Republic of Sudan
Ministry of Agriculture and Forestry
Quality Control and Export Development Unit

Sudan's Country Report contributing to

The State of the World's Biodiversity for Food and Agriculture







December
2015

FOREWORD

Sudan is a part to the FAO Commission on Genetic Resources for Food and Agriculture, the only intergovernmental forum which deals with whole range of genetic resources for food and agriculture. The importance of the genetic resources for food and agriculture stems from the fact that it is building block of biodiversity. It is realized that biodiversity provides the basis for livelihood and sustainable social and economic development; and safe ecological safety and food security.

The commission requested FAO to prepare a first report on *the state of world biodiversity for food and agriculture* (SoWBFA). The process of preparing the SoWBFA report is based on information from country reports as baseline information to the global report. Accordingly Sudan as participating country has appointed a national focal point for the coordination of the preparation of the report and also a national committee, which represented different sector including gender specialist, to oversee the preparation of the country report. The report has been developed in a consultative process to achieve the essential role of the country reports in filling gaps of the existing information and establishing baseline information on biodiversity for food and agriculture.

The present report includes the variety and variability of Plants, Animals, and microorganism at the genetic, species and ecosystem level that sustain the structures, functions and process in and around production systems in Sudan, and that provide food and non food agriculture products.

I would like to take this opportunity to thank FAO and the Commission in giving us this chance, and for their unlimited support. Thanks are extend to all those who were involved in preparing this report. We are looking forward for further cooperation and collaboration among all stakeholders at national regional and international levels.

Prof. Ibrahim El Dukheri
Federal Minister, Ministry of Agriculture and Forestry
December 2015

PREFACE

Preparation of the country report is an essential step in the process of preparing the first report on" *The state of the World's Biodiversity for Food and Agriculture*". It is expected to fill in gaps to existing information on biodiversity for food and agriculture; similarly it provides a base line analysis of the state of knowledge and fulfills the commitments of Sudan towards its obligations in that respect.

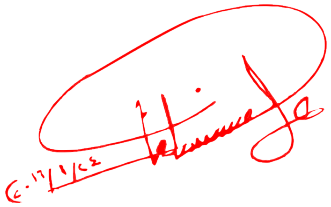
The report provides comprehensive information regarding the state of biodiversity for food and agriculture in Sudan. Incomplete or gaps in information were identified, a matter that certainly help future planning and setting priorities.

Utmost efforts were exerted to share the responsibility of developing this report with all relevant stakeholders, source institution and national experts.

Our appreciation should go to the Focal Point the Quality Control and Export development Unit of the Ministry of Agriculture and Forestry and the National Committee of biodiversity for food and agriculture

I would like to thank all teams from different sectors, all experts and consultants who work hard to complete this task in time.

I wish also to express my great appreciation to FAO and the Commission for their support.



Eng. Ali Gadoom El Ghali Osman
Undersecretary, Ministry of Agriculture and Forestry
December 2015

ACKNOWLEDGMENTS

Sudan*'s* Country Report is comprehensive information on the status of the biodiversity in the country contributing to *The State of the World's Biodiversity for Food and Agriculture* (SoWBFA) that will be presented to the Commission. It is based on FAO request to the countries member in the commission on genetic resources for food and agriculture to prepare such report. Countries are advised to take into account the Guidelines prepared by FAO to assist countries in preparation of their reports that are eventually contribute to the SoWBFA.

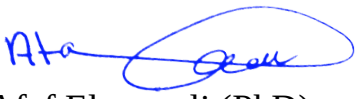
The report provides information pertinent to the interaction of the biodiversity with the state and trend of crops, forest, livestock, fisheries and aquaculture sectors. Also about associated biodiversity comprises species of importance to the ecosystem function including; microorganism, invertebrate, vertebrate and wild and aquatic plants. The report also described the use of biodiversity in food and agriculture for food security, nutrition, and rural livelihoods. Further the report suggested the future agendas for conservation and sustainable use of the biodiversity for food and agriculture.

The scope of the report is built upon the contribution of the relevant sectors by providing integrative analysis of interaction, so it is the output of a valuable contribution of key stakeholders from different sectors.

I appreciate the efforts and inputs from all government sectors and individual experts who contribute in different ways in the preparation of this report.

Successful completion of this report would not have been possible without the assistance and cooperation of the staff of the Quality Control and Export Development Unit.

Finally, I would like to express my sincere appreciation to the Ex-Undersecretary of the Ministry of Agriculture and Forestry, Mr. Bahaeldin Mohmmed Khamis for his encouragement and financial support to prepare the country report.



Afaf Elgozouli (PhD)
Quality Control and Export Development Unit
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December 2015

CONTRIBUTING INSTITUTES

- Agricultural Research Corporation, Agricultural Plant Genetic Resources Conservation and Research Center (ARC-APGRCRC)
- Fisheries Research and Aquatic Center (FRAC), Aquaculture Station
- Forests National Corporation (FNC)
- Freelance Experts
- Ministry of Agriculture and Forestry, Food Security Technical Secretariat (MOAF -FSTS)
- Ministry of Agriculture and Forestry, Quality Control and Export Development Unit (MOAF -QCEDU).
- Ministry of Agriculture and Forestry, Plant Protection Directorate (MOAF -PPD)
- Ministry of Animal Recourses fisheries and Range Land (MARFRL)
- Ministry of Environment, Natural Resources And Physical Development
  Higher Council for Environment and Natural Resources (HCENR)
- University of Bahri, College of Natural Resources, Department of Forestry
- University of Khartoum (U of K), Faculty of Science

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Acronyms and Abbreviations

ACRD-DS	Route Delineation–Darfur States.
ACSAD	The Arab Center for the Studies of Arid zones and Dry lands
AEWA	The African-Eurasian Water Bird Agreement
AIS	Alien Invasive Species
AnGR	Animal genetic resources.
APGRC	Agricultural Plant Genetic Resources Conservation and Research Centre.
APRC	Animal Production Research Center
AqGR	Aquatic Genetic Resources
ARC	Agricultural Research Corporation
ARRC	Animal Resources Research Corporation.
BMP	Biodiversity Management Plan
CAADP	Comprehensive Africa Agriculture Development Program
CAHWs	Community animal health workers
CBD	Convention on Biological Diversity
CBPP	Contagious Bovine Pleuropneumonia (vaccine)
CBRR	Community-Based Rangeland Rehabilitation
CCPP	Contagious Caprine Pleuropneumonia (vaccine)
CCRF	The FAO Code of Conduct for Responsible Fisheries.
CFC	Common Fund for Commodity
CIAT	International Center for Tropical Agriculture
CIDA	Canadian International Development Agency
CIMMYT	International Maize and Wheat Improvement Center
CITES	Convention on the International Trade in Endangered Species
CWMP	Community Watershed Management Project
DHP	Dry land Husbandry Project.
DNP	Dinder National Park
EAPGREN	Eastern Africa Plant Genetic Resources Network
EC	European Commission
EEZ	Exclusive Economic Zone
FAnGRs	Farm Animal Genetic Resources
FGR	Fisheries Genetic Resources
FINIDA	Finland International Agency
FNC	Forestry National Corporation.
FRC	Fisheries Research Centre.
GDP	Gross Domestic Product
GEF	Global Environment Facility
GM	Genetically Modified
HCENR	Higher Council for Environment and Natural Resources

HGs	Home Gardens
HHS	Households
IAEA	International Atomic Energy.
ICARDA	The International Center for Agricultural research in the Dry Areas
ICGEB	International Center for Genetic Engineering and Biotechnology.
ICM	Integrated Crop Management.
IGAD	Intergovernmental Authority on Development
ILRI	International Livestock Research Institute
IOTC	Indian Ocean Tuna Commission
IPM	Integrated Pest Management
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
IUCN	International Union for Conservation of Nature
IVIA	Valencia Institute of Agrarian Research
MARF&R	Ministry of Animal Resources, Fisheries and Range.
MCS	Monitoring, Control and Surveillance.
MPA	Master of Public Administration
NA	Not Applicable.
NAIP	National Agricultural Investment Plan
NAPA	National Adaptation Programme of Action.
NBI	The Nile Basin Initiative.
NBSAP	National Biodiversity Strategy and Action Plan.
NCR	National Center for Research.
NEPAD	The New Partnership for Africa Development
NK	Not Known.
NVRP	Nile Valley Regional Program.
NWFPs	Non Wood Forest Product.
OIE	World Organization for Animal Health
OSSREA	Organization for Social Science Research in Eastern and Southern Africa.
PERSGA	Environment of the Red Sea and the Gulf of Aden
PGR	Plant Genetic Resources.
PGRFA	Plant Genetic Resources for Food and Agriculture
RECs	Regional Economic Communities
RPA	Range and Pasture Administration
RPGD	Pasture General Directorate
RSA	Royal Society for the encouragement of Arts
Sida/SAREC	Swedish International Development Corporation Agency
SPCRP	Sudan Productive Capacity Recovery Program
SS	South Sudan
SWS	Sudanese Wildlife Society.

TYLCV	Tomato Yellow Leaf Curl Virus.
UNEP	United Nations Environment Program
UNIDO	United Nations Industrial Development Organization
WCGA	Wildlife Conservation General Administration.
WFP	World Food Programe
WISP	World Initiative for Sustainable Pastoralism

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EXECUTIVE SUMMARY

Sudan is part of the Eastern Africa region with a unique biodiversity and origin of a number of cultivated crops and wild plants in addition to an increasing number of invasive alien plant species. The diversity of cultivated crops includes, land races and improved varieties, besides crop wild relatives. However this diversity is adversely affected by a number of natural factors and intentional human activities including climate change, expansion in use of improved varieties, and other socio-economic factors including local population unrest in some of the regions of the country. Documented information on the status of diversity and use of wild food plants and associated biodiversity such as weed are limited. However, systematic efforts to conserve and document the Plant Genetic Resources for Food and Agriculture (PGRFA) started recently.

Agricultural productions in Sudan comprise irrigated (C5), rain-fed (C9) and livestock grassland-based (L1) systems. The main crops include: three staple cereals (sorghum, wheat and pearl millet), two oil crops (groundnut and sesame) many vegetables, fruit trees and grain legumes, one fiber crop (cotton) and one sugar crop (sugarcane). Research interventions to improve productivity quality and management of the biotic and abiotic stresses had been established since 1905.

Forest production in Sudan comprise two production systems of NWFPs; naturally regenerated forest in tropics (F1) and forest plantation (F5).

Forests contribute to food security, energy, timber, grazing, hunting, medicinal and non-woody products (gums and honey).As source of food forests are particularly important at times of emergencies such as floods, drought, famines and wars. Sudan developed considerable experience and capacity in forest genetic resources through establishment of forest reserves, forest plantations, forest arboreta and seed collection, testing and storage. Forests in Sudan are however under perilous threats from natural and anthropogenic factors. Deforestation and forest degradation are the major threats, as indicated by the survey results on forest cover and biomass changes and deforested areas obtained from successive inventories and remote sensing images taken at various sites as well as forest products consumption surveys carried at the national level

The only policy document dealing with aspects related to conservation and sustainable use of biodiversity for food and agriculture is the National Biodiversity Strategy and Action Plan, which has been recently updated for the period 2015-2020. Sudan is a party to a number of international legally binding instruments including the Convention on Biological Diversity (CBD), the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) and the Nagoya Protocol on Access to Genetic Resources and Sharing of Benefits arising from their Utilization. A draft for a national legislation that deals with different relevant aspects such as conservation, sustainable use, access and benefit sharing , and information management of plant genetic resources in Sudan has been proposed as a part of a domestication process of such agreements. Nevertheless, Sudan facilitates access to some PGRFA that are conserved by the APGRC by inclusion these collections in the Multi-Lateral System established by the ITPGRFA.

