

KSK 30001-

UTILIZATION AND CONSERVATION OF BELOW-GROUND
BIODIVERSITY IN GATUNDURI AND KIBUGU DIVISIONS
OF EMBU DISTRICT: AN ANALYSIS OF POLICY
FRAMEWORK //

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DECLARATION

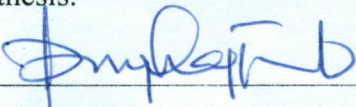
This thesis is my original work and has not been presented for a degree in any other University or any other award.

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DEDICATION

To my dear parents without whose dedication to educate me, I would not have reached this far.

My sincere appreciation to Kenyatta University and all my staff especially Dr. Ayub Mwachia, Dr. Samuel Otor and Dr. Peter Othman for their assistance, advice, patience, moral and professional support during the entire study period. My appreciation also goes to Mrs. Rita Verma of TBSP-CIAF who advised me on various aspects of social science that were relevant to my research. Prof. Albert Muguma of the University of Nairobi, for his advice regarding environmental policy issues. Special thanks go to the Below-ground biodiversity (BGBD) project global coordinator Dr. Jeroen Huizing for providing me with financial support to undertake part of my research. Much gratitude goes to the African Centre for Agroforestry Education (ANAFE) for providing me with a platform to undertake my research work.

More gratitude goes to all the farmers, research scientists and employees of institutions that were interviewed for their collaboration and willingness to give information. I would also like to acknowledge the hard work undertaken by my research assistants in Embu: Rachel Ireri, Murya, Njoki and Muchangi. They worked tirelessly in translating the questionnaires to the farmers as well as interviewing them.

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TABLE OF CONTENTS

DECLARATION	ii
DEDICATION	iii
ACKNOWLEDGEMENTS	iv
TABLE OF CONTENTS	v
LIST OF TABLES	viii
LIST OF FIGURES	ix
ABBREVIATIONS AND ACRONYMS	x
OPERATIONAL DEFINITIONS OF TERMS	xiii
ABSTRACT	xiv
CHAPTER 1	1
INTRODUCTION	1
1.1 Background to the problem.....	1
1.1.1 Policy and its functions.....	5
1.2 Statement of the problem.....	7
1.3 Research Questions.....	8
1.4 Research Premises.....	9
1.5 Research Objectives.....	9
1.6 Significance of the study.....	10
CHAPTER 2	11
LITERATURE REVIEW	11
2.1 BGBD and their importance.....	11
2.2 Status of BGBD in Kenya.....	12
2.3 Links between above-and below-ground biodiversity.....	16
2.4 Current status of BGBD policy in Kenya.....	17
2.4.1 The National Biodiversity Strategy Action Plan (NBSAP).....	18
2.4.2 Policy gaps in biodiversity conservation related policies and legal measures in Kenya.....	20
2.5 The Convention on Biodiversity (CBD).....	24
2.5.1 Considerations for implementing the CBD in Kenya.....	25
2.5.2 Process of Domestication of international conventions and treaties in Kenya.....	27
2.5.3 Material Transfer Agreements (MTA) and Material Acquisition Agreements (MAA) as items of domestication.....	28
2.6 Intellectual Property Rights.....	30
CHAPTER 3	33
RESEARCH METHODOLOGY	33
3.1 Study area description.....	33
3.1.1 Location.....	33
3.1.2 Agro-ecological zones.....	36
3.2 Data collection.....	38

3.2.1	Use of meta-data to relate land to below-ground biodiversity	39
3.2.2	Farmer interviews and focus groups discussions	40
3.2.3	Institutional studies.....	40
3.2.4	Individual scientists' study.....	41
3.2.5	Key informant interviews.....	42
3.3	Sampling procedure.....	42
3.3.1	Systematic sampling.....	42
3.3.2	Purposive sampling	43
3.4	Data analysis.....	44
CHAPTER 4		45
RESULTS AND DISCUSSION.....		45
4.1	Introduction	45
4.2	Relating land-use to BGBD from meta-data, literature review and farmers' interviews	45
4.2.1	Effects of land-use systems and intensities on BGBD	46
4.2.2	Farmers' interviews in Embu	54
4.3	Farmers knowledge and roles in BGBD management and conservation..	55
4.3.1	Farmer's knowledge of BGBD.....	55
4.4	Institutions and their roles in BGBD inventory exchange and transfer	61
4.4.1	Types of genetic resources used by institutions.....	61
4.4.2	Rules and regulations governing collection, packaging, transfer and pricing of genetic resources.....	62
4.5	The Role of policy in BGBD conservation, management, preservation, acquisition, transfer, commercialization, benefit sharing and IPR.....	64
4.5.1	Farmers perceptions	64
4.5.2	Institutions' perceptions	72
4.5.2.1	Material Transfer Agreements (MTA) and Material Acquisition Agreements (MAA).....	72
4.5.2.2	Articles of the Convention on Biodiversity (CBD).....	78
4.5.2.3	Policies and regulations that affect BGBD.....	80
4.5.3	Scientists perception.....	83
4.5.3.1	Participation in soil organisms' research.....	83
4.5.3.2	Acquisition of soil organisms by scientists	89
4.5.3.3	Commercialization of soil organisms.....	91
4.5.3.4	Scientists and Intellectual Property Rights.....	93
4.6	Other BGBD issues worth attention.....	96
4.6.1	Pricing	96
CHAPTER 5		100
CONCLUSIONS AND RECOMMENDATIONS.....		100
5.1	Summary of Findings and Conclusions	100
5.2	Recommendations	102
5.2.1	BGBD and land-use.....	102
5.2.2	Policy gaps and possible intervention mechanisms and means	102
5.2.2.1	Access to genetic resources and benefit sharing	102

5.2.2.2	Prior informed consent and Intellectual Property Rights (IPR)	104
5.2.2.3	Delay in approval and gazettement of regulations	104
5.2.3	Lack of policies	105
REFERENCES		106
APPENDICES		112
Appendix I: Biodiversity Conservation Institutional Questionnaire		112
Appendix II: Questionnaire for farmers		120
Appendix III: Questionnaire for scientists dealing with biodiversity		126
Appendix IV: Interview questions for key informants		130
Appendix V: Status of implementation of the articles of CBD that are relevant to BGBD		132

LIST OF TABLES

TABLE 3. 1: ADMINISTRATIVE DIVISIONS AND POPULATION, EMBU DISTRICT	36
TABLE 3. 2: CHARACTERISTICS OF THE AEZS IN EMBU DISTRICT	37
TABLE 4.1: COMPARATIVE ACCOUNT OF EARTHWORM SPECIES RICHNESS IN NATIVE FORESTS AND MANAGED ECOSYSTEMS IN WESTERN ORISSA, INDIA	49
TABLE 4.2: COMPARATIVE ACCOUNT OF CHEMICAL AND BIOLOGICAL ATTRIBUTES OF NATIVE FORESTS AND MANAGED ECOSYSTEMS IN WESTERN ORISSA,	50
TABLE 4. 3: SHANNON INDEX FOR SOIL MACROFAUNA DIVERSITY IN DIFFERENT LAND USE SYSTEMS IN WESTERN AMAZONIA	52
TABLE 4. 4: FARMERS' KNOWLEDGE OF BGBD IN RELATION TO THEIR FUNCTIONS	57
TABLE 4. 5: ROLES OF FARMERS IN BGBD MANAGEMENT AND CONSERVATION	58
TABLE 4. 6: TYPES OF INTERVENTION NEEDED BY FARMERS FROM THE GOVERNMENT IN CONSERVING BGBD.....	59
TABLE 4. 7: TYPES OF INCENTIVES NEEDED BY FARMERS FROM THE GOVERNMENT.	60
TABLE 4. 8: ORGANISMS AND THEIR SPECIFIC USES	86
TABLE 4. 9: SCIENTISTS' VIEWS ON HOW IPR CAN BE PROTECTED.....	94
TABLE 4. 10: SCIENTISTS OPINIONS IN REGARD TO FARMERS' ROLES IN BGBD CONSERVATION AND UTILIZATION	95
TABLE 4. 11: SCIENTISTS' VIEWS IN REGARD TO RECOGNITION OF FARMERS IN ISSUES OF IPR	95

LIST OF FIGURES

FIGURE 3. 1: MAP OF EMBU DISTRICT	34
FIGURE 3. 2: LAND-USE MAP SHOWING KIBUGU AND GATUNDURI SUB-LOCATIONS OF EMBU DISTRICT	35
FIGURE 4.1: TYPE OF GENETIC RESOURCES HANDLED BY INSTITUTIONS.....	62
FIGURE 4.2: FARMERS OPINIONS ON FUTURE EXCHANGES OF SOIL ORGANISMS AMONG FARMERS AND WITH INSTITUTIONS DEALING WITH BGBD.....	70
FIGURE 4. 3: INSTITUTIONS THAT HAVE SIGNED MTA AND MAA.	74
FIGURE 4. 4: PARTICIPATION OF SCIENTISTS IN SOIL ORGANISM RESEARCH	83
FIGURE 4. 5: SOIL ORGANISMS THAT ARE MOST RESEARCHED ON BY SCIENTISTS	85
FIGURE 4. 6: SCIENTISTS' UNDERSTANDING OF ACQUISITION.....	90
FIGURE 4. 7: INSTITUTIONAL INVOLVEMENT IN EXPORTATION OF SOIL ORGANISMS	96
FIGURE 4. 8: MARKETS FOR SOIL ORGANISMS.....	97

CGIAR *Cooperative Group on International Agricultural Research*

CIAT *International Centre for Tropical Agriculture*

CIPRI *Centre for International Poverty Research*

COMYT *Centro Internacional de Mejoramiento de Maíz y Trigo*

CITLS *Council for International Trade in Scientific Exports*

CoP *Coalition of the Parties*

CSIRO *Commonwealth Scientific and Industrial Research Organisation*

EIA *Environmental Impact Assessment*

EMCA *Environmental Management and Coordination Act*

FD *Forest Department*

GDP *Gross Domestic Product*

GEF *Global Environment Facility*

IBD *International Bank for Development (the same place) is the 1997
 International Bank for Development or Foreign Investment Reference for
 World Bank*

ABBREVIATIONS AND ACRONYMS

AG	Attorney General
ANAFE	African Network for Agroforestry Education
BGBD	Below-ground Biodiversity
CAB	Central Agricultural Board
CBD	Convention on Biodiversity
CEPA	Communication, Education and Public Awareness
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Centre for Tropical Agriculture
CIFOR	Centre for International Forestry Research
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo
CITES	Convention for International Trade in Endangered Species
CoP	Conference of the Parties
CSIRO	Commonwealth Scientific and Industrial Research Organization
EIA	Environmental Impact Assessment
EMCA	Environment Management and Coordination Act
FD	Forest Department
GDP	Gross Domestic Product
GEF	Global Environment Facility
Ibid	Latin, short for <i>ibidem</i> , "the same place") is the term used to provide an endnote or footnote citation or reference for a source that was cited just before

IPA	Industrial Property Act
IPR	Intellectual Property Rights
IUCN	International Union for the Conservation of Nature
KARI	Kenya Agricultural Research Institute
KEFRI	Kenya Forestry Research Institute
KEPHIS	Kenya Plant Health Inspectorate Services
KEMRI	Kenya Medical Research Institute
KIPI	Kenya Industrial Property Institute
KIPO	Kenya Industrial Property Office
KNCPC	Kenya National Cleaner Production Centre
KWS	Kenya Wildlife Service
LVEMP	Lake Victoria Environmental Management Programme
MAA	Material Acquisition Agreement
MTA	Material Transfer Agreement
N	Nitrogen
NARL	National Agricultural Research Laboratory
NARIS	National Agricultural Research Institutes
NBSAP	National Biodiversity Strategy Action Plan
NCST	National Council of Science and Technology
NEAP	National Environment Action Plan
NEC	National Environment Committee
NEMA	National Environment Management Authority

NEPAD	New Partnership for Africa's Development
NMK	National Museums of Kenya
NGOs	Non-Governmental Organizations
MDGs	Millennium Development Goals
PBS	Program for Biosafety Systems
RCMRD	Regional Centre for Mapping of Resources for Development
SoE	State of Environment
TRIPs	Trade Related Aspects of Intellectual Property Rights
TSBF-CIAT	Tropical Soil Fertility and Biology-International Centre for Tropical Agriculture
UK	United Kingdom
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USA	United States of America
USIU	United States International University
WTO	World Trade Organization
WIPO	World Intellectual Property Rights Organization
UPOV	International Union for the Protection of New Varieties of Plants

OPERATIONAL DEFINITIONS OF TERMS

Agricultural Intensification	The effects of land use systems and intensities
Acquisition	Is the process through which one party takes over possession of an item from another
Below-ground biodiversity	Refers to soil organisms. Also called soil fauna (www.ciat.cgiar.org)
Commercialization	The process of introducing a new product into the market
Conservation	The act of preserving, guarding, or protecting; the keeping (of a thing) in a safe or entire state; preservation.
Exchange	The act of changing one thing for another
Land-use	Syndromes of human activities such as agriculture, forestry and building construction that alter land surface processes including biogeochemistry, hydrology and biodiversity.
Land-use intensity	The extent to which land is used.
Land-use systems	Land cover types
Policy	A projected programme of goals, values, and their consistent practice over a considerably long period of time, which benefits from periodic review.
Transfer	Move from one place to another
Utilization	The extent to which something is turned to practical use or account.

ABSTRACT

Below-ground biodiversity (BGBD) in respect to soil organisms has not been given a specific schedule in the policy and legal framework of Kenya. This omission was mainly due to lack of awareness and appreciation among stakeholders. Soil organisms are useful in the broader aspect of environment and natural resources. In this regard, there is need to safeguard them with a clearly defined and comprehensive policy. Currently, there is no specific policy and legislation in the country that governs the use and conservation of BGBD. The sectoral laws that are supposed to outline the use of BGBD have no such provisions. Such laws are the Agriculture Act, the Plant protection Act, the Forest Act, the Pesticides Control Act, and even the most recently enacted umbrella environmental Act, namely, the Environmental Management and Coordination Act (EMCA). This study, therefore, reviewed these pieces of legislation in relation to BGBD. The goal of the study was to contribute to the enhancement of soil biodiversity and sustained utilization of its components in Kenya through an improved policy framework. Two main themes addressed by the study include land use change and intensities and appropriate policy framework for utilization and conservation of soil organisms. Three groups of stakeholders (120 farmers, 30 scientists and 12 research and private institutions dealing with BGBD) were issued with questionnaires to obtain information about their experiences with BGBD. The study with farmers was done in Gatunduri and Kibugu divisions in Embu District while the one with scientists and institutions was done in Nairobi and Embu. Farmers were selected through systematic random sampling so as to obtain diverse views across the two divisions. Scientists and institutions were selected through purposive sampling. Interviews with key informants on specific issues resulted in data analyzed using a Statistical Package for Social Scientists (SPSS). Lack of awareness and appreciation of the importance of BGBD among farmers was found to be a dominant factor. It is therefore, important that such farmers are first of all educated before drawing their attention to policy implementation. Scientists and institutions dealing with soil organisms worked without strictly adhering to any guidelines especially in regard to Material Transfer Agreements and Material Acquisition Agreements. This was particularly when they felt that the numbers of BGBD involved in transfers, acquisitions and exchanges were small. BGBD was mainly valued for its use in research rather than for commercial purposes hence BGBD is not appreciated for its values in other aspects of the environment. Most institutions had various articles of the Convention on Biodiversity (CBD) to adhere to but were not implementing such guidelines due to lack of clear directives on how to implement the same at national and sectoral levels. This calls for the need for proper domestication of international conventions and treaties to an implementable status. It was also found that some of the relevant Acts of Parliament were formulated without policy documents hence the need to formulate policies first. In this regard, most Acts were reviewed in this study rather than policies. In a nutshell, there is limited knowledge on below-ground biodiversity

and its functions among diverse stakeholders. It is therefore, important that such stakeholders are educated first for them to participate in the formulation of a policy that will guard below-ground biodiversity.

INTRODUCTION

1.1 Background to the problem

The soil is home of many organisms. However, it is important that the diversity of such organisms is not lost due to agricultural intensification and other anthropogenic activities (Gardner, 2004). Such soil organisms are also referred to as Below-ground Biodiversity (BGBD) or soil fauna. Among them are small organisms such as bacteria, fungi, protozoa, insects, worms, and other invertebrates (Gardner, 2004). The diversity of BGBD is important for soil health and for the provision of ecosystem services such as nutrient cycling, soil structure, and soil fertility (Gardner, 2004). However, the loss of BGBD can lead to soil degradation and a decline in ecosystem services (Gardner, 2004). The loss of BGBD can also lead to a decline in soil fertility and soil structure, which can lead to a decline in crop yields (Gardner, 2004). The loss of BGBD can also lead to a decline in soil health, which can lead to a decline in soil fertility and soil structure, which can lead to a decline in crop yields (Gardner, 2004). The loss of BGBD can also lead to a decline in soil health, which can lead to a decline in soil fertility and soil structure, which can lead to a decline in crop yields (Gardner, 2004).

Concerns about the loss of soil biodiversity have been highlighted in many studies including those of (Gardner, 2004; Giller et al., 1997; Smith et al., 1996; and Syrett et al., 1998). Even as agricultural intensification becomes a real occurrence, it has become increasingly clear that the loss of BGBD can lead to a decline in soil health, which can lead to a decline in soil fertility and soil structure, which can lead to a decline in crop yields (Gardner, 2004). The reduction of BGBD can decrease agricultural productivity, leading to a higher number of hectares having to be used to get the same yield (Gardner, 2004). The loss of BGBD can also lead to a decline in soil health, which can lead to a decline in soil fertility and soil structure, which can lead to a decline in crop yields (Gardner, 2004). The loss of BGBD can also lead to a decline in soil health, which can lead to a decline in soil fertility and soil structure, which can lead to a decline in crop yields (Gardner, 2004).

CHAPTER 1

INTRODUCTION

1.1 Background to the problem

The soil is home of many organisms, hence it is important that the effects of land use changes and agricultural intensification be thoroughly understood (Okoth, 2004). Such soil organisms are also referred to as Below-ground biodiversity (BGBD) or soil fauna. Among them are small organisms such as bacteria, fungi, protozoa, insects, worms, and other invertebrates. BGBD varies in quantity and variety from one type of soil to another. It also has different ways of coping with its environment (Swift, 1997). It influences crop growth and performance, ecosystem services and nutrient cycling. Agricultural intensification is the major activity that has been blamed for loss of soil biodiversity.

Concerns about the loss of soil biodiversity related with land use change have been raised in many studies including those of Altieri (1999), Giller, et al. (1997), Swift et al (1996), and Symstad, et al. (1998). Even as agricultural intensification becomes a real occurrence, it has received relatively little attention in Kenya (Okoth, 2004). The reduction of BGBD can decrease agricultural productivity (resulting in a higher number of hectares having to be used to get the same yield) and also decrease the resilience of agricultural ecosystems so that they are more vulnerable to erosion, pests, diseases, and the general degradation of the land.

Agricultural ecosystems should be kept healthy and sustainable so that the biodiversity loss, which is usually very high in agricultural systems is reduced (CoP 8, 2006).

Population increase coupled with land scarcity and inappropriate land management techniques have all been identified as factors leading to land degradation and hence the need for policy intervention. Nevertheless, if higher priority is to be given to the conservation and management of the soil and its associated biota, then policy makers need a better understanding of soil-based ecosystems services and their commercial value. In many countries enacting of laws formulated to protect the soil has not kept pace with measures intended to protect other natural resources such as air and water (SP-IPM, 2004). The same case applies to Kenya where there is no specific policy or legislation to guard soil organisms and yet they are affected by land use and agricultural intensification. What exist are sectoral laws and regulations which are not adequately encompassing (NBSAP, 2000).

Studies in the temperate region have shown that many of the practices involved in agricultural management decrease soil biodiversity and alter the structure of soil biological communities (Okoth, 2004). According to Giller *et al.* (1997), an intensive (with many land uses) agricultural system is characterized by its high land-use intensity, dependence on external fertilizer inputs and chemical pest control applications, use of labour and fossil energy and control of irrigation/drainage. As the system gets more intensive its biodiversity decreases

and its ecological function and sustainability may be affected. This decline in functionality is, however, a gradual process and so far no clear criteria or thresholds have been established to act as “early warning” systems. It is likely, however, that sustainability of agriculture can be promoted by revitalizing the ecological functioning through better management of its biological components (Ibid). Such components include BGBD whose management would be well guided by a specific policy framework.

In this regard, a policy framework that provides guidelines on Intellectual Property Rights (IPR) protection is essential. This is because IPR for innovations related to genetic resources is an urgent need and should be done in a uniform manner. The argument used in favour of this stand is: countries without patent protection in areas like pharmaceuticals and agricultural genetic resources unfairly “pirate” innovations. This deprives the innovators of just compensation and reduces the incentive for innovation that the patent protection is designed to foster (Reid, 1992).

In view of this research and its relevance to Kenya, it is important that IPR as well as ownership rights are given to the right owners of BGBD whether individuals or institutions by providing a guiding framework that can be used for formulating policies that ensure legal protection of the parties involved. There are glaring policy gaps in IPR and other BGBD related policies as will be highlighted in this study. This study, therefore, aims to address BGBD policy issues and recommend

ways of improving such policies to include BGBD as a means of enhancing livelihoods and ecosystem services

The evolving sale of BGBD makes it necessary to have a legal provision that regulates collection, transfer and technological utilization of BGBD. For example, in Germany, there are a few companies that produce and sell arbuscular mycorrhizal (AM) fungi (Feldman *et al.*, 2004). Certain websites like that of Dr. David Sylvia's commercial inoculum links are protected with a password due to the high commercial value of mycorrhizae. Another example is that provided by Author Maughs Books found on <http://www.mycorrhizal.com> which says that: mycorrhizal.com is for sale at \$ 20,000 cash. These examples show that soil organisms are commercially beneficial and have a very high value requiring a policy framework that ensures a fair trade.

So far, research on BGBD has resulted in a number of discoveries. It is important in this regard, that policy makers formulate policies to safeguard the organisms as well as the interests of all stakeholders who are involved in this particular process. Such interest groups include: farmers, scientists, as well as public and private research, and commercial institutions. Since these groups have different stakes in BGBD, such a policy would provide guidelines on benefit sharing and incentive measures for all.

1.1.1 Policy and its functions

What is policy?

