COUNTRY REPORT ON THE STATE OF PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

KENYA

THE STATE OF PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE IN KENYA

Compiled by:

Wambugu P.W. and Muthamia Z.K
Kenya Agricultural Research Institute, National Genebank of Kenya
P.O. Box 30148, NAIROBI, Email:ngbk@wananchi.com

SUBMITTED TO FAO COMMISSION ON PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

JULY 2009

Note by FAO

This Country Report has been prepared by the national authorities in the context of the preparatory process for the Second Report on the State of World's Plant Genetic Resources for Food and Agriculture.

The Report is being made available by the Food and Agriculture Organization of the United Nations (FAO) as requested by the Commission on Genetic Resources for Food and Agriculture. However, the report is solely the responsibility of the national authorities. The information in this report has not been verified by FAO, and the opinions expressed do not necessarily represent the views or policy of FAO.

The designations employed and the presentation of material in this information product do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal or development status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The mention of specific companies or products of manufacturers, whether or not these have been patented, does not imply that these have been endorsed or recommended by FAO in preference to others of a similar nature that are not mentioned. The views expressed in this information product are those of the author(s) and do not necessarily reflect the views of FAO.

CONTENTS

PREFACE 9

EXECUTIVE SUMMARY 10

ACKNOWLEDGMENTS 13

ABBREVIATIONS AND ACRONYMS 14

INTRODUCTION 16

1.1 Geographic position 16
1.2 Socio-economic information 16
1.3 Agricultural sector in Kenya 16
1.3.1 Importance of agriculture 16
1.3.2 Constraints facing the agricultural sector 17

CHAPTER 1
THE STATE OF DIVERSITY 19

2.1 Introduction 19
2.2 Important crops 19
2.3 Diversity within and between crops and plants 20
2.3.1 Diversity within and between major crops 21
2.3.1.1 Cereals 21
2.3.1.2 Pulses 21
2.3.2 Diversity within and between minor crops 21
2.3.2.1 Cereals 21
2.3.2.2 Pulses 21
2.3.2.3 Fibre crops 22
2.3.2.4 Root and Tuber crops 22
2.3.2.5 Grasses and Forage species 22
2.3.3 Underutilized/underexploited species 22
2.3.3.1 Root and tuber crops 22
2.3.3.2 Traditional/local vegetables 23
2.3.3.3 Medicinal plants 23
2.3.3.4 Oil crops 24
2.3.4 Pulse crops 24
2.3.5 Wild species 24
2.4 Factors influencing the state of plant genetic diversity 24
2.5 Genetic erosion 25
2.5.1 Causes of genetic erosion 25
2.5.2 Monitoring genetic erosion 25
2.6 Assessment of major gaps, needs and priorities 25

CHAPTER 2
THE STATE OF *IN SITU* MANAGEMENT **26**

3.1 Introduction 26
3.2 Institutions involved on *in situ* conservation 26
3.3 Inventorying and surveying 26
3.4 On-farm conservation 27
3.5 Restoring agricultural systems after disaster 29
3.6 Assessment of major needs for *in situ* conservation and the on-farm management of PGRFA 29

CHAPTER 3
THE STATE OF *EX SITU* MANAGEMENT **30**

4.1 Introduction 30
4.2 Germplasm conservation facilities 30
4.2.1 Kenya Agricultural Research Institute 30
4.2.2 National Museums of Kenya 31
4.2.3 Kenya Forestry Research Institute 31
4.3 Germplasm holdings at the National Genebank of Kenya 31
4.4 Germplasm collection 32
4.4.1 Planned and targeted collection 32
4.4.2 International arrangements and networks in PGR collection 33
4.5 Documentation 33
4.6 Research 33
4.7 Field genebanks 33
4.8 Botanical and home gardens 34
4.9 Duplication 34
4.10 Regeneration 35
4.11 Assessment of major *ex situ* needs 35

CHAPTER 4
THE STATE OF USE **37**

5.1 Introduction 37
5.2 Distribution and use of plant genetic resources 37
5.3 Characterization and evaluation 38
5.4 Crop improvement programmes 39
5.4.1 Type of programme and institutions involved 39
5.4.2 Crops and traits 40
5.4.3 Farmer participation 40
5.5 Seed supply systems 40
5.5.1 Formal seed sector 41
5.5.2 Informal seed sector 41
5.5.3 Role of local seed markets 41
5.6 Assessment of major gaps, needs and priorities 42

CHAPTER 5
THE STATE OF NATIONAL PROGRAMMES, TRAINING AND LEGISLATION **43**

6.1 Introduction 43
6.2 Structure of Kenya's National Plant Genetic Resources Programme 43
6.3 Functions of the PGR programme 43
6.4 Coordination of National PGR programme 43

6.5 Education and training 44
6.6 Information systems 45
6.7 National legislation 45
6.7.1 The environmental management and coordination act, 1999 45
6.7.2 The industrial property act, 2001 45
6.7.3 The statute miscellaneous amendment act, 2000 46
6.7.4 The national biotechnology development policy, 2006 46
6.7.5 The seeds and plant varieties (national performance trials) regulations, 2009 46
6.7.6 Environmental management and co-ordination (conservation of biological diversity and resources, access to genetic resources and benefit sharing) regulations, 2006 46
6.7.7 National Biodiversity Strategy and Action Plan (NBSAP) 47
6.7.8 National bio-safety framework and regulation 47
6.7.9 Protection of traditional knowledge, genetic resources and folklore 47
6.8 Assessment of major gaps, needs and priorities 47

CHAPTER 6
THE STATE OF REGIONAL AND INTERNATIONAL COLLABORATION 48

7.1 Introduction 48
7.2 International networks 48
7.3 International and Regional Fora, Partnerships and Associations 49
7.4 International Non Governmental Organizations (NGO) and Civil Society Organizations (CSO) 50
7.5 International Funding Mechanisms 50
7.6 International agreements 50
7.7 Assessment of major gaps, needs and priorities 50

CHAPTER 7
ACCESS TO PLANT GENETIC RESOURCES 52

8.1 Introduction 52
8.2 Development of access and benefit-sharing regulations 52
8.3 National implementation of access and benefit-sharing arrangements 53
8.3.1 General approaches 53
8.3.2 Benefit sharing arrangements 53
8.3.3 Protection of traditional knowledge, genetic resources and folklore 53
8.4 Challenges in the development and implementation of access and benefit sharing regulations 54
8.5 Access to PGRFA under the International Treaty on Plant Genetic Resources (ITPGRFA) 54
8.6 Farmers' privileges and rights 55
8.7 Assessment of major gaps, needs and priorities 55

CHAPTER 8
THE CONTRIBUTION OF PGRFA MANAGEMENT TO FOOD SECURITY AND SUSTAINABLE DEVELOPMENT 56

9.1 Introduction 56
9.2 Climate change and environmental stability 56
9.3 Food Security 57
9.4 Health 58
9.5 Bio-fuel production 58

ANNEX 1
MAP OF KENYA **59**

ANNEX 2
PARTICIPATING STAKEHOLDERS **60**

LIST OF CONTRIBUTORS

The production of this report was made possible by the invaluable inputs of the Members of the Steering Committee of the National Information Sharing Mechanism on Plant Genetic Resources for Food and Agriculture whose names appear below.

NAME	INSTITUTION
Mr. P.W. Wambugu	KARI – National Genebank of Kenya
Mr. Z.K. Muthamia	KARI – National Genebank of Kenya
Mr. H. Kamau	Bioversity International – SSA Regional Office, Nairobi
Mr. P. Ochieng	Ministry of Agriculture (MoA)
Mr. P. Muthoka	National Museums of Kenya (NMK)
Mr. P. Mungai	Kenya Wildlife Service (KWS)
Mr. M. Wanyiri	Kenya Forest Service (KFS)
Dr. E. Chagala-Odera	Kenya Forestry Research Institute (KEFRI)
Dr. W. Omondi	Kenya Forestry Research Institute (KEFRI
Mr. P. Ndonye	National Environmental Management Authority (NEMA)
Mr. M. Makokha	FAO – Kenya

PREFACE

This country report is a product of a highly consultative, participatory and interactive process on the National Information Sharing Mechanism on Plant Genetic Resources for Food and Agriculture (PGRFA). In Kenya, the process started in 2003 when Kenya Agricultural Research Institute (KARI) spearheaded the pilot phase of the FAO/IPGRI-led participatory approach for country-level monitoring of the implementation of the Global Plan of Action (GPA) on PGRFA. This new approach ensures direct participation of relevant stakeholders in providing and exchanging country-level PGRFA conservation and use information.

During the pilot phase, a total of 10 stakeholders were involved in information gathering and sharing. In 2006, KARI acquired financial support from FAO the Netherlands Programme on Agro-biodiversity (FNPP) to strengthen the already established PGRFA information sharing mechanism in the country. This current phase was geared towards expanding the number of stakeholders to be involved in providing and exchanging information as well as generating a strategic country status report on GPA implementation and PGRFA conservation and use. In order to guide the process, a 10-member steering committee of key stakeholder institutions was established. Kenya Agricultural Research Institute (KARI), and by delegation, the National Genebank of Kenya which is the designated National Focal Point (NFP) for implementing and monitoring the GPA, coordinated the process.

A total of 30 national stakeholders who provided very vital information and data were engaged in the production of this report. The information they provided was later used by the national steering committee to produce this report based on FAO guidelines. The report is a strategic analysis on the state of use, conservation and general management of PGRFA in Kenya. It has been submitted to the FAO Commission on Plant Genetic Resources for Food and Agriculture as an official government document.

EXECUTIVE SUMMARY

Agriculture is the mainstay of Kenya's economy and the growth of the sector is crucial to the country's overall economic and social development. The sector directly contributes about 26% of Gross Domestic Product (GDP) and a further 27% through linkages with manufacturing, distribution and service related sectors. However, over the past decade, the performance of the sector has been far from satisfactory with agricultural growth rate lagging behind the population growth rate. This trend has led to increased incidences of food insecurity, raised poverty levels, declining incomes, loss of employment and a shift from self-sufficiency to reliance on importation and food aid. Kenya's average poverty level exceeds the 50% population mark. The causes of poverty and food insecurity in Kenya include low agricultural productivity, inadequate access to productive assets (land and capital), inadequate infrastructure, limited marketing opportunities, high population pressure on land, inadequate access to appropriate technologies by farmers, effects of global trade and slow institutional and sectoral reform process.

Kenya has a rich plant diversity held by a range of habitats. According to International Union for Conservation of Nature, there is an estimated total of 7 500 plant species growing naturally in the country. Of these, about 475 are national endemics while 258 are threatened. The main food crops in Kenya are maize (*Zea mays*), wheat (*Triticum aestivum)*, beans (*Phaseolus vulgaris)*, peas (*Pisum sativum*), bananas (*Musa* spp.) and potatoes (*Solanum tuberosum*). Maize (*Zea mays*) is the principal staple food of Kenya and it is grown in 90 per cent of all Kenyan farms. Common bean (*Phaseolus vulgaris)* is the most important legume in Kenya. The main agricultural export products from Kenya are tea (*Camellia sinensis)*, coffee (*Coffea arabica*), pyrethrum (*Chrysanthemum cinerariifolium)*, sisal (*Agave sisalana)* and horticultural products (fruits, vegetables and floricultural crops). Based on the number of released varieties, maize (*Zea mays*) has the highest diversity of modern varieties, followed by tea (*Camellia sinensis)*, pyrethrum (*Chrysanthemum cinerariifolium)*, common beans (*Phaseolus vulgaris)* and sorghum (*Sorghum bicolor)*.

The diversity of plant genetic resources (PGR), like diversities of other life forms in Kenya has since the recent past been on the decline due to genetic erosion brought about mainly by desertification, population pressure on land, changes in land use, over-exploitation, drought, floods and negative agricultural development policies. Although no comprehensive study has been undertaken to quantify the level of genetic erosion, reports indicate that over the last decade, a lot of genetic erosion has taken place mainly due to replacement of traditional varieties and other socio-economic factors. *In situ* and on-farm conservation instruments have unfortunately not been fully utilized to enable the conservation of existing diversity. For instance, human population increases and subsequent increase in demand for plant-based products and land for settlement and farming continues to threaten wild flora thereby rendering these conservation strategies ineffective. Adoption of elite varieties of the main crops has led to a decline in crop diversity of especially traditional varieties although a significant number of them have been captured in *ex situ* conservation facilities. Some of the traditional varieties that are reported to have disappeared include *githigu,* which was a very popular traditional maize variety in central Kenya. Some important wild species that have been used as leafy vegetables and which are rare in their natural habitats include *Erythrococa atroviriens, Basella alba, Crotalaria ochroleuca and C. brevidens.* The main neglected and underutilized crops in the country have been identified as *Sesamum indicum*, *Vigna subterranea*, *Dioscorea* spp. and taro (*Colocasia esculenta)*. Others include various medicinal plants.

Ex situ and *in situ* conservation initiatives in Kenya are undertaken by such institutions as Kenya Agricultural Research Institute, National Museums of Kenya, Kenya Forestry Research Institute, public universities, Kenya Forest Service and to a small extent, various private organizations. Ex situ conservation involves use of such specialized facilities as cold stores or chest freezers. Alternatively, materials may also be conserved in the field, botanic gardens or arboreta as living collections

The National Genebank of Kenya is the only long- term seed conservation facility in the country. Besides, there are at least 14 germplasm repositories in the country with seed storage facilities majority of these genebanks having short-term to medium-term and short- term storage capacity. In addition, the country has two field crop genebanks and several botanic gardens and arboreta At the National Genebank, effective management and enhanced use of the existing ex situ collections are hampered by various constraints. The inadequate scientific knowledge on seed storage behaviour of some wild species, shortage of scientific staff with specialised training in various core disciplines on genebanking, inadequate capacity to regenerate stored germplasm to raise viability levels and adequate sample sizes are some of the identified constraints. Others include inadequate information on the diversity and potential value of the conserved

germplasm, lack of information on appropriate seed testing protocols and limited capacity to conduct seed germination tests.

While some efforts are being made to address these constraints, it is imperative that Kenya strengthen its technical and physical capacity both at the National Genebank and other collaborating national institutions if a vibrant NPGR programme is to be assured. Some specific disciplines that need strengthening are plant taxonomy, plant health, information technology including Geographical Information Systems (GIS) and biotechnology. Other areas that require attention include the expansion of the conservation infrastructure, establishment/enrichment of field genebanks and botanic gardens for vegetatively propagated and recalcitrant seeded plants such as yams (*Dioscorea* spp.), cassava (*Manihot esculenta*), banana (*Musa* spp.), sweet potato (*Ipomoea batatas*) and taro (*Colocasia esculenta*). Establishment of a regional gene-bank for safety duplication and long-term storage of the region's core collections also need to be considered.

Only 4 000 accessions of the more than 49 000 conserved at the National Genebank have been distributed for utilization in the last 15 years, of which a total of 3 189 accessions have been distributed over the last 5 years. Distributed materials have mainly been utilized in breeding programmes where they have served to develop improved varieties, specifically in developing improved varieties of maize, sorghum, safflower and French bean. A few have gone into direct use by farmers while others have been utilized in other research programmes. Overall, utilization of the germplasm conserved at the National Genebank has remained relatively low, though this could be explained by the availability of similar materials as active collections in most of the research centres. Other reasons that have contributed to this low uptake include inter alia (i) the inadequate passport and evaluation data of the distributed material regarding their adaptability to biotic and abiotic stresses, and (ii) the small sample sizes offered.

Due to shortage of scientific staff, a lot of the conserved materials have not been characterized. Out of the 1 725 species conserved at the GBK, only 144 have been characterized, none of which has been evaluated for biotic and abiotic stresses. A core collection has been established for only one of the species conserved, sesame. Kenyan breeders have shown a justified preference for materials that have undergone pre-breeding analysis and whose evaluation data is available. A majority of materials at the genebank lack this vital information and hence the low demand. In order to enhance the utilization of stored germplasm, it is important that the capacity of the National Genebank to characterize and evaluate this material is improved.

The seed system in Kenya comprises public sector agencies, private agencies and multinationals. The industry was liberalized in 1996 and currently there are over 40 registered seed companies. The seed sector is serviced by a well-established formal crop improvement sector that combines conventional plant breeding techniques as well as advanced state of the art methodologies and skills. The main institutions involved in plant breeding are Kenya Agricultural Research Institute (KARI), Tea Research Foundation (TRF), Coffee Research Foundation (CRF), Kenya Sugar Research Foundation (KESREF), public universities and private seed companies.

The Kenyan National Plant Genetic Resources Programme was established in 1988. The National Genebank collaborates with a number of institutions and stakeholders including, KARI centres, KEFRI, NMK, Kenya Wildlife Services, relevant government ministries and departments such as Ministry of Environment and Natural Resources, Ministry of Agriculture, the Kenya Forest Service, as well as local public Universities, CBOs, NGOs and farmer groups. Whereas all the stakeholders collaborate at institutional and individual levels in the implementation of specific plant genetic resources activities, overall coordination among them is weak. There is no particular institution or agency charged with the responsibility of coordination. There is need for an Authority to coordinate plant genetic resources matters in the country, preferably a National Biodiversity Centre as proposed in the Seed Act Cap 326.

In the last decade, the country has signed several international agreements that are relevant to PGR and enforced several important legislations. These include, the Convention on Biological Diversity (1994), the International Treaty on PGRFA (2003), the Environmental Management and Coordination Act (1999), the Industrial Property Bill (2001), the Statute Miscellaneous Amendment Bill (2000), the National Biotechnology Development Policy (2006), the National Environment Action Plan (NEAP), The Seeds and Plant Varieties (National Performance Trials) Regulations, 2009, The Environmental Management and Co-ordination (Conservation of Biological Diversity and Resources, Access to Genetic Resources and Benefit Sharing) Regulations, 2006 and the National Biodiversity Strategy and Action Plan (NBSAP. In addition, there are other pieces of proposed legislation including: proposed Seed Act, Bio-safety bill and the National Bio-safety Framework and Regulation. All these are meant to enhance the conservation and utilization of our biodiversity.

Kenya is also party to several regional and international initiatives part of whose endeavour is to address PGR issues. Of particular importance is the Eastern Africa Plant Genetic Resources Network (EAPGREN) which deals exclusively with issues of PGR. Others include Intergovernmental Authority on Development (IGAD), Common Market for Eastern and Southern Africa (COMESA), East African Community (EAC) – Environmental Natural Research and NEPAD besides

several ASARECA networks. There is however need to strengthen the networks in order to increase their efficiency in PGR conservation and utilization and avoid duplication of efforts.

At the national level, there is a raft of legal, administrative and policy instruments dealing directly or indirectly with PGR. However, most of these are silent on access to genetic resources. Kenya has no specific legislation dealing with genetic resources. The only legislative measure that has been put in place thus far is the Environment Management and Coordination Act, 1999 which is a general environmental law. Though a lot of efforts have been made in developing a regulatory framework on ABS, the framework is perceived to be unclear. This situation is exacerbated by poor institutional structures, overlapping mandates and lack of clear institutional policies on germplasm exchange thus leading to uncertainty in sharing of germplasm. Cases of bio-piracy which have often been given extensive media coverage and publicity have led to the wrong attitudes. There is widespread perception that other countries are taking advantage of the countries' PGR hence prompting protectionist tendencies in germplasm exchange.

Future collaboration aimed at promoting conservation and sustainable utilization of PGR should focus on strengthening existing conservation facilities, building regional and international databases, adding value to conserved materials with a view to enhance their utilization and commercialization, and building human resources capacity in areas of molecular characterization, biotechnology, disaster management and taxonomy.

ACKNOWLEDGMENTS

The National Steering Committee is indebted to all those, whose involvement contributed to the successful preparation of this draft country report. Thanks first go to staff of the National Genebank of Kenya, which is the National Focal Point who tirelessly worked for several months in organizing the workshops and meetings, during the data gathering process and eventual compilation of this report. Your collective efforts are highly appreciated. Our highest appreciation goes to FAO for the kind financial support that facilitated all the activities that culminated in this report. Our special thanks go to Mr. Stefano Diulgheroff (AGPS) for the valuable advice and technical backstopping during the whole process of strengthening the national information sharing mechanism and preparation of this report. The input of Dr. Regina Laub and Dr. Lipper Leslie both of FAO in editing the report is highly appreciated. Additional technical backstopping by Bioversity International is also gratefully acknowledged.