Specific actions are proposed in order to ensure conservation of plant biodiversity for food and agriculture in Sudan and enhance their sustainable use. They include conducting necessary germ plasm collection missions to fill geographic and taxonomic gaps such as the genetic resources of range plants and crop wild relatives. Undertaking scientific researches to evaluate local PGRFA for traits such as adaptation to climate changes including for drought tolerance, and resistance to pests and diseases is among necessary actions to be taken.

Livestock plays a great role as a food system, store of value, wealth, and means of access to power and authority in places where the banking systems and market economy do not reach the targeted areas or function properly. It has consistently provided more than 60% of the estimated value added to the agricultural sector in the years 2007-2010. Livestock include big ruminants (cattle and camels) small ruminants (sheep and goats).

Livestock production in Sudan comprises three systems; livestock grassland- based system: Tropics (L1), Livestock landless systems: Tropics (L5) and Mixed systems (livestock, crop, forest and /or aquatic and fisheries): Tropics (M1).

In-situ conservation efforts for indigenous livestock breeds are exemplified by 8 breeding stations for cattle, sheep, goats and camels. Ex-situ conservation plan encompasses gene banks and protected areas. The significant risks and dangers facing conservation and use of animal biodiversity can be signified by droughts, shrinkage of pasture due to desertification, overexploitation, fires, overgrazing, and tribal conflicts that constrained livestock migratory routes. Climate change resulted in shifting of pastoral migratory routes from north to south and eventually caused tribal conflicts between camel herders and farmers. Though some action has been taken to arrest decline in biological wealth, still there are significant gaps in policy formulation, monitoring of population trends and coordination among various institutions.

Sudan is endowed with considerable fishery resources in two production systems; A1(Self-recruiting capture fisheries tropics) A9 (Fed aquaculture tropics), centered on the Red Sea at eastern Sudan, with a coastline of about 853 km long stretching to an Exclusive Economic Zone (EEZ) of 91,600 km2, including a shelf area of 22,300 km2, River Nile and its tributaries , as well as several reservoirs. Estimates of the potential production ranges from 75,000 to over 300,000 tons per year. Major constraints are: weak institutional capacities in terms of manpower and research, insufficient infrastructural facilities especially in the areas of Monitoring, Control and Surveillance (MCS) and enforcement of activities and weak policy framework and fisheries legislation.

More than 5015 insect species belonging to 246 families were reported in the Sudan. About 126 of them are predators and 70 are parasitoids. There is no updated record on the size of the microorganisms in Sudan. A record published in 1955 indicated that the number of the fungal species as 383 belonging to 175 genera. The size of the other microorganisms is not known except for some yeast genera and some microbial degraders of some pesticides, crude oil and heavy metals in addition to some mycorhizal fungi.

The conservation and monitoring of biodiversity of microorganism and vertebrate in Sudan showed a number of gaps and constrain that must be removed for sustainable utilization of biodiversity.

CHAPTER 1

Introduction to the country and to the role of biodiversity for food and agriculture

1.1 Preparation of the Country Report

This report was prepared through a consultative process including experts from different sectors and components of the biodiversity for food and agriculture in Sudan. The process was overseen by a coordinating committee composed of members representing different institutions of relevance production system present in Sudan. Reports on different sectors were initially prepared by teams of specialized experts. Sectors reports were presented in a broad stakeholder consultative workshop (first consultation) convened for this purpose. A draft country report was synthesized by a team of experts using inputs from sector reports and feedbacks received during the consultative workshop and submitted to the commission .the final country report was revised and amended according to the comments of the commission and then presented in a workshop attended by experts and consultants (second consultation) and then adopted by the Federal authorities and submitted formally as Sudan country report sharing in the global report for *the State of the World's Biodiversity for Food and Agriculture* (Lists of participants to this process are included in (Annex 1).

There are Shortcomings and obstacles in preparation of the report. The main challenges faced the preparation of the reports were that the information and data on biodiversity for food and agriculture is fragmented and scattered without government statistic system. Databases, information are not regularly updated due to low priority and/or insufficient funding; information is limited, outdated, un-standardized and often un-reviewed. Due to broad scope and complexity of the common understanding of associated biodiversity for the biodiversity in food and agriculture was not well addressed. In most cases there are no systematic studies especially in the associated biodiversity and ecosystem services, so the tables regarding these issues contain weak and estimated information.

Importance of the country report and SOWBFA for Sudan

- Compilation of information providing an overview of the status of agro biodiversity in the country
- Highlights that biodiversity is key for sustainable agriculture economy
- Underpins the importance of ongoing activities
- Baseline for further evaluation of policy measures at national and international level
- Identify gaps and new areas for research
- Collecting different organizations and experts to work as one team

Future process

- Developing and operating a biodiversity database system and identification of mechanisms to share, exchange, and manage information

- Promote the closer and integrated working relationships between key and relevant department/agencies and stakeholders.

- Promoting the support from international organization in survey activities in the all biodiversity sectors, improving conservation and sustainable use of the biodiversity for food and agriculture and establishing information system for diversity

1.2 General overview of the Sudan

Sudan lies in northeast Africa between latitudes 4^0 and 22^0 north and longitudes 22^o and 38^0 east, with a total area of 188 606 800 hectares or 1, 886,068 km² Sudan is mostly an arid country, within which five ecological zones can be identified: the desert in the extreme north, followed by the low rainfall savanna woodland, the high rain savanna woodland in the south, and the mountain zones. The most salient geographical features of the country are the Nile Valley, Nubian and Bayuda Deserts in the north. The River Nile and its tributaries which traverse the country have varying degrees of influence on irrigated agriculture and livestock production systems. There are also a large number of seasonal rivers and water courses; large ones, such as the Gash and Baraka, originate within the Ethiopian highlands, form two inland deltas in Sudan, and are important for flood irrigation agriculture. Also, there is a vast resource of groundwater, estimated at about 9000 billion m³, which has a varied distribution, quantity and quality in different parts of the country, with the Nubian Sandstone aquifer which is the most important (Figure 1).
The vegetation follow the ecological classification profile and rainfall trends as from north to south with vegetation taking the form of bush land and scattered trees and shrubs in the north and in dense forests of large trees in mixture of acacias and broad-leaved trees in the southern end of the savanna and mountain region. Rich forests grow along the Nile and its tributaries. Most of the wildlife resources of the country are found within the high rain savanna woodland.

The agriculture sector is the most important economic sector in the country. According to the Central Bureau of Statistics, during the period 2009-2013, the Agriculture sector contributes on average about 34% of the country Gross Domestic Product (GDP); ranging between 32.2% in 2009 and 34.4% in 2013. The secession of South Sudan led to contractions in the economy and the agricultural sector. In 2009 the largest share of agricultural GDP was derived from livestock production (47 per cent), followed by large-scale irrigation (28 per cent), traditional rain-fed farming (15 per cent), forest products (7 per cent) and semi-mechanized farming (3 per cent). Agriculture provides a livelihood to approximately two-thirds of the population as of 2013, and employs about 60 per cent of the labor force.

According to the latest population census, Sudan has 37 million populations. As much as 41% of the population is under 15 years of age while 20% is between 15 -24 years.

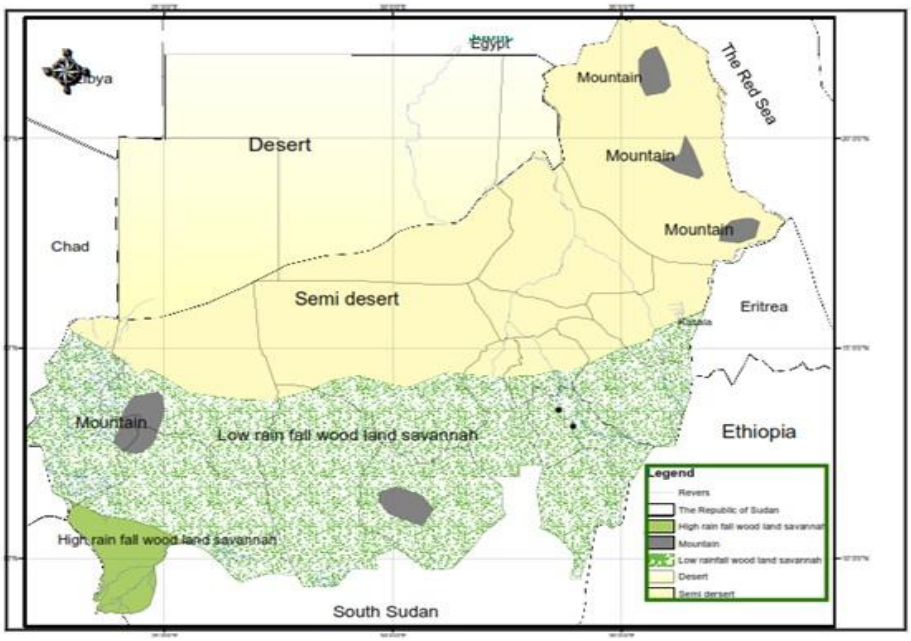

Fig 1: Ecological classification of vegetation covers of the republic of Sudan

1.3 Role of biodiversity for food and agriculture

Sudan is rich in biodiversity within diverse environmental systems making it endowed with flora and fauna. The diversity of plants, animals and microorganisms is essential for maintaining the productivity and sustainability of farm crops and animals, managed forests and rangelands, aquaculture and fisheries.
The agricultural sector has an important role to play in achieving food Security by increasing food production and providing employment opportunities in the rural area. Sudan has cultivable arable land estimated at 86 million hectare. However less than 20% are utilized in three major farming sub-sectors:

The irrigated system is estimated as a 5 million hectare. The sub-sector contributes an average of 21% of the total value of agricultural production, 100%of wheat and 25% of sorghum produced in the country. Although its contribution to sorghum production is low relative to the rain- fed sub-sector, it is more stable. In years of drought it plays an important role in meeting the consumption requirements
.
The semi-mechanized rain fed with an area of about 6 million hectare the two main crops produce by this sector are sorghum and sesame, the crop yield depends on rainfall.

The agro-pastoral traditional rain- fed sector is about 9 million hectares located in the western, central and southern parts of Sudan. The main crops produced by this sector are sorghum, millet, groundnuts, sesame, short staple cotton and gum Arabic.

Cereals dominate crop production in Sudan and provide nearly 53% of the population's daily calorie requirements (FAO-SIFSIA. 2010). The major staple crops are sorghum, millet and wheat.

The Sudan forests and woodlands furnish invaluable 'co-benefits' in the country in the form of important and critical ecological values, that is in ameliorating the climate, providing vital services such as conserving soils and water sources, harbouring rich biodiversity and important genetic resources and serving as habitats for wildlife, providing a wide range of cultural, spiritual and recreational benefits.

Forests and woodlands cover about 64.36 million ha, while rangelands are estimated to cover 24 million ha. (National Committee on Food Security, 1996) Forage from rangelands is estimated to provide, depending upon the region, from 55-80% of the national herd feed requirements.