Questions still abound whether policy is what is articulated, in writing or by word of mouth, or what is done, or said before or not? Or are policies actions that are sustained? Policy comprises decisions taken by those with responsibility for a given policy sector. These decisions usually take the form of statements or formal positions on an issue, which are then executed by the system of government (Walt, 1994). Conceived in this way, policy is a product of a linear process moving through stages of agenda-setting, decision-making and finally implementation. It is however, difficult to define policy in practice just as one British civil servant commented: 'Policy is rather like the elephant-you know it when you see it but you cannot easily define it' (Keeley and Scoones, 2004). Many observers do not see policy as simply as a single decision implemented in a linear fashion but rather, in practice, they see policies generally consisting of a broad course of action (or inaction, for that matter; Smith, 1976) or a web of interrelated decisions that evolve over time during the process of implementation. Policy also needs to be seen as an inherently political process, rather than simply the instrumental execution of realistic decisions.

A policy is a projected programme of goals, values, and their consistent practice over a considerably long period of time, which benefits from periodic review. It is also a document containing visions built on the consensus of the concerned stakeholders. In this regard it acts as a tool for action since it provides strategies

for implementation of certain development goals. Holistically, a policy is a tool for action or simply a guideline (Moyini, 2004). It should be noted that policy is not legislation; it is not an action plan; not an abstract wish but a response to needs; it is not static but dynamic neither is it a timeless wish, but an impression of what can be done (Ibid). In the Kenyan context, given its frequent backtracking and policy reversals, a limiting definition seems appropriate. Policy is really what is done on a sustained basis backed by the appropriate resources – money, staff, equipment, facilities or institutions. It may or may not be expressed in any document; but it is cleared by the political leadership and implicitly by the sitting President. Policy is made because of conviction – a result largely of emotion or life experience; or from analysis – a result largely of reasoning process and relevant empirical evidence; or from non-market payoffs – largely an outcome of self-interest or benefits; or from international or domestic pressure (Moyini, 2004).

Types of policies

There are two types of policies: anticipatory policies and remedial policies. Anticipatory policies, on the one hand, are put in place in good time to confront problems that are likely to happen in future, hence have an element of foresight. Remedial policies, on the other hand, are put in place to address existing problems or problems that have already occurred. They are therefore, reactive in nature (Moyini, 2004). Most of Kenya's environmental policies are remedial as opposed to being anticipatory, for example, water policy, forest policy and wider policy

programmes such as National Environment Action Plan (NEAP) of 1994 and National Biodiversity Strategy Action Plan (NBSAP) of 2000 (ibid). The functions of a policy in this study are to provide frameworks that are harmonized and are important for biodiversity conservation. Such frameworks would guide the formulation of guidelines/regulations that would benefit farmers, scientists/researchers, research institutions, public and private institutions dealing with soil organisms in all aspects.

1.2 Statement of the problem

BGBD is important in crop production and ecosystem services while at the same time it is at risk of being destroyed if agricultural intensification and change in land use systems are not well monitored (Soenartono and Setijati, 2004). In the global biodiversity assessment (UNEP, 1995) documents existing on biodiversity information, the sections on agro-biodiversity, and in particular the below-ground component, are amongst the most incomplete and inadequate. This is reflective not only of gaps in knowledge but also of barriers and failures in information flow and access. This could be a reason why Kenya's policy framework does not have statements supporting BGBD management.

Despite the existence of a number of policies related to biodiversity conservation such as the Agriculture Act, the Plant Protection Act, the Mining Act, the Forest Bill, Pesticides control Act, none of them addresses the specific issues of BGBD.

Even, the Environmental Management and Coordination Act (EMCA), which is considered as the main Act that addresses the issue of biodiversity, is not specific to BGBD. Indeed, EMCA was found to be a framework and not a complete environmental-encompassing biodiversity Act. Therefore, this study was carried out with the objective of identifying gaps in such existing environmental policies and to find out what knowledge and experiences various stakeholders have concerning BGBD. The key outputs were to obtain information on utilization, conservation, transfers, exchanges, acquisition and commercialization of BGBD. This information would be used to popularize BDGD among policy makers and other stakeholders thus giving BGBD a strong hold in Kenya's policy framework.

1.3 Research Questions

The following research questions guided the study:

1. How do different land-use systems and intensities affect the abundance and diversity of BGBD?
2. Which are the various policies that could enhance equitable acquisition, conservation, utilization, commercialization, transfer and exchange of BGBD in Kenya and what are the policy gaps?
3. How should BGBD policies be changed in Kenya to contribute to harmonized institutional arrangements, address farmers' interests and scientific benefits while also contributing to BGBD and ecosystem conservation?

1.4 Research Premises

Because there were no hypotheses to be tested in this research, premises were used instead. For research questions and objectives, see section 1.3 above and 1.5 below.

1. Land-use systems and their management contribute to BGBD loss and lack of sustainability;
2. Appropriate policies are linked to equitable acquisition, conservation, sustainable utilization, commercialization, transfer and exchange of Kenya's soil biota;
3. The existing biodiversity conservation policies can be improved to include soil biota and their biodiversity as a means of enhancing livelihoods and ecosystem services.

1.5 Research Objectives

The study intends to contribute to the enhancement of biodiversity and sustained utilization of its components in Kenya through an improved policy framework.

The specific objectives include:

1. Examining the effects of land-use systems and intensities on abundance and diversity of BGBD in Kenya;

2. Identifying policy gaps that exist with respect to acquisition, conservation, sustainable utilization, commercialization, transfer and exchange of BGBD in Kenya;
3. Recommending areas of improvement in the existing policies to include the component of BGBD in Kenya.

1.6 Significance of the study

This study provides information on the people's knowledge and experiences with BGBD in Kenya. Such knowledge and experiences have mainly focused on utilization, conservation, transfers, exchanges, acquisition and commercialization of BGBD. The study has also provided information through literature review and interviews with farmers on the effects of land use systems and intensities, the latter also referred to as agricultural intensification, on the abundance and diversity of BGBD. Policy gaps in the existing environmental policies have been identified through review of policies relevant to BGBD in Kenya. Proposals on ways and means of improving and revising such policies to include the entire spectrum of BGBD have been documented.

CHAPTER 2

LITERATURE REVIEW

2.1 BGBD and their importance

Below-ground biodiversity (BGBD), or sometimes “soil biodiversity” or soil biota, refers to soil organisms. ‘Soil organisms’ is a collective term for micro-organisms and invertebrates that live in the soil, and include such small organisms as bacteria, fungi, protozoa, insects, worms, and other invertebrates (www.ciat.cgiar.org). From an ecological perspective, BGBD have been classified into functional groups based on their contribution to soil processes functioning. This study was however guided by BGBD classification based on size comprising three main groups: microfauna, mesofauna and macrofauna. Microfauna include protozoa and small nematodes that utilize pores with a diameter of less than 100µm while the mesofauna (nematodes, enchytraeids and microarthropods) occur predominantly in macropores larger than 100 µm but smaller than 2 mm in diameter. Macrofauna vary in size from 2mm to 20 mm and inhabit cracks and root canals. These organisms have ability to barrow and to dig (Senapati *et al.*, 2005).

BGBD contributes to the sustainability of ecosystems and agro-biodiversity by providing the following services: regulating nutrient cycling and the dynamics of soil organic matter; soil carbon sequestration; greenhouse gas emission; modifying soil physical structure and water regimes; enhancing the amount and efficiency of nutrient acquisition by the plant through mycorrhizal fungi and nitrogen fixing bacteria; and influencing plant health through the interaction of pathogens and pests with their natural predators and parasites (Susilo *et al.*, 2004). It plays a role in early decomposition of organic matter (Dittmer and Schrader, 2000). Earthworms have an effect on the nature and characteristics of soil through their eating, casting and carving activities. Through these activities, earthworms can improve infiltration, aeration and stability of soil aggregates. In addition, earthworms casting has higher nutrition contents compared to the surrounding soil (Kladivko, 2003) hence they add nutrients to the soil through these activities. Nevertheless, soil biota are very sensitive to disturbances caused by soil tillages (Sri Yusnaina *et al.*, 2004), for instance, ploughing can easily disorient earthworms stabilization of soil aggregates.

2.2 Status of BGBD in Kenya

In Kenya various research activities have been undertaken to investigate the activities and functions of various soil organisms. The use of mycorrhizal symbiosis in Kenyan forests dates back to 1990 when the first soil inoculum was imported from South Africa which lead to the successful establishment of pine

plantations (Walde et al., 2004). Even so, ectomycorrhizal symbiosis has received little attention since their presence was reported first on the exotic tree species. This could be as a result of below-ground biodiversity being looked at as a separate entity from above-ground biodiversity as expressed by Walde *et al.*, (2004).

Studies on nitrogen fixing bacteria in Kenya showed that the microflora was dominated by the acid tolerant *Beijerinckia* spp. (Mwaura and Widdowson, 1994). Species tentatively identified as *B. indica* and *B. fluminesis* were isolated from three soils whose Ph and carbon content ranged from 6.3 to 6.9 and 1.8 % to 6.72%, respectively. In addition to *Beijerinckia* species, strains of *Azotobacter chroococcum* and *Derxia gummosa* were also isolated from one of the soils. Nitrogen fixation studies in Kenya have also included associative N₂ fixing systems. Extensive studies have also been carried out on the roots of *Cyperus papyrus* L., an emergent aquatic macrophyte that grows almost as a monoculture in many riverine and other freshwater ecosystems (Kladivko, 2003). *Beijerinckia*, *Derxia*, and *Azosprillum* species were among the diazotrophs isolated from the roots of the plant (Mwaura and Widdowson, 1994). In agricultural systems, studies on associative nitrogen fixation have involved cereal crops, particularly maize. Local isolates of rhizospheric diazotrophs from maize plant roots had an optimum temperature of around 37⁰ C for N₂-dependent growth while similar isolates from temperate soil grew optimally at 28⁰ C (*ibid*).

The importance and potential benefits derived from nitrogen fixing systems and mycorrhizal symbiosis in low and medium input agriculture and in restoration and rehabilitation of nutrient depleted and degraded soils is currently being undertaken by the “Conservation and Management of Below-ground Biodiversity” project. The project is being implemented in seven tropical countries including Kenya, Brazil, Cote d’Ivoire, India, Indonesia, Mexico and Uganda. It is being coordinated by the Tropical Soil Biology and Fertility Institute of CIAT (TSBF-CIAT) with co-financing from the Global Environmental Facility (GEF), and implementation support from the United Nations Environment Programme (UNEP).

As much as various research activities have been undertaken to investigate the activities and functions of various soil organisms very little work related to soil microbial diversity and decomposition as a vital process in nutrient cycling has been done (Okoth, 2004). Okoth concludes that more research on the gradual changes in diversity at finer levels of taxonomic resolution, and relating these changes to effects on ecosystem function as agriculture intensifies is needed. She adds that taxonomic and methodological difficulties are convincingly identified as constraints to comprehensive evaluation of the biodiversity of soil microbial communities. This is one of the problems to which the international project “Conservation and Management of Belowground Biodiversity” aims to provide solutions.

Under the same project, research on nematodes illustrates the enormous diversity in nematode taxa that may exist in the soil, of which still very little is known (Kimenju *et al.*, 2004). The importance of plant parasitic nematodes that may negatively impact on crop production is also not well understood. Nematodes may be harmful or beneficial to crops, depending on their functional properties. Studies have shown that nematode populations may be regulated through application of particular management practices. However, the underlying mechanisms are not well understood and devising effective and practical management practices is still a big challenge in Kenya (Ibid).

For purposes of this research such evidence can be used to formulate policies that support land use systems that regulate nematode population. This information also shows that land use systems and intensities can either enhance the abundance of both harmful and beneficial organisms or may reduce harmful organisms and increase beneficial ones.

In a nutshell, there is need in Kenya and in other tropical countries, to focus more research on the gradual changes in diversity at finer levels of taxonomic resolution, and relating these changes to effects on ecosystem function as agriculture intensifies (Okoth, 2004).

2.3 Links between above-and below-ground biodiversity

Below-and above-ground biodiversity have been traditionally considered separately, with BGBD being given little attention. It is now recognized that the two components interact to influence community and ecosystem-level processes and properties (Walde *et al.*, 2004). Anthropogenic and natural changes of either above-or below-ground components therefore greatly influence ecosystem processes and properties and subsequently changes the above-ground and below-ground community (Ibid).

Below-ground biodiversity does not live exclusively. There are interactions among below-ground and above-ground biodiversity (Soenartono and Setijati, 2004). Decomposition activities of the below-ground biodiversity will depend on the types of above-ground partners that will be contributed to the former group to work with. Transfer of energy and mineralization that is conducted by the below-ground biodiversity will have no value unless the raw materials are supplied by the above-ground components. There are many ways of the relationships of the below-and the above-ground biodiversity (ibid). For example, pine trees naturally associate with ectomycorrhizal fungi (Harley and Smith, 1983) and successful introduction of pines in tropical Africa was achieved after the introduction of soil from Europe (Kaumi, 1980).

Studies on mycorrhizal symbiosis in Kenya and elsewhere clearly show plant species to have affinities for specific mycorrhizal types. This is strongly reflected in the distinct mycorrhizal types associated with specific plant families (Jefwa *et al.*, 2004). The plant family orchidaceae forms distinct mycorrhizal types, symbiotic affinities in the families Ceasalpinaceae, Mimosaceae and Papillionaceae with mycorrhizal fungi and Rhizobia, members of family Ericaceae forming ericaceous mycorrhizae and other plant families predominantly forming associations with Arbuscular mycorrhizae (AMF). This implies that symbiotic association is a heritable trait in plants and may be specific even within a mycorrhizal type (*ibid*). The distribution of mycorrhizae is also dependent on soil conditions and management practices. Each soil has an inherent composition and abundance. Plant species distribution relates strongly to soil conditions (Wall and Moore, 1999).

2.4 Current status of BGBD policy in Kenya

This section examines different statutes, legislation, institutions and policy that regulate the use of, conservation or protection of BGBD in Kenya. The analysis identifies gaps, possibilities for modification and relevance in BGBD use, management, acquisition, transfer, exchange and commercialization that are considered to be important contributions to this study.

2.4.1 The National Biodiversity Strategy Action Plan (NBSAP)

The Convention on Biodiversity being the main thrust of this study requires that in the process of establishing national strategies, every contracting party uses the already established principles. In this regard, Kenya formulated the National Biodiversity Strategy Action Plan (NBSAP) in the year 2000 (NBSAP, 2000). The overall objective of the NBSAP was to address the National and International undertakings elaborated in Article 6 (General measures for conservation and sustainable use) of the CBD. It is a national framework of action for the implementation of the convention to ensure that the present rate of biodiversity loss is reversed, and that present levels of biological resources are maintained at sustainable levels for posterity. Since the NBSAP is scheduled to be revised soon, it will be important that issues regarding all forms of biodiversity including BGBD be addressed. The NBSAP is descriptive just as all strategies are and have time-frame. For instance, in the current Kenyan system a strategy is revised after three years and such revision is linked to the government funding cycle (ibid). As per this defined period, the revision of the NBSAP is long overdue. The key players in the revision of a strategy are the implementing agencies; sectoral agencies with mandate linked to biodiversity management for example the ministry of agriculture. The normal practice for revision in Kenya is that the process starts at the District to Provincial and finally to the national level; a process which stakes quite a long time but involves a varied and reasonable number of stakeholders.

Another reason for the development of the NBSAP was because the country did not have one integrated national strategy and action plan for biodiversity. Rather, there were a number of sectoral strategies and programmes that normally operate independently of one another, while not necessarily addressing or responding to a clearly set list of national priorities. This is mainly due to the fact that the process of developing strategies and plans was not initially guided by policies in any form. This lack of policy and its documentation to guide the process has resulted in environmental issues being guided by legislation as enshrined in the Acts of parliament to be addressed later in the study. It is with these short-sights that the study sought to review relevant legislation and identify gaps in relation to BGBD related policy issues. Not overlooking other guiding principles in the development of the NBSAP, there is a need to emphasize two of them that are most relevant to BGBD. These are highlighted in Box 1:

Box 1:

Firstly, that the conservation and sustainable utilization of Kenya's biodiversity is key to improving agricultural productivity and sustainability, thereby contributing to national development, food security, poverty alleviation, and the fair and equitable sharing of benefits arising.

Secondly, that utilization of Kenya's biodiversity should be transparent, equitable and efficient.

Source, NBSAP 2000, page 12

These two guiding principles on biodiversity can be made specific to BGBD and could be used to formulate guidelines/regulations or even policy. Such policy would guide the development of a strategy specific to BGBD. Relevant to this

study and as stipulated by the CBD, fair and equitable sharing of benefits accruing from the use of biological resources is the key motivator.

2.4.2 Policy gaps in biodiversity conservation related policies and legal measures in Kenya

Land use activities with direct impact on the environment are covered by the following statutes: the Agriculture Act (Cap. 318 of the Laws of Kenya); the Land Control Act (Cap. 302); the Chief's Authority Act (Cap 128); the Mining Act (Cap 306); the Local Government Act (Cap 268) the Trust Lands Act (Cap 288) the Land Planning Act (Cap. 303); Governments Land Act (Cap 280); the Physical Planning Act of 1996; the Registered Land Act (Cap 300) the Irrigation Act (Cap 347); and the Crop Production and Livestock Act (Cap 321). Of relevance to this study are: the Agriculture Act. The others are the Pesticides Product Control Act, the Plant Protection Act, the Forest Act and the Environment Management and Coordination Act (EMCA). All these Acts lack a specific schedule of soil biodiversity in its entire spectrum.

The Agriculture Act is the principle land-use statute covering, *inter alia*, soil conservation and agriculture land-use in general. Two major parts of the Act deal with the central conservation issues: preservation of soil fertility and prevention or control of soil erosion.

Part IV entitled “The Preservation of the Soil and its Fertility” vests extensive powers in the Minister responsible for agriculture for the purposes of the conservation of the soil; protection of dams or water catchments, the prevention of soil erosion; of the protection of soil fertility; the Minister may, after consultation with the Central Agricultural Board (CAB) make rules prohibiting, regulation or controlling clearing of land for cultivation, grazing or watering of livestock or cleaning of vegetation. Conversely the Minister may make rules requiring, regulating or controlling the afforestation or re-afforestation of land, protection of slopes and catchment area or the drainage of land including the repair of natural or artificial infrastructure, removal of any vegetation which has been planted in contravention of orders, supervision of unoccupied land and prohibiting agricultural activities including de-pasturing of stocks.

The Pesticides Products Control Act regulates the manufacture, importation, exportation, use and disposal of various pesticides within the country. However, the Act lacks information in regard to handling wastes from the pesticides that are not obsolete or expired. Such obsolete or expired or even current pesticides would affect BGBD. This mention is lacking and can be incorporated through improvement of such legislation as guided by the section under waste management regulations in EMCA. EMCA is a framework law that was enacted to guide the formulation of specific guidelines in regard to biodiversity. This has not happened

for BGBD hence the urgency for the formulation of specific guidelines that can easily be enforced.

The Plant Protection Act Cap. 324 of 1937, Section 8 (1) outlines the role of the Minister of Agriculture to prohibit, restrict or regulate the importation and exportation of plants and the soil. These include packages, coverings or wrappings thereof and of any article or class of articles, whether of a nature similar to plants or not, and of any animals or insects likely to infect any plant with any pest or disease. As much as this Section outlines what is to be done with the soil, it does not consider the contents of such soil, for example, soil organisms; neither does it mention anything about organisms that are beneficial to the plants but only those that are harmful.

Under EMCA 1999, the role of conservation of biodiversity is vested in the NEMA. NEMA, in consultation with the relevant lead agencies, is mandated to prescribe measures necessary to ensure the conservation of biodiversity in Kenya. In this respect, NEMA shall in Section 50 (e) and Section 51 (a-f) specify national strategies, plans and government programmes for the conservation and sustainable use of biodiversity. In the view of this study, specific guidelines would be outlined rather than the generalization of BGBD in biodiversity. As earlier outlined, BGBD is a very big group with important functions and numerous discoveries of new species being made. Hence, this group needs specific attention in such laws so as

to address specific BGBD issues. EMCA as it were is a framework law and not a biodiversity policy. As a framework law it should guide the formulation of regulations or guidelines for biodiversity. This means that EMCA was formulated without a policy document hence should be used to formulate specific regulations addressing various aspects of the environment including individual biodiversity groups. So far, a number of regulations formulated have been gazetted including those on land-use and biodiversity conservation and would thus be used as guidelines in formulating a comprehensive BGBD policy.

In regard to agricultural intensification, NEMA has already formulated regulations specific to land-use though these have not yet been approved by the Minister for Environment for legislation. The Mining Act Cap 306 of 1940, Section 7 subsection (a to l), only outlines the classes of land that are excluded from prospecting and mining but does not give provisions in cases where such activities interfere with biodiversity.

The newly enacted Forests Act 2004 in Section 18 (j) establishes a Forest Management and Conservation Fund, which shall be used for the management and conservation of forests for the promotion of biodiversity. This Act contains specific clauses that hinder in-depth address of BGBD. Finally, the Agriculture Act Cap 318 of 1955 stipulates in Section 184 (l) that the Minister may, on the advice of the Central Agricultural Board, make general rules for the preservation,

utilization and development of agricultural land, either in Kenya generally or in any particular part thereof. Such rules lack in consideration of soil organisms which are components of such land.

2.5 The Convention on Biodiversity (CBD)

The CBD forms the main thrust of this study because it is the international convention upon which national laws on biodiversity are derived. Kenya signed and ratified this convention on 5th June 1992 and 26th July 1992 respectively and is therefore, obliged to domesticate the provisions in it into national laws. The purpose of the CBD is to ensure the conservation and sustainable use of biodiversity. The convention came into force on 19th December 1993 and has 188 parties, of whom 168 are signatories. The NEMA acts as the national focal point with regard to the Convention in Kenya (NEMA, SoE, 2004). The CBD has three main objectives: first, is the conservation of biodiversity; second, the sustainable use of the components of biodiversity and third, the sharing of benefits arising from the commercial exploitation, intellectual property rights, and other utilization of genetic resources in a fair and equitable way.

Prior to the CBD, there was no international regime to regulate access to genetic resources and promote benefit sharing (Mugabe *et al.*, 1996). The CBD assigns specific responsibility and rights to contracting parties to take their own appropriate legislative and regulatory benefits to formulate specific policy and

legal measures to enable implementation of the provisions. The CBD articles relevant to this study include: Article 6 on general measures for conservation and sustainable use, part of Article 8 on in-situ conservation (section c, d, f, i, j, k and l), Article 10 on sustainable use of components of biodiversity, Article 11 on incentive measures, and Article 15 on access to genetic resources (Convention on Biodiversity, 1992). These articles and their implementation status in Kenya are outlined in appendix V.