The Directors of all the participating institutions deserve special thanks for their cooperation in the entire process. The various contact persons in each of the participating institutions who spared their valuable time contributing to the strengthening of the NISM are fully appreciated. I am indebted to the Director KARI for his invaluable moral, logistical and material support.

Mr. Z.K. Muthamia
Chairman, National Steering Committee

ABBREVIATIONS AND ACRONYMS

ABSA	Access and Benefit Sharing Agreements
AEZ	Agricultural Ecological Zone
AFLP	Amplified Fragment Length Polymorphism
AHI	African Highlands Initiative
ALVs	African Leafy Vegetables
ASALs	Arid and Semi Arid Lands
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ATIRI	Agricultural Technology and Information Response Initiative
BARNESA	Banana Research Network for Eastern and Southern Africa
CBD	Convention on Biological Diversity
CBOs	Community Based Organizations
CIAT	International Centre for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
COMESA	Common Market for Eastern and Southern Africa
CORNET	Coffee Research Network
CRS	Catholic Relief Services
DMP	Desert Margins Programme
CRF	Coffee Research Foundation
EAC	East African Community
EAPGREN	Eastern Africa Plant Genetic Resources Network
EARRNET	East African Root Crops Research Network
ECABIO	Eastern and Central Africa Biotechnology and Biosafety Programme
ECABREN	Eastern and Central Africa Bean Research Network
ECAMAW	Eastern and Central Africa Maize and Wheat Research Network
ECAPAPA	Eastern and Central Africa Programme for Agricultural Policy Analysis
ECARSAM	Eastern and Central Regional Sorghum and Millet Network
ECARRN	Eastern and Central Africa Rice Research Network
EWS	Early Warning Systems
FAO	Food and Agriculture Organization
FOODNET	Post harvest Processing Network
GBK	National Genebank of Kenya
GIS	Geographical Information System
GDP	Gross Domestic Product
GLP	Grain Legume Project
GPA	Global Plan of Action
GoK	Government of Kenya
GTZ	German Technical Co-operation Agency
IARC	International Agricultural Research Centres
ICRISAT	International Centre for Research in Arid and Semi Arid Tropics
IGAD	Intergovernmental Authority on Development
IITA	International Institute of Tropical Agriculture
IPGRI	International Plant Genetic Resources Institute
ITDG	International Technology Development Group
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture

IUCN	International Union for Conservation of Nature
KARI	Kenya Agricultural Research Institute
KEFRI	Kenya Forestry Research Institute
KEPHIS	Kenya Plant Health Inspectorate Service
KESREF	Kenya Sugar Research Foundation
KFS	Kenya Forest Service
KIRDI	Kenya Industrial Research Development Institute
KSU	KARI Seed Unit
KWS	Kenya Wildlife Service
MBNET	Maize Breeders for Africa Network
MENR	Ministry of Environment and Natural Resources
MoA	Ministry of Agriculture
NARL	National Agricultural Research Laboratories
NBSAP	National Biodiversity Strategy and Action Plan
NCST	National Council for Science and Technology
NEAP	National Environment Action Plan
NEPAD	New Partnership for Africa's Development
NES	National Environment Secretariat
NGO	Non Governmental Organization
NMK	National Museums of Kenya
OP	Office of the President
OPVs	Open Pollinated Varieties
PCPU	Plant Conservation and Propagation Unit
PGR	Plant Genetic Resources
PGRFA	Plant Genetic Resources for Food and Agriculture
PREPACE	Regional Potato and Sweet potato Improvement Network in Eastern and Central Africa
RAIN	Regional Agricultural Informational Network
RAPD	Random Amplified Polymorphism Deoxyribonucleic
RFLP	Refracted fragment length polymorphism
SOW	State of the World
TRF	Tea Research Foundation
TRIPS	Trade Related Intellectual Property Rights
UPOV	Union for the Protection of Plant Varieties

INTRODUCTION

1.1 Geographic position

Kenya lies approximately between latitudes 4° 40'N, and 4° 30'S and longitudes 34°E and 41°E with a total area of 582 600 km^2. Sudan, Ethiopia and Somali border Kenya to the northwest, north and east respectively while Uganda, Tanzania and Indian Ocean are to the west, south and southeast. Lake Victoria is shared by Kenya, Tanzania and Uganda.

1.2 Socio-economic information

Kenya has a population of about 33 million people (2005) with a density of about 52 persons/km^2. The rate of population increase has been 2.0% (1995-2000). The capital of Kenya is Nairobi which has a population of about 3 million people. Agriculture is the main occupation in the country with coffee and tea being the main cash and export crops. Sugar, fruits, horticultural crops and floriculture have also become important export crops. Livestock farming for export of meat and dairy products has recently increased due to improved marketing occasioned by revival of key industries namely Kenya Meat Commission (KMC) and Kenya Cooperative Creameries (KCC). Fish production mainly from Lake Victoria and also from the Indian Ocean is exported to the European Union (EU) countries and Japan. Tourism is an important and well-developed industry in Kenya. The Gross National Product (GNP) per capita for Kenya is US$330 and the annual growth rate of Gross Domestic Product (GDP) is 2.1% (1999).

1.3 Agricultural sector in Kenya

1.3.1 Importance of agriculture

Agriculture is the mainstay of Kenya's economy and the growth of the sector is crucial to the country's overall economic and social development. The sector directly contributes about 26% of GDP and a further 27% through linkages with manufacturing, distribution and service related sectors. About 68% of Kenya's population live in the rural areas and depend mainly on agriculture and fisheries for livelihood. In addition, 87% of poor households live in rural areas[1].

Small scale farmers account for about 80% of the farming community. Farm sizes in the small scale farming areas such as Nyeri, Kisii, Bungoma and Siaya average about 02 – 12 ha., while those in large scale farming areas such as Kericho, Nakuru, Uasin Gishu, Trans Nzoia and Laikipia are about 700ha. Overall, 25% of all farms are on average about 20-50ha.

During the first two decades after independence, the economy recorded an impressive growth rate of 6% with the agriculture sector playing the dominant role. Since then, the performance of the sector has been far from satisfactory with the rate of agricultural output lagging well behind that of the population. This trend has led to increased incidences of food shortages, increased poverty levels, declining income, loss of employment and a shift from self-sufficiency to reliance on importation and food aid. To date, Kenya's average poverty level exceeds the 50% population mark.

It is estimated that about 56% of the population is food insecure at one time or another during the year. Out of this, some 2 million people out of a total population of over 33 million are food insecure and permanently depend on relief food. This figure usually rises to five million people during droughts. These people who live in absolute poverty are estimated to be 53% and 49% of the rural and urban population respectively. The state of food scarcity leads to lack of physical and economic access to sufficient, safe and nutritious food for an active and healthy life.

[1] Government of Kenya, 2003. Economic Strategy for the Revitalization of Agriculture. Government Printers, Nairobi

As far as domestic marketing is concerned, most agricultural products are consumed in the neighbourhood of their production because of the poor road and transport infrastructure within the country, except for the major urban centres, where products come from farther away. It is therefore not uncommon to have food rotting in one part of the country whose production surpasses the local demand and has no storage facilities, while there is famine nearby.

1.3.2 Constraints facing the agricultural sector

According to the Strategy for Revitalization of Agriculture (SRA) 2004-2014, the main constraints that have led to the dismal performance of the agricultural sector in the last decade include: unfavourable micro and macro-economic environment, inadequate markets and marketing infrastructure, unfavourable external environment, inappropriate legal and regulatory framework, inadequate financial services and inadequate storage and processing capacity for perishable commodities. Others include weak and ineffective research-oriented-farmer linkages, poor coordination with other support sectors such as water, roads, energy and security, natural disasters such as floods, pests and disease outbreaks, poor governance in key institutions supporting agriculture and declining soil fertility.

To transform Kenya's agricultural sector, there is need for drastic changes touching on the following areas among others:

- Encouraging product diversification to stabilize and increase income-earning opportunities.
- Encouraging participatory approaches to development through the empowerment of local communities to initiate and implement their priority projects.
- Training farmers to manage their activities in a business oriented manner
- Applying a multi-sectoral approach in planning, implementation as well as monitoring and evaluation of projects and programs.
- Increasing financial and technical support to the sector.
- Facilitating private-public sector partnerships to encourage investment, competitiveness and improved market access.
- Rationalizing the role of government in commercial activities by divesting from public enterprises.
- Encouraging optimum capacity utilization to lower unit costs of production and improve competitiveness.
- Review of national policies on agriculture (competition by cheap imports, subsidies, etc)

CHAPTER 1

THE STATE OF DIVERSITY

2.1 Introduction

Kenya has a rich plant diversity held by a range of habitats. According to International Union for Conservation of Nature (IUCN), there is an estimated total of 7 500 plant species in the country. Of these, about 475 are national endemics while 258 are threatened. Among these are wild species of vegetables, fruits, forage grasses, legumes, browse plants, cereals, pulses, oil crops, forest species, medicinal plants; all of which are of great significance to man. Although no comprehensive study has been conducted to quantify the level of genetic erosion that has taken place, it is believed and disturbing to note that in the last decade a lot of diversity has been lost in the country despite the efforts being made in germplasm conservation. Land fragmentation means that *in situ* and on-farm conservation are no longer able to maintain the existing diversity. Human population increase and the subsequent increased demand for plant-based products, land for settlement and farming continues to threaten wild flora, thereby rendering these conservation strategies ineffective. *In situ* conservation especially of wild plants has further been hindered by illegal settlement and clearing of forestland. *Ex situ* conservation, although unable to conserve the evolutionary processes that take place in the natural environments, has endeavoured to conserve as much genetic diversity as possible ranging from local crop varieties to improved cultivars. This chapter describes the diversity available in the country for both major and minor crop species as well as neglected and underutilized species. The chapter concludes with an assessment of gaps and needs on the state of diversity in the country.

2.2 Important crops

The main food crops in Kenya are maize (*Zea mays*), wheat (*Triticum aestivum)*, beans (*Phaseolus vulgaris*), peas (*Pisum sativum*), bananas (*Musa sp.*) and potatoes (*Solanum tuberosum*). Maize (*Zea mays)* is the principal staple food of Kenya and it is grown in 90% farms. Maize is a strategic food security crop and poor yields almost inevitably result in food shortage and famine in the country. It is also a major income-generating crop and accounts for about 25 per cent of agricultural employment. Banana is another important food security and cash crop in Kenya particularly among small-scale farmers. Common bean is the most important legume and second to maize as a food crop.

The main agricultural export products from Kenya are tea (*Camellia sinensis*), coffee (*Coffea arabica*), pyrethrum (*Chrysanthemum cinerariifolium)*, sisal (*Agave sisalana)* and horticultural products (fruits, vegetables and floricultural crops). Other crops that are gaining popularity due to their nutritional value and adaptability to marginal environments include sorghum (*Sorghum bicolor*), millets (*Eleusine coracana*) and cassava (*Manihot esculenta*). Different crops are of varied importance in different regions of the country as shown in Table 1 below.

TABLE 1
Important crops and their relative importance in different regions

Crop	Region
Maize (*Zea mays*)	Whole country
Rice *(Oryza sativa*)	Whole country
Wheat (*Triticum aestivum*)	Whole country
Sorghum (*Sorghum bicolor*)	Eastern, Nyanza, North Rift, and Coast
Cassava (*Manihot esculenta*)	Nyanza, Western and Coast
Beans (*Phaseolus vulgaris*)	Eastern, Western, Nyanza and Central
Millet *(Eleusine coracana*)	Eastern (Tharaka and Meru)

Crop	Region
Cowpeas (*Vigna unguiculata*)	Eastern and Nyanza
Green grams (*Pisum sativum*)	Eastern and Coast
Mangoes (*Mangifera indica*)	Coast, Eastern and Central
Cashew nuts (*Semecarpus anacardium)*	Coast
Pineapples (*Ananas comosus*)	Central (Thika), Coast and Western
Oranges (*Citrus sinensis*)	Coast and Eastern
Avocado (*Persea americana*)	Central, Eastern and Coast
Bananas (*Musa* spp.)	Nyanza (Kisii), Central, Eastern and Western
Sugarcane (*Saccharum officinarum)*	Western and Nyanza

2.3 Diversity within and between crops and plants

Based on the number of released varieties, maize (*Zea mays*) has the highest diversity of modern varieties, followed in a decreasing order by tea (*Camellia sinensis)*, common beans (*Phaseolus vulgaris)* and pyrethrum (*Chrysanthemum cinerariifolium)* (Table 2). While the diversity of modern varieties in majority of the crops is on the increase, that of the traditional varieties is on the decline.

TABLE 2
Number of released varieties for the main crops[2]

Crop	Number of released varieties
Zea mays	164
Camellia sinensis	63
Phaseolus vulgaris	28
Chrysanthemum cinerariifolium	24
Triticum aestivum	22
Saccharum officinarum	19
Sorghum bicolour	18
Solanum tuberosum	17
Helianthus annuus	14
Mangifera indica	13
Manihot esculenta	12
Vigna unguiculata	10
Hordeum vulgare	9
Ipomoea batatas	8
Glycine max	8
Cajanus cajan	7

[2] Anonymous, 2009, National Plant Variety Release List, Ministry of Agriculture. Available at www.kephis.org. (Accessed on 30th July 2009)

2.3.1 Diversity within and between major crops

2.3.1.1 Cereals

Kenya is considered to have very important local maize genetic diversity. Maize harvested from some parts of the country such as western and coastal Kenya, show a colourful display of black, purple, red, yellow, white and mixed-colour ears, of varying length and circumference. Indeed, the bulk of landraces among the 22 000 accessions found in CIMMYT's maize genebank originate from this region. These varieties carry traits that breeders and future generations may find extremely useful.

Wheat is the second most important cereal after maize and the most important species found in the country include *Triticum aestivum* and *Triticum durum.* Rice is ranked third among the cereal crops and it is mainly produced in Eastern (Mwea and Bura) and Nyanza (Yala and Ahero) provinces. The country has a diverse wealth of rice germplasm. The most common cultivated species is *Oryza sativa*. Other species of wild rice include *Oryza punctata, Oryza longistaminata* and *Oryza hexandra*.

Sorghum diversity in Kenya is represented mainly by *Sorghum bicolor* which is the most commonly cultivated species. The varietal diversity within *S. bicolor* is enormous as can be distinguished by seed colour, panicle size & shape, maturation rate, and plant height among other traits. Other species include *Sorghum arundinaceum, Sorghum sudanense, Sorghum vesicolor, Sorghum verticilliflorum* and *Sorghum purpureosericeum,* which are mainly found in the wild.

2.3.1.2 Pulses

Kenya has a very rich diversity of common bean. The diversity is mainly represented by one species namely *Phaseolus vulgaris*. Based mainly on seed colour over 100 cultivars have been identified in the country. Other phenotypic characteristics that distinguish varieties include growth habit (determinate and indeterminate), seed size, seed shape and days to maturity. Other species in this genus include *P. lunatus* and *P aureus*. Cowpea (*Vigna unguiculata)* is the second most important grain legume in Kenya after the common bean. It is estimated that 85% of the area under cowpea cultivation lies in the Arid and Semi Arid Lands (ASALS) of Eastern Province. The crop has a wide diversity represented by various subspecies both cultivated and wild. Other *Vigna* species found in the country include *Vigna radiata, Vigna parkeri, Vigna trilobata, Vigna mungo, Vigna membranacea, Vigna gracilis, Vigna aconitifolia, Vigna heterophylla, Vigna vexillata, Vigna stuhlmannii, Vigna reticulata, Vigna schimperi, Vigna sinensis, Vigna oblongifolia* and *Vigna parvifolia*. Some of these species occur in the wild, while others are found in form of landraces or primitive cultivars.

2.3.2 Diversity within and between minor crops

2.3.2.1 Cereals

Finger millet (*Eleusine coracana*) is an important cereal crop in some parts of Eastern (Tharaka and Mbeere), Western (Busia & Teso) and Rift Valley (Bomet & Buret). There is substantial varietal diversity within *E. coracana* as can be illustrated by differences in seed colour, panicle size and shape, finger placement and shape and time to maturity among other traits. The wild species in this genus found in various parts of the country include: *Eleusine indica, Eleusine intermedia, Eleusine jaegeri* and *Eleusine multiflora*. The other minor cereals mainly found in Eastern Kenya are pearl millet (*Pennisetum americanum*) and teff (*Eragristis teff*). About 5 – 8 different varieties of *P. americanum* do exist. The diversity within *Eragrostis teff is* rather minimal.

2.3.2.2 Pulses

Pigeon pea is an important crop especially in the dry areas of Eastern province. It is however believed to have very limited diversity with the only species being *Cajanus cajan.* Although, eight varieties of *C. cajan* have been released, varietal diversity among the farmers is quite limited. A majority of farmers mainly grow two varieties. The other important pulses among the people of central Kenya are dolichos (*Dolichos lablab*) and garden peas (*Pisum sativum*). In terms of seed colour, there are three main varieties of dolichos namely: black, red/brown and white seeded. There are also other variants in terms of time to maturity. Other species of Dolichos found in the country include *D. argenteus, D. trilobus* and *D. sericeus.* Soya bean (*Glycine max*) is grown only on a very limited scale. Its varietal diversity is similarly quite limited.

2.3.2.3 Fibre crops

The main crop in this category is cotton whose diversity is represented by both cultivated and wild species with *Gossypium hirsutum* being the most commonly cultivated species. Other cultivated species include *Gossypium arboreum* and *Gossypium hybrid*, which are believed to have been introduced from other countries such as Pakistan, Russia and India. Wild form of cotton is represented by *Gossypium barbadense*, which have been found in Samburu district. The other fibre crops are sisal (*Agave sisalana*) and jute (*Hibiscus cannabinus*). Only a few large scale-farming companies grow sisal to a limited scale. The potential of jute, which has diverse wild relatives in the country, is largely non-exploited. The wild *Hibiscus* species include *H. aponeurus, H. calyphyllus, H. acetosella, H. fuscus, H. lunariifolius, H. mastersianus, H. micranthus, H. ovalifolius, H. panduriformis, H. trionum, H. vitifolius, H. hispienol, H. diversifolius and H. dictyocarpus*.

2.3.2.4 Root and Tuber crops

The two main crops in this category are sweet potato (*Ipomoea batatas*) and cassava (*Manihot esculenta*). Sweet potato is mainly grown in parts of Nyanza province. It is also grown in parts of Western, Central and Eastern provinces. A wide varietal diversity of *Ipomoea batatas* has been reported in several parts of the country. Most of these cultivars have been assembled in a sweet potato field genebank at Agricultural Research Centre Muguga South. The main distinguishing factors are colour of leaves, flowers, tuber skin and flesh colour, tuber shape and leaf shape. The wild forms of *Ipomoea* potato include *Ipomoea jaegeri, I. carioca, I. hilderbrandtii, I. kituiensis, I. mombassana, I. spathulata, I. braceata, I. cicatricosa, I. donaldsonii, I. longituba, I. plebeian* and *I. pescaprae.* Irish potato (*Solanum tuberosum*) is another important food security crop in the country but its diversity is however limited.

2.3.2.5 Grasses and Forage species

Kenyan ecosystems are rich in various grasses and other forage species. *Trifolium* is a common forage legume, which has high genetic diversity in the country. Species of *trifolium* found in the country include *Trifolium repens, T. lugardii, T. pratense, T. lanceolatum, T. semipilosum, T. tembense, T. steudneri, T. subterraneum, T. spumosum, T. usambarense, T. cheranganiense, T. burchellianum, T. elgonense, T. cherleri, T. alexandrinum* and *T. rueppellianum.* Other important forage species include *Chloris gayana, Panicum maximum, Pennisetum* sp., *Setaria* sp. *Neonotonia wightii* and stylo. Diversity of stylo is represented by *Stylosanthes fruticosa, S. hamata. S. humilis, S. scabra, S. guianensis, S.subsericea, S. mucronata, S. hamata* and *S.viscosa.*

2.3.3 Underutilized/underexploited species

In a recent study conducted in Kenya to gather information on the current status of the neglected and underutilized crop species, 4 main crops were considered neglected and/or under-utilised[3]. These are *Sesamum indicum*, *Voendzea subterranea*, *Dioscorea* spp. and taro (*Colocasia esculenta)*, indigenous vegetables and various medicinal plants.