There is upsurge concern about the production, quantities, values producers, uses, marketing and other commercially important Non Wood Forest Products (NWFPs) in Sudan. However, with the exception of gum Arabic, the value of the NWFPs has not been enumerated and negligible quantity is marketed or traded. They are generally consumed by the gatherers. Some effort had been done by the (World Bank, 1986) and the FAO Project "Forestry Development in Sudan (1994)". NWFPs are collected or produced from natural forests (reserves or non reserves) as well as from trees planted or conserved on a farm, on communal land and at homestead.

Livestock husbandry in its various forms is practiced by an estimated 40 percent of the population. It plays a great role as a food system, store of value, wealth, and means of access to power and authority in places where the banking systems and market economy do not reach the targeted areas or function properly (Igad, 2013).Local livestock breeds which help maintain biodiversity are also an integral part of the livestock keeper's environment and many of these breeds have played a central role in the cultures of the people who keep them (LPP *et al*., 2010).

Sudan is endowed with diversified surface and underground water resources, and arable lands that are suitable to support a vigorous capture fisheries and aquaculture industry. Currently, capture fisheries activities are centered around the River Nile and its tributaries, and the territorial waters of Sudan on the Red Sea

.

In-situ and ex-situ conservation

In-situ conservation efforts for indigenous livestock breeds are exemplified by 8 breeding stations for cattle, sheep, goats and camels. These breeding stations represent the focal points for conservation and sustainable use for about 14 gene pools from the national herd of the country. The most important effort in this type of conservation is achieved by pastoral communities who have conserved their genetic resource over centuries by traditional means.

Ex-situ conservation plan encompasses gene banks and protected areas

The main institutions responsible for fisheries management and development in the country are the Directorate General of Fisheries within the Federal Ministry of Animal Resources, Fisheries and Range (MARF&R), State Fisheries Departments, and the Fisheries Research Centre (FRC).

The significant risks and dangers

The significant risks and dangers facing conservation and use of biodiversity for food and agriculture on one hand can be signified by droughts, shrinkage of pasture due to desertification, fires, overgrazing, and tribal conflicts that constrained livestock migratory routes. On the other hand, unclear wildlife policy and weakness in awareness and education frame work, mining activities in some regions had lead to habitat destruction and/or fragmentation, expansion of mechanized agricultural irrigated schemes. As regards to fisheries constraints facing conservation and use of aquatic biodiversity include weak institutional capacities in terms of manpower and research, insufficient infrastructural facilities and enforcement of activities, weak policy framework and fisheries legislation, poor organization of the artisan craftsmen and their low socio-economic profile and fishing capacity with the use of rudimentary fishing gear and techniques and very limited access to markets due to poor road infrastructure.

The microorganism and invertebrate play an important role on biodiversity for food and agriculture. The study on population of native honey bees in Sudan showed more than one species, it has estimated that there are about 200000 honey hives in Sudan and 50000 bee keepers, The protein structure, physiochemical properties and mineral composition of *Apis melifera* honey of different floral origin, commercialized in several states in Sudan and there is need for more studies and information to assist in developing policies for conservation of the native honey bees in Sudan.

Several Sudanese yeast strain proved to produce ethanol from molasses, and several promising isolates of microbial degraders of some pesticides, crude oil and heavy metals are obtained.

Most of fungi studies are plant pathogenic fungi causing leaf spot, rusts, smut, sooty molds, powdery mildew, downy mildews, soil born diseases and others. Large numbers of fungal species had been reported as the causal agent of many others diseases of field and horticultural crops and forest tree in the Sudan.

The management and control of Alien Invasive Species (AIS) in Sudan is very expensive and need more efforts from government and organizations of stakeholders from different sectors.

The pressures represented by climatic changes, droughts and floods, biotic factors (pests and diseases) and AIS in addition to modern agriculture, socio economic factor and development constructions are the main threats to plant agro- biodiversity.

1.4 Production systems in the country

Table 1: Production systems present in the country

Sector	Code	Production system names	Present (Y/N)
Crops	C5	Irrigated crops	Y
	C9	Rain fed crops, which includes: Mechanized rain fed subsector: Mechanization is practiced in land preparation seeding and threshing. The total area of this sector is estimated at 6.3million hectares. Traditional rain fed subsector, which covers all areas under traditional production where non-mechanized farming tools predominant the total cultivated area of this sector is estimated at 8 million hectares.	Y
Forests	F1 F5	Three production systems of NWFPs are recognized: 1. Supplementary activities by farmers (inside farms) and pastoralists (along their routes). 2. Small scale activities by household members as a daily basis source of income. 3. Large scale production with camps of producers in large forest areas, including gum collection.	Y Y
Livestock	L1	Livestock grassland-based systems: Tropics	Y
	L5	Livestock landless systems: Tropics	Y
	M1	Mixed systems (livestock, crop, forest and /or aquatic and fisheries): Tropics	Y
Aquaculture and Fisheries	A1	Self -recruiting capture fisheries tropics	Y
	A9	Fed aquaculture tropics	Y

Table 2: Production systems present in the country

Code	Production system names	Description
C5	Irrigated crops	It includes gravity irrigated schemes from the Nile and its tributaries, and irrigation from bore holes. The total area of this sub sector is estimated as 5million hectares. Main crops include food crops such as wheat, sorghum, vegetables and fruit trees, oil crops such as groundnut, and cotton as a cash crop (see Annex 2)
C9	Rain-fed crops	It includes: **Mechanized rain-fed subsector:** Mechanization is practiced in land preparation seeding and threshing. The total area of this sector is estimated at 6.3 million hectares. The main crops cultivated in this sub-sector include sorghum, sesame and sunflower. **Traditional rain-fed subsector,** which covers all area sunder traditional production where non-mechanized farming tools predominant. The total cultivated area of this sector is estimated at 8 million hectares. Main crops cultivated in this sub-sector include sorghum, pearl millet, sesame, groundnut, seed watermelon, Roselle (see Annex 2)
F1 F5	Naturally regenerated forests in the tropics Forest plantation	**Forest management systems:** Forest management has always been a tool for managing forest recourses. Any environmental activities at war and conflict affected sites should consider sound management methodologies such as inventory, planning, organization and control. These entire components are obligatory for forest management, and it will act as a means of identifying what can be done to enhance and protect the values and aspects of recourses that are most important. The Sudan experience of plantation management has been long and effective in bringing the plantations into sustainable systems (Abdel Magid, 2001). ***Share of the population and number of employees contributing to the production systems:*** Employment in the public forestry sector represents an important source of livelihood. Around 5 million were depending on gum production in the gum belt of Sudan. For these populations - among the poorest and most vulnerable in Sudan - gum Arabic can contribute up to 50 percent of total cash incomes. ***Importance of the production systems to the incomes,***

		livelihoods and well-being of rural communities: A large segment of people in the rural areas is forest dependent using the forests for various livelihood support including on farm trees, feed for livestock, wood harvesting and collection of NWFPs inclusive of aromatic, culinary and medicinal plants. For small-scale farmers, gum Arabic represents a diversification strategy to mitigate crop failure and a way to meet household's cash needs. There are also socio-economic benefits from gum collection, which stretch beyond the simple cash value of the gum. Millions of people are involved in harvesting and cleaning the gum, and because it is an activity that is carried out during the dry season it does not put demands on the farmer when he needs to tend other crops (Abdel Magid, 2001; Abdel Nour, 2001). Most of the energy consumed in the Sudan (about 80%) is obtained from the trees, as documented by the demand survey, 1994. Forest products provide the foundation of many local and national economies, in addition to ecological and social services. Most of these products are harvested for home consumption, local sales and, to a limited extent, for export. (Abdel Magid, 2001; Elsiddig et al, 2011). ***Level of agricultural intensification and reliance upon synthetic inputs, modern varieties, fossil foils, etc.*** Fossil fuels are used for the transportation of forest products from the production sites to the consumption areas in different locations. Also fossil fuel is used for the transporting of seedlings from the central and localized nurseries to the plantation sites.
L1	Livestock grassland-based systems: tropics	**Livestock management systems:** **Pure pastoral nomadic system:** Mobility is the main husbandry management mechanism. Based largely on the herding of camels, sheep and goats by the camel herders in the semi-arid and arid north (< 600 ml) (Map 1). *Both pastoral nomadic and semi-nomadic agro Pastoralism* groups own 80- 90% of the total number of cattle, 100% of camels, 80% of sheep and 60% of the goats of the country. The herd sizes in the system vary, averaging 200, 70, 90 and 200 for cattle, sheep, camels and goats, respectively. The systems are the main sources of meat for the local demand and for export (Sudan's Fourth National Report to the Convention on Biological Diversity, 2009). ***Share of the population and number of employees contributing to the production systems:***

		Pastoral nomadic and semi-nomadic agro Pastoralism supports at least 500,000 households (HHs) of primary producers (Ahmed, 2012; Abdel Ghaffar M. Ahmed, 2014). At least 34,000 full time jobs supported by pastoral systems outside primary productions were identified, and a volume of business of at least 350 million SDG besides livestock trade (Krätli *et al*., 2013). These systems generated full-time jobs and auxiliary markets at home benefiting a number of temporary employees along the market chain (IGAD, 2013). ***Importance of the production systems to the incomes, livelihoods and well-being of rural communities:*** Pastoralists use their small ruminants as means of exchange to satisfy needs for goods they do not produce. The role of livestock as a food system, store of value, wealth, and means of access to power and authority in places where the banking systems and market economy do not reach the targeted areas or function properly is recognized (IGAD, 2013). Livestock strengthen group solidarity by allowing, for example, those who have large herds to lend some animals to those who have smaller herds or those who lost their herds due to drought or epidemics and civil wars. Value of subsistence milk alone in the 2008 census was estimated to be above one billion SDG per year (or 500 million USD) (Krätli *et al*., 2013). Surplus milk in *Livestock grassland-based systems* is processed into sour milk and ghee by women e.g. Beja and Baggara tribes (Ahmed and Musa, 2014). ***Level of agricultural intensification and reliance upon synthetic inputs, modern varieties, fossil foils, etc.*** This production system (L1) is based on extensive management. Manure is used as organic fertilizer in crop production in subsistence agriculture. ***Sedentary system****:* cattle and small livestock are reared in close proximity to villages, mainly in the central belt from Gedaref to Kordofan& Darfur (UNEP, 1998). Also it is practiced in traditional small agricultural schemes where a few heads of goats, sheep or cattle may be kept. Grazing of range, fallow land and along irrigation canals plus house waste and crop residues and sometimes green fodder are the main sources of feed. ***Share of the population and number of employees***

		contributing to the production systems: Estimated at 258,000 agricultural smallholders, owning small livestock herds as a coping strategy against crop failure and for home consumption (Mohammed and Babiker, 1990). ***Importance of the production systems to the incomes, livelihoods and well-being of rural communities:*** Livestock supply HHs with dairy products & meat. Oxen and camels are used as means of transport. Used for sacrifices during circumcision, marriage and other social occasions and part of the payment of a bride's wealth and school fees. ***Level of agricultural intensification and reliance upon synthetic inputs, modern varieties, fossil foils, etc.*** Inorganic fertilizers are used in green fodder production. Cross breeding with exotic goats breeds is practiced by some HHs in the peri-urban areas e.g. Sannen, Shami breeds.
L5	Livestock landless systems: tropics	Large commercial dairy & poultry enterprises located in peri-urban areas around large cities e.g. Khartoum. Dairy Cooperatives. Both large commercial dairy enterprises and dairy cooperatives intensive dairy production is practiced using irrigated fodder and concentrates with exotic or cross-bred breeds. Artificial insemination is heavily used. All herds are vaccinated and veterinary coverage is wide. These systems supply milk, meat and poultry for the increasing demand of urban populations. **Feedlot operations** For fattening cattle and sheep trekked for long distances from the Western States of the country to urban areas and markets. Nutrition is based on agro-industrial by-products and sorghum grains. Feedlot operations exist in 7 States. Western Baggara cattle breed and desert sheep breeds are the most common pastoral breeds used in feedlots. ***Share of the population and number of employees contributing to the production systems:*** Secures 650 full time jobs (UNEP, 2013). About 180,000 head of cattle every year in Khartoum State alone (UNEP, 2013). These cattle feed lotting produces 10,692 tons of dry dung per annum used in brick making.