2.5.1 Considerations for implementing the CBD in Kenya

The implementation of the CBD impacts on land in many ways hence impacting on BGBD too because these biodiversity is found in the soil. For example, the designation of reserves or protected areas for preservation of flora or fauna restricts the use of such land. The provisions of the Convention have been integrated in many laws of Kenya. To start with, EMCA of 1999 provides for the conservation of biodiversity. NEMA in consultation with lead agencies is charged with maintaining a record of biodiversity; determining which components of biodiversity are endangered, rare or threatened with extinction, establish national plans on the protection and sustainable use of biodiversity and access and sharing of benefit arising from genetic resources. Guidelines on access and benefit sharing have been approved (Confirmation with NEMA by thesis writer) and a leaf could be borrowed from these to address specific issues of benefit sharing for each variety of BGBD because of their growing numbers and enhanced utilization. The

domestication of the convention into policies and legislation that guard BGBD could be guided by the examples below:

The provisions of the CBD are domesticated in the Wildlife (Conservation and Management) Act, (Cap 376) which mandates the Kenya Wildlife Services (KWS) to manage and conserve wildlife for the benefit of Kenyans in terms of cultural, economic, aesthetic and scientific gains. They are also domesticated in the Forest Act (Cap 385), which provides for the conservation and management of flora and fauna in lands declared by the Minister to be forest or natural reserves. Any activity on such land is regulated and controlled so as to ensure that utilization of the resources is not at the expense of the natural biodiversity.

The Seed and Plant Varieties Act (Cap 326) regulates seed development, transfer, importation and use. The Act's scope includes seed testing, certification, cross-pollination and importation. Plant varieties are indexed in accordance with the CBD as new varieties are developed. The use of specific plants and seed varieties on land is regulated by the Act. The Act also seeks to deal with the grant of proprietary rights (Intellectual Property Rights) to persons breeding or discovering new varieties.

The Plant Protection Act (Cap 324) aims to preserve plant varieties, by preventing and controlling pests and diseases that are likely to damage the faunal diversity.

Section 3 of the Act empowers the Minister to make regulations that assist in the control of pests and diseases. The onus of applying the regulations is placed on the owner or occupier of land. The Plant Protection Order and the Plant Protection Rules enumerate pests and diseases that fall within the realm of control of the Act. The lead agencies are as vast in number as the domesticated laws. They include NEMA, KWS and the ministries in charge of Forests and Agriculture.

2.5.2 Process of Domestication of international conventions and treaties in Kenya

Section 124 of the EMCA provides for NEMA's role vis-à-vis multi-lateral environmental agreements. Under the direction of National Environment Council (NEC), NEMA shall:

1. Initiate legislative proposals to the Attorney General (AG) to give legislative effect to the provisions of the treaty
2. Identify other appropriate measures necessary for the national implementation of the treaty
3. Assist relevant lead agencies in negotiating environmental related treaties.

As much as EMCA has provided this framework for domestication to NEMA, the process of domestication has not yet occurred. Recently, though, revised biodiversity regulations have been gazetted it remains a challenge for enforcers to

sensitise the public and disseminate this information adequately. The local people on whose land, land-use changes occur also need to be sensitised on policies and laws addressing land-use issues.

2.5.3 Material Transfer Agreements (MTA) and Material Acquisition Agreements (MAA) as items of domestication

MTA and MAA should form part of such a domestication process and are used by institutions and countries as tools for monitoring transfer, exchange, acquisition and commercialization of most genetic resources. Since the process of domestication has not occurred in Kenya, there is no clear directive on how to use MTA and MAA. Transfers, exchanges, acquisition and commercialization are done for purposes of research, biotechnology as well as profit making in business. An MTA is a binding legal agreement between the owner of research material and the recipient of the material; it sets forth conditions of transfer and use, protects proprietary interests and restricts distribution of the material. An MTA can take the form of a short shipment document, a simple standard delivery notice, a standard invoice containing minimal standard requirements or a more detailed specific contract including tailor-made mutually agreed terms. The most important MTA aspect is that it removes any liability on the part of the provider that might arise from the use of the research property. An MTA helps preserve the IPR of the institution and inventor, and it provides a record of the property transferred (Material Transfer Agreement, 2005).

An MAA is an agreement between or among countries, organizations or individuals that serves as a means of obtaining possession of biological material/resources through collection or receipt (Material Acquisition Agreement, 2004). Among the countries that have practical MTA and MAA include Australia, Netherlands, United States (U.S.A) and Sierra Leone. Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT); a Consultative Group on International Agricultural Research (CGIAR) organization also uses MTA. For example one between CIMMYT and KARI. In Kenya, the only MTA in lead agencies that has undergone a formal process of formulation is that between the Royal Botanic Garden of the United Kingdom and the National Museums of Kenya. The process was formal because it followed the draft access regulations at that particular time. The NMK therefore operated under an Interim Material Transfer Agreement that would subjugate itself to the terms and conditions of the Access Regulations once they came into force. Other lead agencies and universities have MTAs and MAAs but they all lack a regulatory policy. These agreements have also no legally binding statements hence can easily be breached.

2.6 Intellectual Property Rights

Intellectual property rights allow a person or a corporation to claim ownership of knowledge, uses and resources, giving a single person or group an economic monopoly on a specific idea or resource. This set of instruments and values reflects the value of expert science, money and privilege and negate the rights of local, indigenous, poor or developing country persons or groups to gain benefits from the knowledge, innovations or practices over which they may have original ownership. Examples of such instruments are the TRIPs agreement (trade related intellectual property rights) under the WTO and the WIPO (World Intellectual Property Rights Organization) and UPOV (the International Union for the Protection of New Varieties of Plants) which recognize patents and the rights of groups such as plant breeders who use or gain access to biological and genetic resources and claim rights (ownership) of them and their products (CoP 8, 2006).

Kenya has IPRs legislations administered by various organs. IPRs are administered by KIPi, KEPHIS and Copyright Office, AG Chambers. The Industrial Property Rights are administered by the Kenya Industrial Property Institute (KIPi). KIPi administers industrial property rights that include patents, industrial designs, utility model, technovations and technology transfers. These are protected under the Industrial Property Act (Cap. 509). Trade Marks Acts (Cap. 506) provides protection for marks and is also administered by KIPi. KIPi was

established in 1990, one year after the relevant Act (Industrial Property Act) was enacted. KIPi was established in 2001 as a body corporate under the Ministry of Trade and Industry and protects parts of products of biotechnological processes in form of invention. The Industrial Property Act has a provision for protection of genetic resources or improvements thereof (Koech, 2003)

According to KIPi, patenting of new micro-organisms is allowed as long as such micro-organisms are new, have an inventive step, are industrially applicable and are deposited in an internationally recognized Depository Institutions. Such institutions are 33 in the world but none is in Africa. This is because the maintenance of such an institution is expensive. So long as the patent is in force, the organism should be alive (that is, for 20 years). In Kenya, only the KEMRI and KARI are nationally recognized as depository institutions. KIPi has guidelines that protect the inventor of a new organism or technology but no guidelines for where such an organism has come from. This is biased because; it possibly encourages private more than public ownership (Personal communication with Fredrick Otswongo; Patent Examiner and Public Relations Officer, KIPi).

One of KIPi's functions is to screen technology transfer agreements and licenses. Any license involving technology transfers are registered at a fee by KIPi. Before registration, there is vetting/screening and this has been biased towards machines and drugs. As a guideline, Material Transfer Agreements are covered under the

section on contractual agreements. KIPi has not encountered requests to sell biological resources hence there is no example of how such a process has occurred. As earlier mentioned, such cases have only been dealt with where machines and drugs are involved. Section 109 (1) of the IPA on criminal proceedings declares the intentional infringement of a patent or registered utility model or industrial design as an offence.

KIPi uses the Bonn guidelines as a guide to the CBD on biosafety issues. They suggest that Kenya should approach the guidelines through NEMA. Since IPA is TRIPS, compliant, a lot needs to be done so as to fit into the CBD. It is also proposed that in this approach, lawyers should be the regulators while the commercial sector should determine the value of soil micro-organisms and biological resources in general (Personal communication with Fredrick Otswongo; Patent Examiner and Public Relations Officer, KIPi).

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Study area description

3.1.1 Location

The study was carried out in Gatundori and Kibugu sub-locations which are both located in Embu District. Embu District borders Mbeere District to the East and South East, Kirinyaga to the West and Meru South to the North. The District lies approximately between UTM Zone 37N (0291326, 0387864 Eastings and 9989543, 9986270 Northings). It occupies a total area of 708Km² and is divided into 5 administrative divisions: Central, Kyeni, Nembure, Runyenjes and Manyatta. These five divisions are sub-divided into 15 locations and 52 sub-locations with about 45,000 farm families, only two of the sub-locations were used in this study. Embu district has a population of more than 278,000 (Table 3.1). Excluding 210 Km² of Mount Kenya, this translates into a high population density of 456 people per Km². The total arable land area is 478 Km² with total available agricultural land area covering 371 Km². The forest cover an estimated 230 Km² (Tea and coffee report, Kenya, 2005).

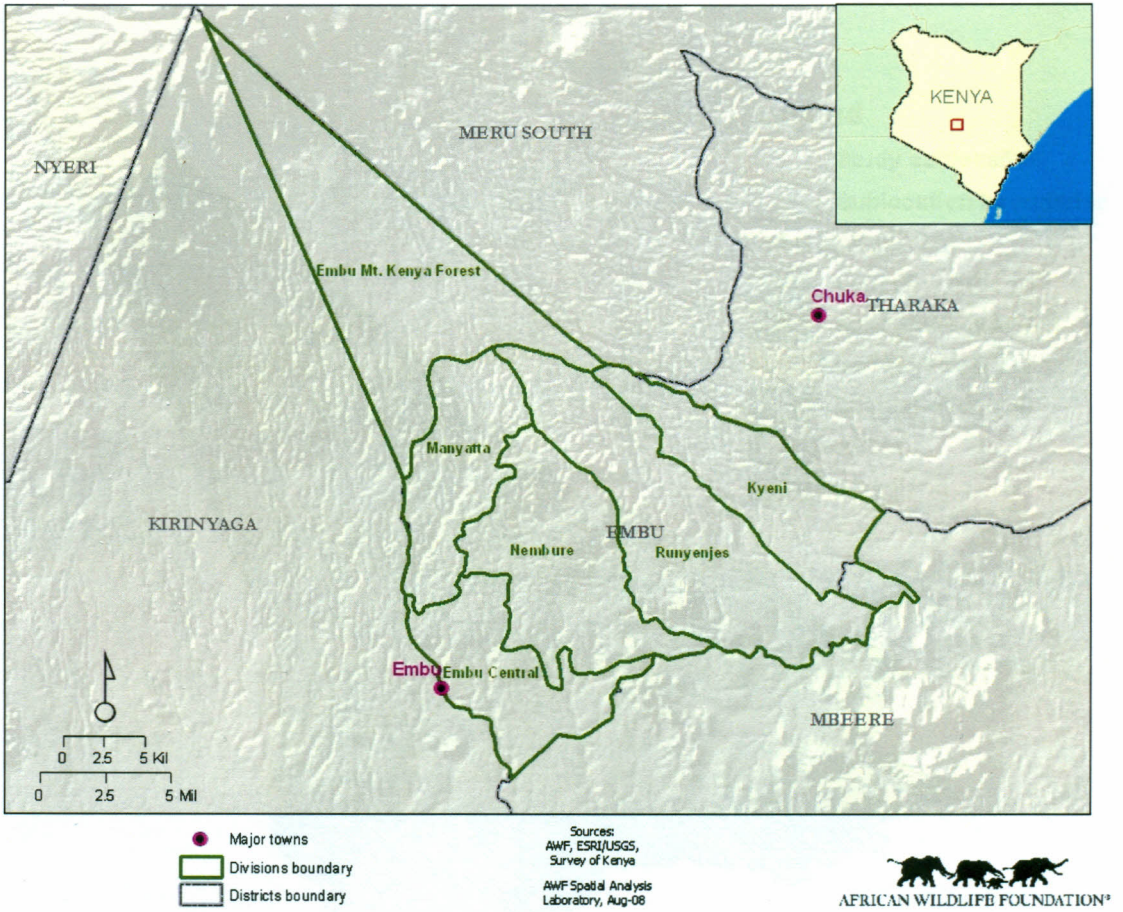


Figure 3. 1: Map of Embu District

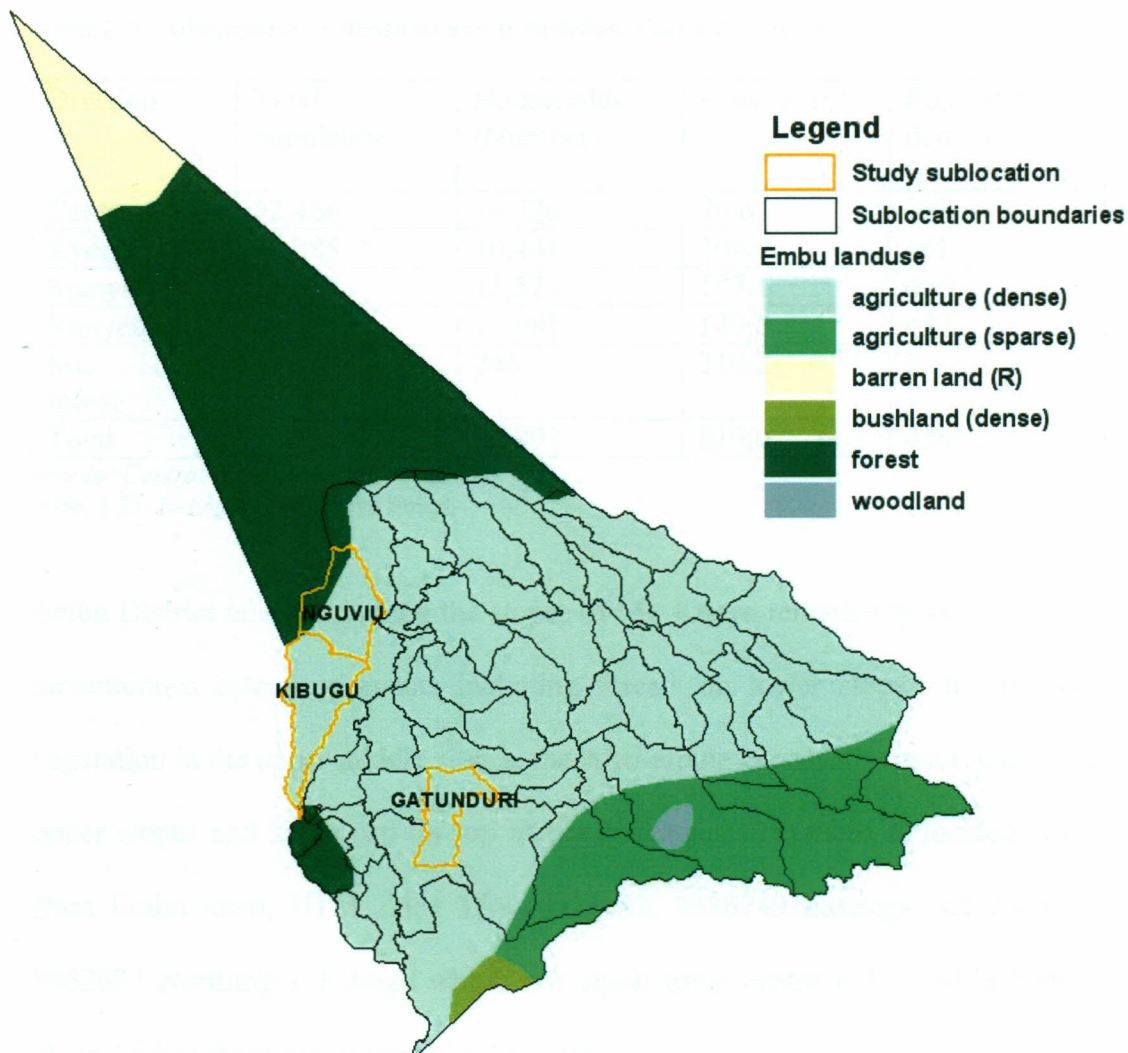


Figure 3. 2: Land-use map showing Kibugu and Gatunduri sub-locations of Embu District

Table 3. 1: Administrative divisions and population, Embu District, Kenya

Division	Total population	Households (Number)	Area (Km ²)	Population density (persons/Km ²)
Central	52,466	14,726	70.6	743
Kyeni	48,385	10,441	104.9	461
Manyatta	71,332	15,523	197.1	666
Runyenjes	64,111	13,981	149.0	432
Mt. Kenya forest	332	246	210.2	2
Total	278,216	63,893	819.0	456↑

Source: Central Bureau of Statistics (2001)

Note: ↑ Excluding Mount Kenya forest

Embu District is located along the slopes of Mt. Kenya remarkably known for the mountainous catena of events including forests on lower slopes, the Bamboo vegetation in the upper middle slopes, the Afro-alpine grasslands (moorland) in the upper slopes and snow cap on top of the mountain. Gatunduri is located 10Km from Embu town, UTM Zone 37N (0323842, 0326749 Eastings and 9948966, 9952027 Northings). Kibugu which is a small town centre is located in Nguvio about 15 Km from Embu town, UTM Zone

3.1.2 Agro-ecological zones

Embu District consists of five agro-ecological zones in (Table 3.2). The study area only covered the following agro-ecological zones: tea-coffee dairy farming system and food crop cultivation land-use systems.

Tea-coffee dairy farming system

Most of the agriculture in the study areas is small-scale traditional subsistence farming. However, coffee, tea, and dairy cows, are cultivated, and reared,

respectively, as important cash crops and animals. The crops are not old to the study areas. According to Brokensha and Riley (1980), for instance, the growing of coffee and tea was promoted by the local government in the 1950's and 1960's in the upper areas.

In the study areas tea cultivation was observed above 1700m with a few coffee trees. Coffee plants grown by small-scale farmers numbered from 100-500 plants. This system is in use in Gatunduri and Kibugu sub-locations at altitudes 1590-1830m, with an average annual rainfall of 1150 and evapotranspiration is 1-400mm (Jaetzold and Schmidt, 1983). Soils in this farming system are mainly well-drained nitisols with a moderate fertility (Government of Kenya, 2001).

Table 3. 2: Characteristics of the AEZs in Embu District

Characteristic	AEZ 1	AEZ 2	AEZ 3	AEZ 4	AEZ 5
Altitude (m)	1770	1590	1320	980	830
Mean temperature(0C)	16.8	18.2	20.2	21.4	22.6
Rainfall (mm)	1750	1400	1200	900	800
Main soil types	Andosol/ Nitisol	Nitisol	Nitisol	Luvisol	Lixisol
Main land use	Tea/diary	Tea. coffee/dairy	Coffee/maize	Tobacco/food crops	Livestock/ Shifting cultivation

Source: After Jaetzold and Schmidt (1983).

Food crop cultivation land-use system

The prevailing cropping pattern in the study areas was intercropping in which maize is intercropped with mainly beans and cow peas (Jaetzold and Schmidt, 1983). Other crops grown mainly for subsistence are bulrush millet, sorghum, finger millet, pigeon peas, cow peas, white potatoes, sweet potatoes, cassava, banana and yams. Sole cropping was not observed in the study areas because of the small farm sizes. The other reason for intercropping was to ensure the production of subsistence food within a given farm with limited input (communication with farmers).

3.2 Data collection

This section of the thesis outlines the individual methodologies used to collect data that are reported in the subsequent chapter. Several methods were used in the data collection ranging from reports and publications; survey data from field visits to Gatunduri and Kibugu sub-locations of Embu District. The following sub-sections detail the methodology used for gathering different data required to answer to the objectives of the thesis.

The data was collected over a period of two months. Data collection in Nairobi Province was done within one month because appointments had to be made for interview sessions. Another one month was spent collecting data in Embu District.

This is because the number of farmers scheduled for interviews was large (one hundred and twenty) and they all had to answer questions in details.

3.2.1 Use of meta-data to relate land to below-ground biodiversity

The use of meta-data in this research was to obtain the general information on the effects of land use systems and intensities on the diversity and abundance of soil organisms in Embu. Such data are found in literature, published papers and in grey literature existing in institutions. In the case of this research, current information was obtained from work done by ongoing project (the conservation and sustainable management of below-ground biodiversity) in Kenya and in six other tropical countries (Indonesia, Brazil, Mexico, Uganda, India and Code Ivoire).

The chapters in this thesis draw a lot from the material published by the Conservation and Sustainable Management-Below-ground Biodiversity (CSM-BGBD) Kenya team including papers in the Journal of Tropical Microbiology of 2004 featuring a special issue with selected topics on below-ground biodiversity in Kenya (see reference for articles from this journal). The document analysis method also sought to identify gaps in the existing policies which address environmental and biodiversity issues in Kenya through review of relevant policy and legislation.

3.2.2 Farmer interviews and focus groups discussions

Another method employed was a survey of farmers' perceptions and current knowledge on BGBD through interviews and focus group discussions. One hundred and twenty (120) farmers from both Gatunduri and Kibugu sub-locations were interviewed and the purpose of the questionnaires was to gauge impressions of the farmers on the effect of agricultural intensification on the abundance and diversity of BGBD. The questionnaires were intended to find out if farmers had any knowledge on management and their view of such undertakings in future. A total of three focus group discussions were held. The groups were organized based on gender with the first group constituted mainly by women, the second by men and the third by both men and women. Each group had a membership of 10 persons where the last group consisted of 5 women and 5 men. The purpose of the focus group discussions was to further analyze and understand the previously obtained results from individual farmer interviews (Kreuger, 1988). The groups, therefore, comprised farmers of all ages including the youth, middle-aged and the elderly farmers.

3.2.3 Institutional studies

Institutional studies were carried out in Nairobi and Embu Districts. Among the institutions visited were the University of Nairobi, KARI, KEFRI, NMK, the KIOF), KEPHIS, CABI, ICRAF, NCST, KIPi and DuduTech/ Homegrown company. Two professionals from each institution were issued with questionnaires (Appendix I) which were answered on behalf of the institutions. Such

professionals were: microbiologists, patent officers, natural resource managers, pathologists, quality inspection officers and biodiversity research coordinators.

The use of open-ended questionnaires for this part of the study was to probe the institution for information that would otherwise be restricted as is the case with close-ended questionnaires. The use of questionnaires enabled the researcher to present questions in a uniform manner thus reducing bias (Walonick, 1997). Information from the questionnaires in this study was analyzed using the Statistical Package for Social Scientists (SPSS).

3.2.4 Individual scientists' study

Thirty (30) individual scientists were issued with questionnaires to gauge their experiences with BGBD. These scientists were from different institutions dealing with different genetic resources including plants, micro-organisms, plant pathogens as well as those dealing with regulations regarding these resources for example, IPR. The experiences shared included management, transfers, exchanges, acquisition and commercialization of BGBD as guided by existing policies and regulations in Kenya. Copies of the questionnaires are attached as Appendix III.