2.3.3.1 Root and tuber crops

Yams – *Dioscorea* spp.: Although there is very little published information on Kenya's yam, available literature suggest that the crop's diversity is represented by a number of cultivars among *D. rotundata, D. minutiflora, D. bulbifera,* and *D. dumetorum* and are grown for food mainly by elderly farmers in the Eastern, Central, Western and Coastal regions of the country. Farmers distinguish up to 13 cultivars of yams by among other characters, maturity period, leaf shape, leaf colour, stem colour, stem texture, stem width, tuber size, tuber shape, tuber flesh colour and taste. A unique aerial tuber type has been reported in parts of Embu and Meru South. Diversity of wild yams in the country is represented by *Dioscorea quadrata.*

Unfortunately, this diversity of yams has in the recent past contended with immense genetic erosion from among other causes, abandonment of some species and cultivars by farmers for entirely other crops, and gross destruction and modification of natural habitats. Consequently, widespread erosion of yam diversity is taking place both from its traditional area of cultivation and from the wild. Safe for only one accession of wild yam (Dioscorea quadrata) conserved at the National Genebank of Kenya, there appears to be no other conservation effort for the crop in the country[4]. Little is known on many important aspects of yams such as diversity since research on the crop has also been low. However, a study funded by EAPGREN is currently going on at the National Genebank of Kenya and it is expected to shed light on among other things, diversity, production, utilization and marketing of yams.

[3] Nyamongo D.O., Mutegi, E., Muthamia, Z.K. and Ngae, G.N. 2004. Preliminary Report on the Neglected and Underutilized Crop Species in Kenya. Kenya Agricultural Research Institute, ARC- Muguga South.

[4] Nyamongo D.O., Mutegi, E., Muthamia, Z.K. and Ngae, G.N. 2004. Supra note 3.

Taro - *Colocasia esculenta*: Up to 3 varieties have been identified. Distinguishing variables are colour of the flesh, water requirement during growing period and length of time to cook. Production is mainly along riverines but farmers also cite some 'rain fed' varieties that require considerably low amounts of water. No deliberate efforts on conservation work on this crop in the field have been noted. The constraints cited by some institutions as hindering any conservation initiatives include decline in river banks, changes in eating habits and changes in agricultural systems[5].

2.3.3.2 Traditional/local vegetables

A total of about 210 African Leafy Vegetable species have been recorded in Kenya The top African leafy vegetable species in the country include *Cleome gynandra, Solanum villosum, Curcubita moschata, Vigna unguiculata, Amaranthus blitum, Corchorus olitorius, Solanum scabrum, Crotalaria ochroleuca, Crotalaria brevidens* and *Brassica carinata.* These species belong to seven botanic families *Amaranthaceae*, *Brassicaceae*, *Capparaceae, Fabaceae, Solanaceae* and *Tiliaceae*[6].

In the *Solanaceae* family, the *Solanum* genus has the highest diversity of both cultivated and wild species. The most common species representing this enormous diversity include *S. aethiopicum, S. americanum, S. villosum, S. scabrum, S. nigrum, S. macrocarpon, S. gilo and S. melongena.* Other species in this genera include *S. anguivi, S. angulatum, S. arundo, S. coagulans, S. dasyphyllum, S. dennekense, S. giganteum, S. hastifolium, S. aculeastrum, S. incanum, S. mauense, S. renschii* and *S. sessilistelatum.* Majority of these species are used as traditional vegetables, fruits or as medicinal plants.

The *curcubitaceae* family has considerable diversity species used as traditional vegetables. The most common genera include *Citrullus, Cucurbita, Lagenaria, Momordica* and *Cucumis*. Species in the *Cucurbita* genus include *C. maxima, C. ficifolia, C. moschata, C. foetidissima* and *C. pepo* while those in the *Citrullus* genus include *C. colocynthis* and *C. lanatus*. Among the species in the *Lagenaria* genus are L. *siceraria,* L. *sphaerica,* L. *abyssinica,* and L. *breviflora*. There is however no known use of L. *abyssinica* either as a vegetable or a medicinal plant.

Within the *Amaranthaceae*, the Amaranths exhibit the highest diversity of species exploited as traditional vegetables. Among the common ones include *Amaranthus hybridus, A. dubius, A. spinosus, A. blitum, A. caudatus, A. graecizans, A. lividus, A. tricolour* and *A. viridis.*

With increasing pressure on both wild habitats and agricultural land, due to demographic and socio-economic changes, the ecological niches of many leafy vegetables are fast disappearing, and genetic erosion is therefore rapid. For example, farmers in Kilifi District of Coast Province have reported disappearance of a small leaved *Amaranthus*. The occurrence of stinging nettle (*Urtica massaica*) is also limited in most parts of Central Kenya where it used to be abundant.

Other neglected crops include oats where the main species in the country are *Avena sativa* and *Avena fatua.*

2.3.3.3 Medicinal plants

Medicinal plants in Kenya not only offer huge opportunities for income generation, but provide alternative healthcare and contribute to reducing environmental degradation as well. However, these opportunities have not been sufficiently recognized or exploited by the Government and the people of Kenya. Consequently, most of the species with medicinal properties remain grossly underutilized. Some of these include *Mondia whytei* whose value is slowly being recognized by the rural communities. It is one of those species listed in a World Bank report as a critical and money-minting herb, and among the top four with global use and trade values. Credit on its production is of course, given to Kenya.

Traditional medicinal plant species in Kenya have been ranked according to utility value and sustainable use. According to this ranking, the top ten priority species are *Prunus africana, Warburgia ugandensis, Ceasalpinia volkensii, Fagaropsis hidebrandtii, Securidaca longipendunculata, Zanthoxylum gilletti, Zanthoxylum usambarense, Strychnos henningsii,* Zanha *africana* and *Zanthoxylum chalybeum*.[7] Other plants that have medicinal value include *Aloe kedongensis, Ocimum kilimandscharicum, Eucalyptus globules, Pistacia aethiopica, Ajuga remota, Olinia rochetiana, Juniperus procera, Pentas longiflora* and *Zehneria scabra among many others*[8].

Diversity in most of the medicinal plants is however threatened due to high population growth rate, competing land uses, environmental degradation, loss of indigenous knowledge, increased commercialisation of traditional medicine and increased demand in the local and international markets[9].

[5] Nyamongo D.O., Mutegi, E., Muthamia, Z.K. and Ngae, G.N. 2004. Supra note 3.
[6] Abukutsa-Onyango, M.O. 2002. Market survey on African Indigenous vegetables in Western Kenya. In. J.M. Wesonga, T. Losenge, C.K. Ndung'u, K. Ngamau,J.B.M. Njoroge, F.K. Ombwara, S.G. Agong, A. Fricke, B. Hau and H. Stutzel (Eds). Proceedings of the second horticultural seminar on sustainable horticultural production in the tropics. JKUAT 2002: 39-46.
[7] Kariuki, P.M. & Simiyu, S. 2005. CBCMP Technical report on the Conservation Assessment and Management Planning (CAMP) Workshop, 3 – 5 April 2005. Machakos District, Kenya. Unpublished report, IDRC/National Museums of Kenya, Nairobi. 34 pp.
[8] Gachathi, F.N. 1989. Kikuyu Botanical Dictionary of Plant Names and Uses.
[9] Kariuki, P.M. & Simiyu, S. 2005. Supra note 7

2.3.3.4 Oil crops

Sesame–The most common species of sesame in the country is Sesamum *indicum* L. Sesame is a very ancient oil seed crop and an important traditional annual crop cultivated in small plots by small holders. It is potentially a valuable food crop, as well as a cash crop for both local and international market. Sesame is a versatile crop with many uses. Despite the apparent and prospective uses of sesame, it has remained in a status of neglect in most of its traditional areas of growth. The major constraint that hinders production is lack of markets leading to low prices. Harvesting and subsequent processing of the produce is considered labour intensive, further discouraging farmers from growing the crop on a large scale.

Based mainly on the colour of the grains, farmers and agricultural field staff, distinctively identified three main varieties namely: white seeded, brown seeded and black seeded. Other wild species of sesame available in the country include *Sesamum latifolium, Sesamum anguistifolium*, *Sesamum alatum, Sesamum angolense* and *Sesamum calycinum*.

Besides the National Genebank of Kenya, which is the duplicate global repository of sesame, no other organization has been found to be actively involved in the conservation of the crop. The bank has close to 2 000 accessions of both wild and cultivated sesame[10] assembled from over 50 countries

2.3.4 Pulse crops

Bambara nuts – *Voendzea subterranea*: Based mainly on seed colour, 5 varieties are identified in the country. The dominant varieties in western Kenya are the brown, red and cream types, while the brown and red types are dominant at the coast. Apart from the National Genebank of Kenya, which has a total of 7 accessions in its collection, no other institution is involved in the conservation of this crop. The crop is considered a "grandmother's" crop by the young generation, who do not rate it very highly. The major constraint in production is lack of market for the crop leading to very low prices and exploitation by traders, which discourages farmers from growing it and hence low supply of seed that pushes its prices high. This cyclical nature of this problem has drastically reduced the number of farmers growing the crop.

2.3.5 Wild species

Some important wild species that have been used as leafy vegetables include *Erythrococa atroviriens, Asytasia mysorensis, Commelina africana, Basella alba, Sesamum calycinum* and *Launaea cornuta*. These are species which are normally collected from the wild during periods of food scarcity without any formal cultivation or occur as weeds in cereal crops and taken advantage of. However, farmers in Western Kenya have reported the disappearance of several of these species from their habitats. Other wild species that have been used as fruits include *Rubus apetalus, Rubus steudneri, Rubus volkensii, Syzygium guineense, Ensete vetricosum, Sambucus africana, Acokanthera schimperi, Flacourtia indica, Physalis peruviana, Pachystela brevipes, Syzygium cordatum, Dovyalis abyssinica, Lantana rhodesiensis, Rhus natalensis, Carissa edulis, Lantana trifolia* and *Myrianthus holstii*[11].

2.4 Factors influencing the state of plant genetic diversity

The classic example of a change in importance of crops in the country is that of African traditional vegetables. While some of these vegetables are community-specific, others cut across different communities. Crosscutting African indigenous vegetables include Amaranths, African nightshades, cowpeas and *Cleome gynandra*.

The previous aggressive promotion of a few exotic vegetables resulted in the abandonment and neglect of indigenous vegetables in the country. Recently however, on realization of their high nutritive & medicinal value and low input requirement, there has been intensified awareness creation resulting in increased production, consumption and marketing of these vegetables. Even those that were previously community limited in terms of consumption e.g. *Crotalaria* (*mito*) are now becoming widespread among different communities due to the intensive promotion.

[10] Nyamongo D.O., Mutegi, E., Muthamia, Z.K. and Ngae, G.N. 2004. Supra note 3.
[11] Gachathi, F.N. 1989. Supra note 8

2.5 Genetic erosion

2.5.1 Causes of genetic erosion

The diversity of plant genetic resources (PGR), like diversities of other life forms in Kenya has since the recent past been on the decline due to genetic erosion brought about by both biotic and abiotic factors. The factors include: droughts, desertification, population pressure on land, changes in land use, changes in eating habits and over-exploitation. While the diversity in high potential areas is already severely diminished due to continued land cultivation and other forms of land exploitation, the decline in ASALs is now at its peak being exacerbated by the effects of global warming. Immigration into these areas in search of cultivable land is causing untold damage to the diversity existent therein whose erosion is already worsened by desertification.

The country has in recent years suffered severe droughts that have impacted negatively on the survival of our plant genetic resources. The latest of these droughts was witnessed early 2006 especially in Northern Kenya, which not only led to death of huge numbers of livestock but also claimed many human lives. The rains that followed caused massive floods that may have led to inevitable loss of biodiversity. The increased dependence on relief food in these regions due to such factors as drought and other natural calamities has also led to a decline in crop diversity.

Increased genetic erosion can also be attributed to policies that have to a large extent, advocated for the use of high yielding cultivars hence the displacement of traditional plant varieties. For instance, a local maize variety, *githigu* which was very popular in central Kenya has in the last decade disappeared from the farming system. The breakdown of traditional systems of natural resource management with the parallel loss of local plant varieties, and associated cultural knowledge can also be blamed for the increased genetic erosion.

2.5.2 Monitoring genetic erosion

Genetic erosion is assessed through land surveys and inventories, environmental impact assessments, gene bank monitoring, reports on land use changes and eco geographic surveys. Traditionally, genetic diversity was assessed through agro morphological characterization. However, in the last decade, several techniques have been introduced that detect molecular variability between and within species. Three of these widely applied techniques are the use of restriction fragment length polymorphisms (RFLPs), Deoxyribonucleic acid (DNA) finger printing and specific amplification of polymorphic DNA fragments with polymerase chain reaction (PCR). Other methods in use include Amplified Fragment Length Polymorphism (AFLPs) and isozymes. The use of these methods by many institutions is hampered by lack of facilities, high operational costs and lack of manpower. There is clearly a need to form regional thematic networks that will improve the capacity of countries to use these technologies. There is also need for capacity building in areas of molecular biology in order to better understand diversity within and between crops and species.

2.6 Assessment of major gaps, needs and priorities

- Improve the countries capacity to assess genetic diversity, genetic erosion and vulnerability through provision of necessary equipment and training.
- Establish comprehensive baseline data on the status of the countries' genetic diversity. This will assist in monitoring future trends on the state of diversity in the country.
- Establish mechanisms of monitoring the current diversity and the changes in it. This should also include monitoring genetic erosion and establish systems that can help detect any impeding genetic erosion early enough.
- Develop and adopt reliable methods for assessing genetic diversity at the national level.

CHAPTER 2

THE STATE OF *IN SITU* MANAGEMENT

3.1 Introduction

According to the Convention on Biological Diversity (CBD) *in situ* conservation is "the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings, and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties." As human populations increase, environmental problems are likely to intensify. Climate change, deforestation, desertification and other processes could have serious consequences for crop productivity. By conserving genetic diversity where it occurs naturally *(in situ),* we can facilitate the natural processes of evolution and adaptation, thus mitigating the effect of these problems.

From a general perspective, *in situ* management remains the most neglected area of genetic resources management in the country. The implementation of *in situ* conservation activities in Kenya is through various leading agencies which have been poorly/not sufficiently coordinated in either planning or implementing such activities. This chapter highlights the main institutions involved in *in situ* conservation and the state of on-farm conservation in the country before ending with an assessment of major gaps, needs and priorities.

3.2 Institutions involved on *in situ* conservation

The key institution involved in *in situ* conservation is Kenya Wildlife Service (KWS) which is guided by the Wildlife Conservation and Management Amendment Act, 1989. KWS has the mandate of conservation and management of wildlife in general. Though KWS has the responsibility of managing protected areas, very little *in situ* conservation activities are being undertaken in those areas.

The Kenya Forest Service (KFS) is the other agency that manages a system of protected areas that are critical for *in situ* conservation purposes. Significant initiatives here have included the Kenya Forestry Master Plan, the Kenya Indigenous Forest Conservation Program and the Indigenous Forest Conservation and Management Project. Kenya Forestry Service activities include an extension service for on-farm forestry, and a number of collaborative arrangements with KWS in the management of specific areas. The Kenya Forestry Service is also extensively supported by the work of the Kenya Forestry Research Institute (KEFRI). KEFRI conducts a wide range of activities but particularly significant in the context of *in situ* conservation are (i) its research involving the socio-economics of communities living in and around key forest areas and also (ii) its efforts at supporting the propagation and cultivation of indigenous tree species. This is done through training of local communities in seed propagation techniques and seedling production.

In situ conservation activities at the National Museums of Kenya (NMK) mainly target its mandate species, which include rare, endangered and endemic ones. This principally consists of support activities through units such as the Plant Conservation and Propagation Unit (PCPU). The PCPU targets vulnerable areas and conducts ecological studies. Where necessary, seed germplasm and replicate plant stocks can be stored and maintained. The greatest challenges to *in situ* conservation of PGRFA include climate change, habitat change, invasive alien species, overexploitation, pollution and introduction of new varieties leading to the loss of traditional crop diversity.

3.3 Inventorying and surveying

The lead institutions in conducting inventories and surveys of PGR include Department of Resource Surveys and Remote Sensing, Kenya Wildlife Service (KWS), Kenya Forestry Research Institute (KEFRI), National Museums of Kenya (NMK) and the Kenya Forestry Service (KFS). However, currently there is no coordinated and systematic surveying and inventorying based on national priorities. Each institute works within its mandates, needs and priorities. This has resulted in very little

survey or inventory work being carried out on PGRFA especially in protected areas compared to other components of biodiversity in these areas. This is principally due to the nature of mandates of the lead institutions.

In addition to lack of coordination and unclear responsibilities, which have already been cited, other challenges to systematic surveying and inventorying include lack of funding, lack of human resources, skills and knowledge, low national priority, inaccessibility of *in situ* areas, and difficulties with obtaining necessary permissions. Permissions to gain entry into protected areas such as parks and national reserves are given by KWS and may sometimes involve lengthy and bureaucratic procedures in addition to being costly. Due to the threats posed by wild animals, entry into some protected areas requires that one has to be guided with the cost of the guide being met by the surveyor/researcher.

3.4 On-farm conservation

On-farm conservation activities in the country are also uncoordinated. The challenges and constraints relating to the local management of the biodiversity are many and varying. The following can be cited:

- Lack of platforms to address indigenous food production & consumption systems
- Limited access by local communities to agricultural information
- Inadequate coordination among programmes and initiatives addressing indigenous food production systems
- Over time a lot of emphasis has been put on cash crops at the expense of indigenous food crops which have been largely neglected.

While there are many ways in which farmers can benefit from a greater use of local crops and varieties, in most cases action is needed to make them more competitive with modern varieties and major crops. Potential interventions to increase competitiveness include: better characterization of local materials, improvement through breeding and processing, greater access to materials and information, increasing consumer demand, and more supportive policies and incentives.

Noting the important role played by on-farm conservation in enhancing food security and PGR conservation, there is an urgent and growing need to support farmers in improving on-farm conservation methods. In order to achieve this, there is need to promote relevant policies, legislation and tools that will encourage the community to participate in PGR conservation. The capacity of community-based organizations (CBOs) to engage in conservation efforts should be boosted through appropriate training programs. Some of the incentives that have been used in the country to support on-farm management of crop diversity include:

- Community seed shows/rural seed fairs - This is an informal participatory event, which is held after the harvest where farmers come together to display their harvest. The displays are then evaluated by a panel of judges for diversity and variety and awards given for the best displays. The shows provide an opportunity for information sharing and exchange, in addition to stimulating crop diversity.
- Community seed banks
- Farmer seed training programmes
- Field days and demonstrations
- Provision of seeds of new crops, species and varieties
- Linking farmers to appropriate markets for their produce
- Financial assistance to start alternative crop based income generation activities
- Using agricultural extension service providers who understand better the role of men and women farmers in PGR management.

About 80% of all PGR are produced and reproduced every year on Kenya's farms. As in many other parts of the world, these and other activities related to on-farm conservation and management of PGR are conducted by women farmers (Table 3 and 4). Most farmers, especially the poor are forced to diversify their livelihood systems and plant different food crops, in order to improve their food security.

TABLE 3
Gender and on-farm seed selection, processing and storage in Odhuro[12]

Activity	Responsible person		
	Man	Woman	Child < 18 years
Seed selection in the field and after harvest	17.9%	61.6%	7.1%
Seed processing (drying, threshing, cleaning)	42.9%	78.9%	2.4%
Seed storage	7.6%	39.5%	3.35
Seed treatment	9.8%	75.0%	

Box 1
Men and women farmers and their management of PGR

Men and women farmers have different roles in management and utilization of plant species and varieties. Based on these differences, men and women farmers have different knowledge. E.g. women farmers play a big role in production and utilization of under-utilized and wild crops and traditional/local vegetables and are often the reservoir of traditional knowledge on cultivation, maintenance and use of traditional plant varieties. In addition they deal with high levels of plant diversity and are local seed selectors for most subsistence crops. In this regard women play important roles in utilization and conservation of PGRFA because they have the primary responsibility to produce subsistence crops and assure household food security. Given the prominent role of women in agriculture, knowledge about their responsibilities in management of PGRFA is required if conservation of PGR has to be achieved. Therefore an explicit recognition of gender realities and disparities in the management of PGRFA is necessary.

