Conservation of Nature (IUCN) Red List, 2008).

Research methods and data analysis

The paper employed a mix of approaches for data collection and analyses. Both primary and secondary sources of data were utilized. This allowed for effective triangulation of data (Yeasmin and Rahman, 2012). The first part entailed content analyses of scientific literature, national policy documents, biodiversity strategy and action plans, global biodiversity databases, web content,

conference documents and reports, national reports, and institutions that are responsible for biodiversity issues in SSA countries. This detailed literature review provided a useful overview of existing policies, institutional arrangements, frameworks and action plans for biodiversity conservation and management in sub-Saharan African countries. These outcomes informed the questions that were asked in the online survey.

The second part included the administration of an online survey using survey monkey. A semi-structured questionnaire was sent out to various experts and stakeholders to obtain information on current situation regarding biodiversity policies, the value of biodiversity information, relevance, challenges, and the impact of policies on the generation and access to biodiversity information and data. The semi-questionnaire included a set of open questions (questions that prompt discussion). The statements in the questionnaire were defined based on the initial literature assessment carried out on the subject. Two reasons inform this approach- one, to provide valuable information from the context of respondents' experiences, allowing them to explore responses further, and two, to provide uniformity (Horton et al., 2004). Respondents included representatives from government ministries and agencies responsible for biodiversity conservation, policymakers, and experts from research institutions, universities, non-governmental organizations, and biodiversity informaticians. A total of 60 respondents from 32 countries participated in the research through an online survey.

Primary data were collected at interval levels using a 5-point Likert-scale. The application of this ordinal scale allows users to measure the gradations in attitudes, opinions, and behaviors of respondents (Dillman et al., 2009). To determine the level of impact of biodiversity information on biodiversity management in SSA, participants were tasked to rate the predefined and open statements on a scale of 1 to 5 with the following rating: No impact = 1, low extent = 2, medium impact = 3, High impact = 4, Very high impact = 5. To assess the extent to which certain factors affect biodiversity information management and to assess the impact of biodiversity information on biodiversity management, we defined a 5-point rating scale which included: Very great extent = 5, Great extent = 4, Some extent = 3, Little extent = 2 and No extent = 1. Following the ratings by respondents, we calculated the mean scores and standard deviations of the various ratings by the respondents. We also set out a cut-off mark of 2.5 and below for all statements that were not significant.

RESULTS AND DISCUSSION

In the first part of this section, drawing from various documentations including literature, reports, plans and policies, we examined the policies and institutions that have emerged in response to the growing recognition of the importance of biodiversity and the alarming rate of biodiversity loss around the world. Based on the responses from the online survey conducted, the second part involves the analysis of the potential impact of existing policies, legislations and regulations on the processes that facilitate the generation of biodiversity information as well as the factors that affect the management of biodiversity information in sub-Saharan African countries.

Policy and institutional analysis on biodiversity in SSA

In recognizing the value of biodiversity to humanity and

Table 1. List of policies and legislations in SSA countries.