3.2.5 Key informant interviews

Interviews with individuals with knowledge on specific issues on BGBD that the researcher sought to find were carried out. Such issues included: policies relevant to BGBD, revision and improvement of policies to incorporate BGBD issues, intellectual property rights and individual handling of BGBD. The key informants were four, a patents' officer from KIPI, a natural plants specialist from KEFRI, an Environmental Lawyer from the University of Nairobi and an EIA specialist from NEMA.

3.3 Sampling procedure

3.3.1 Systematic sampling

In systematic sampling subjects are chosen at regular intervals for example, every ninth individual from the sampling frame. Ideally, one has to select randomly a number to determine where to start selecting the subjects from the list. The population of farmers in Gatunduri was found to be three hundred and forty five, out of this a sample of sixty farmers were obtained randomly. To get the sampling interval 345 was divided by 60. This gave 5.75 which was rounded up to 6. The number 3 was picked randomly using a hand-held calculator as the starting point. From this, 6 was used as the sampling interval until 60 farmers were reached. The same procedure was carried out in Kibugu where the number of farmers was obtained as 406. $406/60=7$. Here 4 was picked as the starting point then 7 used as

the sampling interval until 60 farmers were reached. This brought the total number of farmers interviewed from the two localities to 120.

The 120 farmers were issued with open-ended self administered questionnaires (See Appendix II). The questionnaires were self-administered because they were written in English and research assistants helped the researcher to translate them to the local language which is “Kiambu”. Translation of the questionnaires was necessary because many farmers were non-literate and semi-literate. The questions were open-ended to get in-depth information instead of confining respondents to pre-defined answers. The questionnaires were non-anonymous because the researcher needed to know the names of the farmers in case of further clarification of BGBD issues. The questionnaires were used for the purpose of presenting uniform questions and avoiding middle-man bias (Walonick, D, 1997). That is, the researcher sought to know farmers’ knowledge and experiences with BGBD.

3.3.2 Purposive sampling

This method involves making a planned selection of the specific cases. Such cases are thought to be “typical” in the target population. The sampling was used because it involved picking individuals who are knowledgeable in biodiversity and its conservation in Kenya. It was only applied to subject matter scientists and institutions. The sampling method was also appropriate because the researcher had prior knowledge of institutions dealing with biological resources in general and soil biodiversity in particular. Twelve (12) institutions were identified and 30

scientists dealing with soil organisms approached. The individuals were employees and professionals in lead agencies, relevant ministries, NGOs, universities, the private sector and some were technical advisors. The method sought to gather precise information on institutions and scientists experiences with BGBD on issues of material transfers, exchanges, acquisition and commercialization as guided by existing policies and regulations.

3.4 Data analysis

The data collected by means of questionnaires were analyzed using Statistical Package for Social Scientists (SPSS). The data were first 'cleaned' before coding was done by giving various codes for different answers. The information was then entered into cells (like those of Microsoft excel) then analyzed using provisions in the programme. Frequencies and percentages, means and modes were determined. Bar graphs, tables and pie charts, were then drawn to elaborate the information obtained from interviews with farmers, scientists and institutions and from the focus group discussions.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents results and analysis of four sets of questionnaires (appendices I, II and III and IV) that were self administered to one hundred and twenty farmers; thirty scientists dealing with biodiversity; twelve institutions (government, non-governmental and private) dealing with biological resources and key informants.

The main issues presented include: results obtained from literature on effects of land-use systems and intensities on BGBD; Farmers' roles in management and conservation of soil organisms have also been highlighted. In addition, policies and regulations that affect BGBD have been highlighted while institutions and their roles in BGBD inventory exchange and transfer has been examined.

4.2 Relating land-use to BGBD from meta-data, literature review and farmers' interviews

From literature and discussions it was noted that land-use systems and agricultural intensification affect the abundance and diversity of BGBD. This section dwells on the relationship between above and below-ground biodiversity.

4.2.1 Effects of land-use systems and intensities on BGBD

Land conversion and agricultural intensification are significant causes of biodiversity loss (Giller *et al.*, 1997). This loss is also likely to be reflected in BGBD, with consequent negative effects both on the environment and the sustainability of agricultural production. Changes in abundance and diversity of BGBD are often thought to follow those of plants, although there is evidence that the soil community may be more functionally flexible than the above-ground biota (Giller *et al.*, 1997). As land conversion and agricultural intensification occur, the planned biodiversity above-ground is reduced (up to the extreme of monoculture) with the intention of increasing the economic efficiency of the system. This affects the associated biodiversity of the ecosystem, for example, micro-organisms and invertebrate animals both above- and below-ground thus lowering the biological capacity of the ecosystem for self-regulation and hence leading to further need for substitution of biological functions with agrochemical and petro-energy inputs. Similar effects have been observed in intensive cattle pastures (Lavelle *et al.*, 1999). The sustainability of these systems therefore, depends on external and market-related factors rather than internal biological resources (Ibid).

Under extensively grazed native pastures, the effect of land management is of little significance and re-colonization of macrofauna after traditional management by burning is rapid. Earthworms are favoured by grazing and fire but their importance decreases with overgrazing. Termites respond in clearly opposite directions and

the earthworms/termite ratio may be considered as a sensitive indicator (Giller *et al.*, 1997). It has been observed that sowing introduced forage grasses and legumes and increasing animal production on improved pastures has a very important impact on soil macrofauna, especially on earthworm populations that increase their biomass significantly (from 4.8 g/m^{-1} to up to 51.1 g/m^{-1}) (Giller *et al.*, 1997). This implies that if land-use regulations/guidelines/policies are reinforced, improved pastures should be considered as an appropriate land-use system due to this significant increase in biomass of soil macrofauna.

Annual crops have a dramatic effect on earthworms, with a spectacular decrease of biomass, population density and taxonomic richness (Lavelle, 1997). The factors responsible for this dramatic effect can be found in agricultural practices such as tillage, fertilization or application of pesticides, in the reduction of root production and the modification of the soil microclimate occurring after clearing the natural vegetation. The loss of abundance and diversity of communities under annual crops may result in a loss of certain important soil functions (Lavelle, 1997). In Kenya, most of the subsistence and food-crop farming is based on annual crops such as cereals and grain legumes. It is important from the foregoing observations by Lavelle that annual crops cultivation in Kenya be accompanied by appropriate management of BGBD as more information and knowledge becomes available.

Recent studies in India have shown that changes in land-use pattern directly affect the population size and composition of earthworm communities (Bhadauria *et al.*, 2000). Indian earthworm fauna is predominantly represented by 368 native species, which constitute 89% of total earthworm species in the country. Some exotic peregrine forms (45 species) have also been introduced in the area presumably by humans and other agencies (Julka, 1988). These exotic species mostly occur in disturbed habitats following deforestation and intensive cultivation. This is in accord with the first premise of this study, that land-use systems and intensities affect diversity of BGBD as is the case with the exotic species.

In South East India, the conversion of native forest to shifting agriculture results in a decline in species richness as well as prominent alteration in relative abundance of different soil fauna groups (Tables 4.1 and 4.2). This evidence concurs with the first objective of the study that land use systems and intensities affect the abundance and diversity of BGBD. It therefore, implies that native forests should be conserved to ensure species richness and abundance. Plantation of exotic trees such as eucalyptus, pine, beech and acacia lead to a higher level of depletion/alteration of species diversity, density and biomass of soil fauna compared to shifting agriculture also as reported by Senapati *et al.*, (2005). This implies that plant diversity affects litter decomposition through changes in litter species composition (Bhadauria *et al.*, 2000).

Table 4. 1: Comparative account of earthworm species richness in native forests and managed ecosystems in Western Orissa, India (+ and – denote species presence or absence respectively).

Earthworm species	Ecosystem type				
	Native forest		Shifting cultivation		Eucalyptus plantation
	Protected	Disturbed	8yr old fallow	Cropping phase	
<i>Drawida calebi</i>	+	+	-	-	-
<i>Drawida willsi</i>	+	-	-	-	-
<i>Eutyphoeus incommodus</i>	+	-	+	+	-
<i>Eutyphoeus</i> sps.	+	-	-	+	-
<i>Eutyphoeus waltoni</i>	-	-	-	+	-
<i>Lampito mauritii</i>	+	+	-	-	+
<i>Lenogaster dashi</i>	-	-	-	-	+
<i>Lenogaster pusillus</i>	+	-	+	+	-
<i>Ocnerodrillus occidentalis</i>	+	+	-	-	-
<i>Octochaerona surensis</i>	+	+	-	-	-
<i>Pellogaster bengalensis</i>	+	+	+	+	-

Source: Yusnaini et al. (1999)

Table 4. 2: Comparative account of chemical and biological attributes of native forests and managed ecosystems in Western Orissa, India

Parameter	Ecosystem type				
	Native forest		Shifting cultivation		Eucalyptus plantation
	Protected	Disturbed	8yr old fallow	Cropping phase	
Soil pH	5.94	6.25	4.94	5.95	5.89
Oxidisable organic carbon (%)	4.14	0.70	2.46	2.34	0.57
Total Nitrogen (%)	0.20	0.03	0.12	0.11	0.02
Total earthworm biomass (gm ⁻²)	32.69	12.33	24.84	11.50	1.62
Total termite biomass (gm ⁻²)	0.23	-	0.44	1.9	-
(Termite/earthworm)X100	0.73	-	18.0	17.0	-
Index of diversity (H)	2.29	1.96	1.27	1.65	0.45

Source: Yusnaini *et al.*, (1999)

Termites proliferate at the expense of earthworms following land use intensification as in tea plantations or following disturbances associated with shifting agriculture. Intensive pesticide spray for reducing the losses due to pests in tea plantations causes 60-70% loss of non-target organisms like earthworms which play important role in maintenance of soil fertility. Continuous use of herbicides in soil conservation tillage is considered to decrease non-target soil biota. However, some research results showed that application of glyphosphate herbicide of up to 21 seasons did not decrease population of arbuscular mycorrhizal fungi (AMF) (Yusnaini *et al.*, 1999), diversity of earthworms and mesofauna and population of Rhizobium (Ibid). Molla *et al.* (1987) mentioned that

at normal dose, pesticides do not have an effect on soil mesofauna. This implies that there is need to study and understand the quantity of pesticides that should be used so as not to affect the non-target organisms. Since the pesticides control Act is already in place in Kenya, it could be considered for revision so as to incorporate BGBD considerations after obtaining good knowledge on the same.

Other studies in India show that tea gardens in the State of Tamil Nadu were inhabited by only 6 species of earthworms compared to 13 species found in the native forest (Senapati *et al.*, 2005). It is this researcher's observation that from a long-term perspective, in that the advantages gained by protecting tea plantations from pest attacks by the use of pesticides, could easily be outweighed by the disadvantage of soil fertility loss as a result of adverse impacts of pesticides on organisms like earthworms.

In conclusion, experiences from India show that depletion of soil fauna following tea or exotic forest tree plantation in cleared-natural forests is partly due to the biological specificities of the introduced/planted species and partly due to the management practices associated with them such as monoculture, mechanization and application of huge quantities of fertilizers and pesticides (Senapati *et al.*, 2005).

Table 4. 3: Shannon index for soil macrofauna diversity in different land use systems in Western Amazonia

	Macrofauna richness	Shannon index	Evenness
Disturbed forest	16	2.22	0.62
Fallow	17	2.14	0.55
Agroforestry	13	1.92	0.53
Pasture	10	1.73	0.52
Annual crop	16	1.63	0.43

Source: Barros *et al.* (2002)

Studies in other countries show similar results. For example, the numbers of species decrease severely after deforestation. This was evident in Manaus (Central Amazonia) where 156 macroinvertebrate morphospecies were recorded in forests. After conversion to pastures, only 29-48 morphospecies were found, of which 15-30% had been found previously in the forest soils (Barros *et al.*, 2004). In sites investigated in Western Amazonia, diversity evaluated by the Shannon index calculated on the number of large orders was higher (2.22) in the forest than in any other system. Diversity decreased gradually with increasing intensification of land use from fallow (2.14), to agroforestry (1.92), pasture (1.73) and annual crop systems (1.63) (Table 4.3).

From Table 4.3 and from the preceding discussion, it is clear that policies or regulations that favour conservation of BGBD through conservation of natural/native forests, natural fallows and agroforestry systems may be necessary as a strategy of conserving BGBD.

Nematode abundance and trophic compositions vary from one agroecosystem to another; this is proof that land management has significant influence on nematode communities (Kandji *et al.*, 2001). Desaegeer and Rao (2000) demonstrated a reduction in the population of root-knot nematodes in *Sesbania* plots with increased exchangeable calcium and magnesium in soil. In a study in Kenya by Kimenju *et al* (2004) concentrating on a review of nematodes associated with cultivated crops showed that almost every crop is attacked by one or several nematode pests, which cause significant yield losses.

In this study it was established that the importance of plant parasitic nematodes in crop production depends to a large extent on the cropping system being practised. For example, crops grown under natural conditions are usually free of parasitic nematodes while neighbouring irrigated farms are heavily infested. The ecological conditions in warm irrigated lands are ideal for rapid multiplication of nematodes if susceptible hosts are planted. Extensive damage by plant parasitic nematodes is extremely rare in crops produced immediately after bush clearing. Population densities and the damage caused have also been shown to vary from one sampling site to another (Kimenju *et al.*, 2004). This is an example which shows that not all BGBD are beneficial and as such when formulating policies the harmful BGBD should also be given a schedule.

In yet another Kenyan study carried out to characterize the nematode communities in different cropping systems, populations of plant parasitic nematodes were lower

under long-term natural fallows when compared with improved fallows or continuous maize/bean cultivation (Kandji *et al.*, 2001). Free-living nematodes were least under continuous maize/bean cultivation and most abundant under long-term natural fallows. The ratio of free-living to plant parasitic nematodes was highest, intermediate and lowest under long-term natural fallows, improved fallows, and continuous maize/bean cultivation respectively (*ibid*).

4.2.2 Farmers' interviews in Embu

Land use in Embu like in other places has caused major changes in biodiversity. Because of continuous cultivation in the upper altitudes, it is difficult to find natural vegetation and wildlife; particularly the large mammals are completely wiped out (Maituma *et al.*, 2004). Continuous cropping that is highly practised by most farmers in Embu may decrease plant richness and consequently reduce the diversity of food resources to the soil fauna hence their variation with different management practices (questions 12, 13, 14 and 15 in appendix II). Studies have shown that such changes in the land-use systems lead to reduced abundance, biomass and diversity of soil fauna communities (Dangerfield, 1997).

In order to find out how different land use systems had affected BGBD, Questions 13, 14 and 15 of Appendix II were asked.

4.3 Farmers knowledge and roles in BGBD management and conservation

4.3.1 Farmer's knowledge of BGBD

Farmers were asked to express their knowledge about soil organisms (Question 1 of Appendix II). The purpose of this question was to approve or disapprove information published in the UNEP 1995 report about the stakeholders' limited knowledge in BGBD. It was established that all farmers interviewed were aware of the existence of soil organisms but had limited knowledge about their functions. The total number of organisms that farmers were aware was 39.

In response to Question 2 of Appendix II, which sort to know whether farmers knew both beneficial and harmful organisms, it was established that all the farmers interviewed knew both beneficial and harmful organisms but all in all most known organisms were said to be harmful rather than beneficial. For instance, in answering Question 2: Are the organisms harmful or helpful? 93 farmers out of 120 (77.5%) responded that they were harmful while 27 farmers (22.5%) knew about both harmful and beneficial organisms. From these responses, farmers' lack of knowledge about beneficial organisms justifies concerns raised about lack of knowledge of BGBD by most stakeholders in a global biodiversity assessment report by UNEP (1995).

Table 4.4 shows farmers responses to Question 4 of Appendix II which required farmers to rate the roles of soil organisms in their farms, soil mixing and decomposition were identified as the most beneficial activities of soil organisms while small ants, millipedes, centipedes and earthworms were identified as the most dominant soil organisms. Earthworms, millipedes and centipedes were associated with penetration of soil as well as mixing of such soil. Ants were considered both as harmful and beneficial. The small ants were reported as slow eaters of crop stems while at the same time were considered beneficial in chewing litter thus reducing the surface area for easy decomposition.

It was also established that when ant hills and termite hills are broken down and such ground is tilled, its fertility is higher than a place without hills. This was in response to Question 5 of Appendix II whose purpose was to relate specific soil organisms' functions to specific organisms. The information obtained implied that termites being ecosystem engineers influenced the access of litter to other faunal groups hence their abundance over the rest. Termites may as such be able to survive a wide range of conditions. This concurs with the work done by Christopher (1994) that showed that the influence of termites is not confined to certain litter qualities, and that they control the accessibility of litter to other decomposers to an extent that exceeds their influence by direct consumption.

Table 4. 4: Farmers' knowledge of BGBD in relation to their functions

Type of soil organism	Function	Usefulness
Small ants	Chewing of litter, slow eaters of crop stems	Both harmful and beneficial
Earthworms, millipedes and centipedes	Soil penetration and soil mixing	Beneficial
Ants	Formation of fertile anthills	Beneficial
Termites	Influenced access of litter to other faunal groups	Beneficial

Source: Interviews with farmers in Gatunduri and Kibugu sub-locations

4.3.2 Roles of farmers in managing and conserving soil organisms

Farmers were asked to outline ways that they were aware of that would help to increase the effects of the beneficial organisms. The purpose of this question was to find out if farmers had any knowledge in the management of BGBD. In response, 53.3% (64 out of 120 farmers) said that their role was to add manure and mulch to the soil so as to increase the activities of the soil organisms. While such organisms fed in the process of decomposition, they would reproduce thus increasing their numbers. Abundance would then be high particularly for the beneficial ones. This implies that the quality and quantity of litter influence the soil conditions and consequently dynamics of the fauna on farms as observed by Tian *et al.* (1997).

The farmers interviewed found out that those groups living in deeper soil layers are not immediately affected but may eventually suffer from reduction in food resources. Another valid practice in maintenance and conservation of soil

organisms was that given by 6.7% (8 out of 120 farmers) that they would reduce the use of agrochemicals since they felt that such chemicals reduced the abundance of soil organisms by providing an intolerable environment. The farmers expressed concern that some species may end up being extinct though they did not have a specific one which had been useful but was now not being seen as a result of long term use of agrochemicals. The effect of agrochemicals on soil organisms as observed by these farmers is in assentment to studies conducted by Matson *et al.* (1997) that established that agrochemicals have injurious environmental effects to adjacent and even distant ecosystems (See Table 4.5 for other roles).

Table 4. 5: Roles of farmers in BGBD management and conservation

NB: Total number of farmers is 120

Role of farmer in managing and conserving BGBD	Number of farmers	Percentage (%)
Applying manure and mulch	65	54
Proper farm management	14	12
Improve farming	12	10
Implementing education and research	12	10
Reducing agrochemicals	8	7
Maintaining soil fertility	5	4
Conserving useful organisms	4	3

Source: Interviews with farmers in Gatunduri and Kibugu sub-locations

Farmers were asked if they would require any protection from the government or other facilitation (Question 18 in Appendix II) to carry out their roles. The purpose of this question was to find out if farmers would trust the government because in many instances farmers have always not preferred working with the government. In response, 85% (102 farmers) said yes while 15% (18 farmers) said no. Types of support needed from the government were enumerated and the three most

significant were: provision of farm inputs 20.8% (21 out of 102 farmers, price control and tax policy 20.7% (21 out of 102 farmers) and provision of market links 16.7% (17 out of 102 farmers) (Table 4.6)

Table 4. 6: Types of intervention needed by farmers from the government in conserving BGBD.

Type of government intervention needed by farmers in conserving BGBD	Number of farmers	Percentage (%)
1. Provision of farm inputs	25	20.8
2. Price control and tax policy	25	20.7
3. Provision of market links	20	16.7
4. Training on good farming methods	15	12.5
5. Supply of fertilizers	15	12.5
6. Protection from harmful organisms	10	8.4
7. Provision of extension services	5	4.2
8. Land insurance	5	4.2

Source: Interviews with farmers in Gatunduri and Kibugu sub-locations

Farmers' preferences of incentives were sought through Question 20 in Appendix II. The purpose of this question was to gather information that would provide informed decisions on incentive measures. In response on whether to be given incentives or not, 51.7% (62 out of 120 farmers) felt that they needed to be given incentives by the government for conserving the soil organisms. The need for incentives from the government shows that farmers related all activities that involve agriculture to the government. They associate agricultural improvement to the ministry of agriculture safe for BGBD. Another reason for needing incentives from the government in regard to BGBD is due to the farmers' lack of knowledge about the benefits of BGBD. 41.7 % (50 out of 120) had no idea of what was being referred to as incentives and therefore, sought awareness creation first. For the 51.7% (62), the incentives with high percentages named were: 46.7% preferred

farm inputs and 20% of the farmers; cash to determine what to buy on their own (Table 4.7)

Table 4. 7: Types of incentives needed by farmers from the government

Type of incentive	Percentage of farmers	Number of farmers
Farm inputs	46.7%	29
Cash	20%	12
Advice/education	13.3%	8
Price control	6.7%	4
Loans	3.3%	2
Market linkages for farm produce	10%	6

Source: Interviews with farmers in Gatunduri and Kibugu sub-locations

In response to Question 21 of Appendix II whose purpose was to determine whether farmers had any attachments to soil organisms to the extent of ownership; the following responses were obtained: 46.7% (56 out of 120) farmers felt that they owned the organisms because they were on their farms while 50.0% (60 out of 120) said they were natural occurrences. This implies that farmers have not yet attached ownership to BGBD due to lack of knowledge about their importance and commercial values. They therefore, do not know how much they would gain in terms of benefit sharing and incentive measures if they claimed ownership of BGBD. There is need therefore, for informed knowledgeable BGBD Stakeholders to sensitize farmers on the issues raised.

4.4 Institutions and their roles in BGBD inventory exchange and transfer

4.4.1 Types of genetic resources used by institutions

As indicated in figure 4.1, employees of institutions dealing with genetic resources were asked to specify what types of genetic resources their institutions were dealing with (Question 1 in Appendix I). The purpose of this question was to determine which institutions were dealing with soil organisms in all aspects and those who were handling soil organisms besides other genetic resources. It was established that a significant 62.5% of the institutions interviewed were dealing with soil organisms hence the need for this research.

The variation in percentages was due to the fact that some institutions were dealing with more than one type of genetic resource. For instance, an institution like the University of Nairobi's Kabete campus, deals with livestock, crops as well as soil organisms. In this regard, it was also established that these genetic resources were used in association, for instance, crops were used to test inoculum, and dung from cattle was used in experiments for decomposition.