		Level of agricultural intensification and reliance upon synthetic inputs, modern varieties, fossil foils, etc. Feed concentrates are used in fattening processes. Veterinary medicines and veterinary biological are available to feed lotters. Fossil fuels are used for transportation of feeds inputs and animals.
M1	Mixed systems (livestock, crops, forest and / or aquatic and fisheries: tropics	**Semi-nomadic agro Pastoralism.** Both agriculture and livestock production are practiced. Livestock mobility is for short distances, e.g. Baggara (cattle herders) and Butana tribes in the western and central part of eastern Sudan. Subsistence agriculture practiced e.g. Sorghum & millet and types of livestock raised are cattle& sheep (Baggara tribes). **Integrated crop - livestock system**: prevails in Khartoum State, Gezira irrigated agricultural scheme and Red sea region. Probable future areas are: Halfa & Rahad irrigated agricultural schemes. In Gezira irrigated agricultural scheme famous dairy cattle keepers (Kenana & Butana breeds) use this system to support their herds during dry season. Small ruminants are also raised. ***Share of the population and number of employees contributing to the production systems:*** In Khartoum State there are 3 large irrigated agricultural schemes: Kuku complex (where several dairy cooperatives operate), Seliet and Soba. The number of households is 1,125 (MAAI, 2014). ***Importance of the production systems to the incomes, livelihoods and well-being of rural communities:*** The majority of the HHS is small producers with family contribution in management activities, selling milk or buying inputs. The system provides city consumers with dairy products and meat. ***Level of agricultural intensification and reliance upon synthetic inputs, modern varieties, fossil foils, etc.*** In this system, semi-intensive dairy production is practiced using irrigated fodder, concentrates and cross-bred exotic breeds (e.g. Friesian) or indigenous local cattle populations. Veterinary medicines are available but clinical coverage is not sufficient in some regions. Most of the agricultural schemes used inorganic fertilizers

		for fodder production. Fossil fuels are used for the transportation of agricultural inputs and livestock and livestock products. **Feedlot operations:** Fattening is practiced in large privately owned rain-fed mechanized agricultural schemes on crop residues and agro-industrial by-products. Unspecialized fattening operations targeting maintenance and reconditioning of sheep herds e.g. Dubasi breed are conducted in some States (Gazira, White Nile, Blue Nile, Gadarif & Kassala) (Krätli *et al*., 2013). Nutrition is based on agro-industrial by-products. Fossil fuels are used for the transportation of agricultural inputs and livestock and livestock products.
A1	Self-recruiting capture fisheries tropics	Capture fisheries activities are artisanal in nature, mainly centered around the man-made lakes on River Nile and its tributaries, and the territorial waters of Sudan on the Red Sea. Rough estimates (for the area previously known as Sudan) suggest that the sector employs directly almost 13,000 people and as many as 50,000 additional folk in the secondary sector (FAO, 2014).
A9	Fed aquaculture tropics	An aqua culture activity in Sudan incorporates cultivation of oyster in the marine environment and finfish in fresh water.

Table 3: Area under production, production quantity and contribution to the agricultural sector economy for production systems in the country

Code	Production system names	Number (Head)	Production quantity (t)	Contribution to the agricultural sector economy (%)	Reference year
C5	Irrigated System	Crop: Cultivated Area (000 fed) Sorghum: 1138 Millet: 20 Wheat: 552 Groundnuts: 298 Sunflowers: 42 Cotton: 143	Crop: Production ((000Ton) Sorghum: 894 Millet: 7 Wheat: 467 Groundnuts: 286 Sunflowers: 18 Cotton: 158		
C9	Irrigated System	Crop: Cultivated Area (000 fed) — Mechanized / Traditional Sorghum: 15588 / 8339 Millet: 683 / 9130 Wheat: - / 12 Groundnuts: - / 6119 Sesame: 3469 / 4295 Sunflowers: / 138 Cotton: / 33	Crop: Production (000Ton) — Mechanized / Traditional Sorghum: 3563 / 1712 Millet: 116 / 1122 Wheat: - / 6 Groundnuts: - / 1585 Sesame: 377 / 344 Sunflowers: - / 33 Cotton: 18 /		
F1	Naturally regenerated forests-	NK	NK	NK	
F5	Planted forests: Tropics	NK	NK	NK	2009 & 2012
L5	Livestock landless systems: tropics		Feedlots: About 180,000 head of cattle every year in Khartoum State (UNEP, 2013).	The feed value was of about 109 million SDG (or 18 million USD in June 2012).	2012
M1	Mixed systems (livestock, crops, forest and / or aquatic and fisheries: tropics	75,000 dairy cows in Khartoum State alone	Milk 316,000 t/yr. (MAAI, 2014).	NK	2014
A1	Self-recruiting capture fisheries tropics	142,000 Km^2	34,000 Tone	The contribution of capture fisheries to the country's GDP is 0.4% in 1999	2012
A9	Fed aquaculture tropics	NK	2,000 Tone	NK	2012

Proportion of production that destined for export

Production and Export by Commodities during 2011- 2014

(Production (000T)-or (000000) head of animal)

commodities	2011/12		2012/13		2013/14	
	Production	Quantity export	Production	Quantity export	Production	Quantity export
Sesame	187	211,826	562	208,916	205	239,458
Groundnuts	1032	1,385	1767	5,667	962	28,192
Hibiscus Flower	42	18,531	25	15,656	NK	13,873
Melon Seeds	66	29,369	51	33,800	NK	9,642
Senna Pods	NK	3,176	NK	1,981	NK	5,052
Dura (Sorghum)	1882	72,575	4524	55,880	4271	243,443
Sugar	686,78	7,586	674,57	-	628,54	-
Wheat Bran	324	20,335	265	18,350	194	65,848
Sheep	39.2	97,415	39.480	105,760	39.57	3,899,320
Goats	30.6	2,876	30.840	3,082	30.98	133,332
Cattle	29.6	6,555	29.84	48,703	30.03	9,546
Camels	4.7	31,552	4.75	41,474	4.77	100,923
Fish (Fresh or Chilled)	NK	654	NK	346	NK	400
Vegetables	3034,6	2,297	3881,89	16,921	4146,4	10,522
Fruits	3518,5	1,671	2638,4	2,572	2754,1	24,649

CHAPTER 2

Drivers of change

2.1 Effects of drivers of change on associated biodiversity

Due to broad scope and complexity of the common understanding of associated biodiversity and in most cases no systematic studies about it, so no information or data was available for the effect of the all drivers on associated biodiversity except the effect of the driver, pollution and external inputs which is caused by the mismanagement and excessive use of pesticides. Use o of broad -spectrum insecticides for the control of insects pests of various crops resulted in elimination of beneficial insects such as predators, parasitoids and pollinators, also the extensive use of pesticides, particularly the broad- spectrum for control of insects and pests of field and vegetable crops and fruits trees was adversely affect the survival of the beneficial insects like bees.

2.2 Effects of drivers of change on biodiversity for food and agriculture

Changes in land and water use and management:

Drilling for oil, mining for gold, deviation from recommended practices and technical packages in water management methods led to reduction in the actual cultivated areas and in crop productivity and production. Importation of some crops seeds (e.g. millet seeds) led to the advert of some diseases (downy mildew disease on millet) resulted in crop failure in several seasons.

In the C5 System the water was used to be managed by the government (Ministry of Irrigation) regarding the storage and distribution including maintenance of the canals and drainage. Later this responsibility was transferred to the private sector with little guide line for the management which led to poor efficiency in the system of the irrigation in C5 production System**.**

Dams' construction and water harvest schemes as a positive effort led to availability of water and expansion in cultivated areas in C9.

Due to the uncontrolled expansion of mechanized and traditional rain-fed agriculture on the account of grazing lands, most of the land used for grazing in the savannah belt started to shrink (Shazali and Ahmed, 1999). There was a decrease in rainfall from 425 ml/yr during 1941-1970 to 360 ml/yr during 1970-2000 (RPA, 2009). This constituted an average reduction of 0.5% annually. Accordingly, agro ecological-zones shifted southwards and this affected pasture production. Drought conditions which resulted in reduction of available pasture and drinking water are considered the single threat to livestock survival. The arid and semiarid lands have rainfall patterns that are highly variable, both temporally and spatially, making pasture and water availability for livestock unpredictable. (Elasha and El Sanjak (2009) reported that predicted changes in the climate may increase competition between farmers and pastoralists and consequently compromising the provision of potable water.

Water in Darfur is a limiting factor affecting economic development and contributing negatively to the wellbeing of the population. At present, many livestock watering points have been engulfed by farms resulting in more pressure on the rainy season for grazing

areas, a matter that led to range deterioration and dominance of annuals grass in these areas (PAS, 2007).
Table 4 displays the effect of drivers on sector biodiversity within production systems in the country.

Pollution and external input

In Sudan the miss use of pesticides in agriculture is common, although there is a good regulations and laws (the pesticides act 1974) under supervision in the National Council of Pesticides. The miss management is due to abuse of application of non recommended pesticides, smuggling and counter field in local market, lack of observation of safety period, poor storage and lack of proper disposal.

Over-exploitation and overharvesting

In Sudan, forest resources are under severe menace and both the areas under forest cover and the quality of forests are diminishing. Mechanized agriculture have, so far, put stress in increasing production through the expansion of cultivable land at the expense of the natural land resources-base that yield wood and non-wood forest products. A number of studies in the literature indicated the deforestation of the forest resources in Sudan, where various interrelated factors have contributed to it. The most notable effects on forests and trees include:

• Degradation of forests and forest land, thus undermining their economic and ecological functions, and resulting in desertification.

• Loss of forest biodiversity, whose many consequences are yet not fully recognized Abdel Magid and Badi, 2008).

Over exploitation of the diminished resources has led to rangeland degradation and the latter was considered the most prominent environmental problem associated with livestock husbandry in Sudan (UNEP, 2007). Abduljabbar Abdalla Fadul (2009) stated that reduction in rainfall in Darfur had led to changes in the composition of range plants, for example after 1986, the number of range plants had decreased in one area first from 12 to 6 and to 1 in the present time. This was due to seed gene bank depletion and over exploitation of land due to overgrazing**.**

Population of some fish species are decreasing due to overexploitation (using of destructive fishing gears , the violation of fishing period and illegal fish trawling especially in Red Sea (Hamid et al., 2009).

There is severe over-fishing for Sea cucumbers in the vicinity of Dungonab Bay where Sea cucumbers have been fished out from many shallow areas forcing divers to travel further and exploit deeper waters (PERSGA/GEF, 2004). Similarly, the mollusks *Trochus* spp., *Strombus* spp., *Lambis* spp., and *Murex* spp. have been severely fished. Most individuals of these species observed in the wild are small and occur at low densities (PERSGA/GEF, 2004).