National policies and legislations	Countries
Biodiversity Policy	Nigeria, Rwanda, Ethiopia, South Africa
Forest Policy	Angola, Burundi, Kenya, Lesotho, Malawi, Mauritius, Namibia, Nigeria, Senegal, Somalia, Sudan, Togo, Zambia, Zimbabwe
Forest Code	Burkina Faso, Central African Republic, Ivory Coast, Guinea, Senegal
Forest Act	Botswana, Gambia, Kenya, Lesotho, Malawi, Mauritius, Sierra Leone, South Africa, Sudan, Uganda, Zambia, Zimbabwe
Forest Law	Benin, Burundi, Central African Republic, Ethiopia, Guinea Bissau, Liberia, Madagascar
Wildlife and Conservation Policy	Botswana, Ghana, Kenya, Mozambique
Forest and Wildlife Law	Cameroun,
Wildlife Policy	Eritrea, Namibia, South Sudan, Tanzania, Uganda, Zimbabwe
Wildlife Act	Gambia, Swaziland, Uganda, Zambia, Zimbabwe,
Wildlife Law	Ethiopia, Senegal
Wildlife Code	Ivory Coast, Guinea
Wildlife Conservation and National Park Act	Botswana, Benin, Ivory Coast, Guinea Bissau, Kenya, Lesotho, Liberia, Malawi, Sierra Leone, Sudan, Tanzania,
Environmental Policy	Ethiopia, Ghana, Lesotho, Liberia, Malawi, Mali, Mauritius, Mozambique, Nigeria, Rwanda, Somalia, Swaziland, Tanzania, Uganda, Zambia, Zimbabwe
Environmental Management Act	Gambia, Ghana, Kenya, Lesotho, Malawi, Seychelles, Somalia, South Africa, Sudan, Swaziland, Uganda, Zambia,
Environmental Law	Angola, Comoros, Chad, Guinea Bissau, Liberia, Madagascar, Mali
Environmental Code	Burkina Faso, Guinea Bissau
Environmental Assessment Act	Impact Guinea Bissau, Mozambique, Seychelles, Uganda, Zambia, Zimbabwe
Fisheries Act	Gambia, Liberia, Rwanda, Tanzania,
Fisheries Policy	Kenya
Wetland Policy	Mali, Rwanda, Uganda, Zambia

survival of planet earth, the global community has over the past four decades established policies, institutional mechanisms and legislative instruments aimed at curbing the declining biodiversity, promoting sustainable use, and ensuring fair and equitable access to biological resources (Cardinale et al., 2012). At the 1992 Earth Summit in Rio, a global consensus was agreed upon by nations present about the impact of human actions in the destruction of biological diversity, ecosystems, and the elimination of genes and biological traits around the world at a disturbing rate. A major milestone was achieved when the Convention on Biological Diversity (CBD) was agreed and passed by member countries to promote the conservation, sustainable utilization, and fair and equitable benefit-sharing of biological resources. The CBD was regarded as the first global comprehensive multilateral agreement that placed environmental, social and economic goals on the same level. The CBD boasts of all the 198 countries who are signatories to the convention including all the sub-Saharan African countries.

Analysis of the various policies and documentary evidence in sub-Saharan African countries revealed that existing policies and legislative instruments on

biodiversity have mainly focused on the sector-based issues such as environment, forest and wildlife resources (Table 1). For example, many SSA countries have created separate policies and legislative instruments such as forest policy, wildlife policy, environmental policy, forest code, wildlife act, fisheries act, environment management act, among others, which are implemented by different institutions with sometimes overlapping and duplications in responsibility.

Under the Convention on Biological Diversity, contracting parties were required to develop and implement national strategies, policies and action plans to address environmental and conservation issues. The convention in many ways contributed to the formulation of policies and institutions in sub-Saharan countries that are geared towards streamlining biodiversity issues into national development planning (Perrings and Lovett, 2000).

As a commitment to meet the requirement of the Article 6 of the CBD, all SSA countries have already put in place a National Biodiversity Strategy and Action Plan (NBSAP). The NBSAPs function as the policy strategy and implementation framework for biodiversity conservation, and in part viewed by most countries as a

substitute for a standalone biodiversity policy. In spite of the effort made in policy and legal frameworks, there exists many gaps in relation to actual implementation of NBSAPs and biodiversity related policies in most SSA countries (Hens and Nath, 2003; Hens, 2006). Administrative level mandates for the implementation of NBSAP remain unclear. The review of NBSAP implementation in SSA countries highlighted the following challenges: the lack of coordination in implementing actions and compliance monitoring, limited understanding of the plan, and weak implementing institutions, among other factors. The implementation challenge raises question as to the suitability of the NBSAPs as policy strategy and action plan to guide the sustainable management of biodiversity conservation as well as the generation of biodiversity information to inform policy decision-making.