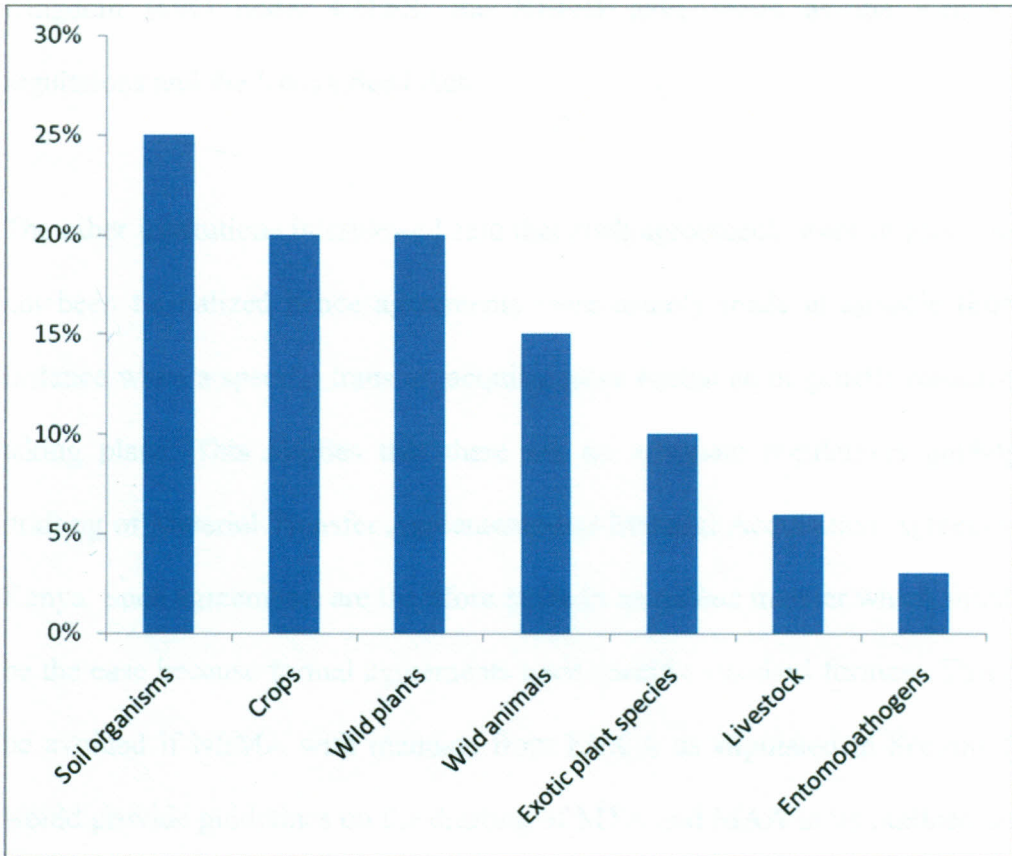


Figure 4. 1: Type of genetic resources handled by institutions

4.4.2 Rules and regulations governing collection, packaging, transfer and pricing of genetic resources

The purpose of Question 18 in Appendix I was to obtain information about rules and regulations governing collection, packing, and transfer and pricing of genetic resources. Seventy five percent (9 out of 12) of the institutions interviewed agreed that they have rules and regulations governing the above mentioned activities. Such rules and regulations were said to be found in the following documents: the NMK gave the CITES red book and a material transfer agreement (MTA) signed

between the Kenya government and the royal botanic gardens in the United Kingdom (UK) under CITES; the KEFRI gave theirs as the Kenya seed regulations and the Kenya Seed Act.

The other institutions interviewed said that such agreements were in place but had not been formalized hence agreements were usually made at specific times for instance when a specific transfer, acquisition or exchange of genetic resources are taking place. This implies that there are no adequate regulations guiding the drafting of Material Transfer Agreements and Material Acquisition Agreements in Kenya. Such agreements are therefore made in an *ad hoc* manner which should not be the case because formal agreements need specific standard formats. This could be avoided if NEMA with mandate from EMCA as stipulated in Section 50 (e) would provide guidelines on the drafting of MTA and MAA in its outlined duty of specifying national strategies, plans and government programmes for conservation and sustainable use of biodiversity.

Among the stakeholders involved in such agreements were: the government of Kenya, the Royal Botanic Gardens, KEFRI whose role is quality assurance or production; gene bank for storage and conservation; KEFRI, KARI, FD and KWS for research and management; KEPHIS whose role is to regulate the trade or production; NMK also does production; Kenya wildlife Service (KWS) which does licensing for export; attorney general's office and NEMA in policy formulation and regulation and farmers who participate in production of BGBD.

For such activities to be undertaken in harmony and for them to apply to BGBD, NEMA and the mentioned lead agencies with their outlined duties should consult each other. Such consultations will ensure the prescription of measures necessary to formulate rules and regulations for drafting and signing MTAs and MAAs. It would be in line with EMCA section 50 (e) which stipulates that NEMA in consultation with relevant lead agencies shall undertake measures intended to integrate the conservation and sustainable utilization ethic in relation to biodiversity in existing government activities and activities by private persons.

4.5 The Role of policy in BGBD conservation, management, preservation, acquisition, transfer, commercialization, benefit sharing and IPR.

4.5.1 Farmers perceptions

Farmers were asked if they knew if soil organisms can be used in trade if properly identified for type and function in the soil (Question 22 of Appendix II). The purpose of this question was to learn more on farmers' knowledge in commercialization with BGBD. The following responses were obtained: 31.7% (38 out of 120) said yes, 38.3% (46 of 120) said no while 30% (36 out of 120) said that they would be in a better position to answer this question when educated about such issues before hand. Out of the 120 farmers interviewed, 58.3% (70 out of 120) had an idea of what transfer of soil organisms was. Out of the 70, 36 (51.4%)

said it was the removal from one farm to another while 34 out of 70 (48.6%) said it was the movement of soil organisms from one farm to another. The remaining 50 out of 120 (41.7%) farmers had no idea about transfers at all. This implies that there is limited knowledge (UNEP, 1995) among farmers about BGBD activities. This lack of knowledge has led to a lack of appreciation as indicated in the same report.

Two questions were asked in relationship to transfers: Question 24 of Appendix II was to determine if farmers were aware of transfers that had taken place in their village. 15% (18 out of 120) were aware. The other question was in regard to the places where the organisms had been transferred from (Question 24 of appendix II). The aim of these two questions was to obtain information on transfers from varied BGBD stakeholders of whom farmers are an important component. The transfers that farmers were more familiar with were those in which soil organisms are carried in manure, for example, the case of the dung worm-locally known as "marindi". Other organisms transferred in manure were enumerated as: small black ants, big beetles, millipedes, centipedes, termites, earthworms and nematodes. The other significant transfer was from their farms to the University of Nairobi, and the Kenya Agricultural Research Institute (KARI), for research. One farmer shared his experience as indicated in Box 2.

Box 2

“We do not know where they were taken since people in a team came and took samples from our plots and never returned. They even put pegs which are still here up to now but did not explain what the pegs were for! Soil samples have been picked on a number of occasions but we have no idea what was extracted from such samples.”

Source: An interview with a farmer in Gatunduri sub-location

This is an outcry that transfers of BGBD occur mainly in form of soil samples being taken away from farmers' farms.

It was important to know farmers' views about continued transfers (Question 25 of Appendix II). Answers and explanations by farmers were given as follows: they defined their roles as follows: 81.7% (98 out of 120) said they would ensure proper farm management. This implies that farmers are always willing to properly manage their farms. All they need is education particularly enhanced agricultural extension services and subsidized farm inputs to carry out the activities. This is justified in their response to Questions 26 and 27 of Appendix II which address the issue of benefits to the farmer. The purpose of these questions was to get insights on farmers' perceptions on issues of benefit sharing. In regard to the benefits a farmer should get as a result of transfers: 52.5% (63 out of 120) said farm inputs while another 39.2% (47) said money. As to who should determine such benefits (Question 27 of Appendix II), a significant 66.7% (80 out of 120) would not determine the exact determinant because they felt the need to be educated first while 26.7% (32) said the farmer. This implies that farmers lack knowledge on benefit sharing though they still feel that at least a farmer should have an upper hand in determining such benefits. As per the Kenya's third national report to the

CBD Article 11 on incentive measures and Article 15 on access to genetic resources, an initiative should be in place to start off with training of farmers as stipulated by the former followed by the introduction of the draft regulations and benefit sharing before approval by the relevant Minister.

In Question 28 of Appendix II, farmers were challenged to perceive a situation in which a disagreement occurs between the farmer and the person acquiring the organisms for commercial use, who would they want to be the intervening party? The purpose of this question was to link conservation policies with legislation. The following responses were obtained: 56.7% (68 out of 120) said the government- and in this regard the government means the provincial administration of which the sub-chief is the administrator closest to the farmer. The government was also said to be the administration police who would come in, in case the disagreement turns violent. Exchange of soil organisms was understood to mean exchange between farmers 36.7% (44) and taking soil organisms from one farm to another and transfer of soil organisms and replacing them with others 18.2% (22). This shows that farmers mainly understood exchanges as just occurring among themselves and not between them and research institutions or other organizations. This could be due to inadequate knowledge about exchanges of BGBD. All farmers interviewed were not aware of any exchanges (Question 30 of Appendix II) that have occurred in their farms. The only emphasis was that the BGBD group

had visited the place at some point and picked soil samples from the farms but no returns were received (Box 2).

Viewed from the researcher's perspective, this was a serious complaint from the farmers. It implies that researchers have a habit of collecting samples from farms and not returning to tell the farmers what resulted from the work done with the collected samples. This, though a common practice, is professionally unethical because farmers deserve to know whatever is obtained from their farms (CBD, 1992). It also shows that prior informed consent and benefit sharing was overlooked and not negotiated from the beginning (ibid). The lack of proper guidelines on prior informed consent could be a contributing factor hence the need to specifically outline the obligations of all parties involved in the exercise by NEMA and the relevant lead agencies or ministries.

In response to a related question posed to farmers on whether the process of exchange was fair (Question 37 in Appendix II) whose purpose was to determine whether farmers knew about any guiding principles in relation to exchange of soil organisms, the responses from farmers were as follows: the farmers found this inapplicable because no exchanges had taken place between them and other institutions and as much as soil samples had been collected from their farms, they were not aware of what was extracted from them. This shows a gap between scientists' research work and farmers' involvement. It is important for research to

involve all parties to avoid suspicion and resistance for future research. Scientists should therefore, adapt a participatory approach to their work with farmers. It should not be seen by farmers that a secret is being kept away from them, thus raising suspicion! In response to question 39 in Appendix II about future exchanges, farmers unanimously said that first and foremost, there should be creation of awareness. This lack of knowledge is a policy gap that could have been created by limited research-extension- farmer linkages. Policy intervention in regard to public education and awareness is thus required as stipulated by Article 13 of the CBD.

An additional point of view was that exchange can only be possible if the government intervenes on the compensation for loss of soil organisms and in this regard the government was proposed as the regulator of the process of exchange by 56.8% (68 out of 120) of farmers, 30.0% (36) proposed the farmer while 13.3% (16) proposed the researchers. Due to ignorance and misguided perceptions, members of the public always see the government as the intervener in most aspects of their daily lives. This particular issue of the compensation to farmers should be given more in-depth thought. As much as the farmers' views on the need for government intervention are expressed, the collector of the samples should be obliged to pay for it so that the farmer benefits thus improving livelihoods. This is an area that requires policy intervention. It is one mechanism that can ensure 'equitable benefit sharing.'

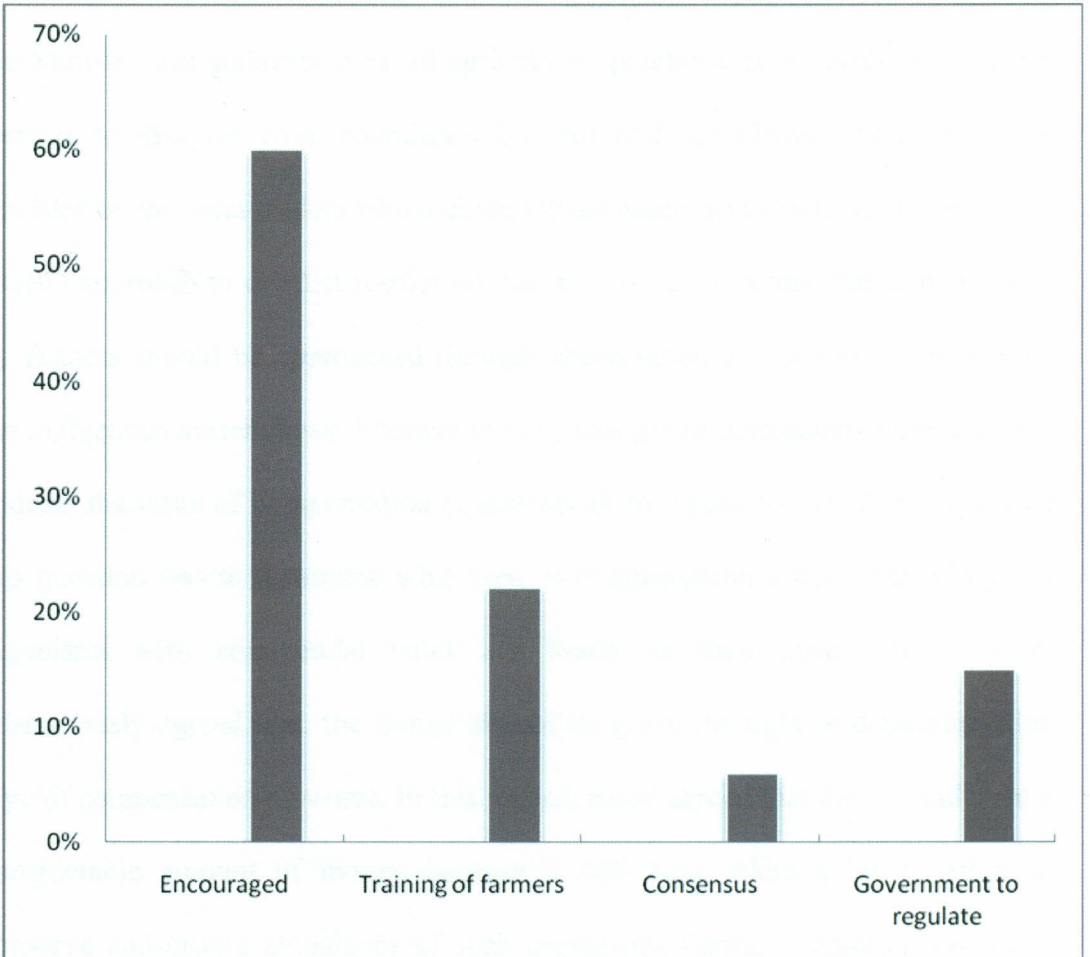


Figure 4. 2: Farmers opinions on future exchanges of soil organisms among farmers and with institutions dealing with BGBD. The titles given on the x-axis are explained as Consensus: consensus needed with farmers; Encouraged-exchanges among farmers and with institutions should be encouraged in future, Farmers T-Farmers to be trained, G regulate-government to regulate.

Farmers were asked about their opinions in case of a disagreement in regard to exchange of soil organisms (Question 41 of Appendix II). The purpose of this question was to find out if farmers are aware of the relationship between policy and legislation; there was a general consensus that the offended person should approach the Ministry of Agriculture. This is due to the farmers' perception that

the Ministry has authority over all agricultural practices. It is usually normal for farmers to disagree over boundaries but not soil organisms. Such issues are resolved by the local leaders who include village elders and chiefs. In this regard, a BGBD approach to conflict resolution that may occur in future due to ownership by farmers should be approached through appreciation and acknowledgement of the indigenous system/laws. Farmers in the focus group discussions were asked to address the issue of compensation (Question 43 in Appendix II). The purpose of this question was to determine what type of compensation a farmer should get if organisms with commercial value are found on their farms. The farmers unanimously agreed that, the farmer should be given the right to determine what type of compensation he wants. In this regard, many agreed that they would want a considerable amount of money because it will have taken a lot of effort to conserve and ensure abundance of such organisms. Farmers' opinions on future exchanges were sought through Question 44 of appendix II. The purpose of this question was to gather information that would enable the inclusion of farmers as relevant stakeholders in exchanges of BGBD. Such information would also be useful when formulating guidelines on BGBD issues. The results obtained are shown in figure 4.2.

The discussions from the focus groups were finalized by the farmers expressing the need and importance of being educated about soil organisms. On the one hand, they said they would want to know the important organisms so as to conserve them

and increase their number. On the other hand, they also needed to know how to eradicate the harmful ones. Additionally, they wanted to be educated on what conditions favoured the multiplication of useful organisms. This implies that farmers lack knowledge in BGBD issues and are eager to learn. Policy in regard to public education and awareness could address this issue.

4.5.2 Institutions' perceptions

4.5.2.1 Material Transfer Agreements (MTA) and Material Acquisition Agreements (MAA)

Information about familiarity with MTA and MAA was sought through Question 22 of Appendix I. The purpose of this question was to find out how many institutions know about MTA and MAA. Familiarity with MTA was at 83.3% (10 out of 12) while unfamiliarity was 16.7 % (2) .For the MAA it was 50.0% (6 out of 12) for familiarity against 50.0% (6 out 12) for lack of familiarity. Most of the agreements termed as MTA and MAA were actually Memorandum of Understanding (MoU). This is because of the value given to BGBD. It is considered as comprising of small organisms and so a simple agreement in the form of a MoU easily transfers them. This shows that transfers were more commonly taking place than acquisition and this explains the fact that soil organisms were mostly used for research between and among institutions rather than such institutions claiming to own the organisms through acquisition.

The signatories to these agreements were given as: lead agencies and governments 66.7% (8) and lead agencies only 33.3% (4), the rest were as shown in fig 4.3. The difference in the percentages explains the fact that both agreements were considered at the same time without separating them. It can also be explained that a lead agency in a government would sign an agreement with a lead agency in another government or from the same government without the governments of such countries being party to such agreements.

The researcher found out that there were a number of flaws in the existing MTA/MAA/MoU. Firstly, they were not strictly adhered to because there were no legislative appendages in such agreements. The draft regulations on access to genetic resources and benefit sharing outline various forms of punishment to offenders who violate the draft MTA regulations (Draft regulations Part V section 35.1, 35.2, 36 and 37). These regulations once approved by the Minister for Environment and gazetted will ensure proper adherence to MTA and MAA. Second, MTAs and MAAs accessed lacked an outline on benefit sharing hence it would be difficult for the stakeholders involved to claim any benefit accruing from the genetic material in question.

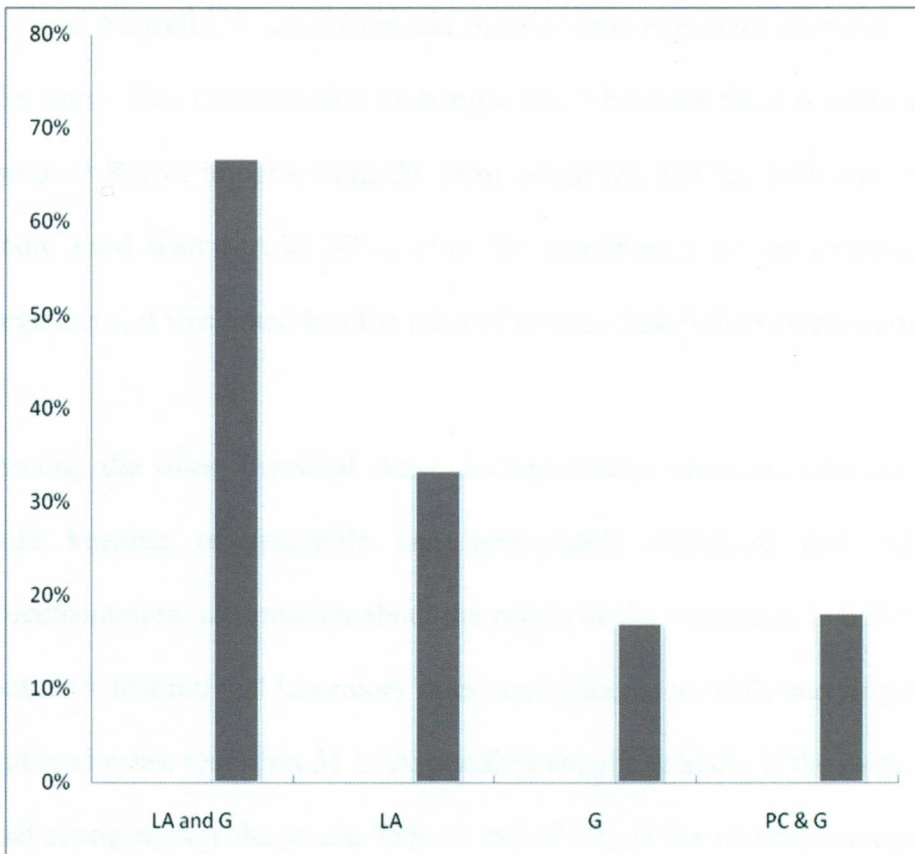


Figure 4. 3: Institutions that have signed MTA and MAA in form of MoUs. The horizontal axis shows the type of institutions while the vertical axis shows the percentage of agreement types signed by different institutions.

Legend: LA and G:-Lead agencies and government, LA:-Lead agencies, G only:-governments only; PC and G:-Private Companies and governments.

Question 24 of Appendix I required information on the precise names of institutions that had signed such agreements. These were: James Finlay Tea Company with KEFRI, Brook bond Tea Company with KEFRI, a MoU between Pan-African paper mills with KARI, KEPHIS, KWS and Moi University, KEW gardens and NMK Kenya. Dudutech and NMK were identified as institutions which have signed both agreements. In regard to importation and exportation of soil organisms, the following countries were given as importers of organisms from

Kenya: Australia, South Africa and Britain while exporters were also identified as the same. This indicates that exchanges occur between these countries and Kenya because Kenya imports from the same countries. MTAs; 80% were found to be more used than MAA; 20%. After the importation and/or exportation of soil organisms, it was noted that the roles of various stakeholders were varied.

Among the roles identified were: documentation, research, curation, sanitation, safe keeping of materials and gene bank sanitation and exhibition. In documentation, information about the origin of the organisms and their uses were outlined. Institutional laboratory rules were adhered to while carrying out the other outlined roles. Question 31 in Appendix I sought to know if the roles enumerated had changed over the years. 75% (9 out of 12) of the institutions confirmed that these roles have not changed over the years while 25% (3 out of 12) explained that the roles, particularly that of research had changed due to new developments and inventions in the field of research. Another reason why research had changed was due to its collaborative nature as well as people from different disciplines handling different aspects of genetic resources. A different answer was explained that with increasing focus on IPRs and other obligations, roles and obligations of the stakeholders have been modified to reflect this.