Fishing pressure was intense at spawning and nursery sites for Nagil and of other species especially at the southern end of Mukawwar Island. Continuation of this form of fishing will undoubtedly lead to the loss of some of the most important fisheries species. The majority of mangrove stands are affected at various levels by camel grazing, felling and limb cutting (HCENR, 2014).

Climate changes

Climate change is the main driver of change that affected all components of biodiversity. Fluctuation in rain fall, including excessive rains and drought spells, increase of the annual mean temperature, contributed negatively to species richness and distribution as well as disappearance of local traditional knowledge. Most of the agriculture in Africa and Sudan is not an exception, is rain-fed and, therefore, very susceptible to climate variability, that is characterized by frequent droughts and occasional floods, that at times destroys crops and livestock. At such times the rural communities increase their reliance on the forests and woodlands for wild foods and other products. (Kowero *et al*, 2009). Climate change resulted in shifting of pastoral migratory routes from north to south and eventually caused tribal conflicts between camel herders and farmers (Harir, 1994).This practice brought the danger of exposing the northern zebu cattle types to crossing with the Southern Sanga types. Desert sheep are also under the threat of crossing with Southern Sudan types. Due to changes in climate and vegetation, switch between animal types was already observed in the Sahel region, where camels replaced cows and goats replaced sheep preceding the drought in the eighties of the last century (FAO, 2007b).The impact of climate change on rangelands was clearly reflected by the reduction of the range productivity per unit area, from 1.2 t/ha in 1980s to 0.2 t/ha in 2009 (RPA, 2009). This has threatened the resilience of pastoral production systems in many parts of the country.

According to the National Adaptation Program of Action (NAPA) in Sudan (2007), the current major climate hazards consist of drought and extreme flooding events. In addition, there are other climate related phenomena such as dust storms, thunderstorms, and heat waves whose occurrences, though less frequent, still pose serious threat to local livelihoods.

Future climate change is expected to see these hazards intensify. In Sudan, negative impacts of climate changes have been observed as following:

Drought and rain fluctuations

Drought, which has been frequently hit the northern parts of western Sudan in Kordofan and Darfur regions of the country resulted in decrease of a number of local varieties of Sorghum and millet. Recurring series of dry years has become a normal occurrence in the Sudano-Sahel region. Consequently, drought is threatening the existing cultivation of about 11 million hectares of traditional rain-fed farming and 5 million hectares of rain-fed mechanized lands in Sudan. Rangelands' cover has been subjected, particularly in the semi-desert and savannah ecological zones, to recurrent droughts in the last three decades, showing a decrease of palatable “desirable” species and increase in unpalatable and invader species.”

Fluctuation in rain fall together with its concentration into a short rainy period impacts adversely on rain-fed cultivation as well as on range vegetation growth and productivity. The ultimate consequence is threats to livelihoods and food security prospects of both pastoral groups and traditional farmers.On the other hand, the increase in rainfall in the last few years, which is being observed for all the eastern Africa, has a positive impact on

agro biodiversity, resulting in increase of the areas under rain-fed production that grown with local indigenous crops such as pearl millet, sorghum and sesame among others.
NAPA (2007) stated that natural disasters that threaten animal production and resilience of production systems are droughts and high temperatures. In the mid-eighties, the Hawaweer, a nomadic pastoralist group inhabiting the northern part of Sudan, were forced to migrate because of drought and hunger (Haug, 2002).

Natural disasters

Floods

Traditional areas of banana production along the rivers banks have been also exposed to flooding of the rivers during the late 1990s and early 2000s resulting in a lot of destruction of banana farms, where the traditional type of Dwarf Cavendish banana is grown.

Wild fire

Intentional of wide fire happens generally in L1 System and in some areas and crops of C5 System.

Pests, diseases, Invasive Alien Species (IAS)

There are many invasive alien plants, insect and animal species in Sudan introduced accidentally or deliberately for various purposes. They are causing serious losses and posing serious threats to the biodiversity. Pests and diseases of crops usually have negative effects on crop genetic variability. Exotic insect pest such as (*Palmapsis phoenicis,* Green Pit Scale of date palm, *Tuta absoluta* Tomato leaf miner, *Parlatoria blanchardii* Scale insect of date palm, the fruit flies, *Ceratitis capitata*, *Ceratitis cosyra* , *Bactrocera cucrbitae, B. Invadens.* And the Parasitic weeds *Orbanche crenata, Orbanche ramose* (haluk) and the woody species (*Prosopis juliflora* (Mesquite). Those plants constitute a threat to agriculture, biodiversity and may lead to deterioration of natural vegetation and pastures. *Eichhornia crassppes* (Water hyacinth) is highly invasive species and has a tendency to cover and choke major waterways and lake surfaces, which have numerous detrimental ecological, biological, diversity, fisheries, hydroelectric, transportation and economic results. It controlled by biological control methods. The prevalence of diseases in Sudan limits livestock productivity through morbidity and mortality, resulting in the loss of animal products e.g. meat, milk, eggs and by-products e.g. wool, skin and hides, manure and services e.g. animal traction (FAO, 2010). Rainfall fluctuations can result in drought and the loss of livestock, or endemic diseases accompanied by heavy parasitic infestations that lower productivity and prevent livestock exports (FAO, 2010). Due to conflicts between sedentary farmers and pastoralists mobility of livestock herds was restricted to some areas e.g. the case of camel herders south of Mara'a Plateau. This restriction had resulted in animal health implications and epidemics due to malnutrition (Jaspars and O'Callaghan, 2008).Pastoral migration through international borders also exposed national herds to contract infectious diseases.

Changing economic, sociopolitical and cultural factors

i. **Economy** plays a significant role in shaping human preference. Moving surplus food products to food-deficit areas is constrained by poor infrastructure. Disruption of trade routes and communication reflected in high transport costs inhibits trade and the distribution of food and production inputs (FAO, 2012).

ii. **Increase in mono cropping** at the expenses of multi cropping because of market demand, negatively affected biodiversity. Farmers tend to grow high yielding varieties, which is a common trend for vegetable farmers who used to grow a number of local varieties in addition to modern varieties in Khartoum state. On the other hand informal introduction of some crop species has a positive impact on some of plant agro biodiversity. The introduction of new date palm varieties for investment purposes, although it had a negative implication on local germplasm, but it contributes to increase of varietal diversity in the country.

iii. **Shifting to activities** that generate higher and quick incomes other than cultivation of crops has also been a trend in the last few years, in addition to migration of rural people, which are mostly belonging to farmers' and pastoralists' communities to the capital city in Khartoum and other big towns. This phenomenon might have been affecting negatively the diversity of agricultural plants.

iv. **Local conflicts** are experienced in different parts of the country, where considerable areas that are rich in agricultural biodiversity in Sudan are under unrest or political conflict conditions such as Darfur, South Kordofan and Blue Nile states. The consequences of such situations result in loss of agro biodiversity, either by inhabitant displacement and hence no more productive activities (farming or rearing animals) are practiced or by losing wealth of crops and animals due to violence activities.

v. **Cessation of South Sudan:** South of former Sudan is rich in biodiversity including the agricultural plant biodiversity, which became part of a different country after born of the new state of the Republic of South Sudan in 2011.

vi. **social life** of pastoralists in some areas is affected by political issues. A good example of this is the increased tensions in the border regions between Sudan and South Sudan in February 2013 where about 37,500 Umbararo Falata cattle herders of South Darfur were forced to settle in Tulus and Dimso after they were expelled from South Sudan. Large numbers of cattle that normally graze in South Sudan during the hot dry season were reportedly confined just north of the border (FEWS NET, 2012).

Policies

The policy frame that developed and adopted in Sudan, highlighted the increased levels of awareness of biodiversity and it is important and play crucial role on conservation and sustainable use of biodiversity. A number of changes have occurred in Sudan recently at the policy level leading to changes with regard to state of agricultural plant biodiversity, including the following:

Ratification of the International Treaty on Plant Genetic Resources for Food and Agriculture enable Sudan to be a member and thus to establish effective measures for promotion and conservation of agro biodiversity for food and agriculture using funding provided by the treaty.

Development of the National Biodiversity Strategy and Action Plan (NBSAP) that serve conservation of the biological diversity of the country, it has taken into account several factors including, the current status of biodiversity in the country, threats to biodiversity and actions needed to ensure proper conservation and sustainable use.

Development of the Strategic Action Plan of Natural Range and Pasture Plants (PSAP) that aims through implementation of its projects to build the resilience to climate-induced crises affecting pastoralists and agro-pastoralists in two ecosystems of Sudan, to contribute to food security and poverty reduction in the face of climate change. In addition to that, certain sustainable livelihoods measures that operate as climate change adaptation options can be integrated into the planning of national adaptation strategies for the pastoral sector in semi-desert and low rainfall savannah in Sudan.

Proposed draft of a Plant Genetic Resources Legislation has been drafted in 2011 by a task force of technical and legal experts formed by the Ministry of Agriculture and Forestry. This draft legislation has been developed in order to attain the following objectives:

- Conservation of PGR
- Sustainable use of PGR for food security and other public goods.
- Facilitated access to PGR for conservation and sustainable use.
- Equitable and fair sharing of benefits arising from the use of the PGR.
- Sudan Report on the State of Plant Biodiversity for Food and Agriculture
- Protection of farmers' and community rights related to PGR.
- Capacity building and transfer of technology related to PGR.
- Protection of traditional knowledge, techniques and practices related to PGR.

Establishment of a seed Center in the Agricultural Research Corporation aiming to collect and preserve breeder's lines produced by the ongoing research conducted in the ARC.

Upgrading the Plant Genetic Resources Unit into a Center has improved it is capacity and equipment to play more effective and significant role on conserving biodiversity for food and agriculture. The Agricultural Plant Conservation and Research Center (APGRC) conserve more than 13.000 accessions from different crop species with suitable capacity for storage and adequate well trained personnel; this achievement is being possible by implementation of the Eastern Africa Plant Genetic Resources Network projects under phase two.

The Plant Genetic Resources Unit of the ARC which has been upgraded into a centre under the name "The Agricultural Plant Conservation and Research Center (APGRC)" The objectives of the new centre are outlined as following:

- Conservation of the local farmers' varieties of crops and their wild relatives, as well as breeders' lines.
- Enhancement of utilization through characterization, and evaluation for the main desirable characters such as productivity and resistance against pests and diseases.

- Documentation of the data and information relevant to these genetic resources in a manner that facilitates their retrieval, analysis and use.
- Protection of the national rights on the local genetic resources through contribution into building and implementing national systems and mechanisms that regulate the access to genetic resources and provide for equitable and fair sharing of benefits arising from their utilization.

Inadequate policies lead to the degradation of the forest resource base; deforestation and desertification in Sudan. Large scale forest losses and environmental degradation created a state of vulnerable conditions at various sites within the dry lands of Sudan (Abdel Magid and Badi, 2008). Karrar et al (1986) stated that the environmental and development policies were based on the wrong assumption that the natural resources are inexhaustible. Agriculture was given the top priority at the expense of forests and live stock. Pastoralists in some parts of the country are socially, economically and politically marginalized and they face government strategies that favor the development of agriculture and settlement at the expense of grazing and nomadism (Bovin and Manger, 1990). Livestock and wildlife have great social and economic importance for Sudanese poor communities, but there has been little progress incorporating livestock into development policies and projects. Some government policies, particularly agricultural policies and those that encourage investment in the rain-fed subsector, pricing policies and different types of fees had negatively impacted the pastoral sector (Zaroug, 2006).There is no defined breeding policy in the country as well as lack of organizational body for AnGR management. Most of the policies favor disease control.