With the exception of Ethiopia, Nigeria, Rwanda and South Africa, most SSA countries do not have standalone biodiversity policy. In Nigeria, the National Policy on Conservation of Biological Diversity established in 1999 seeks to integrate biological diversity issues into national planning, and decision-making, and to conserve and enhance the sustainable use of biological diversity. The Biodiversity Policy for Rwanda was adopted and approved by parliament in 2011 and a law on biodiversity was passed in 2013. In this policy, the Government of Rwanda highlighted the scattered nature of biodiversity data and information in different sectors, and the need to ensure the mobilization, accessibility and management of data and information to support conservation and decision-making. South Africa's Biodiversity Policy and legislation instruments for biodiversity are well developed, providing a strong basis for the sustainable utilization and conservation of biological diversity. The White paper on Conservation and Sustainable use of South Africa's Biological Diversity (1997) laid the foundation for the establishment of a legislative framework for biodiversity. The Biodiversity Act (Act 10 of 2004) under the umbrella of the National Environment Management Act (1998) seeks to resolve the fragmented nature of biodiversity-related legislation by consolidating different laws and bring into effect the principle of cooperative governance. South Africa is among the very few countries with an established National Biodiversity Institute. Analyses of these countries' standalone biodiversity policies revealed the extent to which biodiversity issues are considered important within the national agenda.

Towards biodiversity information generation and access- the role of institutions in SSA countries

Several institutions and agencies at the national levels have notably been responsible for biodiversity issues in SSA countries. For instance, research institutions have been mainly responsible for the generation, collection

and analysis of biodiversity data and information.

National Histories and Museums, and Herbaria play an essential role in biodiversity data and information storage and reference labs. The Forestry and Wildlife Services are responsible for the management of forest concessions, forest reserves, wildlife sanctuaries and national park systems. Non-Governmental Organizations have also played a role in biodiversity conservation, data generation, policy advocacy, and capacity building. Communities have emerged as legitimate local institutions responsible for creating and managing community forest and wildlife reserves. Such arrangement sometimes created a challenge for biodiversity management due to the lack of horizontal cooperation, ineffective collaboration and lack of information flow among the different institutions and agencies.

In the analyses of institutions in SSA countries, it became evident that many countries are yet to establish specialized institutions that facilitate the generation, processing and sharing of biodiversity data and information in Africa. Some renowned biodiversity institutions promoting the generation and storage of biological diversity data on Africa are domiciled outside Africa. For example, the African Biodiversity Information Centre (ABIC) based in Belgium provides African countries with information resources on biodiversity in the Royal Museum for Central Africa's (RMCA) animal and plant collections. Funded by Belgian Development Cooperation, the ABIC is an RMCA initiative which, as stipulated in the Convention on Biological Diversity signed by Belgium, aims to share data on African biodiversity with African institutions.

Recently, we are witnessing the emergence of several initiatives at the sub-regional and national levels that targets the generation, processing and use of biodiversity information. For instance, the East African Biodiversity Informatics project (EABIP), established in 2007 aims to develop a baseline for biodiversity data for monitoring, assessing and setting priorities for the conservation and sustainable use and development of biodiversity information in Kenya, Tanzania and Uganda. The initiative has established a working platform with existing regional initiatives, such as the Botanical and Zoological Network for Eastern Africa (BOZONET) and the East African Regional Initiative on Medicinal Plants (EARIMP) to coordinate information on taxonomy, biodiversity status and sustainable use. Another existing initiative is the ARCOS Biodiversity Information System (ARBMS), a platform to promote data sharing and information exchange on biodiversity to support informed decision in the Albertine Rift region. Established in 2007, ARBMS makes accessible data mobilized and published through the ARCOS standard Integrated Publishing Toolkit (IPT). At the country level, one noticeable initiative is the Tanzania Biodiversity Informatics Facility (TanBIF) which is an extensive, decentralized system of national biodiversity information units that aim to provide free and