Responses from institutions were sought on new ideas for the coming years and especially with regard to commercialization (Question 37 in Appendix I). The purpose of this question was to get ideas from varied groups of stakeholders on

their perception as regards commercialization. The following responses were received: that there should be the development of a policy for indigenous knowledge, safety measures when handling genetic material; and there should also be fair play that is, fair trade to ensure the sustainability of the sources, establishment of a regulator for the trade or exchange in micro-organisms, development of mechanisms for the trade and researchers to be involved in import and/or export of micro-organisms. These are critical issues that require guiding policy. Firstly, a policy for indigenous knowledge is possible because there are already draft regulations on indigenous property rights.

Secondly, the fair play issue would simply be addressed as benefit sharing which already has a schedule in part V of the draft regulations on 'the conservation of biodiversity and biological resources, access to genetic resources and benefit sharing and the protection of environmentally significant areas of 2003. Thirdly and lastly, the issue of trade and regulation of importers and exporters is in the docket of KEPHIS and KIPI. A critical policy intervention is the recognition of the innovator rather than the origin only by the Industrial Property Act.

Another idea was that if Kenya develops the proposed indigenous knowledge, genetic resources and folklore policy, all MTAs and MAAs discussions will be based on the same policy for uniformity and compliance. Apart from MTAs and MAAs (Question 38 in Appendix I), other agreements that were found to be used

by institutions included: Material Exchange Agreements and Material Multiplication Agreements.

An outline of the roles of different stakeholders within such agreements was sought through Question 39 of Appendix I. Varied responses were obtained. For instance, 85.0% felt that the role of the local community is the provision and sharing of indigenous knowledge. Other roles mentioned were the undertaking of continuous in-situ conservation. These two roles were cross-cutting among all the three groups of stakeholders (local community, farmers and land-owners) listed. 75.0% (9 out of 12) of the institutions felt that the agreements adequately cover benefits sharing. They explained this in the context that the products of the trials of exchange is usually given to the farmer or land owner while the information collected is handled by the research institution.

This was a biased observation by the researchers because what they meant were things like seeds which are tried then given back to farmers for planting. With BGBD, there is need for equitable sharing because several stakeholders are involved at every level and have various stakes. It was also said that community members are given jobs to collect the germplasm and are also trained and given technical or financial support to raise indigenous tree species. As a negation to the above, among the 25% of the institutions interviewed, a reason was given that very rarely are benefits set out in agreements, especially as the main thrust is research

that may not have commercial value. From these observations it can be concluded that in institutions dealing with soil organisms, knowledge of benefit sharing prevails unlike in the case of farmers. It can also be concluded that the issue of benefit sharing is critical and thus needs immediate policy intervention hence the need to incorporate BGBD benefit sharing in the existing draft regulations on access to genetic resources and benefit sharing

To determine the rate of satisfaction with the agreements currently in place, Question 42 of Appendix I was posed. 75.0% (9) of the interviewees were satisfied with the agreements that are in place. The dissatisfied 25.0% (3) gave their ways on how to improve on such agreements as follows. The agreements should discuss the idea of rights to innovation with the farmers and land owners. They should include the percentage of benefits that is allocated to various people involved. Such agreements should also first of all outline the creation of awareness within communities on the need to collect and conserve resources. They should also consider IPR issues.

4.5.2.2 Articles of the Convention on Biodiversity (CBD)

Adherence of institutions to various articles of the CBD was sought by asking question 44 of Appendix I. Among the Articles adhered to by various institutions included: Article 7 on identification and monitoring, Article 13 on public education and awareness, article 9 on ex-situ conservation and Article 15 on access to genetic resources. The latter was the article that was most adhered to by

most institutions. This is mainly due to the fact that most institutions deal with varied genetic resources and for them to carry out research with them; they must first of all have access to the same. Institutional practical implementation of these articles was pursued by asking Question 45 of Appendix I. 50% (6 out of 12) of the interviewees attested to the fact that their institutions had been able to implement the requirements of the stated Articles while 50 % (6) had not. In response to the Question 46 of Appendix I; how the implementation process has been, i.e., successful or unsuccessful on a scale of 1-10; 1 being least successful and 10 being most successful, a mean of 6.25 was obtained; meaning partially successful

A follow up Question (47) on the reasons for success was asked and the following responses were received: that access has been made easy through exchange and MoUs and that through ex-situ and in-situ conservation, sustainability of genetic resources have been ensured. Various institutions were found to have the same mandates in the field of genetic resources (Question 48 of Appendix I). For example, the NMK has one of its mandates similar to that of the KEMFRI; also similar to NMK in this regard are KARI, KEFRI, KFS, KWS and public universities. For the KEFRI it shares similar duties with the KARI, ICRAF, and the CIFOR and the CSIRO.

4.5.2.3 Policies and regulations that affect BGBD

It was important to find out what existing policies institutions think could have impacts on below-ground biodiversity (BGBD), the effects of such policies and their possible improvements (Question 51 in Appendix I): The Wildlife Act whose effect is to reduce overexploitation was quoted. The possible improvement on this Act was cited as its implementation which is mainly hampered by limited funding which is a policy issue that could be due to lack of a trust fund. The other citation was the CBD 2010 target whose effect is to increase biodiversity by the year 2010. The possible improvement on this is monitoring. This is because the various institutions carrying activities in relation to the implementation of the CBD individualize the monitoring processes. For instance, there are temporal monitoring processes with the KEFRI and the KFS of the Ministry of Environment. Findings from monitoring processes carried out by government institutions are not shared with the public or civil society organizations. Lack of stakeholders' participation in the monitoring processes does not reveal all implications. Some of the reports published into books usually have censored information.

This is a policy gap which can be addressed through harmonization of clauses outlining monitoring in different policy documents into one that is all encompassing. In this regard, NEMA should harmonize regulations on monitoring. The effect of the Agriculture Act was cited as improved agricultural biodiversity

and there is need to improve its implementation particularly in regard to education and public awareness programmes. This is a policy gap that could be the reason for the weak link in research-extension services with farmers, as earlier mentioned in the text. The Forest Act plays a role in increasing forest cover and biodiversity and hence improvement also needs to be made on its implementation in terms of addressing practical issues as outlined in the National Biodiversity Strategy and Action Plan that was developed and published in March 2000. EMCA was also cited because it covers all biodiversity in general.

In response to Question 52 in Appendix I: If such policies do not exist now but were to be formulated, whom would you propose as the regulator, custodian and target? The following were the answers obtained for the different categories: for the regulator NEMA, KEPHIS, NCST, KIPI and a consortium of research bodies were proposed. The first four institutions were considered as having the capacity to regulate while the consortium was justified in that, researchers are the ones who do the actual research work. The government of Kenya was overwhelmingly proposed by 91.7% (11 out of 12 institutions) interviewees as the custodian while an individual institution like NMK proposed itself and the KWS. In regard to the target (Question 52 (c), it was 100% (12 out of 12) agreed that it should be all users of soil organisms including institutions (both public and private), farmers, traders, scientists and the government. The only reason given for the specifications above was that different groups are affected in unique ways.

Institutional perceptions of the sufficient coverage of all biodiversity issues by EMCA were sought (Question 53 of Appendix I). The purpose of the question was to determine whether institutions were aware of the application of EMCA as an Act or a framework. 16.7% (2 out of 12) of the interviewees felt that EMCA's coverage of biodiversity issues is sufficient for soil biodiversity while 16.7% (2) felt it is insufficient. The remaining percentage did not commit to answer because they were not aware of what exactly said about biodiversity by EMCA. The reason given for insufficiency was that there is no specific regulation or rules within the Act for this purpose. As a suggestion for improvement; rules and regulations should be instituted within the Act or a specific Act of parliament be developed to ensure adequate coverage and control. The latter statement justifies the fact that EMCA is not a complete Act but a framework which should be used to formulate specific guidelines/regulations in conservation of biodiversity (see 1.2).

As a summary to this section, 75% of the interviewees alluded to the fact that there is need to formulate a holistic soil biodiversity policy in Kenya (Question 55a and 55b of Appendix II). The reason given for this was that just as above-ground biodiversity is important, so is below-ground. Indeed, the wealth of Kenya in terms of agriculture, industry and medical are below-ground. The other reason was that details of biodiversity guidelines are needed to avoid unhealthy competition for BGBD use.

4.5.3 Scientists perception

4.5.3.1 Participation in soil organisms' research

Question 1 of Appendix III was for the purpose of determining how many scientists had participated in soil organisms' research. The following responses were obtained: 70% (21 out of 30) of the scientists had participated in soil organisms' research while 30% (9 out of 30) had not (fig 4.4).

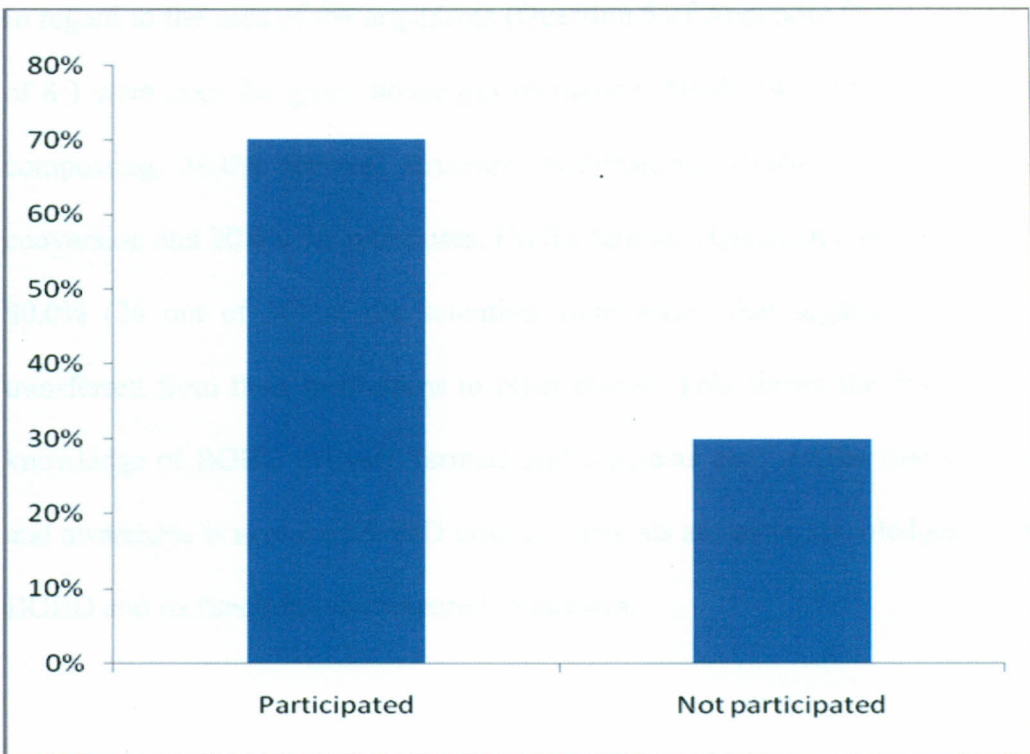


Figure 4. 4: Participation of scientists in soil organism research

Mycorrhizae and rhizobia were determined as the organisms that were mostly researched on. 26.7% (8 out of 30) of scientists had worked with mycorrhizae while 20.0% (6 out of 30) had worked with rhizobia (Fig 4.5). The regular use of these two types of organisms is because both mycorrhizae and Rhizobia have the

ability to form symbiotic associations with plants of varied species thus facilitating nutrient cycling which is vital for plant growth. Their association with plants is also solid evidence of how the above and belowground biodiversity are linked. Other organisms that had been used in research were caecians, fungi, termites, earthworms and nematodes (Fig. 4.5).

In regard to the uses of the organisms (Question 5 of Appendix III), 62.5% (5 out of 8) were used for green house gas regulation, 50.0% (4 out of 8) for vermin composting, 30.0% for soil structure modification, 10.0% for organic matter conversion and 20.0% for other uses. Unlike farmers (Question 6 of Appendix III), 80.0% (24 out of 30) of the scientists were aware that organisms have been transferred from their institutions to other places. This shows the discrepancy in knowledge of BGBD between farmers and scientists and justifies that knowledge and awareness is useful in BGBD issues. Scientists are more knowledgeable about BGBD and its functions as compared to farmers.

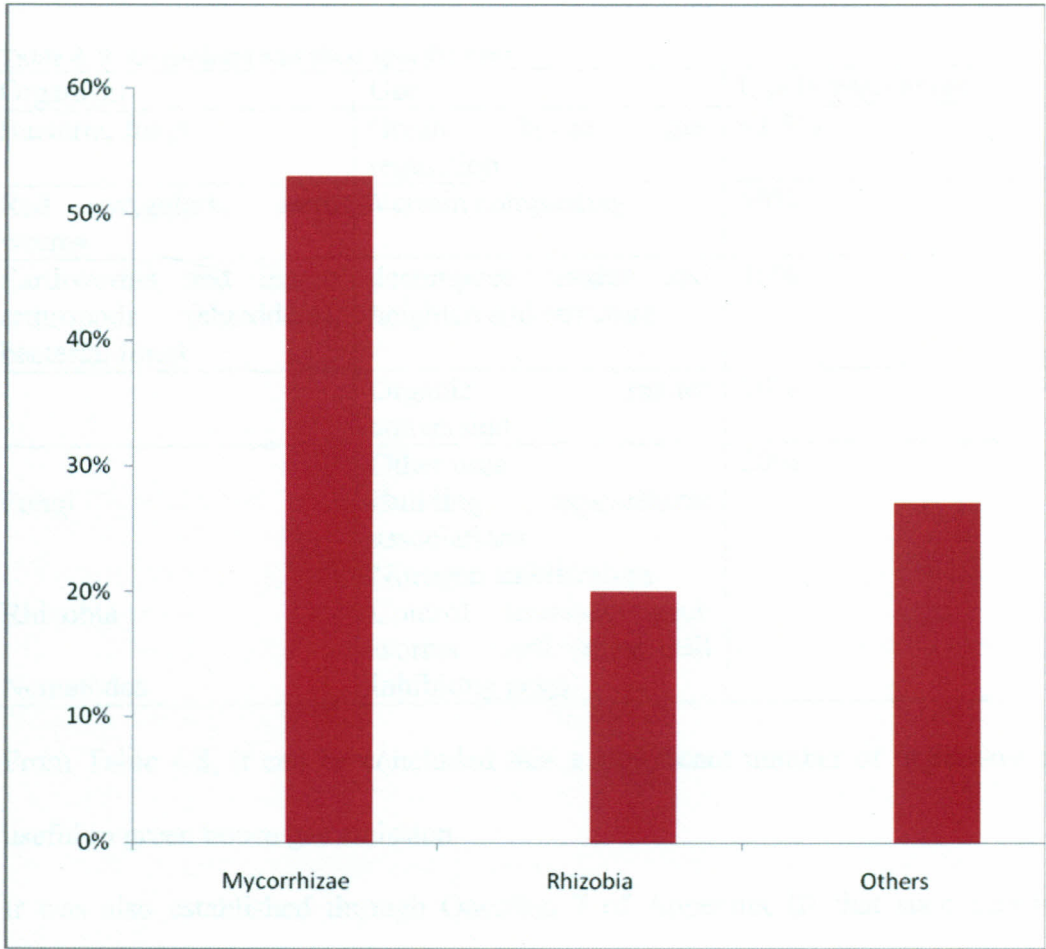


Figure 4. 5: Soil organisms that are most researched on by scientists

Table 4. 8: Organisms and their specific uses

Organism	Use	Use in percentage
Bacteria, fungi	Green house gas regulation	62.5%
Red wrigglers, earth worms	Vermin composting	50%
Earthworms and macro arthropods (shredders), bacteria, fungi	decompose residue and heighten soil structure	30%
	Organic matter conversion	10%
Fungi	Other uses	20%
Rhizobia	Building mycorrhizal associations	
Nematodes	Nitrogen stabilization Control termites, grub worms and other soil inhibiting pests	

From Table 4.8, it can be concluded that a significant number of organisms are useful in green house gas emission.

It was also established through Question 7 of Appendix III that such transfers mainly took place between farms and laboratories either in universities or in lead agencies and institutions handling soil organisms. Transfers also occurred between institutions of research, for example, transfer of organisms from University of Nairobi's Microbiological Resources Centre (MIRCEN) laboratory to Australia, from University of Nairobi to KARI and to NMK. There were also incidences in which organisms were transferred from institutions in Kenya for identification in the United Kingdom. 80% (24 out of 30) of researchers were aware that exchanges had taken place and attested to the fact that such exchanges did not involve money but entailed exchanging one organism with another for purposes of research.

In regard to participation in exchange, it was found that this was very similar to transfers and occurred mainly among research institutions. From these responses it is clear that transfers and exchanges take place between/among institutions for purposes of research and use in agriculture though there is no regulating policy. With the current arrangement, transfers and exchanges are done without taking into consideration the origin and innovator of the soil organisms thus overlooking IPR issues. As a result agreements on exchanges and transfers are made in an adhoc manner resulting to lack of adherence due to absence of legal statements. As much as there are guidelines on what MTAs and MAAs should contain, these guidelines are still in draft form and have not been approved by the Minister for environment. Once approved and gazetted, they could be used to guide exchanges and transfers.

Individual transfer of organisms (Question 10 of Appendix III) was found to have been carried out by 80.0% (24 out of 30) of researchers. Individual transfers mainly occurred in a case where a particular scientist is allocated some research work to do and goes ahead to carry out such activities or when such an individual is carrying out research either for a masters' or PhD programme. KEFRI had researchers who had transferred organisms country-wide, NMK had researchers who had transferred organisms from Taita Hills. At the University of Nairobi, organisms had been transferred and exchanged with countries like Uganda,

Zimbabwe, Zambia, Australia, Thailand, U.S.A (Hawaii), Japan and Belgium. The University of Nairobi had made a majority of transfers and exchanges as compared to other institutions. This could be due to the fact that the university has a large faculty of agriculture and science with a large number of research scientists. Individual transfers were very rare because most scientists do not work as individuals but are affiliated to institutions.

Among the organisms transferred were mollusks, arthropods, annelids, mycorrhizae and rhizobia. Just as it were for soil organisms researched on, mycorrhizae and rhizobia formed the largest percentage of organisms transferred and exchanged. Thirty percent (9 out of 30) of researchers gave their reason for transfer generally as for research, while the remaining were specific about the uses. These included: identification and curation 20.0%, inoculation 10.0%, isolation 10.0%, nutrient cycling 10.0%, soil structure modification 10.0% and carbon sequestration 10.0%. The reason for BGBD being used for research only could be because their economic importance has not been documented. Another reason could be the lack of guidelines in their use both economically and commercially. Ninety percent (27 out of 30) of researchers had not individually exchanged soil organisms and this can be explained by the fact that most of them work for institutions which undertake exchange on their behalf. It also shows that use of BGBD is minimal especially at individual level. The remaining 10.0 % (3 out of 30) had exchanged mycorrhizae in plenty while few mollusks, annelids and

arthropods had also been exchanged. The common use of mycorrhizae implies that they are among the most important soil organisms in agriculture (Jefwa *et al.*, 2004).

4.5.3.2 Acquisition of soil organisms by scientists

Scientists were asked to explain what they understood by the term acquisition of soil organisms, Question 18 of Appendix III. The purpose of this question was to find out the difference between scientists' understanding of acquisition and that of farmers. 30.0% (9 out of 30) said that it meant being in possession of soil organisms while 20.0% (5 out of 30) said it is the procurement of soil organisms. Other responses are as shown in fig 4.6. In relation to this, 76.7% (23 of 30) of the scientists had acquired soil organisms while 23.3% had not.

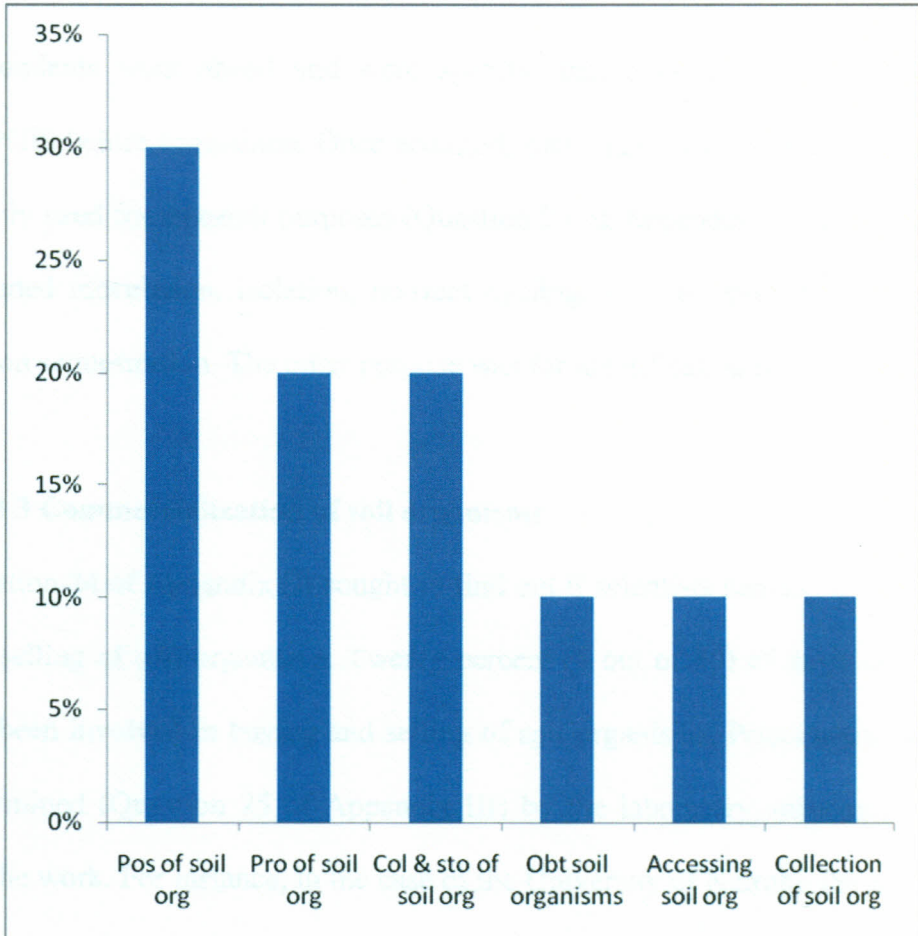


Figure 4. 6: Scientists' understanding of acquisition

Legend: Pos of soil org-Possession of soil organisms; Pro of soil org-Procurement of soil organisms; Col & sto of soil org-Collection & storage of soil organisms; Obt soil organisms-obtaining soil organisms.