Population growth and urbanization

As of 2013 estimates Sudan have a human population of 35 million, of which about two thirds of them live in rural areas. The population is growing quickly - 2.5% per year - reflecting the relatively high fertility rate.

The nomadic groups in the East and West of the country make up 9.1% of the population. There are historically high levels of labour migration and a significant nomadic population and those displaced by conflicts or natural disaster had lost or sold their animals. Migration between states has increased by 5 times during the last 52 years, predominantly from rural to urban areas, thus weakening the rural productive capacity. About 3.7 million people reported migrating in 2008, the year of the last census.

Urbanization in the country is rapidly increasing, predominantly in the national and state capitals. The uneven population distribution as a result of labour migrations has led to considerable variations of population density between states, with Khartoum State being the most populated area (15 times the national average) (United Nations Population Fund (UNFPA).Population Dynamics of Sudan (http:// country office .unfpa.org/filemanager/files/sudan/facts/population_fact_sheet_final1.pdf).

Advancement and innovations in science and technologies

No information available.

Table 4: Effect of drivers on sector biodiversity within production systems in the country, by animal (AnGR), plant (PGR), aquatic (AqGR) and forest (FGR) genetic resources

Production systems	**Drivers**	**Effect of drivers on sector biodiversity for food and agriculture** (2, 1, 0,-1, -2, NK, NA)			
Code or name		PGR	FGR	AnGR	AqGR
C5, C9, L1	Changes in land and water use and management	-1	-1	-2	NK
C5, C9, F1	Pollution and external inputs	-1	-1	NK	NK
C5, C9, L1, F5	Over-exploitation and overharvesting	-1	-2	-2	NK
C5, C9, L1, F5	Climate change	-1	-1	-2	NK
C5, C9, L1, F5	Natural disasters	-1	-1	-1	NK
C5, C9, L1, F5	Pests, diseases, alien invasive species	-1	-2	-2	-2
C5, C9, L1, F5	Markets, trade and the private sector	NK	1	NK	NK
C5, C9, L1, F5	Policies	-1	2	-1	NK
C5, C9, L1, F5	Population growth and urbanization	-1	-2	NK	NK
C5, C9, L1, F5	Changing economic, socio-political, and cultural factors	-2	1	0	NK
C5, C9, L1, F5	Advancements and innovations in science and technology	1	NK	+1	NK

2.3- Effects of drivers of change on ecosystem services

Due to broad scope and complexity of the common understanding of ecosystem services and no systematic studies about it, more over few experts in this field, so the only information is following;

The ecological and social friction initiated by large-scale mechanized agriculture is well-documented in the literature, and can be held blamed for three types of conflict:

- Conflicts among traditional farmers and owners of the large schemes.
- Conflict between local people in the vicinity of the schemes.
- Conflict involving the state, as a major backer of the scheme owners, and the small farmers and pastoralists.

When the buffer zone between the semi-desert and the savannah is blocked by large-scale mechanized farms, then the entire way of life of the agro-pastoralists collapses.
The new reality created by the secession of South Sudan (SS) in July 2011 has resulted in reduction of some 8.26 million people, 25% (619 745 km²) of the total land area, 68% of forest & woodland areas, and 47% of wildlife reserved and protected areas. The area classified as arid increased from 65% to 90%. More critically, while the livestock population fell by only 28% to 104 million head, the natural rangeland resources on which they depend fell by 40% (Abdel Magid and Warrag, 2011). The major drivers and their effect on ecosystem services in production systems are shown in Table 5

The impact of changes in biodiversity for food and agriculture on ecosystem for micro-organism genetic resources associated biodiversity on pollination and pest and disease regulation are not known (NK).
During the past 10 years the effect of the drivers: Pests, Diseases and Alien Invasive Species is strongly negative (-2) on the production systems in Sudan.

Table 5: Major drivers and their effect on ecosystem services in production systems

Production systems	Drivers	Effect of drivers on ecosystem services[16]								
		Pollination	Pest and disease regulation	Water purification and	Natural hazard regulation	Nutrient cycling	Soil formation and	Water cycling	Habitat provisioning	Production of oxygen/
F1 F5	Changes in land and water use and management	NK	2	2	1	0	0	1	2	2
	Pollution and External inputs	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Over-exploitation and over harvesting	NK	0	1	1	1	1	1	2	2
	Climate change	NK	2	2	1	1	1	1	2	2
	Natural disasters	NK	2	1	1	1	1	1	2	2
	Pests, diseases, alien invasive species	NK	2	0	0	0	0	0	1	0
	Markets, trade and the private sector	NK	1	1	1	1	1	1	2	2
	Policies	NK	2	2	1	2	2	1	2	2
	Population growth and urbanization	NK	0	1	1	1	0	0	2	2
	Changing economic, socio-political, and culturalfactors	NK	2	1	1	1	1	1	2	2
	Advancements and innovations in science	NK	NK	NK	NK	NK	NK	NK	NK	NK

Note: Table 5 only deals with forestry; data for other sectors is not available

2.4 Effect of driver of change on wild food

However, expansion of mechanized farming, which developed at horizontal expansion of cropland, contradicts with the comprehensive national strategies (1992 – 2002 and 2003 – 2027) which stated forest and other natural resources policy objectives that aim at conservation, environmental protection and poverty alleviation at national and community levels. Large scale forest losses and environmental degradation created a state of vulnerable conditions at various sites within the dry lands of Sudan which have affected the wild food (Table 6) (Abdel Magid and Badi, 2008; El siddig et al, 2011).

Table 6: Drivers affecting availability, knowledge and diversity of wild foods

Drivers	**Effect of drivers (2, 1, 0,-1, -2, NK,NA)**		
	Availability of wild foods	Knowledge of wild foods	Diversity of wild food
Changes in land and water use and management	-2	-1	-2
Pollution and external inputs	NK	NK	NK
Over-exploitation	-2	NK	-2
Climate change	-2	NK	-2
Natural disasters	NK	NK	NK
Pests, diseases, alien invasive	-2	NK	-2
Changing markets	-2		-2
Policies	2	2	2
Population growth and urbanization	-2	NK	-2
Changing economic, socio-political, and cultural factors	-1	NK	-1
Advancements and innovations in science and technology	NK	NK	NK

2.5 Effects of drivers of change on traditional knowledge, gender and rural livelihoods

a) Drivers that have had the most significant effect on the involvement of women in the maintenance and use of biodiversity for food and agriculture:

Droughts: women are the most affected groups during drought cycles. This can be exemplified by Shukriya women during 1984 drought in Butana plains in central Sudan. Women with illiteracy rate of 95% were considered the most affected groups because men migrated to urban centers leaving them shouldering the heavy responsibilities of the HHs and face scarcity of drinking water in summer season. Famines and diseases caused by malnutrition are spreading among the pastoral communities (Ahmed and Musa, 2014). Another group of nomads is the Rashaida tribe in the eastern part of the Sudan, had been stricken by the drought of 1970s and lost their camels and their behavior of keeping large numbers of animals for export had then changed (Ahmed and Musa, 2014)

b) Drivers that have had the most significant effect on the role of biodiversity for food and agriculture in improving food security and sustainability

Droughts and other climate disasters have had high implications on pastoralist development in accelerating the deterioration of water resources (Hermance, 2014).

***Policy and governance*:** Sandford (2006) stated that pastoralists did not adapt to climate change due to policy and governance which blocked pastoral development .Elasha-Osman (2008) and Elasha-Osman & Sanjak (2007)also stated that policies followed in the past to address climate-related disasters focused on short term solutions e.g. emergency relief.

***Market driven factors*:** Small producers are forced to meet the demands and to respond effectively to the requirements of the export market, to deal with issues related to the health of small ruminant's trade restrictions, poor infrastructure of the market and the lack of information about export markets and policies (Aw-Hassan *et al*., 2005).

c) Drivers that have had the most significant effect on the maintenance and use of traditional knowledge relating to biodiversity for food and agriculture *(AnGR)*:

Civil instability: There are many factors that have affected the inherited traditional knowledge in preserving local breeds. The unfavorable conditions for civil instability and consequently the unprecedented movement among rural people with their animals in all directions for sake of security and the tribal conflicts and raids resulted in armed robbery especially of livestock. The result was a considerable breed-mix (Sudan's Fourth National Report to the Convention on Biological Diversity, 2009). Herd mixing also occurred as a result of the migration of nomadic pastoralist to neighboring countries.
Market demands: Another reason that traditional herders have embarked on a wide range of AnGR mixing is to satisfy market demands (Elasha-Osman, 2008).

Pests, Diseases and Alien Invasive Species had the most significant effect on the maintenance and use of the traditional knowledge relating to biodiversity for food and agriculture.
Pests, Diseases and Alien Invasive Species had the most significant effect on the role of biodiversity for food and agriculture in improving food security and sustainability.
There are many species actively managed and control to help provide regulating or supporting ecosystem services.
In Plant Protection Directorate, mainly control the National Pests which strongly affect ecosystem and food.

2.6 Countermeasures addressing current and emerging drivers of change, best practices and lessons learned

Route Delineation–Darfur States (ACRD-DS)
This project has been prepared in partnership with the World Initiative for Sustainable Pastoralism (WISP): a project of the Global Environment Facility implemented by UNDP and executed by IUCN. The Route Delineation–Darfur States (ACRD-DS) project role is to demarcate the transhumance routes facilitate services and development. Eight main routes and thirty seven branches, amounting to 2299 km in length, were designated for demarcation .Amendment of existing laws and local orders include the revision and amendment of the Organization of Farming and Herding Law (1996) of South Darfur State. The law was actually amended in 2005 (PAS, 2007). The government attitude has started to change towards encouraging local community participation in development interventions.

Women role in improving food security and sustainability
The Dry land Husbandry Project (DHP) - Sudan project in Kassala State in eastern Sudan was financially supported by the Swedish International Development Corporation Agency (Sida/SAREC) and regionally coordinated by the Organization for Social Science Research in Eastern and Southern Africa (OSSREA). It is a bottom up approach set out by people at the grassroots and it was initiated in 1995and ended in 2003. Rashaida pastoralist women in this region were taught to be more responsible for animal raising and development of milk processing into sour milk and ghee and handicrafts (Ahmed and Musa, 2014). Another example is Beja pastoral woman where 20 young women from this tribe were taught how to process surplus milk into three types: fine cheese, dry cheese, and mozzarella. Also yoghurt and a thick type of sour milk (mish) were processed (Ahmed and Musa, 2014).
Females who were capable of reading and writing were trained in paravet training program. They were equipped with drug kits and sent to remote areas where they could deal with animal health issues. A revolving fund was allocated for purchasing the drugs (Ahmed and Musa, 2014).

Community contribution in disease prevention and treatment:

Community animal health workers (CAHWs) which started in 2007 by FAO made a great difference in the community of livestock keepers in Eastern Sudan (FAO, 2012).The project achieve the following results:

Besides reducing the number of traditional healers, CAHWs provided efficient veterinary services, increased awareness of their importance among livestock keepers; Helped herders increasing their herd size and diversifying the types of animals they raise and Livestock disease outbreaks in North Darfur have been reduced due to vaccination campaigns carried out by FAO and CAHWs.