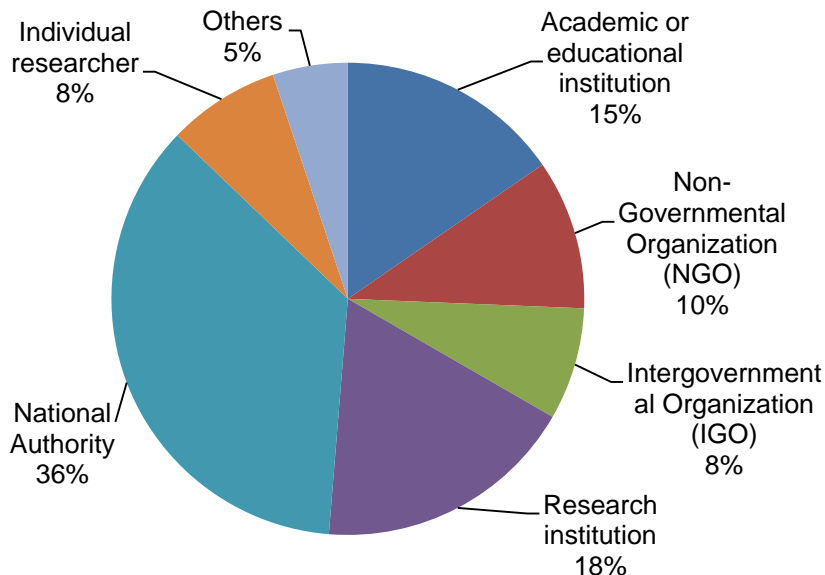


Figure 2. Background of survey respondents.

universal access to data and information on Tanzania's biodiversity. Established in 2008, TanBIF facilitates, mobilizes and digitizes primary biodiversity data; promote the use of scientific data in biodiversity policy and decision-making; and make biodiversity data and information universally available and accessible via the Internet.

Impact of biodiversity information on conservation and management in SSA

A total of 60 responses from the online survey were received from respondents in 32 out of the 49 sub-Saharan African countries. Respondents were from different institutions and different professional backgrounds that are all related to issues of biodiversity. The distribution of biodiversity experts and stakeholders that participated in the surveys is presented in Figure 2. Majority of the respondents (36%) were officials from government institutions, 18% were from research institutions, 15% worked with academic and educational institutions, 10% were from non-governmental organizations, and 8% each were from individual researchers and intergovernmental organizations. Only 5% came from other sources.

The fair distribution of the respondents across various stakeholder categories in the biodiversity sub-sector meant that information and data received were inclusive and capable of providing veritable guidance and policy direction on biodiversity information in the region. More so, the representation from up to 32 SSA countries provides room for diverse opinion which can be harmonized and used for generalization for both

interventions and programmes.

Table 2 shows the mean scores and standard deviations from respondents on the impact of biodiversity information on biodiversity conservation and management in SSA. To determine the impact, respondents rated predefined impact statements on a scale of 1 to 5, with 1 being "no impact" and 5 being "Very high impact". The results showed that the mean scores of the ratings of the impact statements ranged between 3.9 and 4.40. According to respondents, all the impact statements defined in the table showed varying degrees of significance with their impact on the conservation and management of biodiversity. However, the most significant among the impact statements were on 'access and use of high quality biodiversity information (4.36); improved knowledge and understanding of biodiversity information (4.36); impact on environmental and ecosystem restoration (4.27 Integrated biodiversity information system (4.18); enhanced value of biodiversity conservation (4.18); and impact on plant and wildlife conservation (4.00). Several findings from other studies support the results from this study and emphasized the importance of biodiversity information and data in the management of biodiversity and prevention of environmental degradation (Bisby, 2000; Oliver et al., 2000; Edward et al., 2000; Krishtalka et al., 2002). The efficient mobilization of biodiversity information in a structured and unified form presents a new opportunity to understand the trend of biodiversity loss, while providing a vast amount of high quality and reliable information for sound policymaking (Peterson, 2003). It also offers a great potential to apply novel tools in numerous biodiversity studies ranging from prediction of species distribution and invasion (Raxworthy et al., 2003; Peterson, 2003),

Table 2. Mean scores of respondents on the impacts of biodiversity information on biodiversity conservation and management in SSA.