Currently, there is limited knowledge on gender roles because most National Information Sharing Mechanism (NISM) have not incorporated gender roles into the analysis. For this reason, a dis-aggregated gender analysis of PGRFA conservation offers a more objective way of capturing the concerns of both male and female farmers.

TABLE 4
Gender Analysis/Input for Seed Harvesting, Processing, Storage, Treatment, Post Harvest Seed Selection[13]

Questions	Woman %	Man %	Both %	Child under 18 %
1. Who selects food crop seeds after harvest on-farm in all the sites?	68.5	16.9	11.5	3.1
2. Who processes cash crops seeds after harvest in all the sites?	78.9	8.8	7.9	4.4
3. Who stores food seeds after harvest in all the sites?	83.3	9.8	6.1	0.8
4. Who treats the food crop seeds after harvest?	83.3	9.1	5.3	2.3
5. Who selects underutilized crop seeds after harvest for long storage in West Yimbo?	80.8	13.1	6.2	-
6. Who processes underutilized crops seeds after harvest in Odhuro?	80.5	14.1	3.9	1.6
7. Who stores underutilized seeds after harvest in Gombe?	77.9	19.1	2.3	0.8
8. Who treats underutilized seeds after harvest in West Yimbo?	80.0	16.2	3.1	0.8

[12] Opole, M. and Laub, R. 2007. IN Seed systems: Understanding factors affecting access to Seed in Bondo - Kenya from an Engendered perspective
[13] Opole, M. and Laub, R. 2007. IN Seed systems: Understanding factors affecting access to Seed in Bondo - Kenya from an Engendered perspective.

3.5 Restoring agricultural systems after disaster

Natural disasters including drought and flood have increased in the country in the past decade. These natural disasters, in addition to their devastating effects on the environment, often destroy farmers' fields and sources of seeds. However, in spite of their recent increased incidence, the country's capacity to deal with them in terms of restoring agricultural systems is still poor. In most cases, the only efforts made in response to calamities are in form of emergency relief food and seeds for planting to restore agricultural systems in the affected areas. However, quite often there is no sufficient seed of locally adapted varieties for re-introduction to communities. The Kenya Red Cross Society, NGOs and the Government usually undertake these efforts with the latter making great strides to improve its capacity to respond to disasters. The Government has recently created a Ministry of Special Programs, which is currently responsible for coordinating relief operations not only in terms of food but also in provision of planting materials. In view of the country's capacity to respond to disaster, there is need to:

- Establish national mechanism that will help in identifying, producing and distributing appropriate seeds to communities affected by disaster.
- Review existing laws in order to allow for distribution of farmers varieties through the formal seed system as the current Act prohibits this.
- Create a database on local varieties, their characteristics and adaptability in order to hasten germplasm reintroduction and restoration efforts after disaster.
- Support on-farm seed production and conservation systems through for example the establishment of community seed banks, improvement of traditional seed storage methods and farmer training programs in areas of seed production, selection and storage.

3.6 Assessment of major needs for *in situ* conservation and the on-farm management of PGRFA

A number of challenges and priorities have been identified especially in the area of inventory and surveys. Some of these include:

- Priority areas for genetic resource erosion should be quickly identified at the national level through a gap analysis evaluation i.e. protected versus unprotected areas.
- There is need to co-ordinate inventories within the same ecosystems or habitats to avoid duplication of efforts.
- Training and capacity building: There is need for capacity development in most institutions involved in inventories, in particular, capacity for methods and technology applications, specialists in taxonomy among others.
- Limited resources: Inventories and surveys are expensive; hence adequate funds should be available to the institutions concerned.
- There is need for interoperability of data formats and geo-referencing of data for communication purposes across focal points.
- Relevant policies and legal instruments should be developed to guide surveys and inventories. There is critical and urgent need for a policy on indigenous vegetation on unprotected land.
- Support is needed at national level to support programmes prioritizing PGRFA and host habitats for conservation.
- Standardized methodologies for surveys and inventories should be emphasized.
- In order to promote on-farm conservation these is need to support the informal seed sector. Some of the crops that farmers are conserving in their farms are not served by the formal seed sector. There is therefore need for promotion of community seed banks, strengthening mechanisms for accessing and exchanging information and seed and implementing appropriate seed and IPR policies and legislation.

CHAPTER 3

THE STATE OF *EX SITU* MANAGEMENT

4.1 Introduction

Ex situ conservation is the most common and most developed method of germplasm conservation in the country. *Ex situ* conservation activities and initiatives are widespread in Kenya where the main institutions include the Kenya Agricultural Research Institute (KARI), NMK, KEFRI, public universities, KFS and various botanic gardens. The main methods employed in *ex situ* conservation are in the form of specialized facilities, such as cold stores, freezers, or in the field. Kenya has one of the largest, most developed and leading genebank in the sub-Saharan region. This chapter highlights some of the institutions involved in *ex situ* conservation and the type of storage facilities that they have. The chapter also addresses a number of facets of *ex situ* conservation such as germplasm collection, duplication, characterization, documentation, field genebanks and botanical gardens. It ends with a brief assessment of ex situ conservation needs and priorities for the future.

4.2 Germplasm conservation facilities

There are at least 14 genebank (seed storage) facilities in the country majority of which have medium-term and short-term storage capacity (Table 5).

TABLE 5
Germplasm conservation/storage facilities in Kenya

Genebank facility	Number
Long-term	1
Medium-term	7
Short-term	6

Below are some of the institutions involved in *ex situ* conservation.

4.2.1 Kenya Agricultural Research Institute

Within the framework of KARI is the National Genebank of Kenya (GBK) which is the only long term conservation facility in the country. It was established with financial and technical support of the German Technical Co-operation Agency (GTZ) and became operational in July 1988. This was as a result of recommendations from FAO and Bioversity International catalyzed by threat to the global genetic erosion.

During the first phase of the establishment of the Genebank, five cold stores were established in various agricultural research centres affiliated to KARI. These were short/medium term storage facilities to provide breeding work with controlled storage facilities for the day to day working germplasm stocks. The Genebank maintains duplicate samples of the same in base collection from all the above-mentioned KARI Centres. Besides conservation of crop germplasm, the Genebank targets other plant species with medicinal, socio-economic and cultural value.

The goal of the Genebank is to enhance conservation and sustainable utilization of agro biodiversity in Kenya. It therefore strives to conserve plant genetic resources using appropriate and improved technologies for the benefit of present and future generations.

The Genebank has 2 cold storage rooms each 75 cubic meters and with a storage capacity of 60 000 accessions. One storage room runs at - 20 ^{0}C, while the other is at + 5 ^{0}C. There is also a dehumidified walk-in walk-out drying unit which runs at 20^{o}C and 18-20% relative humidity with a capacity of handling over 200 seed accessions and capable of drying the seeds to below 5% moisture content.

4.2.2 National Museums of Kenya

The National Museums of Kenya (NMK) has a number of *ex situ* conservation related activities, principally under the umbrella of its Centre for Biodiversity. These activities specifically target threatened and endangered species and ecosystems. Where necessary, NMK is able to undertake limited storage of seed germplasm and conduct replications. The seeds are stored in aluminium packets in a freezer at - 20 ^{0}C. NMK also houses a plant nursery display garden, the National Botanic Garden and the East African Herbarium. These departments contain a wealth of information, both current and historic. The botanic garden is able to assist in propagation and reintroduction activities where necessary. The PCPU is a key element in these *ex situ* conservation strategies.

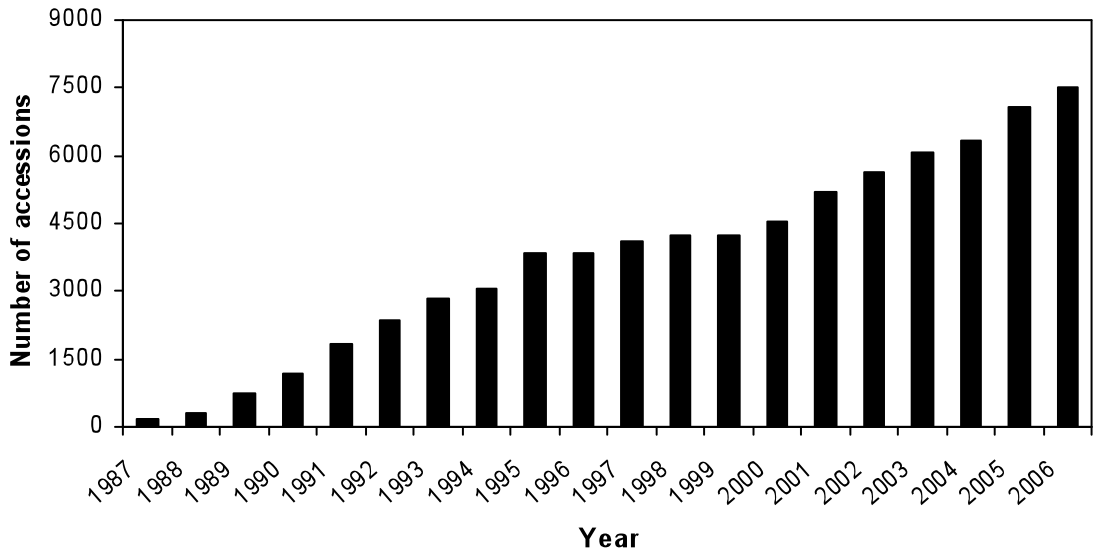
4.2.3 Kenya Forestry Research Institute

The Kenya Forestry Research Institute (KEFRI) operates a Seed Centre which was established in 1985 with support from German Technical Co-operation Agency (GTZ) on behalf of the Republic of Germany. The overall goal of the Centre has been the provision of site appropriate, high quality tree seed in sufficient quantities. The Centre therefore produces and freely distributes tree seeds. These are mostly indigenous species but in some cases also include other commercially useful exotic species. KEFRI also undertakes significant activities involving medicinal plants, including extensive cataloguing activities and the establishment of a series of ethno-botanic gardens in various parts of the country. Tree seeds are stored in cold stores in 3 different storage temperatures namely 1 °C, 5 °C and 10 °C. A store maintained at ambient conditions also exists.

4.3 Germplasm holdings at the National Genebank of Kenya

Since NGBK became operational in 1988, a total of 49 000 accessions of plant germplasm representing 165 families, 893 genera and 1 725 species have been assembled through both in-country collections missions and donations from within and outside Kenya. Over 60% of the accessions conserved are from Kenya, while the remaining ones are from more than 137 countries. As shown in Figure 1, the number of accessions collected in the country has been growing steadily over time and currently stands at around 8190.

FIGURE 1
Trend of germplasm collections at the National Genebank of Kenya since its inception



At least seven major crop commodity groups are represented in the Genebank with forage and cereal germplasm forming the bulk. Unique categories such as traditional vegetables and medicinal plants are also found in the collections but are underrepresented. Fifteen out of the total 1 725 species conserved in the Genebank account for over 60% of the collections. Sorghum forms the bulk of the accessions with close to 6 000 accessions (Table 6). Notably, all the major food and forage species are represented in the top 15 species.

TABLE 6
Germplasm holding for the top 15 species at the Genebank[14]

Species	Common name	Number of Accessions	
		1996	2006
1. Sorghum bicolor	Sorghum	5 333	5 649
2. Avena sativa	Oat	4 188	4 188
3. Phaseolus vulgaris	Common beans	3,305	3 428
4. Eleusine coracana	Finger millet	2 823	2 852
5. Sesamum indicum	Sesame	1 671	1 677
6. Panicum maximum	Guinea grass	1 918	1 938
7. Zea mays	Maize	1 423	1 792
8. Cajanus cajan	Pigeon peas	1 228	1 282
9. Chloris gayana	Rhodes grass	1 172	1 190
10. Oryza sativa	Rice	712	1 004
11. Cenchrus ciliaris	African foxtail	991	995
12. Vigna unguiculata	Cowpea	748	875
13. Eragrostis superba	Love grass	795	798
14. Stylosanthes guianensis	Stylo	749	749
15. Setaria sphacelata		651	654

4.4 Germplasm collection

4.4.1 Planned and targeted collection

Despite the urgency to preserve our biodiversity, conservation efforts have largely been restricted to species and provenances of proven value thus neglecting some species and ecosystems. Among these are the arid and semi arid lands (ASAL) some of which have been severely degraded to the point that species diversity of these habitats has been significantly eroded. For this reason under the Seeds for Life Project, targeted and planned collections are being conducted specifically in these areas of the country. Since 1996, a total of about 4 000 accessions have been collected from various regions in the country and conserved at the National Genebank of Kenya.

Priority for collection has been identified for underutilized crops and species such as taro (*Colocasia esculenta)* bambara nuts and medicinal plants such as *Mondia whytei* and *Vernonia galamensis* whose *in situ* diversity is not sufficiently reflected in the *ex situ* collections. Priorities for germplasm collection should also focus on regions with high rate of genetic erosion and degradations such as Northern Kenya where ethnic animosity and natural calamities including floods and droughts have contributed to persistent loss of PGR.

Genetic diversity studies using different markers are essential to undertake germplasm collection for *ex situ* conservation and to identify sites with high genetic diversity for *in situ* conservation. However, such studies have not been carried out for many species in the country thus hindering a rational collecting strategy. Genetic diversity studies therefore remain a priority research need to define important characters' variability and their patterns of distribution, and hence generate information for further germplasm collection.

[14] National Genebank of Kenya Database

4.4.2 International arrangements and networks in PGR collection

Kenya has been a partner in several international arrangements involved in the conservation of PGR. Some of these include East African Plant Genetic Resources Network (EAPGREN), which is an Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) network and draws its funding from SIDA (Chapter 6). Other initiatives include the Seeds for Life Project (SFLP), which is a Seed Conservation undertaking that has grown out of the Royal Botanic Garden, Kew global initiative known as the Millennium Seed Bank Project (MSBP). The Seeds for Life Project is multi-organizational involving 5 Kenyan institutions namely KARI, KWS, KFS, KEFRI and NMK. The aim of the Project is the conservation of indigenous plants from arid and semi arid lands (ASAL) through, *inter alia*:

- The conducting of joint expeditions to collect seeds and corresponding herbarium material in ASAL in an ecologically sustainable manner;
- The storage of seed collections in Kenya and the United Kingdom for long-term conservation and safe keeping;
- The conducting of taxonomic verification and seed studies upon the seed collections to determine their viability and to enable long-term conservation.

The Project is in line with Decision 23 of COP 5 (May 2000) which establishes a work programme for Dry land Biodiversity and addresses the Guiding Principles of the 1999 Environmental Management and Co-ordination Act and the National Biodiversity Strategy and Action Plan, 2000 as they relate to the need to *"prescribe measures for the conservation of biological resources ex situ especially for those species threatened with extinction"* and to *"increase [our] capacity for ex situ conservation"*, by *"creating synergies among on-going activities"* through the recognition of the importance of *"indispensable national, regional and international co-operation"*. Furthermore, the Project's long term and short term objectives directly address the "general objectives" of the NBSAP, that is:

- The enhancement of *ex situ* and *in situ* conservation and sustainable utilisation of plant genetic resources indigenous to Kenya; and
- The enhancement of technical and scientific co-operation nationally and internationally, including the exchange of information, in support of biodiversity conservation.

4.5 Documentation

At the National Genebank of Kenya, combinations of manual and computer data handling techniques are employed in documenting *ex situ* PGR. The manual system consists of a set of data sheets which are used to organize and record raw data for eventual input into a computer system. In the case of the computer system, a Microsoft Access Relational Database Management System has been designed to hold the data that includes passport data, seed testing data and storage data among others. Under the system passport data of all the 49 000 accessions conserved at NGBK are documented. Records of 12 749 accessions of characterization data representing about 80 species have also been captured in the system. More information on information systems used in other institutions is provided in chapter 5.

4.6 Research

In its conservation efforts, the National Programme addresses specific problems through adaptive, applied and strategic research. This research has been in areas of seed science, germplasm evaluation, diversity studies, characterization, spatial analysis, and gene-flow/bio-safety. This research aims at promoting long-term conservation and genetic enhancement and understanding the diversity resident in the germplasm. It also helps in adding value to the germplasm. Seed science research has mainly concentrated on seed dormancy, seed longevity and ecological studies. More collaboration and funding are required in order to further these studies nationally and regionally as they are a research priority.

4.7 Field genebanks

While a majority of plants produce seeds which can be dried to low moisture content to enable long term conservation in seed banks, there are some that produce seeds which cannot withstand desiccation and/or freezing. Other plants do not produce seeds at all and thus are vegetatively propagated. One option of conserving these 2 classes of taxa is

through field genebanks. Currently, the National Genebank of Kenya has field genebanks for crops such as cassava, yams, sweet potatoes, mangoes, sugarcane and coconut. Some of these field genebanks need to be rehabilitated, enriched and maintained.

4.8 Botanical and home gardens

The country has several botanical gardens but which are mostly oriented towards the conservation of forest genetic resources. These are generally situated in or near towns or within premises of forestry institutions and universities. Arboreta of tree species are located in Nairobi, Mombasa, Nakuru, Kisumu and other major towns.

Of special mentioning due to its relevance to PGRFA is the Maseno University Botanic Garden where medicinal plants and traditional African leafy vegetables are conserved. The garden has also been providing seedlings for development and for the *in situ* conservation of Kakamega forest, parts of which have been seriously depleted by indiscriminate harvesting of forest products. Since its establishment in 2001, the Botanic Garden has been actively cooperating with local communities and researchers for the efficient utilization of plant products for sustainable development. Attention has also been paid to benefit sharing with the local communities especially in economic ventures related to plant products, where the communities play a major role in the conservation of biodiversity. Farmers are getting involved in academic research as on-farm experimental participants. In return they get free technical advice and training in new technologies.

4.9 Duplication

To date, a total of 7 404 accessions of various plant species at NGBK have been duplicated in various seed banks. Out of these, 4 898 accessions comprising of 81 genera and 210 species have been duplicated in various CGIAR centres as shown in Table 7 below. A total of 4 444 accessions of these are being held in trust.

An additional 1948 accessions comprising 117 Families, 619 genera and 989 species have also been duplicated at Royal Botanic Garden, Kew.

TABLE 7
Germplasm duplication in CGIAR centres[15]

CGIAR Centre	Number of accessions duplicated	Percentage of total accessions duplicated to CGIAR centres
AVDRC	61	1.2
CIAT	866	17.7
CIMMYT	254	5.2
CIP	5	0.1
ICARDA	42	0.9
ICRAF	25	0.05
ICRISAT	2 429	49.6
IITA	203	4.1
ILRI	743	15.2
IRRI	266	5.4
WARDA	4	0.1

Recently, the country duplicated an additional 558 accessions comprising of *Sorghum bicolor*, *Eleusine coracana* and *Phaseolus vulgaris* at the newly established Svalbard seed vault in Norway.

[15] SINGER, (System-wide Information Network for Genetic Resources) http://www.singer.cgiar.org (Accessed on 12th June 2008)

4.10 Regeneration

Regeneration is conducted for materials whose viability has fallen below 85% as determined during viability monitoring. At the National Genebank of Kenya, regeneration and characterization are always done simultaneously. To avoid problems posed by adaptability, the NBGK has taken the strategy of undertaking, multiplication and regeneration of materials in the region where they were collected. This is mostly done in KARI centres, which are distributed throughout the country and is made possible by assistance obtained from scientists in these centres. To preserve the genetic integrity of each population, cross-pollination between accessions is prevented by the use of appropriate isolation mechanisms. The number of seeds used during regeneration and multiplication is in accordance with the recommended standards in order to preserve the genetic integrity of the accession.

4.11 Assessment of major *ex situ* needs

While the National Genebank of Kenya which is the key institution involved in *ex situ* conservation, has evolved over time to become one of the centres of excellence in PGR matters regionally[16] and globally, a number of priority areas need to be addressed so as to enhance its capacity in PGR conservation.