UNDP/GEF project 'Community-Based Rangeland Rehabilitation (CBRR) for Carbon Sequestration' (Elasha-Osman et al -2006).

The UNDP/GEF project was initiated in 1992 covering 17 villages in the Central Bara Province**.** The aim of the project was to implement a simple model of community-based natural resource management to prevent over-exploitation and degradation of marginal lands and rehabilitate rangelands for the purpose of carbon sequestration. The project included both mitigation and adaptation outcomes. The project produced a variety of reported benefits:

- Human capital for more efficient management of natural resources was increased through training and other capacity building activities.
- Physical capital benefits include improved food storage facilities and increased stores of grain for dry periods.
- Financial capital was increased by improved access to local and national markets, production of marketable sheep, and greater access to credit through revolving credit funds.
- Social capital benefits include enhanced living conditions of women through participation in community gardens and other activities.

CHAPTER 3

The state and trends of biodiversity for food and agriculture

3.1 Over all synthesized assessment of forest, aquatic, animal or plant genetic resources

Diversity of cultivated plants species do exist in Sudan that could be explained by the fact Sudan is part of the East African Region of crop genetic diversity, which is one of the eight global centers of diversity of cultivated crops (FAO, 1996) .In addition to that being part of the African belt that extend in sub Saharan Africa from the extreme west to the extreme east provide wealth of diversity of the African tropical crops. Some species were considered to be originated in Sudan/or Sudan is part of its center of origin such as (*Sorghum bicolor*), pear l millet (*Pennisetum glaucum*), okra (*Abelmoscus esculentus*), melons (*Cucumi smelo*), sesame (*Sesamum indicum*) and dry dates (*Pheonix dactylifera*), where wild relative and feral form do exist. Sudan also considered a secondary center of diversity for others such as hot pepper (*Capsicum spp*) and Roselle (*Hibiscuss abdariffa*). Local cultivars from old introduced germ plasm for other crops such as maize, faba bean, cowpea and chickpea, are still existing and being utilized by some farmers. The agricultural sector in Sudan contributes to GDP by about 40%. The major production systems are:

- **C5 (Irrigated crops)** which includes gravity irrigated schemes from the Nile and its tributaries, flush irrigation, and irrigation from bore holes. Production is based either on tenancy or direct labour. The total area of this sub sector is estimated as 5 million hectares.
- **C9 (Rain fed crops**) which includes:
  Mechanized rain fed subsector: Mechanization is practiced in land preparation seeding and threshing. The total area of this sector is estimated at 6.3million hectares

  Traditional rain fed subsector which cover all areas under traditional production where non mechanized farming tools predominate. The total cultivated area of this sector is estimated at 8 million hectares.
- **L1 (Livestock grassland-based system)**
  Encompasses different ecological zones extending from desert and semi desert in the north to low and high rainfall savannah in the southern border. Nearly 80% of all the rangelands are located within the semi-desert and low rainfall savannah ecological zones that are characterized by uncertain amount of rainfall. The rangelands of importance to traditional livestock rising are confined to the semi–desert, low rainfall savannah and the northern fringes of the high rainfall areas.
  In the semi- desert, the plant cover is a mixture of grasses and herbaceous plants intermingled with *Acacia* trees and shrubs representing the main grazing areas for camel and sheep. .
  Among the total annually cultivated area in Sudan, about 66% is occupied by C9 (rain-fed crop production system), where traditional farmers' varieties are still used. The total

cultivated area increased by 23.1%. From 18 million hectare in season 2011/2012 to 22 million hectare in season 2012/2013 This increase was due to the expansion of areas in C5 (irrigated crop production system) from 1.5 million hectare in 2011/2012 to 1.6 million hectares in 2012/2013, in addition to the expansion of the areas under C9 (rain-fed crop production system) from 16 million hectare in 2011/2012 season to 20 million hectares in 2012/2013 season. The table below shows the distribution of cultivated areas between the two agricultural production systems (C5 and C9). It is obvious that (C9) occupies majority of the cultivated area in the country.

Distribution of cultivated areas between different production systems (1000 Feddan), (1 Fed= 0.42 ha))

Crop	Irrigated (C5)	Traditional Rain-fed (C9)	Mechanized Rain fed (C9)	Cultivars*
Sorghum	1138	15588	8339	FVs/ IVs
Wheat	552	12	-	IVs
Millet	20	9130	683	FVs/ IVs
Sesame	-	4295	3469	FVs/ IVs
Ground nut	298	-	6119	FVs/ IVs
Cotton	143	33	-	IVs
Sunflower	42	-	138	IVs
Total	2193	29058	18748	

* FVs = Farmers' varieties, IVs = Improved varieties

State of biodiversity in the agriculture sector

Cereal crops

The cereal crops grown in Sudan include sorghum, wheat and pearl millet, maize and rice. The three wild sorghums species (*S. aethiopicum*, *S. verticilliflorum*, and *S. arundiaceum*) are believed to be the progenitors of the cultivated sorghum in Sudan. Sudan is also the origin of the important forage species, *S. sudanense* (Sudan grass). Production in C5, where improved varieties dominate and C9 where both improved and traditional varieties are grown .Wheat is a relatively new crop in the Sudan produced in the cooler areas of C5. Heat is main constrain, about 18 wild species of pearl millet (*Pennisetum*) were reported in Sudan in addition to many landraces. Among the wild species are:

Pennisetum glaucum (L.) R. Br subsp. *monodii* (Maire) Brunken, *Pennisetum stenostachyum* Kloyzcsh ex. A. Br. and Bouche, which attain at present a high priority for collecting from Sudan as crop wild relatives to the cultivated pearl millet.

The present collection status of such wild relatives is very poor as only 34 accessions are recorded as wild from more than 2800 accessions of pearl millet accessions conserved in the gene bank of the APGRC. Production is mainly in C9 system and depends mainly on traditional farmers 'varieties. Old cultivars of maize (Zea mays) are also grown in the

country mainly in C9, with variation in crop size, and seed colour are observable in these cultivars. Rice (*Oryzasativa*) is grown in a limited scale in C5. The wild red seeded rice (*O. punctata*) grows in some parts of the country.

Food grain legumes

Variability of species and uses is recorded for food grain legumes. Generally this group of crop can be divided into winter adapted grain legumes and summer adapted grain legumes. Mostly the winter adapted grain legumes are grown in C5 while the summer adapted grain legumes are grown in C9. Cow pea (*Vignaun guiculata*) comes among the most important summer-adapted food grain legumes in Sudan. It is believed to be introduced into western Sudan from West Africa resulting in a considerable diversity of cowpea types. The cultivation of other summer-adapted grain legumes, which include pigeon pea (*Cajanuscajan*) and hyacinth bean (*Lablabpurpureus*), is dependent on old cultivars that show remarkable variation in seed colour and size Faba bean (*Viciafaba*) is the major winter-adapted food legume crop in Sudan. It is grown in the Northern and Darfur regions. The faba bean varieties grown by farmers are primarily landraces named after the locality of production Chickpea (*Cicerarietinum*), is an important a winter-adapted grain legume in Sudan. Although a number of improved cultivars were released, farmers still cultivate their local landraces. Other winter-adapted legumes include haricot bean (*Phaseolus vulgaris*) and lupin (*Lupinusalbus*). Old introduced cultivars from haricot bean and lupin are still grown by farmers in Sudan.

Oil crops

The most important oil crops grown in Sudan are sesame at C9, groundnut at C5 and C9 and sunflower at C5 andC9. Wild and cultivated accessions of sesame (*Sesamum*) collected from C5 and C9 are preserved. Grouping is based largely on seed colour. Farmers' varieties of Groundnut (*Arachishypogea*) previously grown were of the runner type locally known as "Abu Hibailat, a type believed to be available at present only in some remote and isolated areas, with a high risk of disappearance. Groundnut accessions collected so far showed a considerable variation in growth habit, seed size and color.

Vegetable crops

Vegetables from most families are grown mainly in production systems C5 and C9. Crops that are widely grown are onion (*Allium cepa*), tomato (*Lycopersicum esculentum*), okra (*Abelmoschus esculentus*), peppers (*Capsicumspp.*) melon (*Cucumismelo*) and water melon (*Citrulluslanatus*).

Okra (*Abelmoschus esculentus*) is the most popular vegetable in Sudan, where both cultivated and wild types are known. Farmers almost depend on the local land races, which in many cases are designated names relevant to the localities where they are produced.

Fruit crops

Several fruit producing plants are grown in Sudan. Some are indigenous others are recently introduced. Date palm banana, citrus, mango and guava are the most important. Date palm (*Phoenix dactylifera)* is grown in C5 Different local and old cultivars and seedling races are known. Banana (*Musa*) is produced in C5. Dwarf Cavendish is the dominant variety. New improved cultivars have been released recently. Mango **(***Mangifera indica*) is believed to be introduced into Sudan from India via Egypt. About 57 cultivars of mango are reported existing in Sudan. Mango is produced in C5. Citrus fruits are produced in C5 and C9. They include sweet orange (*Citrus sinensis*), grape fruit (*Citrus paradise*) and lime (*Citrus aurantifolia*). All are introductions.

Fiber crops

More than 30 species indigenous to Sudan are used for fiber production. Many of them grow in the wild, and the most widely of them is perhaps the Doum palm (*Hyphaene thebaica*). The most important fiber crop cultivated in Sudan is cotton. The growing of cotton crop in Sudan dated back to a period before the Christian era. It is produced in several production systems (C5 and C9).

Sugarcane

Sugar cane is a commodity crop, produced in C5 system

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State of range plant diversity

Rangelands (L1) are estimated as 68.6 million hectares or 36% of the total country area. Nearly 80% of all rangelands are located in semi-desert and unpredictable low rainfall savannah ecological zones. The plant cover is a mixture of grasses and herbaceous plants intermingled with Acacia trees and shrubs representing the main grazing areas for camel and sheep. No recent information regarding the composition, types, nor the endangered plant species of the different ecological zones except for few scattered surveys carried out during 2000-2014 for certain areas as components of some projects. The surveys revealed that certain important named range plant species are becoming scarce or extinct and some areas are invaded by unpalatable plant species. However, thirteen valuable plant herbaceous species were reported as decreasing in Semi Desert and Low Rainfall Savannah ecological zones that include: *Blepharis linariifolia, Chrosophora brochidiana (Argassy), B. edulis (siha), Aristida palmosa, A. paposaByad, A. mutablis, A. mutablis, Panicum turgidum, Cenchrus species, Eragrostis temula ,Andropogon gyanus (Abu rakhees), Schenfoldia gracilis and., Dismodium dichotomum.*

Wild Food Plant Species

In Sudan, there are some plant species that exist in wild form and used traditionally for their food, fodder, fiber, oil or medicinal properties. These species have been neglected due to a variety of reasons. Wild food plants are essential substitutes to meet food shortage that arises for several reasons. They are annual or perennial woody trees, herbs, shrubs or weeds. Utilization of the wild food trees for timber product purposes threatens

the existence and causes the depletion of the genetic resources of highly preferred food species (Salih and Ali, 2014). Some wild food plants have other uses such as cosmetics and medicals etc. Scientific based information is scarce and scattered. A list of the scientific, vernacular and English names of the commonest wild food plants is available (Appendix 2).