S/N	Statements	Mean	SD
1	Access and use of high quality biodiversity information	4.36	1.43
2	Integrated biodiversity information system	4.18	1.56
3	Facilitate national development agenda and decision-making	3.95	1.53
4	Improve academic and further research work	3.91	1.54
5	Impact of environmental and ecosystem restoration	4.27	1.31
6	Impact on plant and wildlife conservation	4.00	1.48
7	Impact on economic livelihoods	3.95	1.52
8	Improve knowledge and understanding of biodiversity information	4.36	1.43
9	Enhanced value of biodiversity conservation	4.18	1.44

*Cut-off mark- 2.5.

ecological and geographical distribution modeling (Canhos et al, 2004), and variability impact on biodiversity (Siqueira and Peterson, 2003; Thomas et al., 2004).

The Convention on Biological Diversity recognized that successful implementation of the convention heavily relies on the combined efforts of member countries and international organizations as well as integration of biodiversity knowledge and information systems (Canhos et al., 2004). Article 17 of the CBD demands “the exchange of information from all publicly available sources, relevant to the conservation and sustainable use of biological diversity” among contracting parties. “Such exchange of information shall include exchange of results of technical, scientific and socio-economic research, as well as information on training and surveying programmes, specialized knowledge, and indigenous and traditional knowledge” (Convention on Biological Diversity (CBD), 2010).

The cases of Ethiopia, Rwanda and South Africa provide visible impact of generation and use of biodiversity information to improve biodiversity conservation and management. For example, since 1998, the Ethiopian Biodiversity Institute has evolved to become the leading public institution responsible for undertaking research on Ethiopia’s Biodiversity and associated indigenous knowledge; establishing participatory conservation mechanisms; ensuring fair and equitable access and benefit sharing; and promoting sustainable utilization of biodiversity for sustainable development. As an important strategy in the 2011 National Biodiversity Policy, the Rwandan Government plans to collaborate with stakeholders to establish a National Biodiversity Information Network (NBIN) and a National Biodiversity Information Management System (BIMS) to facilitate the collection, sharing, analysis, distribution and management of data and information for the biodiversity conservation and sustainable use. In South Africa, the South African Biodiversity Institute (SANBI) has built a reputation in biodiversity conservation beyond its national boundaries, becoming more of a regional institution that is SANBI in

Partnership with Global Biodiversity Information Facility (GBIF) have organized a series of training and capacity building workshops to mobilize African biodiversity data while strengthening regional collaboration and capacity in biodiversity informatics. Availability of biodiversity information also had significant influence on the level of environmental degradation and plant and wildlife conservation. Countries with adequate information on the level of environmental degradation and biodiversity loss are more able to take informed steps to reduce degradation effects and minimize biodiversity loss (Peterson et al., 2002b; Siqueira and Peterson, 2003; Thomas et al., 2004).

Factors affecting biodiversity information management in sub-Saharan Africa

In Table 3, respondents ranked the factors affecting biodiversity information management in SSA which ranged between 3.80 and 4.20, with a cut-off mark of 2.5. Highly significant among the factors were the lack of funding (4.18) and the weak institutional capacity (4.05) for the generation, processing and management of biodiversity data and information. The results align with the findings of Muhumuza and Balkwill (2013) which reported that lack of adequate funding and improper government policy implementation are key factors affecting biodiversity information management in SSA. In majority of SSA countries, national financial priorities are far from being allocated to building biodiversity information systems and database. The largest proportion of investment in biodiversity conservation comes from foreign contributions. According to the Africa Environment Outlook 2, approximately US\$ 245 million is invested annually by international donors for the management of protected area in SSA. The effectiveness of such investments in ensuring the conservation of biodiversity spearheading the field of biodiversity informatics in Africa. depends partly on the availability and reliability of

Table 3. Mean response on factors that affect biodiversity information management in SSA.

S/N	Statements	Mean	SD
1	Lack of funding	4.18	1.14
2	Weak institutional capacity	4.05	0.84
3	Lack of human capacity	3.95	0.95
4	Lack of equipment such as computers, models, application and tools	3.91	1.11
5	Lack of policy or poor policy implementation	3.82	1.06

*Cut-off mark- 2.5.

information on the spatial distribution and condition of biodiversity (Balmford and Gaston, 1999).