Of top priority is for Kenya to strengthen its technical capacity for *ex situ* conservation and utilization of plant genetic resources at the national levels, with a special focus on:

- Strengthening of human resource capacity in areas of taxonomy, pathology, GIS, molecular techniques, database management and inventory.
- There is need for strengthening the seed handling and storage capacity of the seed bank facilities to meet national needs through provision of equipment, installation of cold store power back up system. Equipment includes: Zigzag seed blower, two way thermo-gradient plate, germination incubators and oven. For those seed banks using cold room based facilities, there is need to shift to other cold storage facilities such as deep freezers which are more economical and less risky in terms of their operations.
- Establishment of field genebanks for crops such as yams (*Discorea* sp.), cassava (*Manihot esculenta*), banana (*Musa sapientum),* sweet potato (*Ipomoea batatas*) and taro (*Colocasia esculenta)* whose field genebanks have not yet been established. *In vitro* collections of these crops should also be established.
- Diversity enrichment for those field genebanks that already exist through germplasm collections.
- Value addition and enhancement of conserved materials through characterization, evaluation and pre-breeding.
- Increasing the infrastructural capacity to do regeneration, characterization and multiplication of germplasm.
- The establishment of regional gene-bank probably in the Eastern Africa region for safety duplication and long-term storage of the regions base collections.
- Constituting core collections which is an important *ex situ* conservation strategy
- Providing adequate financial resources for conservation activities
- There is need to develop stronger links between conservation and use of conserved germplasm.

Other constraints that have hampered efforts to sustain the existing *ex situ* collections include:

- Unknown viability status of the conserved germplasm due to limited capacity to conduct viability tests
- Limited information on seed storage behaviour of some species especially the wild ones
- Inadequate capacity in terms of staff and facilities to rejuvenate and multiply stored germplasm. This leads to low viability levels and limited sample sizes hence limiting their availability for distribution to interested users.
- Inadequate information on the diversity of the conserved germplasm
- Inadequate information on the potential value of the conserved germplasm hence limiting its use by interested users such as plant breeders
- Inadequate information on appropriate seed testing protocols especially for wild species

To overcome these constraints below are some of the proposed interventions:

- Training of staff to empower them with skills to conduct seed dormancy, storage and viability monitoring studies.
- Strengthening the infrastructural capacity of institutions to conduct experiments and routine tests through for example, the purchase of incubators.

[16] Refers to the Eastern Africa Region

- Morphological and molecular characterization to enable selection of core collections and hence add value to the conserved germplasm.
- Conducting preliminary evaluation in order to add value on the conserved materials
- Providing adequate financial resources to undertake research in propagation techniques.

While efforts should be made in strengthening national programmes on plant genetic resources, there is also a clear need to develop and implement a regional strategy for *ex situ* conservation. This can be achieved for example by identifying centres of excellence that could serve as institutional references for well-targeted conservation, research and development initiatives. This will assist in taking advantage of comparative advantages and strengths of the different institutions, pooling of resources and avoiding duplication of efforts. Such a strategy will contribute to better, more sustainable and focused germplasm conservation initiatives. It will lead to creation of synergy, linkages and promote collaborative advantages. There is also need for strengthening existing regional programmes and networks on plant genetic resources, and the development of linkages to enhance collaboration between them.

CHAPTER 4

THE STATE OF USE

5.1 Introduction

Germplasm is assembled both for long-term conservation and immediate utilization. Immediate utilization ranges from direct introduction on-farm to plant breeding, scientific research and education. Some traditional and local varieties are often important socially and culturally. The National Genebank of Kenya distributes between 200 – 700 accessions every year, both within and outside the country for utilization mainly in crop improvement and basic research. The absence of data on economic returns coupled with the perception that only limited number of accessions out the total conserved have actual use are threatening continued support for conservation efforts in many countries, including Kenya[17]. This chapter gives highlights of the uses to which some of the materials distributed by NGBK have been put. It also highlights some of the achievements in crop improvement as a result of the use of these materials. The chapter concludes with an assessment of major gaps, needs and priorities in the area of germplasm use.

5.2 Distribution and use of plant genetic resources

At the NGBK, when germplasm is distributed to various users, the ensuing information is captured in the documentation system both in the computer and manual files. In a germplasm survey conducted in various parts of the country between June 2004 and February 2005 with the aim of studying the extent of utilization of plant genetic resources in Kenya, it was found that while the NGBK conserves about 49 000 accessions, only 4 000 samples were distributed over a period of 15 years[18] The distributed materials comprise at least 290 plant species and have been distributed to at least 150 users within and outside the country. Sorghum (*Sorghum bicolor*) and common bean (*Phaseolus vulgaris*) form the bulk of the distributed germplasm. National Agricultural Research Institutes ranked first among germplasm recipients with 40 percent of the share, while international research institutes and universities followed with 32 and 23 percent respectively. Schools, colleges, commercial companies and farmers in a decreasing order shared 5 percent of the germplasm.

During the survey, more than half of the respondents reported that they utilized the germplasm for research purposes only, followed by direct use only, breeding only, breeding and research, a combination of breeding, research and direct use and lastly a combination of research and direct use (in a decreasing order) (Table 8).

TABLE 8

Utilization of material distributed by the GBK for 15 years (1988 – 2003)[19]

Purpose	Percentage of respondents
Research only	58
Direct use only	14
Breeding only	11
Breeding & research	11
Breeding, Research & Direct use	3
Research & Direct use	3

[17] Mutegi E., Muthamia Z.K., Mutisya J. and Muoki S. 2005. Study on the extent of utilization of plant genetic resources in Kenya. Agricultural Research Center, Muguga South. Annual Report. 2005. Kenya Agricultural Research Institute.
[18] Mutegi E., Muthamia Z.K., Mutisya J. and Muoki S. 2005. Supra note 17
[19] Mutegi E., Muthamia Z.K., Mutisya J. and Muoki S. 2005. Supra note 17

About 26% of the respondents in the survey indicated that they had utilized the material in their breeding programmes. In fact, the germplasm had been used to develop varieties in at least two major food crops [maize (*Zea mays*) and sorghum (*Sorghum bicolor*)], one commercial crop (French bean) and one neglected oil crop (safflower). Below are examples of the use of the distributed germplasm for crop improvement purposes:

- **Maize (*Zea mays*)**: At least 107 accessions distributed in the year 2000 were screened and some genotypes were utilized to develop five high altitude varieties that were currently undergoing late testing for release by the time of the survey.
- **Sorghum (*Sorghum bicolor*)**: Sixteen accessions distributed in late 1980s were evaluated for grain colour and stalk borer resistance. Two of the accessions were found to be resistant to stalk borer, while one was found to have a deep rooting system. These three accessions were used to fix the two traits in a commercial variety, KARI Mtama 1which was released in the year 2000.
- **French bean**: One accession of GLP 20 variety was found to be resistant to field rust, anthracnose and Bean Common Mosaic Virus (BCMV) and was crossed with some breeder's lines to develop two varieties that have been released. The two released varieties are now attracting huge attention from the major seed companies in the country.
- **Safflower (***Carthamus tinctorius* L*)***:** Three accessions of safflower distributed in the year 2000 have been included into KARI-Njoro's oil crop breeding programme, where at least 11 varieties have been developed and were undergoing multi-location yield trials in at least four marginal areas of the country by the time of the survey.

In a recent survey supported by Bioversity International (then IPGRI), which attempted to document the constraints for effective utilization of genetic resources conserved *ex situ,* it was revealed that despite knowledge of existence and functions of the NGBK, most potential users never acquired materials because they lacked adequate information about the material conserved or they felt that material appropriate for their work was not available. Other constraints identified to the use included lack of adequate information on performance or evaluation data especially for biotic and abiotic stresses; poor linkages between the NGBK and potential users; inadequate information (taxonomy, passport and characterization data) accompanying the distributed material; small sample sizes offered to the clientele and complexity and long delays in obtaining germplasm from the NGBK.

Majority of those unaware of the existence of the NGBK were farmers. This was not unexpected because genebanks are mandated to primarily support the formal breeding programme and rarely deal directly with the farmers.

The fact that germplasm demand by farmers and private seed companies was very low, serves as a pointer for the NGBK to expand its scope of operations. The general view of the private seed companies was that the genebanks should store varieties produced by the local breeders and distribute them with permission of the relevant authority to make work easier, as these companies have to source their materials from outside the country.

Although many recipients were satisfied with passport data quality and quantity, those from the universities and research institutions called for improvement of taxonomic information of the conserved germplasm and broadening of the diversity base of collections in the NGBK so as to include important economic crops and trees such as coffee, tea, potatoes among others. The recipients called for improvement and rehabilitation of field banks, increased cold storage capacity and personnel training for better handling of the germplasm. In addition to limited intra and inter-specific diversity, the low demand for germplasm from recipients who had previously acquired germplasm is probably also due to their dissatisfaction with the seed quality as only few respondents were satisfied with the germination results. However, it is also possible that the problem could actually be due to inappropriate germination protocols employed rather than low germination *per se.* There is thus a need to provide important information like pre-treatments for the germplasm when distributing germplasm.

5.3 Characterization and evaluation

Inadequate evaluation and characterization data is one of the major challenges limiting utilization of germplasm from the NGBK. Only 18 303 accessions representing about 37% of the germplasm holding at NGBK have been characterized for agro-morphological but none using molecular markers. Percentage of accessions characterized per crop range between 3 and 90% with majority falling below 50%. Out of 1 725 species conserved at NGBK, 144 have been characterized. However, none has been evaluated for biotic and abiotic stresses.

The constitution of core collections has been achieved only in the sesame collection, whereby 110 accessions out of 2 000 constitute the core collection. There is a possibility that NGBK is conserving duplicate and genetically redundant

accessions. This increases the Genebank's operational costs and decreases the efficiency of characterization and evaluation efforts and hence any germplasm enhancement programmes.

The inadequate characterization and evaluation of conserved germplasm can be mainly attributed to lack of scientific staff. The successful implementation of these activities would require the establishment of well-trained multidisciplinary teams able to address botanical, bio-chemical, agronomic and economic aspects.

TABLE 9
Top 15 species that have been characterized at the National genebank of Kenya[20]

Genus	Species	Number of accessions
Sorghum	*bicolour*	3 911
Eleusine	*Coracana*	1 785
Sesamum	*Indicum*	1 278
Phaseolus	*Vulgaris*	1 000
Vigna	*unguiculata*	608
Zea	*Mays*	590
Oryza	*Sativa*	484
Sesamum	*Indicum*	459
Gossypium	*Hirsutum*	219
Vigna	*radiate*	213
Arachis	*Hypogaea*	121
Cucurbita	*Moschata*	97
Cajanus	*Cajan*	95
Cleome	*Gynandra*	82
Triticum	*Aestivum*	79

Training and research on the use of advanced bio-techniques, including molecular characterization, "allele mining" and genomics-based germplasm enhancement should also be gradually pursued to form a cadre of national expertise and build capacity for increasing utilization potential of conserved germplasm. Furthermore, in order to promote utilization, characterization and evaluation, data have to be made promptly available to breeders, through adequate and efficient information systems.

5.4 Crop improvement programmes

5.4.1 Type of programme and institutions involved

The history of crop improvement programme in Kenya can be traced to the colonial times when the first hybrid seed maize was released from the National Agricultural Research Station at Kitale in 1962-1963. Since then the programme has grown into a vibrant and dynamic sector that has undoubtedly made great impact in terms of increasing food security in the country and improving the economic livelihoods of a great majority of people. The programme is a well-established formal sector that combines both the conventional plant breeding and also advanced and state of the art methodologies and skills. It is probably one of the most developed programmes among the developing nations.

The main institutions involved in plant breeding include KARI, the Tea Research Foundation (TRF), Kenya Seed Company, public universities, the Kenya Sugar Research Foundation (KESREF), the Coffee Research Foundation (CRF). These institutions enjoy both financial and technical assistance from a number of other institutions such as CIMMYT, the Rockefeller foundation and CIAT. KARI is by far the institution that has released the greatest number of crop varieties. For instance, within the period 1985-2002, KARI released a total of over 46 improved varieties of food and horticultural

[20] National Genebank of Kenya Database

crops including maize (*Zea* mays) [22], wheat (*Triticum aestivum*) [18], grain legumes (32), Irish potatoes (6) and sorghum (*Sorghum bicolor*) and millets (*Eleusine coracana*) [20].

5.4.2 Crops and traits

Virtually all agriculturally and economically important crops in the country have benefited from plant breeding activities. Some of these include, maize (*Zea mays*), beans (*Phaseolus vulgaris*), wheat (*Triticum aestivum*), sorghum (*Sorghum bicolor*), peas (*Pisum sativum*), sunflower (*Helianthus annuus)*, millets (*Eleusine coracana*), oats (*Avena sativa*), barley (*Hordeum vulgare*), cowpeas (*Vigna unguiculata*), cassava (*Manihot esculenta*) and sweet potato (*Ipomoea batatas*) among many others. To date, more than 400 improved varieties of various crop species have been released in the market and are now within the farming systems.

The objectives of the breeding programmes are as diverse as the crops targeted but overlaps abound between them. As expected, yield and yield stability is by far the trait that has been bred for in almost all the crops. Others include resistance/tolerance to both biotic and abiotic stresses. Incidences of pests and diseases have been shown to significantly reduce crop yields and thus continually threaten sustainable crop production. Breeding programs have therefore been initiated for most crops with the main objective of strengthening resistance and tolerance to pests and diseases. Some of these include maize streak, grey leaf spot, rust and stem borers in maize (*Zea mays*); angular leaf spot, root rots, common bacterial blight, rust, fusarium wilt and anthracnose in beans (*Phaseolus vulgaris*); cassava mosaic in cassava (*Manihot esculenta*) and late blight in tomato *(Solanum lycopersicum*) among others. Breeding for tolerance to drought and early maturity have also been major breeding objectives. Germplasm sources are mainly from CGIAR centres such as CIMMYT and IITA and genebanks from developed countries. Kenyan breeders have shown a justified preference for materials whose evaluation data is available and those that have undergone pre-breeding. This partly explains why utilization of germplasm conserved at the NGBK which has not been evaluated is low.

For forest trees, KEFRI is the main institution with a tree breeding programme. The programmes have focussed on breeding for yield for various tree species including *Eucalyptus grandis, Grevillea robusta, Cupressus lusitanica* and *Pinus patula*. Some of the programmes have also successfully bred for resistance to blister rust in *Cupressus lusitanica* and pine woolly aphid in *Pinus patula.*

5.4.3 Farmer participation

While breeding efforts have in the past tended to be conducted by breeders with little or no involvement of farmers, the trend is quickly changing. Globally, it has been noted that when farmers are not involved in the breeding process, their chances of adopting the developed varieties are low since in most cases they lack the preferred traits. For crops such as maize, beans, cassava, pigeon peas and sorghum farmers are increasingly being involved in setting breeding priorities. In addition, they are also involved in the selection process. In most cases, farmers are invited to the research stations during for example preliminary or advanced yield trials where they participate in variety assessment and selection. This approach has been shown to be beneficial as it enables scientists drop unacceptable varieties at early stages of variety development, hence increasing variety selection efficiency. Related to the traditional gender roles, it is especially important to involve women farmers in plant breeding activities. KARI has successfully conducted participatory improvement of various crops. However, despite these efforts the challenge of low adoption of improved varieties is still great and a concern to scientists.

In order to increase the participation of farmers in research and crop improvement, KARI launched the Agricultural Technology and Information Response Initiative (ATRI). The primary objective of ATIRI is to empower farmers to make technological and information demands on KARI and other service providers, to facilitate KARI and other service providers to respond to this demand, to promote up-scaling of technology adoption through creation and strengthening of partnerships and to integrate farmer feedback into KARI research agenda.

5.5 Seed supply systems

Seed systems can be classified into two broad categories; formal and informal. Formal systems involve institutions in both the public and private domain that develop, multiply and market seed to farmers through well defined methodologies, controlled stages of multiplication and in the framework of national regulations. Seed produced within formal systems is often of modern varieties. The informal system on the other hand is that practiced by farmers themselves who produce, select, use and market their own seed through local, generally less regulated channels. Kenya has both formal and informal seed sectors.

5.5.1 Formal seed sector

The formal seed sector in Kenya comprises public sector agencies, private agencies and multinationals that play a dominant role in the multiplication and marketing of seeds of many plant varieties. The sector is characterized by well-organized marketing and research services and attracts mainly varieties of commercial importance.

In 1996, in order to improve efficiency in the seed industry, the crop seed industry was liberalized. This has allowed any company registered as seed merchant in Kenya to undertake research, breeding, multiplication and marketing in the country. Currently, there are over 40 registered seed companies. However, given the critical role of the seed industry in Kenya's agriculture, strict adherence to the Seeds and Varieties Regulations (1991) is mandatory. This requirement is enforced by KEPHIS, by ensuring that the seeds being marketed by all companies are certified. Any defaulters are prosecuted as provided in the law.

Major constraints to the formal seed sector include production of adequate quantities of seed, poor accessibility to remote areas, deterioration in quality of seeds (partly due to lack of isolation distances), increasing transportation costs leading to unaffordable seed prices, late delivery and poor implementation of quality control regulations. Others are adulteration of seeds by unauthorised dealers, over reliance on a limited number of crop species and sometimes adverse weather conditions during production. Traditionally, formal seed supply system has focused more on production of seeds of high potential crops (especially maize (*Zea mays*) , wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), sunflower (*Helianthus annuus*) and pasture) for which there is stable demand, especially among the resource rich farmers, and less on pulses [beans (*Phaseolus vulgaris*), pigeon peas (*Cajanus cajan*) and cowpeas (*Vigna unguiculata*)], most of which are produced by smallholder farmers and do well in arid and semi arid areas which constitute about 82% of Kenya's landmass.

In order to ensure reliable quality seed and planting material supply, especially for crops not handled by commercial seed companies, the KARI Seed Unit (KSU) has embarked on an aggressive breeder and basic seed production, as well as farmer training programmes on informal quality seed production. Since 1997, KSU has sold basic seed to over 40 NGOs that assist seed groups in the ASAL areas, thus directly benefiting over 360 000 farmers who would otherwise not have been served by commercial seed companies. Likewise, for forest trees the KFSC has widened its seed collection species range to cover some wild species of specific uses such as medicinal value.

5.5.2 Informal seed sector

The informal seed sector sometimes referred as local seed sector is mainly characterised by on-farm seed production and distribution. On-farm seed production refers to the collective effort of farmers and their communities who save and store part of their harvest for sowing in the next season. It also includes purchase from the local grain market and exchange with neighbours. It is the most important source of seeds and other planting materials accounting for about 80% of the total supply in some parts of the country such as Western Kenya[21]. The informal seed systems are especially important not only as a source of cheap and easily accessible seeds but also because they help in the maintenance of rare of crop varieties. They therefore play an important role in on-farm conservation. However, the present regulatory Framework does not support this sector since according to the Seeds and Plants Varieties Act Cap 326; it is illegal to trade in seeds that are not certified. Most of the exchange of seeds in the informal sector takes place in the form of informal trade. It is therefore important to put in place regulatory mechanisms and policies that would encourage rather than inhibit this informal sector.

5.5.3 Role of local seed markets

Markets in the country especially in the local areas have been a very effective way of increasing genetic diversity within the farming system. Markets enable farmers to obtain seeds of rare crop varieties and also to identify seed sources.

A study conducted in Eastern Kenya showed that for most crops, traders in the local grain and seed markets handled several varieties (Table 10). The study showed that the traders with more knowledge and diversity of particular crops were more favoured by buyers. This serves to exchange and hence increase diversity within the farming system.

Closely associated with markets are seed fairs which have also enabled farmers to access more crop diversity.

[21] Wambugu, P.W. 2006. On-farm Seed Production, Storage and Preservation of Selected Local Maize (Zea mays L.) Germplasm in Western Kenya: The case of Siaya and Busia Districts. Unpublished Master of Philosophy Thesis, Moi University

For example, seed fairs held by International Technology Development Group (ITDG) -Kenya in two successive years recorded a 10% increase in the number of crop varieties exhibited. Seed fairs are also good fora for exchange of ideas on farming and of seeds.