The most acquired was rhizobia at 40.0% (12 out of 30) followed by mycorrhizae at 26.7% (8 out of 30). The process of acquisition of these organisms was both formal in some cases and informal in others (Question 22 of Appendix III) and this added to 30.0% (9 out of 30), those who had carried out the process informally made 10.0% (3 out of 30), formally only 20.0% (6 out of 30). 30.0% (9 out of 30) did not find this question applicable to them as it is normal routine to them and had not thought about it being formal or informal. Ten percent (3 out of 30) of the

respondents went ahead and were specific that a permit was obtained from KEPHIS before acquisition. Once acquired, such organisms were determined to be mainly used for research purposes (Question 23 of Appendix III) whose activities included inoculation, isolation, nutrient cycling, soil structure development and carbon sequestration. The other purpose was for identification and curation.

4.5.3.3 Commercialization of soil organisms

Question 24 of Appendix III sought to find out if scientists had engaged in buying and selling of soil organisms. Twenty percent (6 out of 30) of those interviewed had been involved in buying and selling of soil organisms. Prices were said to be determined (Question 25 of Appendix III) by the laboratory attendants carrying out the work. For instance, in the case of the University of Nairobi, the prices were determined by MIRCEN. Several factors were used to determine such prices and these included the cost of production and shipment. With regard to how future commercialization should be regulated, 50.0% proposed lead agencies (15 out of 30), 10.0%, individual institutions, 10.0% KEPHIS, 10.0% laboratory, 10.0%, manufacturers and 10.0% felt that, prices would be determined by demand.

For those who said that institutions should be the regulators of prices, their reasons were as follows: such institutions are capable of carrying out economic valuation and because they are also involved in research. Lead agencies' involvement was justified in that they can control production. On their part,

manufacturers would know the inputs and efforts put to attain the final product. Laboratories are the source of knowledge and know what it entails to do business. Question 29 was posed to determine the role of scientists in commercialization. Sixty percent (18 out of 30) responded as follows: identification of best biotypes, quality control, checking the quality of inoculum, establishing a sustainable utilization framework, sensitizing the farmers on the value of BGBD so that they are not short changed and training farmers on best practices to ensure maximized gains. Regarding the role of the farmer in commercialization (Question 30 of Appendix III), 50.0% (15 out of 30) felt that the farmer should receive benefits of the commercialization venture or be given some percentage of the proceeds. Twenty percent (6 out of 30) felt that the farmer needs to be empowered so that he/she can also participate in determining the prices and markets for such organisms. Thirty percent (9 out 30) were for the idea that the farmer should be left out because until a sample of soil taken from his farm is analyzed and found to have beneficial organisms, he cannot claim ownership since he did not know about it in the first place.

When collecting soil organisms, 80.0% of scientists are governed by professional ethics, 10.0% just do it informally while it did not apply to 10% since they do not do the collecting. In relation to what is done by various institutions, the role of scientists in such institutions stood at 40.0% for collection, 30.0% for collection,

identification and coding, 10% indicated other duties for example, ensuring proper storage for survival.

4.5.3.4 Scientists and Intellectual Property Rights

Concerning IPR issues, 33.0% of the scientists admitted that it has been addressed in their institutions. In response to how it arose, 80.0% commented that it is a new issue and so it has not been fully explored while 20.0% affirmed that it arose pursuant to the CBD. Forty percent of the scientists admitted that they had regulations in place that guide the sharing of benefits in regard to IPR. Ten percent further explained the issues that are addressed by IPR as: building a national repository for scientific reference while 10.0% outlined the issues addressed as follows: NEMA is in place to address issues of access to genetic resources, the National Council for Science and Technology (NCST) regulates permits while KEPHIS regulates certification. Eighty percent found this question not applicable.

In response to the Question, how can IPR be protected? 30.0%, said that there is a need to formulate an all inclusive policy, 10.0%, need to inform stakeholders, 10.0% IPR should address the origin of products not only markets, 10.0%, there is need for chartered research institutions, 10.0%, need to prepare property rights locally and internationally, 10.0%, need to recognize rights to ownership. The question was not applicable to 20.0% (Table 4.9)

Table 4. 9: Scientists' views on how IPR can be protected

How can IPR be protected	Number of scientists (total 30)	Percentages (%)
Through formulation of an all inclusive policy	9	30%
Through informing and involving stakeholders	3	10%
By IPR addressing the origin of products and not just the markets	3	10%
Through the formation of chartered IPR institutions	3	10%
Through preparation of property rights locally and internationally	3	10%
Through recognition of rights to ownership	3	10%
Question not applicable	6	20%

The role of farmers in BGBD was perceived as follows: 30.0%, they should be educated and then they can play a crucial role, 10.0% conservation of soil organisms, 10% custodians of BGBD on private land, 10.0%, they should carry out good farming practices to ensure diversity and abundance of soil organisms is maintained, 10%, should be owners of soil organisms within their farms, 30.0% found the question not applicable (Table 4.10).

Table 4. 10: Scientists opinions in regard to farmers' roles in BGBD conservation and utilization

Role of farmers in BGBD conservation as perceived by scientist	Number of scientists (out of a total of 30)	Percentages (%)
They should be educated and then they can play a crucial role	9	30
conservation of soil organisms,	3	10
Custodians of BGBD on private land,	3	10
They should carry out good farming practices to ensure diversity and abundance of soil organisms is maintained,	3	10
should be owners of soil organisms within their farms,	3	10%
Question not applicable	9	30%

90.0% felt that farmers should be recognized in issues of IPR and went ahead to outline this involvement as follows: 15 %, benefits and long-term conservation, 25%, educate them first on IPR issues, 10%, recognize indigenous knowledge, 50.0%, not applicable (Table 4.11).

Table 4. 11: Scientists' views in regard to recognition of farmers in issues of IPR

Scientists views	Number of scientists	Percentages (%)
Should be considered in terms of benefit sharing and long-term conservation	4	15
Educate them first on IPR issues	8	25
Recognize indigenous knowledge	3	10
Question not applicable	15	50%

4.6 Other BGBD issues worth attention

4.6.1 Pricing

About distribution of organisms after importation, 33.4% of the institutions that agreed they were exporting gave their distribution chain as through the government procedure and then to institutions. Sixty six point six were not

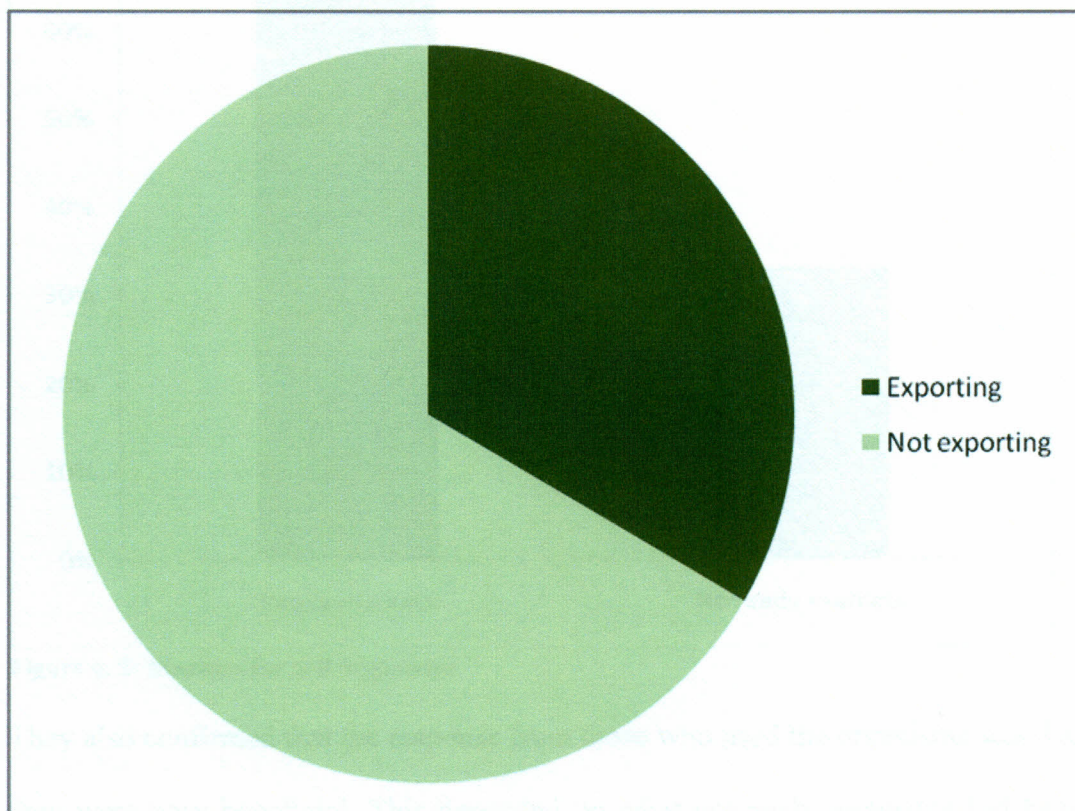


Figure 4. 7: Institutional involvement in exportation of soil organisms

exporting any soil organisms (fig 4.7).

66.7% of the institutions agreed that there were ready markets for soil organisms while 33.3% were not aware of such markets (fig 4.8). To expound on the market

issue, those that agreed to the existence of such markets said that they included research organizations, farmers and commercial tree growers.

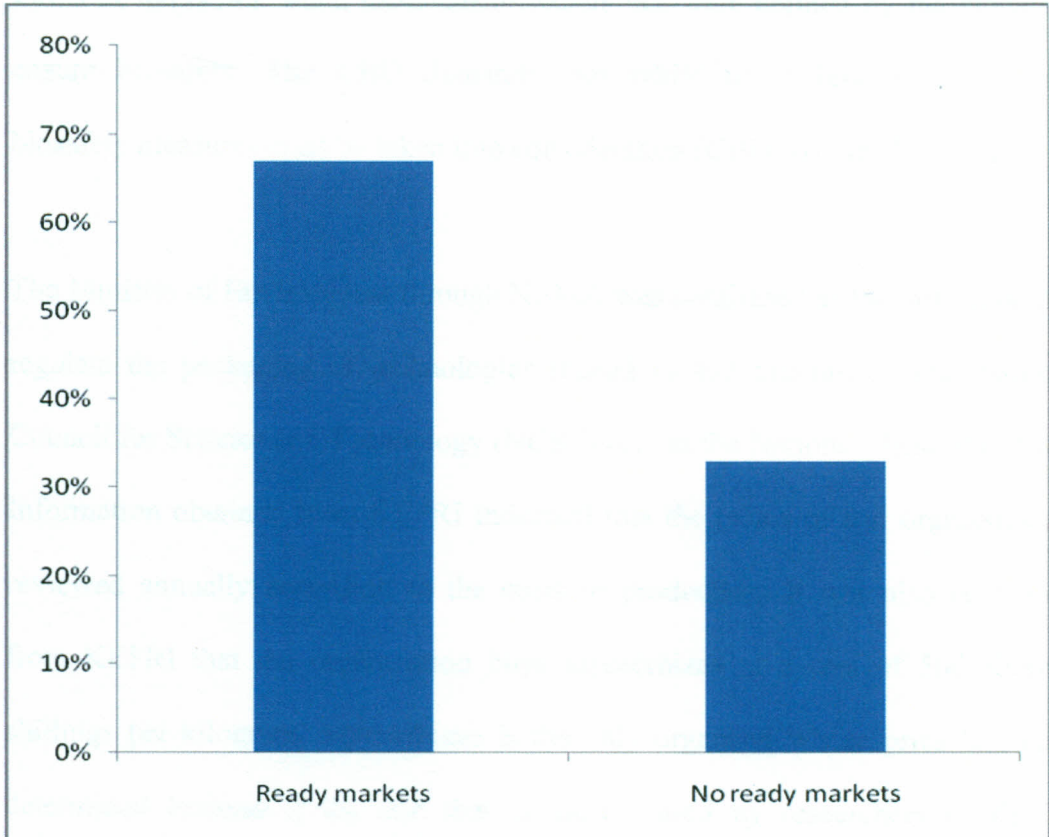


Figure 4. 8: Markets for soil organisms

They also confirmed that the response from those who used the organisms was that they were very beneficial. This depended on what use such organisms had been put into. For example, at KEFRI mycorrhizae was sold at five hundred Kenya shillings per kilogram to farmers who had established eucalyptus woodlots. This could be because mycorrhizal symbiosis enhances root functions and could therefore improve nutrient uptake by roots under low input systems as outlined by Jefwa *et al* (2004). Molecular techniques, soil fumigators, culturing and

multiplication and use of Ultraviolet light (can either be harmful or useful) were listed as the mechanisms/techniques used to monitor the use of soil organisms on farms or industries. Such mechanisms/techniques were applied by individuals to ensure biosafety. The CBD demands that while using biological resources biosafety measures must be taken into consideration (CBD Article 19 Section 3)

The Ministry of Environment through NEMA was confirmed as the institution that regulate the packaging of technologies related to soil organisms. The National Council for Science and Technology (NCST) acts as the National Biosafety office. Information obtained from KEFRI indicated that the prices of soil organisms are reviewed annually according to the costs of production. It was also confirmed from KEFRI that the organization buys mycorrhizae at a cost of 500 Kenyan shillings per kilogram. Mycorrhizae is the only organism whose price had been determined because it is the one that is mostly used by researchers in KEFRI particularly in eucalyptus plantations. Up scaling the technology, manufacturing and marketing or distribution are the major roles of the private sector in the trade of soil organisms. This implies that commercialization of soil organisms has not gained much ground in Kenya. The only institution that uses soil organisms commercially though indirectly is homegrown/dudutech. At homegrown there is mass production of fungi and insects that prey on other insects. Their main purpose is to reduce the use of chemicals to eradicate pests and diseases. For example, they use trichoderma to control fusarium. This encourages biological

control of pests thus reducing large amounts of build-ups of chemicals on the food crops. Chemical build-ups can be a source of terminal diseases like cancer. It also ensures reduced mutations of pests, since the use of chemicals always makes pests to mutate and become resistant to certain pesticides or herbicides while continuing to attack crops.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Findings and Conclusions

The first objective of this study was to examine the effects of land-use systems and intensities on abundance and diversity of below-ground biodiversity. This objective was to be achieved by referring to information in Meta data and interviews with farmers. Such data were found both in literature published, and in institutions. A lot more current information was obtained from work done through an ongoing project currently in Kenya and in six other tropical countries. Synthesis and analysis of results obtained from studies and publications in the countries and from interviews with farmers show that land-use systems and intensities affect the abundance and diversity of BGBD in Kenya.

The second objective of the study was to review policies relevant to BGBD and identify policy gaps and possible intervention mechanisms and means that could enhance equitable acquisition, conservation, utilization, commercialization, transfer and exchange of BGBD in Kenya. Such gaps were found to exist in the relevant policies that were reviewed and these included: the Agriculture Act, the Plant Protection Act, the Forest Act and the EMCA. As much as the Acts listed had sections that needed an inclusion of BGBD, none of them addressed BGBD

issues with specificity. Of most relevance was the EMCA which is considered as an umbrella environment Act. EMCA which was formulated in 1999 has been established to be a framework and not a complete Act but can address BGBD issues entirely if specific guidelines and regulations are formulated as stipulated in the Act. Such regulations can be formulated by the relevant organizations/lead agencies with the lead of NEMA.

The third objective of the study was to propose ways and means of introducing BGBD policies in Kenya such that they contribute to harmonized institutional arrangements, address farmers' interests and scientific benefits while also contributing to BGBD and ecosystem conservation. From the information obtained from the three groups of stakeholders (farmers, scientists and institutions dealing with genetic resources), it is clear that firstly, there is need to include all the key stakeholders in the process of policy formulation. This is because all have different and important stakes in BGBD issues. In this regard, the proposed ways and means include firstly, having prior informed consent of all the stakeholders involved when handling BGBD. Second, is the consideration of having incentive measures to ensure proper utilization and conservation of BGBD. Such incentive measures need to be outlined in a national policy document or in regulations formulated by relevant authorities. Third, is to have regulations specific to BGBD on equitable benefit sharing. Lastly, there should be guidelines stipulating the formulation of

MTAs and MAAs to ensure harmonized institutional arrangements in relation to transfer, exchanges, acquisition and commercialization of BGBD.

Likewise, issues dealing with IPR, custody, awareness creation and dissemination, and farmer involvement need to be included. In view of these observations the following section provides recommendations on possible areas for policy intervention that could make a difference in BGBD management, utilization, exchange, transfers, acquisition and conservation.

5.2 Recommendations

The recommendations are structured according to the research questions posed in chapter 1 of this thesis and are as outlined below:

5.2.1 BGBD and land-use

NEMA, the Ministry of Agriculture and all researchers doing research with farmers, should sensitize and educate them on the importance of BGBD and how land-use and land-use changes affect the proliferation and reduction of BGBD. They should also be educated on the need to practice farming systems that are productive and yet enhance the proliferation of BGBD.

5.2.2 Policy gaps and possible intervention mechanisms and means

5.2.2.1 Access to genetic resources and benefit sharing

Issues emanating from analysis included lack of knowledge on transfers and exchanges of BGBD as well as lack of knowledge on incentives and equitable benefit sharing. As a policy intervention, it is recommended that both KARI and the Ministry of Agriculture and livestock development increase their allocations to

research-extension-farmer linkages. Proper planning of the methods to be employed is necessary and this should be done together with the Ministry of Agriculture and Livestock development and farmers. The researchers should be trained to understand and accommodate farmers and extension staff to enhance communication. In regard to farmers training and education, efforts should be made to develop curricula for the various agricultural training institutions with the following aims: to train farmers on the importance of both below- and above-ground biodiversity and how they relate with each other; the importance of conserving BGBD; BGBD transfers and exchanges and the benefits that can be obtained from such transactions.

In regard to MTAs and MAAs as documents that aid transfers and exchanges, draft regulations have been approved that should be adhered to. It is therefore, the duty of any institution dealing with BGBD to be guided by these regulations in drafting their MTA's and MAAs. The National Council for Science and Technology should be the overseer of such a process while NEMA ensures regulation to avoid breaches.

From past experiences in Kenya, amendment of existing sectoral laws on natural resources takes a very long process. In order to give BGBD a specific schedule in the Kenyan policy and legal framework it is important that the framework proposed in this study be included in the approved regulations on access to genetic

resources and benefit sharing. These regulations are found in part V of the (conservation of biodiversity and biological resources, access to genetic resources and benefit sharing and the protection of environmentally significant areas) regulations, 2003.

5.2.2.2 Prior informed consent and Intellectual Property Rights (IPR)

Information obtained from this research shows that the Industrial source of the genetic material is given higher priority than the innovator of the material. This is a disadvantage particularly to the farmers because it disqualifies them from being potential IPR holders. It is recommended that in the revision of the Kenyan Industrial Property Act (Cap. 509), the innovator be included. It is also recommended that a section on IPR be included in the guidelines mentioned in 5.2.2.1 during revision. Such guidelines should stipulate the type and quality of genetic material in question; the role of each party involved in the innovation and the percentage benefits accrued to each party. NEMA should be the regulator, KIPRI to administer the industrial property rights and the NCST should set quotas.

5.2.2.3 Delay in approval and gazettelement of regulations

The Ministry of Environment should ensure that draft regulations are forwarded in time for approvals while the AGs office should quicken the redrafting process. The need for political will is core in this case. For instance regulations on land-use systems and agricultural intensification were formulated five years back by NEMA but have been approved recently hence a lot has changed since their formulation and are due for revision. Another hindrance is the fact that there is

monopoly by the AGs office and so it is not responsive to clients. The drafting department at the Attorney General's Chamber does not operate within a programme. This department has no strategic plan, no programme and hence responds to demand, that is, those who are in a position to exert pressure are served first. Such laxity delays the process of adoption and implementation by the relevant sectors.

5.2.3 Lack of policies

All sectors dealing with environmental issues in Kenya should ensure that policies are formulated prior to Acts of parliament. This is because policies outline objectives and how to achieve them while Acts are legislation that needs to be guided by policies. In cases of development as it is for BGBD, reference to Acts rather than policies would then be avoided. For instance prior to EMCA, the government had developed the National Biodiversity Strategy Action Plan (NBSAP). This was done without a policy document and as much as the NBSAP has policy statements, this would have been included in a full environment policy. It is important to note that an environment policy is currently being developed after the framework Act (EMCA of 1999) is already in place. A policy should always precede a strategy and an Act.

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APPENDICES

Appendix I: Biodiversity Conservation Institutional Questionnaire

Name of Interviewer _____

Name of Respondent _____

Institution _____

Location _____ Date _____

A. Genetic resources

1. What type of genetic resources does your institution deal with? Tick appropriately:

- i. Wild animals ()
 - ii. Wild Plants ()
 - iii. Livestock
 - iv. Crops
 - v. Soil organisms
 - vi. Others
-

2. Who uses them and for what?

3. If soil organisms, how many types do you import annually? Tick appropriately-
If not relevant proceed to section C

- i. One ()
 - ii. Two ()
 - iii. Three ()
 - iv. More(specify) _____
-

4. How many do you export annually? Tick appropriately

- i. One ()
 - ii. Two ()
 - iii. Three ()
 - iv. More(specify) _____
-

5. Are there any mechanisms put in place to check whether such organisms are pathogenic? Yes () No ()

6. (a) How are such organisms stored?

i. Gene bank ()

ii. Others

(b) How long are they stored?

i. Less than six months

(specify) _____

ii. Six months ()

iii. One year ()

iv. More than one year

(specify) _____

B. Pricing of soil organisms (If not relevant, proceed to section C)

7. (a) How are the organisms distributed once they are imported? Tick appropriately:

i. Through the government ()

ii. Through other institutions ()

iii. Other ways (specify)

(b) How are the organisms distributed once they are exported? Tick appropriately

i. Through the government ()

ii. Through other institutions ()

iii. Other ways (specify)

8. Is there a ready market for such organisms or related technologies? Yes ()

No ()

9. Which are these markets? Please specify

10. Which mechanism/instruments are used to monitor the use of soil organisms on farms or industry? Please Outline:

11. (a) What has been the response of those who have used these organisms?