The lack of adequate funding to afford equipment coupled with the weak institutional capacity in terms of number of staff and expertise are major impediments to the generation, processing and digitization of biodiversity information in SSA countries. These challenges enumerated by respondents reflected the biodiversity information management experiences shared by participants at a recent project workshop of African biodiversity informaticians in Pretoria (SANBI, 2014). Majority of African professionals and their institutions (competency and capability respectively) are inadequately equipped with modern technologies and tools to generate and process biodiversity information. Employing new technologies and scientific approaches in the field of biodiversity has significantly improved the analysis, interpretation, integration, and visualization of biodiversity data and information (Canhos et al., 2004). While advances in hardware and software technologies for biodiversity information processing is improving globally, availability of these technologies and tools to the larger part of the world particularly the developing world is lagging behind (Swetnam and Reyers, 2011). Additionally, while growing biodiversity research is generating unprecedented quantity of data around the world (Scholes et al., 2008); significant volumes of such data continue to disappear after project completion (Güntsche and Berendsohn, 2008). In cases where data is available, there is high tendency for individuals, institutions and organizations to be reluctant to share data and information on biodiversity, which is driven by the notion that data users may profit “unfairly” or misinterpret the data. The availability and access to accurate and up-to-date information on biodiversity is considered as one of the main prerequisites for the successful implementation of biodiversity conservation and management programs (Swetnam and Reyers, 2011). There is a need to shift towards valued, demand-driven approaches towards the generation and processing of biodiversity information to transform behaviours while developing the competencies and capacities of individuals and institutions respectively on the application of emerging technologies and the values of biodiversity information management for national development.

Conclusion

In this paper, we have explored how the importance of biodiversity has risen over the past three decades due to the global recognition of rapid rate of biodiversity loss and its implication for sustainable socio-economic development. This global narrative triggered a global dialogue on biodiversity that have resulted in the establishment of conventions aimed at encouraging countries around the world to pay attention and commit towards addressing the imminent threat that is associated with the decline of biodiversity. In the light of this, we have witnessed the development of policies, legal instruments and networks of institutions that have sought to provide effective strategies and interventions to manage biological diversity sustainably. Yet, the implementation of these policies, strategies, and interventions to curb biodiversity loss has remained unsuccessful as the state of the world’s biodiversity continues to decline rapidly. In this paper, we have examined the policy and institutional landscapes in relationship with biodiversity issues including the generation, processing and use of biodiversity information to inform decision-making in sub-Saharan Africa countries. We have also looked at the impact of biodiversity information on biodiversity conservation and management and the factors that affect biodiversity information management.

Analysis of the various policies and documentary evidence in sub-Saharan African countries revealed that there are numerous policies and legislative instruments related to biodiversity that are mainly focused on sector-based issues such as forest, wildlife, fishery resources, among others. Many SSA countries formulated separate policies and legislative instruments such as forest policy, wildlife policy, environmental policy, forest code, wildlife act, fisheries act, and environment management act, among others that are implemented by different institutions with sometimes overlapping and duplications in responsibility. A major policy gap for biodiversity is that while all these policies are presumably geared toward biodiversity conservation and management, they have not been able to adequately address biodiversity due to the fact that biodiversity issues are spread between different policies and managed by different institutions.

Most of the SSA countries as revealed through the

analysis do not have a standalone biodiversity policy that specifically target biodiversity issues including biodiversity information. In the analyses of institutions in SSA countries, it became evident that many countries are yet to establish specialized institutions that facilitate the generation, processing and access to biodiversity data and information in Africa.

The current status of information on biodiversity in sub-Saharan Africa (SSA) remains patchy and precarious due to multiple factors including lack of funding and investment in modern technologies for data generation, limited capacity of individuals and institutions to generate high quality biodiversity information, and lack of policies that target the generation, processing and use of biodiversity information. The efficient mobilization of biodiversity information in a structured and integrated format presents a new opportunity to understand the trend of biodiversity loss, while providing a vast amount of high quality and reliable information for sound policymaking. There is a need to shift towards valued, demand-driven approach for the generation and processing of biodiversity information to transform behaviours while developing policies, competencies and capacities of individuals and institutions on the application of emerging technologies and the values of biodiversity information management for national development.

Conflict of Interests

The authors have not declared any conflict of interests.

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