TABLE 10

Number of crop varieties handled by grain and seed vendors in various markets in Eastern Kenya between Oct-Nov 2005[22]

Market	Crop						
	Pigeon pea *(Cajanus cajan)*	Maize *(Zea mays)*	Cow pea *(Vigna unguiculata)*	Beans *(Phaseolus vulgaris)*	Green grams *(Vigna radiata)*	Sorghum *(Sorghum bicolor)*	Finger millet *(Eleusine coracana)*
Kitui	2	4	2	3			
Kabati	2	4	1	5	1	2	
Makueni	2	4		4		2	1
Kathonzweni	4	4	2	4		2	
Matiliku	4	2	1	3			
Kalamba	1	2		2	1		
Makutano	4	2		4	1	2	2

5.6 Assessment of major gaps, needs and priorities

- In order to increase utilization, more efforts need to be put towards characterization and evaluation of conserved germplasm. Breeders have shown preference for materials whose characterization and evaluation data is available as this saves on time and resources for doing these activities.
- The links between the National Genebank of Kenya and breeders should be strengthened. The level of awareness on the existence of the Genebank remains lows and hence a publicity campaign is needed in order to raise the level of awareness.
- There is need for capacity building in the area of plant breeding. While the world has embraced modern technologies in plant breeding, the country continues to rely heavily on traditional/conventional techniques. These modern techniques can make an immense contribution in the development of new varieties and hence in the attainment of food security.
- The country still has some unfavourable seed policies which are not conducive for the development of the informal seed sector which is by far the greatest source of seeds and other planting materials. These laws and policies should be reviewed and harmonized in order to spur the development of a strong seed industry.
- The country has so many underutilized and neglected species which are of great economic importance. The level of awareness of the importance of these species is increasing each day. In order to increase utilization of these species, more research is needed on their nutritional importance and other useful traits.
- There is also a need for more fully integrated systems at the national level that provide for effective linkages between conservation, breeding and seed production and distribution, in order to bring the benefits to the farmers themselves, in the form of improved seed.

[22] Audi, P.O., Nagarajan, L., Jones, R. B. 2008. Seed interventions and cultivar diversity in pigeon pea: A farmer based assessment in eastern Kenya. In: Journal of New Seeds. Vol. 9. No. 2. 2008.

CHAPTER 5

THE STATE OF NATIONAL PROGRAMMES, TRAINING AND LEGISLATION

6.1 Introduction

Efficient and well-coordinated national programmes on plant genetic resources for food and agriculture (PGRFA) can contribute greatly to national socio-economic development. This coordination should be between different, sectors, ministries, institutions and stakeholders. Such coordination can increase efficiency, minimize duplication of effort and ensure complementarity between activities.

The Kenyan National Programme has remained largely uncoordinated and this has affected its progress in several areas of PGRFA conservation and utilization. For instance, several initiatives aimed at developing a policy framework on access and benefit sharing failed due to lack of coordination and unclear institutional mandates (chapter 7).This chapter gives highlights of the structure and functions of the Kenyan National programme and as well as its coordination. Some of the legislation relevant to PGR that have been passed since the first SoW are also highlighted. The chapter ends with an assessment of major gaps, needs and priorities.

6.2 Structure of Kenya's National Plant Genetic Resources Programme

The Kenyan National Plant Genetic Resources Programme was technically established in 1978. The programme is a network of institutions undertaking plant genetic resources work in the country and includes the GBK, KEFRI, NMK, Kenya Wildlife Services, the Kenya Forest Service, relevant government ministries and departments such as the Ministry of Environment and Natural Resources, the Ministry of Agriculture, local public universities, CBOs, NGOs and farmer groups. The key institutions have specific roles and responsibilities in line with their mandates and missions.

6.3 Functions of the PGR programme

The main functions and or objectives of the national PGR programme are:

- Promoting the conservation of biodiversity in ecosystems and to preserve their cultural values.
- Enhancing sustainable utilization of resources and ecosystems for the benefit of the present and future generations.
- Ensuring that development policies, programmes and projects do take environmental consideration into account from the onset.
- Initiating and sustaining well coordinated programmes of environmental education and training at all levels of the society.

6.4 Coordination of National PGR programme

Whereas all the stakeholders collaborate at institutional and individual levels in the implementation of specific plant genetic resources (PGR) activities, there is no general agreement on the institution that is responsible for coordinating PGR activities. Biodiversity policy in Kenya was historically coordinated by the National Environment Secretariat (NES). NES was established in 1974 by presidential directive but was never provided with statutory legal status, and as a consequence had no direct enforcement powers and had been consistently under funded. As a result, NES was not able to adequately coordinate the multiplicity of lead agencies and institutions with mandates involving biodiversity issues. This has led to

fragmented legislation, policies and implementation mechanisms dominated by the interests of the major lead agencies with negative repercussions on the efficiency of the overall national programme. Over the years, the International Plant Genetic Resources Institute[23] (now Bioversity International) has helped to develop and strengthen the Kenyan national plant genetic resources programme by providing support, scientific information and training, and encouraging linkages between institutions at both regional and international levels. The National Information Sharing Mechanism has further strengthened the national programme as it has led to the formation of a network of institutions.

TABLE 11
Some key institutions that form the National PGR Programme in Kenya

Organisation	Role in Plant genetic resources conservation and utilization
Kenya Agricultural Research Institute (KARI)-National Genebank of Kenya[24]	KARI's mission is to contribute together with its partners, agricultural innovations and knowledge towards improved livelihoods and commercialization of agriculture through increasing productivity and fostering value chains while conserving the environment. The National Genebank of Kenya is involved in long term conservation of plant genetic resources
Kenya Forest Service	Kenya Forest Service provides services to manage, protect, maintain and expand Kenyan forests in a way that ensures productivity, sustainability and profitability of enhanced natural resource base for the benefit of all Kenyans
Kenya Wildlife Service (KWS)[25]	Manages national parks, game reserves, sanctuaries and marine parks in the country
Kenya Forestry Research Institute (KEFRI)[26]	Carry out research and advisory services in the areas of natural forests, forest plantations, farmlands and dry lands. Also disseminates information on tree and forestry development.
National Museums of Kenya (NMK)[27]	Manages the network of national herbaria, collects plant materials and manages national monuments.
National environment Management Authority (NEMA)[28]	Regulates environmental management law and ensures compliance according to regulations, rules and environment impact assessment for development initiatives.
Kenya Plant Health Inspectorate Services (KEPHIS)[29]	Regulates import and export of plant products through issuance of phyto-sanitary certificates and ensuring health controls
Local Universities	Research in natural resources and plant sciences. Training in plant biodiversity, genetics and plant breeding.
NGOs and Community Based Organizations (CBOs)	Mainly involved in lobbying for conservation and sustainable management of PGR. CBOs are involved in the implementation of mostly conservation projects in collaboration with local communities.

6.5 Education and training

The educational system in Kenya is organized in primary, secondary and tertiary institutions, which include polytechnics, colleges and universities. At the primary and secondary levels the Government has requirements for environmentally related courses, particularly where these intersect with agricultural concerns, but these are not yet fully developed. All public universities offer at least some training courses of relevance to biodiversity conservation for example, seed science and technology courses offered at Moi University, plant genetic resources conservation course at Maseno University, horticulture courses in most of the other public universities. Most of the universities also have strong partnerships both with lead agencies and with the international research centres present in the country. For example, some of the leading institutions such as KARI, KEFRI and NMK have entered into a partnership with Maseno University that has resulted in a Diploma Course on Plant Genetic Resources Conservation, which is mainly offered to staff from these institutions.

Despite these valuable initiatives, plant genetic resources themes are not sufficiently addressed in the educational curricula among institutions of higher learning. In order to improve country capacity to deal with PGR issues, there is need for an increased emphasis and more articulated teaching of these especially at the university level.

[23] www.bioversityinternational.org
[24] www.kari.org
[25] www.kws.oeg
[26] www.kefri.org
[27] www.museums.org
[28] www.nema.oeg
[29] www.kephis.org

Training facilities for seed science and technology, plant breeding, plant genetic resources conservation and other related courses deserve urgent improvements in order to keep up with technological developments in these fields.[30] Priorities for training have been identified in areas of bio-safety regulations and guidelines, molecular diversity analysis, early warning systems, monitoring of use of genetic materials, and natural resource assessment and management.

6.6 Information systems

The three main institutions involved in PGR activities i.e. KEFRI, GBK and NMK routinely document their collections and activities mainly using computerized systems. However, there is no common data management programme and data storage is generally done in various softwares such as word documents, Microsoft excel, Microsoft access or other institutional specific programmes such as Botanic Research and Herbarium Management Systems (BRAHMS). BRAHMS is the most commonly used programme at the NMK especially in handling herbarium data and information.

At the NGBK, a combination of manual and computerized data and information management systems are employed in gathering, storing and manipulating genebank data. The manual system employs a set of data sheets that are used to organize and record raw data as it is generated. These data sets are therefore organized into specific genebank operations e.g. passport data, seed testing data, characterization data and distribution data. Traditional manual files are used to hold data sheets depending on operation and serve as archives.

One of the genebank's key strategic objectives is to document and disseminate germplasm data and information to diverse users including germplasm managers, researchers and policymakers. In order to achieve this objective effectively, the genebank has embraced modern advances in information technology and put in place a computerized relational database management system. The Microsoft Access Relational Database Management System has been designed to hold and manage the various genebank operation datasets as derived from the datasheets. Geographical Information Systems (GIS) are used to map collection sites and to generate germplasm distribution maps.

A 16-port Local Area Network has also been installed with a view to enhancing sound data capture, management and information exchange practices. It is now the endeavor of the NGBK to access and be accessed by wider ranges of potential germplasm users and other stakeholders, the world over via the Internet. This has however not been very successful due to lack of a dedicated internet connection at the NGBK. Dissemination of data and information to the outside world is therefore seriously hampered by this constraint.

6.7 National legislation

In the last decade, the country has passed several important legislations that are relevant to PGR. These are briefly discussed in the following paragraphs.

6.7.1 The environmental management and coordination act, 1999[31]

The Environmental Management and Coordination Act is the key statutory instrument regulating access to genetic resources in Kenya. It was enacted in 1999 and came into force on 14th January 2000. Section 7 of the Act establishes the National Environment Management Authority as a body corporate with perpetual succession. Section 53 stipulates that the Authority shall issue guidelines and prescribe measures for the sustainable management and utilization of genetic resources of Kenya for the benefit of the people of Kenya. The guidelines shall specify appropriate arrangements for access to genetic resources by non-citizens, including the issue of licences and fees to be paid for that access. Guidelines shall also be made for the sharing of benefits derived from genetic resources of Kenya.

6.7.2 The industrial property act, 2001

The Kenyan Parliament has passed the Industrial Property Bill 2001. The Bill seeks to bring the Kenyan industrial property law, particularly the patent law, in conformity with the Trade Related Intellectual Property Rights (TRIPS) Agreement.

[30] Kimani, P.M., 1998. Research and Teaching of Seed Science and Technology in University of Nairobi. In. Ochuodho, J.O, Mathenge, P.W., Rheenen H.K and Auma E.O. (eds). Seed production and certification. Proceedings of a workshop held in Eldoret, Kenya on 26-29th May 1998

[31] Environment Management and Coordination Act (1999), no. 8 of 1999, entered into force 14 January 2000 ["EMCA"].

Section 26 (a) of the Bill stipulates that plant varieties as provided in the Seeds and Plant Varieties Act cap 326, but not parts thereof or products of biotechnological process are not patentable. It is clear from this provision that plants varieties have been excluded from patentability. Recognizing that there is an obligation to protect new Plant varieties, Kenya already has in place a Seeds and Plant Varieties Act that fulfils this obligation. The country therefore provides for protection of plant varieties by an effective *sui-generis* system under provisions of the UPOV convention.

6.7.3 The statute miscellaneous amendment act, 2000

In order to strengthen its position on plant variety protection, Kenya acceded to the 1978 UPOV Convention on April 13th 1999. The accession entered into force on May 13th 1999. Kenya, amongst other developing countries delayed accession because UPOV is more rigid and requires members to adopt its standards and scope of protection. These standards have quite different implications with regard to the breadth and scope of coverage, and utilization of protected material in research and production of propagating materials and crops for sale. In order to give domestic effect to the UPOV accession, the Statute Miscellaneous Amendment Bill 2000 has been published. The Bill domesticates the UPOV 1978 provisions in Kenya.

6.7.4 The national biotechnology development policy, 2006

The Kenyan government has approved a biotechnology policy, which gives details on research, development and application of biotechnology in the country. The National Biotechnology Development Policy 2006 was approved by the cabinet on 28th September 2006 and marked the go-ahead for the use of the technology in the country. It outlines the safety procedures for biotechnology in the context of research and development, technology transfer and commercialization of products that would result from research undertaken in Kenya. The document recognizes the role that biotechnology can play in poverty reduction, enhancing food security and conservation of the environment and biodiversity. The policy outlaws human cloning, terminator technologies and any other technology found to be entailing unethical scientific practice. Any use of biotechnology in Kenya must receive the approval of the designated authority and meet the requirements of Kenya's Environment Management and Coordination Act of 1999.

6.7.5 The seeds and plant varieties (national performance trials) regulations, 2009[32]

The regulations give the procedures required for varieties to undergo National Performance Trials (NPT), an exercise which is conduced by KEPHIS. The regulations require that all varieties of crops listed in schedule 1 must undergo NPT before commercialization. Under the regulations, a Trial Committee whose mandate is to among other things, oversee the conduct of NPTs is to be established. For a variety to pass the NPTs, it must be Distinct, Uniform and Stable after which it is forwarded to the National Variety Release Committee for official release.

6.7.6 Environmental management and co-ordination (conservation of biological diversity and resources, access to genetic resources and benefit sharing) regulations, 2006[33]

Section 53 of The Environmental Management and Coordination Act, 1999 stipulates that the Authority shall issue guidelines and prescribe measures for the sustainable management and utilization of genetic resources of Kenya for the benefit of the people of Kenya. It is in reference to this provision that the Environmental Management and Co-ordination (Conservation of Biological Diversity and Resources, Access to Genetic Resources and Benefit Sharing) Regulations, 2006 were developed. According to the regulations, any person intending to access genetic resources for any purposes must apply to NEMA by filling application forms for an access permit. Such an application must be accompanied by necessary fees as specified in the regulations. The regulations also require the application to be accompanied by evidence of Prior Informed Consent from interested persons and relevant lead agencies, and a research clearance certificate from the National Council for Science and Technology (Chapter 7).

[32] The Seeds and Plant Varieties (National Performance Trials) Regulations, 2009, Kenya Gazette Supplement No. 12, Legal Notice No. 25.
[33] Environmental Management and Co-ordination (Conservation of Biological Diversity and Resources, Access to Genetic Resources and Benefit Sharing) Regulations, 2006. Legal Notice No. 160.

6.7.7 National Biodiversity Strategy and Action Plan (NBSAP)[34]

Kenya has no specific regulatory regime on Access and Benefit sharing in place. Although a potential regulatory structure has been put in place, it is yet to be developed into a substantive regime. There is a range of statutory, regulatory and policy provisions regulating access to PGR. The primary document in this case is the National Biodiversity Strategy and Action Plan that stipulates National Policy on Biodiversity and Trade in PGR based products and processes. Section 4.11 of the strategy states that Kenya will develop and implement policies and legislation to articulate and regulate the rights of access to, and benefit sharing of National PGR. It will strengthen the capacity of Kenyans to carry out bio-prospecting activities. Action 19 provides that Kenya will facilitate access to PGR and transfer of technology, and that Kenya Wild life Services (KWS), National Museums of Kenya (NMK), the National Council for Science and Technology (NCST), and Universities are the lead agencies. Action 21.4 provides that it will explore options and modalities for access and benefit sharing in the National Context and the lead agencies are, NMK, NCST, Universities, national research institutions and NGOs.

6.7.8 National bio-safety framework and regulation

Kenya adopted Regulations and Guidelines for Bio-safety in Biotechnology in 1998.

6.7.9 Protection of traditional knowledge, genetic resources and folklore

Traditional knowledge is closely linked with seed management issues. For example, when a certain seed disappears, the knowledge of the farmers about these biological resources often disappears too, since it is usually transmitted by word of mouth. Since women farmers play an important role in seed management, they generally hold a higher level of knowledge about genetic resources.

The Attorney-General in April 2006 created a Task Force on the Development of Laws for the Protection of Traditional Knowledge, Genetic Resources and Folklore to identify existing traditional knowledge and folklore and recommend laws to protect them. These laws could include mechanisms to protect genetic resources, ways to compensate custodians of folklore and access benefit sharing tools for traditional medicine.

Other policy instruments include: National Policy on Environment and Development; Wildlife Conservation and Management Policy; National Water Resources Policy and Strategy; National Land use Policy; National Wetlands Conservation Policy – under review; National Forestry Policy; Seed and Plant Varieties Act Cap 326 – under review; Bio-safety bill 2007; Traditional Medicine and medicinal plants policy and the National Environment Action Plan.

6.8 Assessment of major gaps, needs and priorities

- The National Information Sharing Mechanism[35] (NISM) which served a very important in building a network of institutions dealing with plant genetic resources should be strengthened.
- In order for the national programme to be more coherent, there is need to establish some coordination mechanisms. Proposals have in the past been suggesting the establishment of a National Biodiversity Centre which should be charged with the role of coordinating the national programme and all PGR related issues.

Though the country has done a lot in putting in place necessary legislation in areas of access and benefit sharing, bio safety, plant breeders' rights, their implementation still remains poor. Appropriate measures need to be taken in order to endure their proper implementation.

[34] GoK, 2000. The National Biodiversity Strategy and Action Plan. Government Printers
[35] www.pgrfa.org/gpa/ken

CHAPTER 6

THE STATE OF REGIONAL AND INTERNATIONAL COLLABORATION

7.1 Introduction

It is a well known and appreciated fact that all countries of the world are interdependent in so far as PGRFA are concerned. This interdependence therefore calls for collaboration both at the international and regional levels. In the pursuit of this collaboration, Kenya has joined hands with a number of countries and institutions in the development of agriculture, environment and natural resources, which are important sectors relevant to the conservation and management of plant genetic resources. These collaborative efforts and arrangements have to a great extent helped the country improve its capacity in the conservation and sustainable management of PGR. This chapter examines some the networks, foras and associations and other mechanisms for promoting and supporting collaboration, particularly at the regional level. It also looks at international funding mechanisms that have continually supported the country in the various PGR related activities. An assessment of the major needs, gaps and priorities as relates to international collaboration is given at the end of the chapter.

7.2 International networks

The most notable development in the area of international networks over the last decade was the formation of the Eastern Africa Plant Genetic Resources Network (EAPGREN)[36]. It is the only network dealing exclusively with plant genetic resources whose activities Kenya participates in. EAPGREN's mission is to harness, conserve and to promote greater use of PGR for food security, improved health and socioeconomic advancement of the rural communities of the present and future generations. EAPGREN is hosted by the Association for Agricultural Research in East and Central Africa (ASARECA) and has membership of ten countries namely Burundi, Democratic Republic of Congo, Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, Sudan, Tanzania and Uganda. The Network is funded by SIDA, with the Nordic Genebank (NGB) and Bioversity International providing technical backstopping. It has undertaken a wide range of activities in eastern Africa since 2003 including the exchange of information, capacity building both training and infrastructural capacity, raising awareness and policy advocacy. A regional strategy for PGR has been developed under GCDT initiative and key *ex situ* collections identified requiring urgent regeneration.

Table 12 summarises some important regional networks relevant to the pursuit of plant genetic resources and environmental development. Most of these are ASARECA based crop networks which have some PGRFA related mandates such as breeding and research.