Tick against the number:

Very Beneficial			Beneficial				Not beneficial	
9	8	7	6	5	4	3	2	1

(b) Explain your response in 11 (a) above

12. Who regulates the packaging of technologies related to soil organisms?

i. Lead agencies ()

ii. Government ()

iii. NEMA ()

iv. Others(specify) _____

13. What are the distribution quotas to each stakeholder? Please outline:

14. How are the accrued benefits shared? Indicate using percentage.

Government _____

Organization _____

Individual _____

15. (a) Are their prices fixed/controlled? Yes () No ()

(b) If yes, how are the prices set?

(c) What are the prices per Kilogram? Indicate in Kenya shillings.

16. What is the role of the private sector in the soil organism trade i.e. buying and selling?

17. How do you protect intellectual property rights (IPR)?

C. Rules and regulations governing collection, packaging, transfer and pricing of genetic resources.

18. Do you have any rules/regulations that govern the collection, packaging, transfer and pricing of genetic resources within Kenya? Yes () No ()

19. If No, in Question 18, why aren't there rules and regulations set yet?

20. If yes in Question 18, please specify the reference document/Act and year of enactment.

21. Who are the stakeholders and what are their specific roles?

22. Are you familiar with Material Transfer Agreements (MTA) and Material Acquisition Agreements (MAA)? Write your answer below:

a) Material Transfer Agreements

b) Material Acquisition Agreements

23. Who are the signatories to the agreements? Tick appropriately:

- i. Lead agencies only ()
- ii. Lead agencies and governments ()
- iii. Governments only ()
- iv. Private companies and lead agencies ()
- v. Private companies and governments ()
- vi. Others(specify)_____

24. From your answer in question 23 above, give the precise name of the institutions

25. Do you know of any institutions that have both agreements? Please specify
-
-
-
26. Assuming such MTA are the sole regulators for the importation of soil organisms/the specified genetic material, where are such organisms/material imported from?
-
-
-
27. Assuming such MTA are the sole regulators for the exportation of soil organisms/the specified genetic material, where are such organisms/material exported to?
-
-
-
28. Assuming such MAA are the sole regulators for the importation of soil organisms/the specified genetic material, where are such organisms/material imported from? _____
-
-
-
29. Assuming such MAA are the sole regulators for the exportation of soil organisms/ the specified genetic material, where are such organisms/material exported to? _____
-
-
-
30. What are the roles of or obligations of the receiving countries, organizations or individuals?
-
-
-
31. Have these roles been changed over the years? Yes () No ()
32. If yes, How?
-
-
-

33. What are the ideas for the coming years?

34. What are the roles of or obligations of the giving countries, organizations or individuals?

35. Have these roles been changed over the years? Yes () No ()

36. If yes, How?

37. What are the ideas for the coming years?

38. Apart from the MTA and MAA, which other agreements do you have in place?

- i.

- ii.

- iii.

39. What is the role of the local community, farmers and landowners in such agreements?

Category	Role
1. Local community	
2. Farmers	
3. Land owners	

40. Do they adequately cover benefits sharing? Yes () No ()

41. Explain your answer in question 40 above

42. Are you happy or satisfied with the agreements? Yes () No ()

43. In your opinion, what should be done to improve them?

D. Articles of the Convention on Biodiversity (CBD)

44. What article/s of the CBD is your institution mandated to implement? Please specify:

i. _____

ii. _____

iii. _____

45. Have you been able to implement it/them? Yes () No ()

46. If yes, how has the implementation process been? Tick appropriately below the numbers

i. Successful ()

9 8 7 6 5 4 3 2 1

ii. Not successful

9 8 7 6 5 4 3 2 1

47. Explain your answer to Question 46 above

48. Apart from your organization, which other institution or organization is mandated to carry out the same duties as yours?

i. _____

ii. _____

iii. _____

iv. _____

49. To what level do you collaborate with other organizations in implementing the CBD articles they/you are mandated to implement? Tick appropriately

i. Highly cooperate ()

ii. Little cooperation ()

iii. No cooperation ()

50. Which institutions do you collaborate with?

E. Policy

51. What (if any) existing policies at the local, national, or international level can you think of that could have impacts on Below-ground biodiversity (BGBD)?

Policy, regulation, or "recommended practices"	Effects	Possible improvements
1.		
2.		
3.		
4.		

52. If such policies do not exist now but were to be formulated, whom would you propose as the:

i. Regulator?

ii. Custodian?

iii. Target?

Why?

53. a) Do you think the coverage of biodiversity issues by EMCA is sufficient for soil biodiversity? Yes () No ()

b) Explain your response in 53 a) above

54. Give your suggestions for improvement?

55. a) Do you think there's need to formulate a holistic soil biodiversity policy in Kenya? Yes () No ()

b) Explain your response in question 55 (a) above

Appendix II: Questionnaire for farmers

Name of Interviewer _____ Sex _____

Age _____

Name of Respondent _____ Level of education _____

District _____

Region _____

Date _____

A) Existence

1. Do you know that there are different organisms in the soil? Yes () No ()
2. What types of soil organisms are you aware of?

Degree of usefulness to farmers (tick the most appropriate)

Organism	What role(s)?	Mostly helpful?	Least helpful
		9 8 7 6 5 4 3 2 1	9 8 7 6 5 4 3 2 1

3. What types of pests and diseases are you aware of that are soil-based or that rely on the soil for part of their life cycle?

4. Give a rating of the roles of soil organisms in your farm by ticking where appropriate.

9 8 7 6 5 4 3 2 1

Nutrient cycling

Disease and pest control

Improvement of crop yields

Soil structure improvement

Composting

Bioturbation

5. Can you relate any of these functions to specific soil organisms?

B) Relevance

6. In which way are soil organisms important to you?

7. What types of questions would you want soil organisms' research to address?

C) Management

8. Are there any ways that you know of that you can:

- i. Increase the effects of the beneficial organisms? Yes () No ()
- ii. If yes, which ones and how?

- iii. Reduce the effects of the harmful organisms? Yes () No ()
- iv. If yes, which ones and how?

9. Do you use any sprays on the harmful ones? Yes () No ()

10. If yes, what types of sprays do you use for which particular ones? Fill in the table below:

Type of Soil Organism	Type of herbicide/ pesticide/biocide
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	

11. Have you been managing to get rid of them with spraying? Yes () No ()

12. During what seasons have you seen various types of organisms? Tick appropriately:

- i. Wet season ()
- ii. Dry season ()

13. What type of farming activity are you carrying out now?

14. What type of farming activity have you carried out in the last:

- i. 2 years? _____
- ii. 5 years? _____
- iii. 10 years? _____
- iv. over 10 years? _____

15. Have the types of organisms changed over time during your different farming practices? Yes () No () If yes, which one? Specify:

16. Do you think there is need for government /policy intervention in the utilization of BGBD? Yes () No () If yes, what kind of intervention?

17. What role would you play in maintaining and conserving the soil organisms? _____

18. Would you require any protection from the government or other facilitation quarters to do this? Yes () No ()

19. Which type of protection?

20. Do you think you should be given incentives for this? Yes () No ()
Which incentives? _____

21. Do you feel you own the soil organisms in your farm? Or do they belong elsewhere?

D. Transfer, Exchange, acquisition and commercialization.

22. Do you know that soil organisms can be used in trade if properly identified for type and function in the soil? Yes () No ()

23. What do you understand by transfer of soil organism? _____

24. Do you know of any transfers of soil organisms that have been done from your farm or any other place in the village? Yes () No ()

i. Where were the organisms transferred from?

ii. Where were they taken to?

iii. What types were they?

iv. Did the farmer get any benefits? Yes () No ()

v. What type of Benefits?

25. If such transfers are to continue being made, what do you think should be the role of the farmer?

26. What should the farmer be given as benefits?

27. Who should determine such benefits?

28. In case of a disagreement between the farmer and the person picking up the organisms for commercial use, who should be the intervening party?

29. What do you understand by the word exchange?

30. Has any exchange taken place on your farm or in the village?

31. What types of organisms was/ were exchanged?

32. Were they exchanged with other organisms Yes () No ()

33. If yes, which ones?

34. Were they exchanged with other materials? Yes () No ()

35. If yes, which ones? _____

36. Who determined the exchange material and the quantity?

37. Do you think it was a fair process? Yes () No ()

38. Explain your response in 37 above

39. What is your opinion about such exchanges for the future?

40. Who do you think should be the regulator?

41. In case of disagreements or unfairness, whom do you think the offended person should approach?

42. In case of illegal acquisition without the farmer's consent, how should the aggrieved party go about it?

43. How should the farmer be compensated if he/she is at a loss or if the organisms found in the respective farm is of commercial value?

Appendix III: Questionnaire for scientists dealing with biodiversity

Name of interviewer Celine Achieng'
 Name of respondent Institution
 Job title/profession Date

A. Research in soil organisms/micro-organisms

1. Have you participated in any research involving soil organisms Yes () No ()
Tick appropriately
2. If yes, which soil organisms?

3. Have you participated in any research involving soil micro-organisms? Yes ()
No ()
4. If yes, which soil micro-organisms?

5. Which of these were the organisms mentioned in question and/or 4 above used for specifically?
 - i. Nutrient cycling
 - ii. Vermin-composting
 - iii. Organic matter conversion
 - iv. Soil structure modification
 - v. Green-house gas regulation
 - vi. Pharmaceuticals
 - vii. Bio-pest management
 - viii. Others (specify)

B. Transfer, exchange, acquisition and commercialization of soil organisms.

6. Are you aware of nay transfers of soil organisms that have taken place in your institution or elsewhere in the country? Yes () No () Tick appropriately.
7. If yes, how did it take place and from which place? Please outline:

8. Are you aware of any exchanges of soil organisms that have taken place in your institution or elsewhere in the country? Yes () No () Tick appropriately.
9. If yes in question 8 above, how did it take place and between who and who? Please outline:
- _____
- _____
- _____
10. Have you as an individual transferred soil organisms from one place to another? Yes () No () Tick appropriately
11. If yes in question 10, from which place? Kindly outline:
- _____
- _____
- _____
12. What kind/species of soil organisms did you transfer?
- _____
- _____
13. What was the reason for transfer?
- _____
- _____
14. Have you as an individual exchanged soil organisms? Yes () No ()
15. If yes in question 14, with whom did you exchange? Kindly outline:
- _____
- _____
- _____
16. What kind of organisms did you exchange?
- _____
- _____
17. What was the purpose of the exchange?
- _____
18. What do you understand by the term acquisition of soil organisms? Please explain:
- _____
- _____
19. Have you as an individual acquired any soil organisms? Yes () No () Tick appropriately.
20. If yes, in question 19, which ones?
- _____
- _____

21. How did you acquire them? Kindly outline the procedure/process.

22. Were there any formalities involved in this process of acquisition or it was an informal process?

23. What did you use the organisms for after acquisition?

24. Have you been involved in any selling or buying of soil organisms? Yes () No ()
Tick appropriately

25. If yes, in question 24, who determined the prices?

26. How were such prices determined by the party mentioned in question 25? Please explain

27. In case commercialization of soil organisms is to take place legally in future in Kenya, who do think should regulate the prices?

28. Explain your answer in question 27.

29. What do you think would be your role as a scientist in the process of commercialization?

30. What about the farmer in whose farm such organisms are obtained?

C. Intellectual Property Rights (IPR)

31. What governs you as a scientist when collecting soil organisms? Is it professional ethics, or something else? Please specify:
-
-
32. What is your role as a scientist in relationship to what your institution does as regards soil micro-organisms?
- i. Is it collection
 - ii. Is it identification
 - iii. Is it coding
 - iv. All the above
 - v. Other(specify) _____
33. How do you perceive institutions in regard to handling of soil organisms?
-
-
34. Has the issue of IPR between your institution and scientists involved in the institutions activities been addressed? Yes () No ()
35. If yes, in question 34, how did it arise? Please specify.
-
-
36. Do you have any regulations in place that guide the sharing of benefits in regard to IPR? Yes () No ()
37. If yes in question 36, what do they address? Please specify:
-
-
-
38. In your own opinion, how do you think IPR can be protected? Please outline:
-
-
39. What do you think is the role of the farmer in regard to conservation of BGBD?
-
-
40. Do you think farmers should be considered in issues of IPR? Yes () No ()
41. If yes in question 40, in what way?
-
-

42. In your opinion if any scientist were to apply an IPR on any scientific discovery on soil organisms, who are the parties you would include in the IPR application and how would you reward the benefits in percentages?

i. List the parties to be included

ii. List benefits in percentages.

Appendix IV: Interview questions for key informants

1. In your opinion, would you recommend a comprehensive legislation with the approval of Kenya's parliamentary body for the conservation of soil organisms/ below ground biodiversity? Yes/ No. Choose appropriately.
2. (a) If Yes in question 1, why? Please explain

b) If No in question 1, why? Please explain

3. What is your opinion about Kenya amending the existing sectoral laws to include provisions for soil organisms/belowground biodiversity?

4. If these amendments are to be done which sectoral laws would you advice that belowground biodiversity be part of? Which section of such law?

	Sectoral law	Section
a)		
b)		
c)		
d)		

5. Who would be the regulator?

6. Who would be the custodian?

7. What is your opinion about adopting a gradualistic approach where a general law or policy is established, with the expectation that it will be followed by a more detailed legislation?

8. What is your opinion about individual contracts between providers and collectors of soil organisms through ad hoc state supervision and monitoring?

9. What do you think are the relevant sectors of government and society that need to address the issue of below ground biodiversity? And how?

Sector

How?

10. If a below ground biodiversity policy framework is established, what institutional processes and capacities would be sufficient to implement it? Kindly outline.

11. Do you think the capacity for microbial prospecting raises a significant issue of Intellectual Property Rights (IPR) concerning ownership of soil organisms discovered in Kenya? Yes/No. Tick appropriately.

12. If yes in question 10, how?

13. If no in question 10, why?

Appendix V: Status of implementation of the articles of CBD that are relevant to BGBD

All signatories to the CBD are supposed to submit national reports to the Conference of the Parties (CoP) to the CBD on the implementation of the convention. Kenya being a signatory submitted its third report in 2005 through NEMA. In this report, the following were outlined as the status of implementation of the CBD articles relevant to BGBD. This section therefore, contains the status of biodiversity conservation as presented in this national report of the year 2005:

Article 6-General measures for conservation and sustainable use

Kenya has not put in place effective national strategies, plans and programmes to provide a national framework for implementing the three objectives of the Convention. This is a failure on Kenya's part, being a signatory to the Convention. Such a process should be guided by NEMA though NEMA lacks the adequate capacity to do so, especially funding. This has resulted in NEMA being unable to revise the EMCA which is a framework for biodiversity conservation. Kenya has not also put any measurable targets within its national strategies and action plans though there is a plan to revise the NBSAP to include indicators and targets. The process of identification of priority actions in its national biodiversity strategy and action plan is not complete. This is a requirement by decision VI/27A of the CBD. There is also no integration of the conservation and sustainable use of biodiversity as well as benefit sharing into relevant sectoral or cross-sectoral plans, programmes and policies. The element of benefit sharing is not very strong in national documents and therefore, needs to be strengthened (Kenya's third national report to the CBD). Regulations of benefits' sharing have recently been gazetted and BGBD issues can be mainstreamed into these regulations.

Article 8: In situ conservation

In regard to Article 8 (i) on whether Kenya has endeavoured to provide the conditions needed for compatibility between present uses and the conservation of biodiversity and sustainable use of its components, the following was reported: The Government is currently developing a land use policy that will address most of the land use conflicts such as between conservation and other uses. The enactment of EMCA ensures that unsustainable use of resources is contained: penalties are provided for environmental degradation. There is an enhanced campaign by NEMA, other government bodies and NGOs for environmental education, which also encompasses the use of biological resources. BGBD being a

biological resource would benefit from such efforts through farmers being educated on how to handle BGBD issues.

The promotion of indigenous knowledge systems that are compatible with conservation and sustainable use of resources is being promoted as a strategy by the locals to manage their own resources based on what they know already (Kenya's third National Report to the CBD) . In regard to this research, farmers already have traditional knowledge of BGBD and if this is promoted coupled with environmental education and new developments on BGBD: farmer awareness and knowledge of BGBD would be enhanced.

There is also a concerted effort by the Government towards cost and benefit sharing as a strategy to manage the biological resources. This effort would guide all stakeholders involved in BGBD conservation and utilization in determining what benefits and incentives each of them is entitled to. The practice of equitable benefit sharing if adopted would ensure fair play in BGBD thus enhancing proper utilization and conservation of the same particularly with farmers.

In regard to Article 8 (k) on whether Kenya has developed or maintained the necessary legislation and/or other regulatory provisions for the protection of threatened species and populations, the response is as follows: The Government has enacted EMCA and regulations, which is supposed to ensure the protection of threatened species and populations. BGBD may be considered as threatened because some species have been determined to reduce in number in relation to the land-use being practiced as well as agricultural intensification. It is therefore, important that institutions dealing with BGBD adopt the available regulations to protect BGBD.

Individual government organizations tasked with dealing with sectoral aspects of biodiversity, e.g., Kenya Forest Service, KWS, marine organizations, etc.; are specifically monitoring species and populations. The lead agencies in species conservation have also put in place some administrative measures to safeguard the species and populations under threat, such as regulation of exploitation, controlled use, and fencing. The country is signatory to relevant international and regional agreements aimed at protecting species and populations.

In this regard, stakeholders in BGBD should champion for BGBD to be considered as a population under threat so that specific administrative measures are set to safeguard it.

In regard to Article 8 (l) on whether Kenya regulates or manages processes and categories of activities identified under Article 7 as having significant adverse effects on biodiversity, the following response is given by NEMA:

The Government, through relevant lead agencies constantly monitors various ecosystems for activities that would impact on the biodiversity of these ecosystems. The Department of Resource Surveys and Remote Sensing (DRSRS) monitors land use cover changes in various habitats, habitat changes within various habitats, livestock/wildlife population trends. Changes in populations of wildlife and livestock, for instance, may be used as indicators of habitat changes in the respective areas. As much as monitoring of land use cover changes is done, it is biased towards above-ground biodiversity hence overlooking BGBD. It is therefore, a challenge to BGBD stakeholders to participate in fora that enable them to table their results on how land-use change affects BGBD diversity and abundance. This will ensure that changes in populations of BGBD are also incorporated as an indicator of habitat change since most of the time such analysis is biased towards above-ground biodiversity.

Article 10: Sustainable use of components of biodiversity

In consideration of Article 10(a), Kenya has integrated consideration of the conservation and sustainable use of biological resources into decision-making in some relevant sectors. There are several initiatives for the promotion of sustainable use and conservation of biodiversity including draft regulations on conservation, access and benefit sharing that has incorporated aspects of sustainable use. BGBD needs to be given a specific schedule in one of the relevant sectors which could be agriculture.

On Article 10 (b); Kenya has adopted measures relating to the use of biological resources that avoid or minimize adverse impacts on biodiversity. Such measures include: programmes and projects developed on conservation of biodiversity in major ecosystems such as conservation and sustainable use of biodiversity in Kakamega forest, Arabuko Sokoke, and fisheries resources in Lake Naivasha. The limitation here is that only the above-ground and larger biodiversity is considered while BGBD is excluded. It is important that BGBD be allocated to specific projects particularly in BGBD hot-spots such as the sites identified in Embu District and Taita District by the Kenya BGBD team.

On Article 10 (d), Kenya has put in place measures that help local populations develop and implement remedial action in degraded areas where biodiversity has been reduced. The EMCA and the forest Act have provisions for the rehabilitation of degraded areas but there is no mention of any incentives that would be given to such locals for motivation.

On incentive measures, Kenya has identified indicators and incentive measures for sectors relevant to the conservation and sustainable use of biodiversity. This is as stipulated by decision V/24. For instance, the Biodiversity Indicators for National Use (BINU) project has developed indicators for wetlands. Kenya has implemented sustainable use practices, programmes and policies for the

sustainable use of biodiversity, especially in pursuit of poverty alleviation (decision V/24). Examples are the butterfly farming being promoted in several ecosystems in the country. There are also programmes on community conservation and closed seasons in fishing and Ecotourism programmes. In this regard, BGBD should also be given the same specific attention because it alleviates poverty by ensuring soil fertility. BGBD farming, for instance, mass production of earthworms and other beneficial organisms to be used for agricultural purposes should be promoted.

Mechanisms to involve the private sector in initiatives on sustainable use of biodiversity are being developed. Several private companies are already involved in processing and sale of biodiversity derived products hence the need to involve them. An example of a company that uses micro-organisms as biological agents in pest control other than chemical herbicides is Homegrown Company in Kenya.

Article 11-Incentive measures

Kenya has established programmes to identify and adopt economically and socially sound measures that act as incentives for the conservation and sustainable use of components of biodiversity. These include programmes implemented by Kenya Forest Service (KFS), Kenya Wildlife Service (KWS) and in the management of wetlands in the country. Incentive measures are designed through empowerment of stakeholders and incorporating factors such as transparency, participation, inclusion and ownership of biodiversity resources. Selecting and designing appropriate incentive measures and taking into consideration the complexity of design methodologies, political, social, cultural and economic parameters are also being examined. BGBD being important as it were needs also to be allocated economically and socially sound incentive measures that are implemented by an institution that can handle a broad spectrum of BGBD issues, for example the Ministry of Agriculture. Alternatively, various aspects of BGBD can be handled separately by different institutions with different mandates. For example, in regard to quotas, the NCST could handle it and certification could be done by KEPHIS while IPR could be handled by KIPRI.

Kenya has developed the mechanisms or approaches to ensure adequate incorporation of both market and non-market values of biodiversity into relevant plans, policies and programmes and other relevant areas (decision III/18 and IV/10). Although the mechanisms are new and are continuously being developed, their focus is on approaches which integrate social impacts of development and environmental economic valuation. The aspect of commercialization of BGBD can be guided by such mechanisms or approaches by first, all the stakeholders in BGBD holding a forum to discuss how these mechanisms apply to the sector and secondly by developing specific mechanisms that will guide BGBD commercialization.

Article 17-Exchange of Information

The only reporting on this article as per the third CBD report is that Kenya has measures in place to facilitate the exchange of information from publicly available sources with a view to assist with the implementation of the Convention and promote technical and scientific cooperation. However, such measures have not been outlined and elaborated on hence making this section deficient.

In view of this research and in relevance to this article, Lead agencies in biodiversity conservation together with NEMA should be champions in ensuring that there is proper information dissemination to all parties involved. The government should avail policies and legislation at a reasonable cost so that many of the stakeholders particularly in BGBD can purchase them and get informed. This is because most of the policies and laws are sold at a high cost by the government press and is not easily affordable especially by students. It is also important to avail such information in languages that the local communities can easily understand.

The government bodies concerned with farmer education for example, the Ministry of Agriculture and the Ministry of Environment should develop a programme of educating farmers on policies and legislation. Institutions of research and development should also have exchange programmes where they educate each other on the available information and new developments.