[36] www.asareca.org/eapgren

TABLE 12
Regional networks in whose activities Kenya participates

Name of Netwok	Network activities
Below are ASARECA Networks in whose activities Kenya participates	
Eastern and Central Africa Bean Research Network (ECABREN)	ECABREN seeks to contribute to the social welfare and economic growth of the people in East and Central Africa (ECA) while protecting natural resource base by providing acceptable and marketable bean based technologies and strengthening institutional capacity to adequately address existing and emerging bean research and development agenda in the region.
Eastern Africa Root crops Research Network (EARRNET)	The network's goal is to emphasize market oriented research and development on cassava.
Eastern and Central Africa Maize and Wheat Research Network (ECAMAW)	The Eastern and Central Africa Maize and Wheat Network (ECAMAW) aims to facilitate regional multidisciplinary and multi partner-client collaboration on technology development and dissemination; address priority constraints to maize and wheat production and value-added traits (nutritional and processing) in eastern and central Africa, while maintaining the agricultural resource base; and mobilize and manage resources for this research on a regional basis.
Banana Research Network for Eastern and Southern Africa (BARNESA)	BARNESA was created in 1994 to encourage cooperation between national research programmes in order to reverse the observed decline in banana production.
Coffee Research Network (CORNET)	CORNET seeks to identify and solve the key constraints to smallholder coffee production, processing, marketing and policy issues in East and Central Africa.
Eastern and Central Regional Sorghum and Millet Network (ECARSAM)	ECARSAM strives to create synergy and effectiveness of national agricultural research systems (NARS) and all stakeholders through networking to remove some of the bottleneck to increased productivity of sorghum and millet, and their use in value addition and processing at farm and village levels by generating and adopting appropriate technologies, knowledge and information.
Eastern and Central Africa Rice Research Network (ECARRN)	The network has yet to undergo priority setting and strategic planning exercises, where the goals and objectives of the network will be revaluated and modified accordingly.
Regional Potato and Sweet potato Improvement Network in Eastern and Central Africa (PRAPACE)	
Maize Breeders for Africa Network (MBNET)[37]	Objectives of MBNET are access to germplasm, breeding new varieties, germplasm custody and public-seed company partnerships.

7.3 International and Regional Fora, Partnerships and Associations

Regional and international associations have continued to play an important role in international cooperation. Some of these include:

- East African Community (EAC) - The regional cooperation, based in Arusha, Tanzania, has an agenda on issues of biodiversity management among others.
- Intergovernmental Authority on drought and Development (IGADD)- IGADD has an agenda on Development of environmental protection and agricultural research
- Alliance for a Green Revolution in Africa[38] - AGRA is a dynamic, African-led partnership working across the African continent to help millions of small-scale farmers and their families lift themselves out of poverty and hunger. AGRA envisions working in eight areas to address key aspects of a functional, sustainable food production system in Africa. One of these areas is developing better and more appropriate seeds and genetic diversity. The alliance acknowledges that few farmers in sub-Saharan Africa have access to new, improved varieties of local food crops capable of producing abundant harvests in what are often harsh conditions. As a result, AGRA has developed programmes aimed at tackling these challenges through projects that bring farmers and scientists together to develop and distribute seeds suitable for local environments while also supporting genetic diversity and farmers' rights to save seeds. AGRA "Programme for Africa's Seed Systems" (PASS) is funding African-led initiatives that use conventional breeding to develop new varieties of maize, cassava, beans, rice, sorghum, and other crops resistant to diseases and pests. The goal is to develop and release more than 1 000 improved crop varieties over the next ten years.

[37] http://www.africancrops.net/maizenetwork/index.htm
[38] http://www.agra-alliance.org

- Biosciences Eastern and Central Africa (BECA)[39] - BECA is a collaborative network, established through a joint venture amongst a group of cooperating institutions that agree to make their facilities available for regional use. It consists of a hub based on the campus of the International Livestock Research Institute (ILRI) in Nairobi, Kenya; and a network of regional nodes and other affiliated laboratories and organizations, for the conduct of research on priority issues affecting Africa's development.

A major part of BECA's research related services which are particularly related to access and germplasm exchange is aimed at enabling more effective management of intellectual property, bio-safety and regulatory issues in Africa. Specific areas include bio-safety policies and practices; communications and knowledge management; information technology; intellectual property management and regulatory management.

7.4 International Non Governmental Organizations (NGO) and Civil Society Organizations (CSO)

The last decade has seen increased participation by NGOs in the area of PGRFA conservation and use. Their participation has mainly been through projects supporting various activities related to PGRFA. Some of these include CARE International, World Vision, Action-Aid, and Catholic Relief Services. Catholic Relief Services has especially been instrumental in supporting informal seed systems in the country.

7.5 International Funding Mechanisms

Over the last decade, the level of funding in the area of PGRFA conservation and plant breeding has increased tremendously. This has been as a result of the realization that PGR being an important raw material in crop improvement is an important vehicle towards the attainment of food security. Most of the funding has been obtained from both bilateral and multilateral funding agencies. Some of these include Rockefeller foundation, Bill and Melinda Gates Foundation, World Bank, European Union, Global Environment Facility (GEF), ASARECA, International Maize and Wheat Improvement Center (CIMMYT), Bioversity International, Royal Botanic Gardens, Kew. United Nations Development Programme (UNDP) and United Nations Environment Programme (UNEP). The funding which is mostly project based has mainly concentrated on *ex situ* conservation, crop improvement, human and infrastructural capacity building.

The latest funding agency that has come into the scene is the Global Crop Diversity Trust (GCDT)[40]. This is an endowment fund that was establishment by FAO and is linked with ITPGRFA. So far, the Trust has provided funds to the National Genebank to support the regeneration germplasm of 4 priority crops that are important to the country for food security and thereafter ensuring their safety duplication in the Svalbard Global Seed Vault in Norway.

7.6 International agreements

Kenya has always been involved in both regional and global processes geared towards shaping PGR conservation and use strategies. Some of these include:

- The International Treaty on PGRFA (ITPGRFA):- In 2003, the country adopted and ratified the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). The objectives of the Treaty are the conservation and sustainable use of plant genetic resources for food and agriculture and the fair and equitable sharing of the benefits arising out of their use. The Treaty covers all plant genetic resources for food and agriculture, while it's Multilateral System of Access and Benefit-sharing covers a specific list of 64 crops and forages.
- The Global Plan of Action (GPA) for the conservation and sustainable utilization of Plant Genetic Resources for Food and Agriculture (PGRFA). The International Treaty on Plant Genetic Resources for Food and Agriculture complements the Global Plan of Action.
- Cartagena Protocol: - Kenya is a signatory to the Cartagena Protocol for Biosafety, which it signed on 24th May 2000 and ratified on 9th Oct 2003.
- Kyoto Protocol – Kenya has signed and ratified the Kyoto protocol.

[39] www.biosciencesafrica.org
[40] www.croptrust.org

Furthermore, Kenya is party to the following regional efforts part of whose endeavour is to address PGR issues: Intergovernmental Authority on Development (IGAD), Common Market for Eastern and Southern Africa COMESA, East African Community (EAC) and New Partnership for Africa's Development (NEPAD).

The key challenges in implementing biodiversity related conventions in Kenya include (i) meeting the increased demand for biological resources; (ii) building adequate expertise and experience on biodiversity; (iii) improving policies and legislative guidelines and fiscal measures for the regulatory use of biodiversity; (iv) strengthening coordination within and between governments; (v) building political support for changes necessary to ensure biodiversity conservation.

7.7 Assessment of major gaps, needs and priorities

Effectiveness in the conservation and use of plant genetic resources can be greatly enhanced by the development of strong and well-coordinated national and regional programmes that bring together stakeholders to discuss priorities and action plans. Future international collaboration should focus on:

- Building a regional and international information base for better conservation and sustainable use of plant genetic resources.
- Improving national and regional scientific and technical capacity for conservation and sustainable use of plant genetic resources. This includes strengthening of conservation infrastructures.
- Enhancing the country's capacity to implement international agreements and other instruments on plant genetic resources and improving its negotiation skills in international treaties.
- Adding value to plant genetic resources, by building capacity to identify economically valuable plant genetic resources traits, with a view towards commercialisation. This may require the development of specialized research laboratories, the re-training of scientists, and a re-orientation of national research and development activities.
- Setting up a network of expertise in plant taxonomy across the region, to address the short supply of these highly valuable technicians. The country faces a shortage of taxonomists.
- Human resource development, particularly in areas of molecular characterization, biotechnology, inventory, disaster management, early warning systems and taxonomy.

Other gaps and needs include:

- In order to achieve their objectives, networks should develop effective sustainability mechanisms. This calls for network member countries to be proactive in sourcing for funds from several sources.
- There is need to streamline the activities if networks in order for them to be more efficient and reduce duplication. In some cases, this may require merging of some networks where they are engaging in similar or related activities.
- There is need for network member countries to own the activities of the network. In some cases, the sense of ownership is missing with the members feeling as if the network is owned by the funding agency/donor. Regular consultative meetings where important decisions are made should be convened in order to instil a sense of ownership and belonging among the participating countries ands institutions.

CHAPTER 7

ACCESS TO PLANT GENETIC RESOURCES

8.1 Introduction

Shifting global conditions have always been a part of human experience, but unprecedented population growth, the decline in water quality and availability, and the loss of species, ecosystems, and arable land, as well as climate change, are some of the biggest challenges facing the country and continue to threaten sustainable development. Unfortunately, these processes will accelerate and dramatically exacerbate problems currently facing humanity, including hunger, disease, and poverty. In order to overcome these challenges, it is imperative that we guarantee the availability of and universal access to genetic diversity. Access to this diversity is important for breeders to develop varieties that are able to cope with various stresses and for farmers to meet the food and nutritional demands of the rapidly growing population. In addition, without this diversity, 70% of the population in Kenya who depend on PGR for healthcare[41], will remain greatly vulnerable to diseases.

Since the first SOW, Kenya just like many other countries has been struggling to put in place legislation governing access to PGRFA. Lack of coordination among government ministries, departments and institutions led to failure of most of the initiatives that had been started in an effort at developing ABS regulations. This chapter highlights the regulatory framework that now exists in the country as well as some of the ABS arrangements. The chapter ends with an assessment of gaps, needs and priorities for the future.

8.2 Development of access and benefit-sharing regulations

Legislative and policy measures on access to genetic resources have long been an issue of discussion in the country. Though the country has shown commitment in developing regulations on ABS, the process has been long and has in most cases been characterized by institutional conflicts. Several initiatives put in place by different institutions aimed at developing appropriate policy regulating access and benefit sharing have in the past failed. Below are some of the efforts that have been made towards this. In an effort to mainstream the ABS into the Government activities, the National Environmental Secretariat (NES) prepared the National Environmental Action Plan (NEAP 1994). This was followed by the preparation of the National Biodiversity Strategies and Action Plan (NBSAP) in 2000, by the National Environment Management Authority (NEMA). During the same time parallel activities were taking place in other institutions, especially the National Council for Science and Technology (NCST) where an Inter-Agency Committee on Genetic Resources and benefit sharing was constituted to draft regulations for the ABS. This led to the gazettment on 14th April 2000 of the National Advisory Research Committee on Genetic Resources as Legal Notice No.40 under the Science and Technology Act (Cap 250). Additionally, the National Museums of Kenya had in 1999 drafted the regulations pertaining to ABS. A task force to develop laws for protection of traditional knowledge, genetic resources and folklore was appointed on 3rd March 2006 through gazette notice number 1415. Subsequently, a gazette notice regulating access to genetic resources and benefit sharing was issued in October 2006.

The only specific legislative measure that has been put in place thus far is the Environment Management and Coordination Act, 1999 which is a general environmental law. Section 53 stipulates that the Authority shall issue guidelines and prescribe measures for the sustainable management and utilization of genetic resources of Kenya for the benefit of the people of Kenya. The Act further states that guidelines shall be issued specifying issues of fees and licences for non-citizens accessing PGR, regulations on imports and exports of germplasm and sharing of benefits derived from PGR in Kenya.

[41] Lambert, J.D.H., Ryden, P.A. and Esikuri, E.E. 2005. Capitalizing on the Bio economic Value of Multi-Purpose Medicinal Plants for the Rehabilitation of Dry lands in Sub-Saharan Africa. World Bank.

As stipulated in EMCA (1999), NEMA developed The Environmental Management and Co-ordination (Conservation of Biological Diversity and Resources, Access to Genetic Resources and Benefit Sharing) Regulations, 2006. According to the regulations any person intending to access genetic resources for any purposes must apply to NEMA by filling application forms for an access permit. Such an application must be accompanied by necessary fees as specified in the regulations. The regulations also require the application to be accompanied by evidence of Prior Informed Consent from interested persons and relevant lead agencies, and a research clearance certificate from the National Council for Science and Technology. Upon receipt of the application, NEMA shall give notice thereof by publication in the Gazette and at least one newspaper with nationwide circulation or in such other manner as the Authority may consider appropriate. Based on the representations or objections from the public, the authority shall review the application and subsequently determine its outcome.

8.3 National implementation of access and benefit-sharing arrangements

8.3.1 General approaches

Currently, Kenya does not place excessive restrictions on the issuance of permits for any kind of access to genetic resources. The few times that such activities have proved problematic due to the regulatory system have been with proposed large-scale collection and / or suspected attempts at bio-piracy. For foreign researchers, they need to identify those benefits that their research and program brings to Kenya including training and resources provided to their Kenyan counterparts. Lead institutions, particularly the public universities, the Kenya Wildlife Service (KWS) and the National Museums of Kenya (NMK), have a long track record of assisting researchers, both foreign and local. Once a researcher has the permit from NEMA, if the project includes collecting genetic resources from certain areas or collections, additional authorizations from other agencies may be required. For example, for any collection in protected areas, there is an additional obligation to get a permit from the Kenya Wildlife Service.

8.3.2 Benefit sharing arrangements

Kenya has on several occasions been involved in the formulation of Access and Benefit Sharing agreements (ABSAs). The latest one is the Seeds for Life Project and Millennium Seed Bank Collaboration. Since 2000, Kenya has been implementing a large-scale access and benefit-sharing project in collaboration with the Royal Botanic Gardens at Kew (UK). The lead institutions are KARI, NMK, KWS, KEFRI and KFS. A Material Transfer Agreement was signed by the Minister of Environment on behalf of the Government of Kenya and by the Director of the Royal Botanic Gardens, Kew. According to the agreement all, materials collected through the project, will be duplicated in RBG, Kew. These materials can however only be used for research and not for commercial purposes. In return, the country has benefited from monetary and non-monetary values. The project has provided necessary inputs to the public institutions to achieve its purpose.

The inputs include research equipment and materials, funds to cover costs on recurrent research and seed storage, running and maintenance, provision of office equipment, vehicles to undertake seed collection, field work, workshops and conferences, and all concomitant training. Most of the scientific and technical staff participating in the project have benefited from either technical and research attachments in the UK, BSc, Msc or PhD training in addition to numerous other training opportunities locally.

Other ABS arrangements include: (1) Kenya Wildlife service, The International Centre for Insect Physiology and Ecology (ICIPE) and Diversa (Verenium) Corporation Partnership and (2) Kenya Wildlife Service - Novozymes Partnership[42]. These 2 arrangements are however beyond the scope of this report.

While KARI has developed some products based on the collection of germplasm from Kenya, it has also made extensive use of the collection of the International Agricultural Research Centers (IARCs) of the Consultative Group on International Agricultural Research (CGIAR). In turn, Kenya has made its national collection of germplasm openly available to CGIAR and other countries.

[42] Secretariat of the Convention on Biological Diversity. 2008. Access and Benefit-Sharing in Practice: Trends in Partnerships across Sectors. Montreal, Technical Series No. 38, 40 pages.

8.4 Challenges in the development and implementation of access and benefit sharing regulations

The greatest challenge has been the overlapping mandates of different ministries and institutions dealing with PGR. For example, while KWS serves as the focal point for ABS in national parks and protected areas, these responsibilities and their relationship with NEMA currently of the ministry of environment and natural resources, have been unclear since new ABS regulations were propagated in 2006[43] (Secretariat of CBD, 2008). The uncertainty in existing legislation, poorly defined institutional mandates, administrative measures and coordination responsibilities over germplasm exchange is undermining the confidence of relevant institutions and individual scientists hence discouraging them from engaging in mutually beneficial exchange arrangements[44]. The country also lacks multidisciplinary scientific, institutional and legal capacity to develop a satisfactory system of ABS. In many cases, there is often very limited awareness among the scientific community about the presence of given national policies. For example, very few scientists are currently aware of the Environmental Management and Co-ordination (Conservation of Biological Diversity and Resources, Access to Genetic Resources and Benefit Sharing) Regulations, 2006 which are the concomitant regulations of EMCA. Lack of awareness on the existence of an enabling policy may create uncertainty in making decisions over germplasm exchange.

Cases of bio-piracy which have often been given extensive media coverage and publicity have led to the wrong attitudes. There is widespread perception that other countries are taking advantage of the countries' PGR. Even when due process of law is followed in exchanging materials outside the country and the benefits shared appropriately and equitably, the exercise is always viewed with a lot of suspicion and mistrust especially by NGOs and the civil society. There is no tacit recognition or appreciation of the fact that for Kenya to achieve food security it has to use PGR from other countries as there is no country that is independent in so far as PGR are concerned. This suspicion and controversy threatened to derail and almost halted the Seeds for Life Project. Though, a Material Transfer Agreement had been negotiated and agreed upon with the benefits to the Kenyan institutions clearly stated, the RBG-Kew scientists were accused of sleaze in order to skew the process in their favour, by offering handsome cash rewards to the frontline negotiators in Kenya. These kinds of suspicions are made worse by the country's lack of capacity to monitor the use to which materials exchanged outside the country are put to.

8.5 Access to PGRFA under the International Treaty on Plant Genetic Resources (ITPGRFA)[45]

With respect to access to plant genetic resources and benefit sharing, Kenya has signed and ratified the Convention on Biological Diversity and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). As Party to the Treaty, Kenya is committed to the Treaty's multilateral access and benefit-sharing scheme for Annex I crops, in particular to use the adopted Standard Material Transfer Agreement for exchanging materials and is expected to benefit from resources generated through this ML System. Being a signatory to the treaty, the country endeavours to abide with its provisions. However, for crops outside Annex 1, the country may consider passing legislation to ensure their special treatment.

Placing materials in the multilateral system: So far as national collections are concerned, Article 11.2 of the Treaty provides that PGRFA of crops and forages listed in its Annex 1 that are under the management and control of the Contracting Parties and in the public domain are to be included automatically in the Multilateral System. The National Committee on Plant Genetic Resources is currently in the process of sending a notification to the Treaty secretariat informing it of the inclusion of materials conserved in the National Genebank of Kenya into the MLS. For other collection holders including research centres and universities, the committee plans to undertake awareness campaigns on the importance of including materials into the MLS.

[43] Secretariat of the Convention on Biological Diversity. 2008. Supra note 42

[43] Wambugu and Muthamia, 2009. Incentives and disincentives for Kenya's participation in the global system for conservation and use of plant genetic resources for food and agriculture and proposals to increase participation: GPG2. Final Project Report.

[44] www.planttreaty.org

8.6 Farmers' privileges and rights

Kenya is a member of the World Trade Organization (WTO). To this end, it is committed to comply with the TRIPS Agreement obligations. A total of 140 countries signed TRIP as part of the new General Agreement on Tariffs and Trade that "member states are obliged to provide the same minimum level of protection of intellectual property". Though Article 14 of the UPOV (1991) rescinds farmers' privilege to the production or reproduction of protected varieties without the authorization of the breeder under certain conditions, Article15.2 of same UPOV Act allows for farm saved seed. Various legislative initiatives have been taken in Kenya with a view to implementing TRIPS Agreement. One such initiative is the country's accession to the 1978 UPOV Convention. Kenya's position on farmers' privileges and rights is that the UPOV Convention permits member states to decide on its domestic legislation whether to recognize farmers' privileges and rights. Kenya supports this flexibility and under the Seeds and Plant Varieties Act Cap 326, Kenya recognizes farmers' privilege and rights. In order to domesticate the UPOV 1978 provisions in Kenya and hence entrench these rights, the Statute Miscellaneous Amendment Bill 2000 was published. The right of farmers to use farm saved seed is therefore provided for in the national legislation. Some institutions e.g. KEFRI have developed their own patenting policy which encourage innovation and provides a framework of benefits sharing arising from commercial products of research.

Part III and Art. 9 of the International Treaty states that, "the responsibility for realizing Farmers' Rights, as they relate to plant genetic resources for food and agriculture, rests with national governments."

"...each Contracting Party should, as appropriate, and subject to its national legislation, take measures to protect and promote Farmers' Rights, including:

- protection of traditional knowledge relevant to plant genetic resources for food and agriculture;
- the right to equitably participate in sharing benefits arising from the utilization of plant genetic resources for food and agriculture; and
- the right to participate in making decisions, at the national level, on matters related to the conservation and sustainable use of plant genetic resources for food and agriculture."

These provisions are entrenched in the national legislation namely The Seed and Plant Varieties Act Cap 326, The Statute Miscellaneous Amendment Act, 2000 and The Industrial Property Act, 2001.

8.7 Assessment of major gaps, needs and priorities

- Limited capacity by competent national focal point in dealing with access and benefit sharing. NEMA which is mandated to handle ABS issues in the country has a very broad mandate against a background of insufficient technical and financial capacity thus putting issues of PGRFA in the periphery as more pressing issues of the environment are given priority.
- The uncertainty and lack of clarity in existing ABS regulations is undermining the exchange of germplasm by institutions and individual breeders and therefore need to be reviewed.
- The capacities of the country in many aspects of ABS are still extremely low leading to decisions often being made on the basis of faulty assumptions hence the need for capacity building
- There is need to harmonize the mandates and activities of various government ministries and institutions to avoid conflicts. The government should build capacity within national focal point and other PGR institutions and ensure their mandate, scope, roles and responsibilities are clear.

CHAPTER 8

THE CONTRIBUTION OF PGRFA MANAGEMENT TO FOOD SECURITY AND SUSTAINABLE DEVELOPMENT

9.1 Introduction

The earlier chapters of this report all seek to update the information contained in the equivalent Chapter in the first SoW report. This final Chapter, however, addresses more specifically how PGRFA can contribute to food security and sustainable development. Sustainable utilization and conservation of plant genetic resources can and has been used as a real tool to address challenges of poverty, food insecurity, environmental degradation, malnutrition and other health related problems. In addition PGR offers immense opportunities in income generation for the communities dealing with them. In recent years, human population increases and subsequent demand for more land for settlement and farming has threatened plant genetic resources. Land degradation, deforestation and overgrazing are among the greatest threats to PGR. Sustainable agricultural development is a process that is ecologically sound, economically viable and socially just, and one that aims to produce the food, and/or the income needed to achieve food security. This chapter therefore highlights the role of PGRFA in dealing with climate change, environmental stability, food security and health.

9.2 Climate change and environmental stability

Eliminating poverty and sustaining development are highest priorities under Millennium Development Goals. The environment is acknowledged as an important component of these goals. Kenya is endowed with a variety of habitats and ecological systems, which makes it a custodian of a unique heritage of biodiversity. This rich biodiversity includes wildlife, forests, farmlands, vegetation, wetlands, marine life forms and micro-organisms. Properly utilized, these resources are a vital component in reducing environmental degradation. Plenty of evidence suggests that many plants and animals in various regions of Kenya have been affected by events associated with climate change. Extreme weather effects (floods and droughts) recently experienced in many parts of Kenya is testimony to gross negative impacts on the lively hoods of many rural communities. Floods in the Lake Victoria basin and persistent droughts in Northern parts of Kenya have impact on plant diversity and productivity through changes in flowering patterns, destroyed habitats and ecosystems. This has already been witnessed by shifting of the traditional maturity periods of local plants and unpredictable timing of farming operations. This scenario has direct impact on food security and deterioration of environment services derived from both flora and fauna of many regions. As a result many birds which were associated with certain plants have since become rare in some regions. Some of these birds were known dispersal agents of specific plants whose ripe fruits formed part of their diet. With the changing weather patterns however, the productivity of and spread of these plants is no longer guaranteed. In addition changes in the environmental stimuli that are associated with plant reproduction have influenced negatively species diversity due to high mortality rates. Any plants which cannot adapt quickly to these changing environmental conditions risk extinction. Examples of such species in Kenya is the Osiris lancelerata (African sandal-wood) currently under threat for its demand in the cosmetic industry and coupled with its problematic propagation and limited dispersal. As a mitigation measure, a programme to safeguard the vulnerable plant genetic resources, in the dry-lands a plant conservation project is involved in the long-term seed collection and storage of wild plants and forest species.

PGR have a positive impact on microclimates and buffer the effects of desertification. These resources also help to check run off and erosion, control flooding, purify water and protect against wind. In view of this, the Government of Kenya and many other organizations such as the Green Belt Movement have spearheaded a campaign that aims at promoting the use of PGR in an effort to reduce environmental degradation.

9.3 Food Security

The sustainable conservation and utilization of PGR are an important means of achieving food security. Agriculture is the backbone of Kenya's economy and the exploitation of PGR has over the years strengthened this sector especially in the areas of food crops. Though food insecurity still poses a significant challenge for the Government and the people of Kenya, use of PGR in crop improvement programmes have greatly increased food production. For example, common bean improvement programmes in the country have led to improved varieties that yield around 5 000kg/ha as compared to traditional varieties which have a potential production capacity of only 250kg/ha. Similarly improved varieties of cassava currently being grown in the country have a potential of producing 30MT as compared to 6MT produced by landraces. Tree improvement programmes has led to great gains. Foe example, in *Eucalyptus grandis*, yield has doubled from $25M^3$/ha/year to 50 $25M^3$/ha/year.

Plant genetic diversity is an important factor in the fight against poverty and food insecurity. Especially for small farmers, struggling to survive with poor soils and limited resources, they continue to allow plant varieties to evolve. Plant genetic diversity is crucial to breeding food crops and is thus one of the central preconditions for food security.

Kenya is endowed with a lot of indigenous vegetables, fruits and other under-utilised species. Such indigenous vegetables as *Cleome gynandra, Amaranthus* spp., *Solanum* spp., and *Crotolaria* spp. among others are highly nutritious, cheap to produce and are well adapted to the environment in which they grow. They are increasingly becoming popular both in the rural and urban areas and have helped in diversifying agriculture and are very important in achieving food security in the country. Most indigenous vegetables are rich in vitamins, minerals, dietary fiber and carbohydrates. Amaranth for example is one vegetable rich in protein, iron and vitamins A and C, a rare example of a vegetable where all these essential dietary components are combined in one. Indigenous fruit trees such as baobab (*Adansonia digitata*) are also endowed with high contents of vitamins, minerals and dietary fibre compared to exotic ones. Table 13 below shows the comparative analysis of the nutritional content of some indigenous vegetables as compared to some exotic ones.

TABLE 13

Nutrient Content of Some Kenyan Indigenous Vegetables and Exotic Vegetables (Per 100g edible portion)[46]

Vegetables	Vit. A (mg Carotene)	Vit.C (mg)	Protein (g)	Calcium (mg)	Iron (mg)	Rank
Indigenous						
Cleome gynandra	6.7-18.9	127-177	5.4-7.7	434	11.0	1
Solanum nigrum	2.7-7.9	37-141	3.2-4.6	215	4.2	4
Amaranthus spp.	5.3-8.7	92-159	4.0-4.3	800	4.1	3
Clotoraria brevidens	2.9-8.7	115-129	4.2-4.9	270	3.8	2
Corchorus olitorius	3.9-5.4	170-204	4.5-5.5	270	7.7	
Cucurbita spp.	2.4-5.3	170-172	3.3-4.2	40	2.1	2
Exotics						
Brassica carinata	2.8-7.4	1-59	2.3-3.1	60-595	0.8-4.5	6
Spinacea oleracea	3.7-5.7	102-142	3.6-3.8	520	6.0	5
Brassica oleracea var. *capitata*	Tr-4.8	20-220	1.4-3.3	30-204	0.5-1.9	7
Brassica oleracea	Tr-0.4	8-114	1.8-3.4	13-43	0.2-1.9	
Lactuca sativa	0.15-7.8	3-33	0.8-1.6	17-107	0.5-4.0	

[46] Opole, M J. Chweya, J and Imungi. 1991. In cultivating local knowledge: Genetic Diversity, Farmer experimentation a. Walter de Boef, Kojo Amanor and Kate Wellard, with Antony Bebbington

9.4 Health

From the qualitative point of view, PGR also play an essential role in dietary nutrition. Breeding efforts to improve nutrient contents and compositions, diversification of on-farm production are concrete examples of how PGRFA management contributes to food security and health. In a recent study by the World Bank, it was reported that 70% (21million) of the country population is not covered by the national healthcare system and must depend on traditional forms of medication, which mostly rely on PGR.[47] This clearly shows the important role by PGR in health care. However, at present the Government has limited information on the role of traditional medicine or medicinal plants in healthcare but part of the Ministry of Health's reform agenda is to participate in the development of a national policy on herbal medicine and the plants. The policy is aimed at both promoting and regulating the use of traditional medicine, and providing alternative forms of treatment to the country's poor. Important medicinal plants being produced in the country include *Ocimum kilimandscharicum*, *Mondia whytei* and *Prunus africana* among others.

In addition to providing nutrients, indigenous vegetables have the potential to improve human health through their medicinal properties. This becomes very important today, where millions of Kenyans are dying of diseases associated with HIV/AIDS. Data from the National HIV/AIDs Control Council of 2004 indicate that 2.5 million Kenyans are infected with about 200 000 infections per year. Indigenous vegetables could contribute significantly in the management of the HIV/AIDs infected and affected persons.

9.5 Bio-fuel production

Kenya has recognised that bio fuel production and use can have both beneficial and adverse effects on biodiversity, including agricultural bio-diversity, and human well-being despite the gaps in knowledge and information associated with the impact of bio-fuel production and use on biodiversity. The country is also amenable to the fact that large-scale production of liquid bio fuel can have positive greenhouse gas balances and contribute to the reduction of emissions, an important indirect contribution to the conservation of biodiversity. The country also appreciates that large-scale bio fuel production can also have adverse impacts on biodiversity, by contributing, *inter alia,* to habitat loss, fragmentation and degradation, increased greenhouse gas emissions from degraded carbon sinks and deforestation, increased water pollution from chemical inputs, soil degradation and erosion, uncontrolled introduction and spread of GMOs and invasive alien species, and overexploitation and increase in food prices.

The Government of Kenya, in collaboration with other stakeholders, is set to roll out a National Strategy on Bio-diesel, in addition to promoting the production of other bio fuels, through which it hopes to cut national kerosene consumption and significantly reduce its diesel usage. The plan involves the promotion of cultivation of Jatropha plant whose seeds will be the source of bio-diesel. Consequently, a National Bio-diesel Strategy is being developed to promote the growing of Jatropha. To prevent competition of the bio-diesel crops with food crops for land, the growing of Jatropha will be confined to the arid and semi-arid lands which are only marginal for agricultural production. Furthermore, production of other bio-fuels such as bio-ethanol from the by-products of sugarcane processing is already underway in the country by most of the local sugar factories. This means that bio-fuel production will not interfere so much with the country's food security objectives. The strategy will promote options for promoting sustainable bio-fuel production, including:

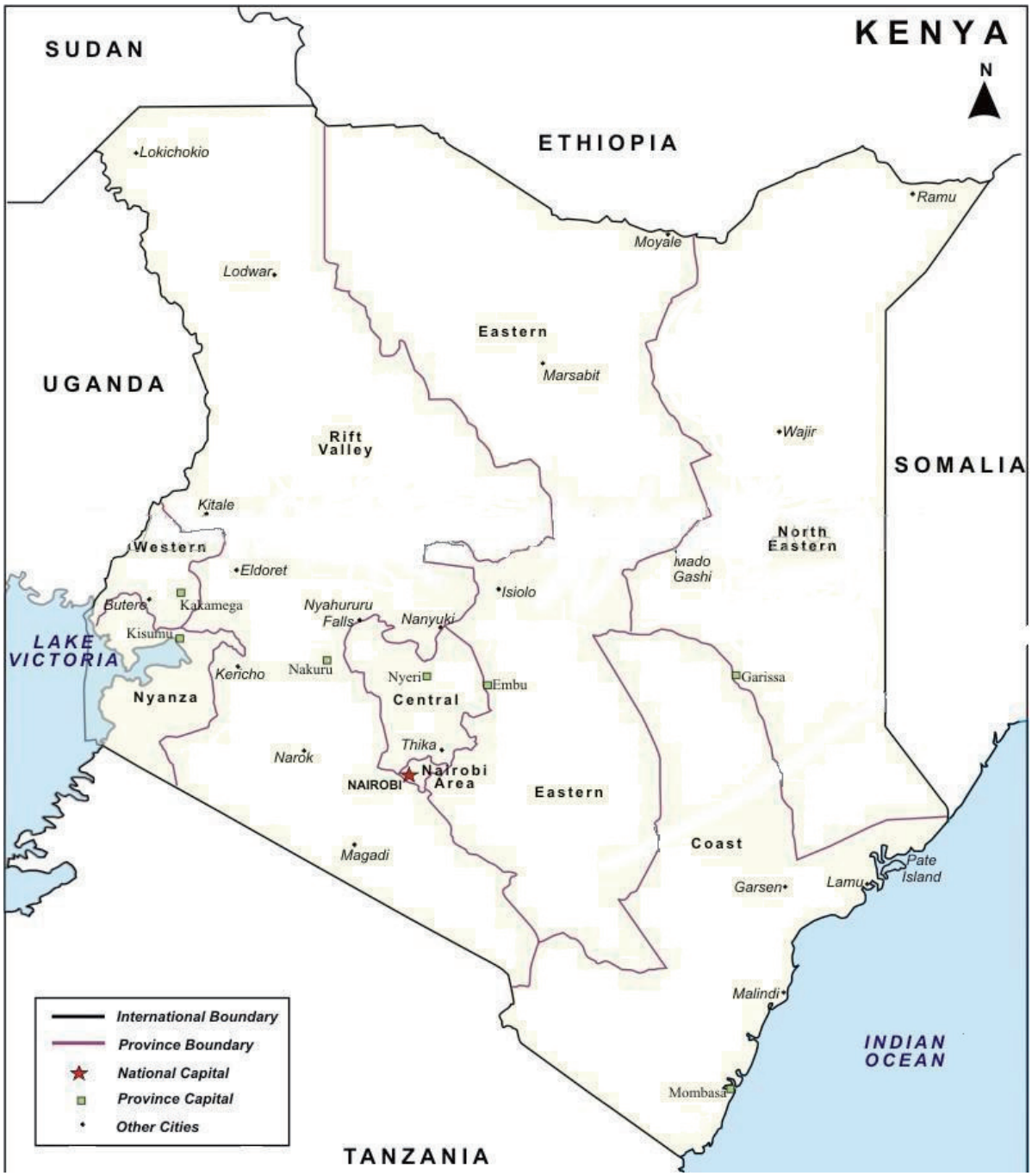
1. the application of guidelines and standards in the framework of the ecosystem approach;
2. the application of biodiversity-inclusive guidelines on environmental impact assessment and strategic environmental assessment;
3. the development of sound policy frameworks that contribute to both the mitigation of greenhouse gas emissions and the conservation and sustainable use of biodiversity; and
4. the promotion of research to improve the economy and yields of energy biomass.

Enhancing awareness on issues relating to bio-fuels among policy makers, farmers, business, and other stakeholders, to enable fully-informed decision making is already taking place through workshops/seminars and the mass.

47 Kenya's Ministry of Health budget for medicines in 2002 was $ 16 million (Sh 1.18 billion) and the national healthcare system provides for conventional drug needs of only 30 percent of the population.

ANNEX 1

MAP OF KENYA



ANNEX 2

PARTICIPATING STAKEHOLDERS

This report was prepared through an intensive consultative process. The information and data presented in the report were obtained from various stakeholders as listed in the table below through the National Information Sharing Mechanism (http://www.pgrfa.org/gpa/ken). These stakeholders were selected by the national steering committee based on the relevance of their activities and mandates in relation to conservation and use of PGRFA.

Institution	Contact
KARI - National Genebank of Kenya	Mr. Z.K. Muthamia P.O. Box 30148-00100 NAIROBI Tel: 020-2700462 or 0722352305 Email: ngbk@wananchi.com
KARI - National Genebank of Kenya	Mr. P.W. Wambugu P.O. Box 30148-00100 NAIROBI Tel. No. 0722563141 Email: werupw@yahoo.com
Kenya Seed Co. LTD	Dr. Jennifer J. Chumo P.O. Box 533 KITALE Tel:054-31909-14 or 0722-821799 or 0722-205144 Email: j.chumo@kenyaseed.co.ke Fax:054-31775
Ministry of Agriculture	Mr. Patrick O. Ochieng' P.O. Box 30028-00200 NAIROBI Tel: 2710911 or 0722-349490 Email: paddyokaka@yahoo.com/okaka@kilimo.go.ke
Tea Research Foundation of Kenya	Mr. Samson M. Kamunya P.O. Box 820 - 20200 KERICHO Tel: 052-20598/9 or 0722-282741 Email:lib-trfk@kenyaweb.com or smachohi@yahoo.com. Fax: 052-20575
University of Nairobi	Dr. Kahiu Ngugi P.O Box 30197 NAIROBI Tel: 020-632121 Email: eckngugi@africaonline.co.ke
Kenyatta University	Dr. Geoffrey M. Muluvi P.O. Box 43844-00100 NAIROBI Tel: 810901 Ext: 339 or 0722-861176 Email: gmmuluvi@ku.ac.ke Fax: 811575
Catholic Relief Services (K)	Mr. George Adem Odingo P.O. Box 49675-00100 NAIROBI Tel: 4210000 or 0722-720045 Email: godingo@crsnairobi.org ademodingo@yahoo.com
Dept. of Resource surveys and Remote Sensing	Mr. Leonard Omullo P.O. Box 47146-00100 NAIROBI Tel: 609013/27 OR 0722719578 Email: lomullo@yahoo.com
Kenya Plant Health Inspectorate Service (KEPHIS)	Dr. Evans O. Sikinyi P.O. Box 49592-00100 NAIROBI Tel:20884545 or 0722-767026 Email: kephis@nbnet.co.ke or esikinyi@kephis.org Fax:020-882265
Kenya Plant Genetic Resources Training Consortium	Prof. Levi S. M. Akundabweni P.O Box 913-00100 Nairobi Email: proflevimudogo@yahoo.com

Institution	Contact
National Museums of Kenya	Mr. Patrick N. Muthoka P.O. Box 40658-G.P.O. NAIROBI Tel: 37433161 Ext: 205 or 0735-489406 Email: mbegu@wananchi.com or muthoka2000@yahoo.com Fax: 3744424
Kenya Forestry Research Institute (KEFRI)	Dr. Ebby Chagalla-Odera P.O Box 20638 NAIROBI Tel: 066-32891/0722671027 Email: chagalaodera@yahoo.com
Kenya Wildlife Service (KWS)	Mr. Mungai Paul P.O Box 40241-254 NAIROBI Tel: 020-600800 or 0733-817579 Email: emu@kws.org
Kenya Institute of Education (K.I.E)	Mrs. Mical Otieno P.O Box 30231-00100 NAIROBI Tel: 3745558 Ext: 237 or 0733-8740003 Email: kied@wananchi.com micalotieno@yahoo.com
Egerton University	Dr. Robert Kariuki Obura P.O Box 536 EGERTON Tel: 051-2217737 or 0722-734181 Email: deanagric@africaonline.co.ke
Jomo Kenyatta University of Agric. & Technology	Dr. Aggrey Bernard Nyende P.O Box 62000-00600 NAIROBI Tel: 067-52711/52181/4 or 0721-624419 Email: abnyende@hotmail.com Fax: 067-52711
Farm Concern International	Mr. Mwangi S. Karichu P.O Box 15185-00100 NAIROBI Tel: 4444031 or 0720-286279 Email: info@farmconcern.org/mwangi@farmconcern.org
Moi University	Dr. Reuben M. Muasya P.O Box 1125-30100 ELDORET Tel: 053-2063160 or 0733-601622 Email: rmuasya@africaonline.co.ke Fax: 053-2063257
Maseno University	Dr. Mathews M. Dida P.O Box 333 MASENO Tel: 57-351620/2 or 0720-306286 Email: mitodida@yahoo.com
Kenya Forest Service	Mr. Maurice Wanyiri P.O Box 30513-00100 Tel: 0734-901386 Email:ccf@wananchi.com/wanyirimaurice@yahoo.co.uk
National Council of Science & Technology	Mrs. Jane B. Omari P.O Box 30623-00200 NAIROBI Tel: 219-420 Ext 223 or 0720574668 Email: omarijab@yahoo.com
National Environment Management Authority (NEMA)	Mrs. Rose Sirali Antipa P.O Box 67839-00200 NAIROBI Tel: 605522/6/7 or 0722-317499 Email: dgnema@nema.go.ke. /rsirali@yahoo.com Fax: 608997
Centre Indigenous Knowledge systems and by products (CIKSAP)	Ms. Monica Opole P .O Box66344 NAIROBI Tel: 444-8150 or 0724-268484 Email: ciksap@nbnet.co.ke/ moniopole@yahoo.com