Among wild food plants that are widely known include species such as wild okra (*Abelmoschus spp*.), of which dried fruits are consumed, and wild jewsmallow (*Corchorus olitorius*)

Sorghum ***Millets*** ***Groundnut*** ***Okra*** ***Tomato***

Fig 2: Photos above show wild types and domesticated genetic resources available in Sudan for some crops in Sudan

The State of Forestry Genetic Resources Biodiversity

Riverine forests; these forests and species are actively managed and used in the production. They are a critical resource for the northern states. They occupy the lands that are flooded when rivers rise in the latter part of the wet season. *Acacia nilotica* – the dominant species – is found as pure dense stands over large areas from the Egyptian border in the north to as far south as Jebelein on the White Nile, and Rosaries on the Blue Nile. The species also occurs along the Dinder and Rahad rivers. In less frequently flooded basins along the Atbara River and in some inland sites. The total area of the river and stream forests, equal 6929353 ha. A number of the sugar companies and agricultural schemes, such as Kenana, Rahad, Guneid, Sennar and New Halfa have implemented programmes for tree planting in their estates. These plantations are generally made up of fast-growing eucalypts, they provide substantial employment to casual labour, and they supply much of the market demand for poles and fuel wood (Total Irrigated Area= 011 751.00 ha. Non- Irrigated Forests "Natural forests":6 756 989 h) (Elsiddig et al, 2011).

The Sudan experience of plantation management has been long and effective in bringing the plantations into sustainable systems. Plantation management is founded on planning and operational programmes since the middle of the 1930s. The first written working plan for the Riverine forest for the period 1948–1958 was a plan for converting Sunt natural forests into plantations. This was followed by the Sawn Timber Working Circle (1958–1968) to all forests south of the Sennar Dam. The plan concentrated on the silvi cultural operations starting from broadcasting or pit sowing, beating up, singling, weeding and first to fifth thinning (part of management process which traditionally applied since, 1932). The rotation age was fixed at 30 years; the target number of trees/ha was the 120

largest and best quality trees. The third working plan (1968–1978) was a continuation of the second plan (Elsiddig et al, 2011). *Acacia nilotica* is by far the most important productive forest formation in Sudan. The tree has the valuable capability of growing on water from river flooding in regions where the rainfall is too low to support other tree species. The most well stocked forests of Sunt are found on the banks of the Blue Nile. The forest policy adopted for the Sunt riverine forest reserves is to produce sawn timber (mainly railway sleepers) and fuel wood to supply big towns in central and northern Sudan, in addition to protection of the Nile eco-system. Eucalyptus microtheca plantations are established on the degraded lands of central Sudan (Abdel Magid and Badi, 2008; Elsiddig et al, 2011).

The State of Farm Animal Genetic Resources (FAnGRs) Biodiversity in Sudan

Recently there is increased recognition of the role and contribution of livestock production (pastoralist systems) in Sudan to the national economy and exports (UNEP, 2013). They represent a livelihood activity for about 60% of the population as well as providing labour for about 40% of the population. Rangelands are the main source of feed for livestock as they provide about 86% of the animals' requirements. Crop residues and agricultural by-products contribute 10%, whereas 4% of the feed is provided by irrigated forage and concentrates. Agro-industrial by-products (molasses, cottonseed cakes, groundnut cakes, sesame cakes, sunflower cakes and wheat bran) play a vital role in supplementary feeding.

Cattle

Sudanese cattle breeds are descendents of *Bos indicus* (zebu) which are heat tolerant and disease resistant particularly tick and tick borne diseases. Nuba Mountain Zebu is known to be trypano tolerant.

Native adapted genotypes:

- Large east African Zebu: Butana , Kenana ,Baggara, Araishai
- Small east African Zebu: Nuba Mountains
- *Kenana*: Sudan, have numerous synonyms related to their tribal (e.g. *Kenana, Rufáai El Hoi* and *Rufáai El Sherik*) and ecological (e.g. *Fung, Gezira* and *White Nile*) origins (FAO and UNEP, 1999). They have also been referred to as *Northern Riverain* or *Northern Province* cattle. They occupied eastern & western banks of the Blue Nile, White Nile and Gazira States in a triangle bounded by Sennar, Singa, Roserires and Kosti. Kenana breed is light blue – grey with gradation from white to steel grey, horns are short and the dewlap is well developed. It is one of the best dairy breeds in Africa.
- *Butana*: They are referred to as *Dar El Reih* cattle across the White Nile and in the northern part of Darfur and Kordofan. The breed which is owned by Shukria and Batahein tribes is mainly located in the Butana Blateau in a triangle of River Atbara, Blue Nile and River Nile and a round Kassla.
- ***Baggara****:* It is mainly located in western part of the Sudan and owned by many tribes in Darfur. Typically used for beef for local consumption as well as for export, and has been characterized for this purpose in a few studies.

- The ***Nuba Mountain*** *Zebu:* This is extremely small animal, often referred to as 'dwarf' or 'pigmy' cattle. Mainly found in Southern Kordofan in Sudan. It is also known as the *Kaolib* cattle. It is phenotypically similar to the dwarf cattle of the Ingessana Hills (Ingessana cattle). Moreover, it thrives in tsetse "pockets" and is, thus thought to be tolerant of trypansomiasis.
- **Umbororo (white Fulani):** Found in Western Sudan moving from Nigeria, Chad, and Cameron up to Ethiopia, owned by Falata Umbororo tribes. They are of big size, very long horns and dark red color. No breeding programme exists (FAO and UNEP, 1999).

Sheep and Goats

Sheep

- Sudan livestock export is primarily based on sheep production. They are used for meat and milk for domestic consumption. They also provide good quality skins for export and local industry. Generally sheep are distributed all over Sudan but the majority is found in Kordofan, Darfur, Blue Nile and Gazira States. The sheep of Sudan belongs to a number of ecotypes: **(**Photos group 1) explains the evolution of wild types and their domesticated Sudan Desert ecotype Sheep.The Desert ecotype is an export animal with excellent meat and carcass characteristics. Its live weight reaches 68-77kg.These is classified into: *Butana (Ashagar), Gezira (Dubasi or Abrag), Beja, Hamari, Kabashi, Watish, Mediob. Beja* population exact number is not known, but not large.

- Arid upland ecotype sheep – (West African): comprises two breeds; Zoghawa and Fallata or M Baroro. Zoghawa population is less than 1% of total population and Fallata or M Baroro population is less than 1% of total population.
- North Riverine: is a wool sheep
- The small size Nilotlic ecotype sheep: comprises Nuba and Ingessana sheep.
- Dwarf: comprises Nuba and Ingessana sheep and their population exact number is not known.
- Stabilized Strains: These are classified into:

a- Sudan Desert & Sudan Nilotlic fused ecotype (e.g. Western Baggara & Fung) and their population is less than 1% of total population.

b- Sudan Desert & Arid upland fused: (e.g. Zaghawa)

Goats

Goats are distributed all over the country and in the various agro-ecological zones (Appendix 3: Photo (1) explains the evolution of wild types and their domesticated progenitor's genetic resources available in Sudan for goats).

- Nubian

It is a dairy goat which is the predominant type and represents more than 50% of the goat population in the country. It has a good reproductive potential that can give birth three times every two years and 50% of the females give twins or triplets (prolific).

- Desert

A meat breed mostly found in Darfur and Kurdofan States. They comprise 17% of the total goat population and are characterized by long-legs and dark brown color. They are raised in the savannah belt in scarcity of water & succulent plants.

- Mountain (Mountainous) goat. Also called (Darraai, Ingessana, Tagger)

Found in Nuba Mountains, Ingasna, and Jabel Marra. It is known with its rapid, light movement and leap that assist in climbing mountains and escape from beasts. (ACSAD, 1996).

- Baggara Hybrid: (Desert X Nilotlic)

Their population in 1981 is 0.8 million (Regional Animal Diseases Control Project, 1981).

- Sudanese local mountain goats (Zaghawa)

Their population in 1981 is population: In 1994: 1% or 165,000 (ACSAD, 1996).

Group 1

Group 2

Fig 3: Photos (group 1 & 2) above explain the evolution of wild types and its domesticated progenitor's genetic resources available in Sudan for sheep (photos - group 1 and goats photos - group 2)

Camels

Camels are widely distributed in the desert & semi desert regions between latitude 12 and 16 north. The one hummed camel (*Camelus drormedarius*) is the type which exists in Sudan. Although camels are used for riding and carry baggage but they are good meat and milk producers. Camels are classified crudely into two types, back and riding camels (Gillespie, 1962).

- **Back camels**

These are divided into two ecotypes:

a) The Arabic ecotype: is the most dominant in the Sudan. It is further divided into 3 subgroups mainly according to size into: light, large and massive.

b) The Rashaidi ecotype: Owned by the Rashaidi tribe and neighboring tribal groups of northeastern Sudan. It is smaller in size, with short legs and slightly white-reddish in colour.

- **Riding camels**

These are lightweight camels of less than 400 kg of body weight and represent 10% of the total population of camels in Sudan. They are distributed between the Nile and the Red Sea. They are used in racing in the Sudan and Gulf countries. There are two main breeds named after the tribes that breed them, the Anafi and Bushari.

a) Anafi (Shukri) found in Butana area and Kassala State. The body is long, small size and light weight; color is white-brown with soft hair. Used for riding and racing for small distances.
b) Bushari Camel (Hadandowi) owned by the Bija and Hadandowa tribes in EL Gadarif, Kassala and Red Sea States. It is of long body, strong muscles, small size & light weight. Color is white sandy an excellent race camel.

- **Poultry**

There are three local breeds: Bare-necked, Betwil and large Beldi. The local Beladi fowl (*Gallus gallus*) is well adapted in the livestock grassland-based systems in the backyard management everywhere in the country. It is a small bird, supporting families in rural areas with eggs. With the developing of poultry industry in the country, a number of exotic breeds were introduced: White leghorn, Brown Sussex, Fayoumi for both broiler and egg production.

Rabbits: *Baladi*
Quail: *Wild Brown Quail*
Ducks: *Muscovy*
Pigeons: *Sudan Pigeons*
Guinea Fowl*: White & Black spotted*

The State of Aquatic Genetic Resources Biodiversity

There are 136 species of fresh water fish listed as recorded at some time in Sudan. Commercial fisheries regularly exploit more than 20 of these species, which differ in size, shape, growth rate and consumer acceptance. Maintenance of fish species diversity is especially important in an age of growing uncertainty due to climate change. Predominant fish species include Tilapia, *Synodontis spp, Labeo spp, Bagrus spp, Lates niloticus, Hydrocynus, Alestes and Mormyrus spp*. The relative importance of each species in commercial catches varies from place to place, seasonally and between different years. The multi-species fisheries deploy multiple gears such as gill nets, seine nets, hooks and traps mainly on reservoirs with much less fishing on the River Nile and tributaries along the extensive stretches of water between reservoirs. Fisheries are small-scale in nature, which maximizes sharing of access and benefits from fishes as common property resources through employment and incomes. Fisher traders and fishermen have for many years organized themselves in different ways into unions and cooperatives but the benefits of group formation to members are not clearly evident (**National Fishers Policy of Sudan, November, 2012.**)

Family	No. of species	Family	No. of species
1. Protoptridae	1	12. Characidae	9
2. Polypteeridae	3	13. Distichodontidae	7
3. Angullidae	1	14. Citharinidae	2
4. Osteoglossidae	1	15. Cyprinidae	25
5. Notopteridae	1	16. Bagridae	7
6. Mormyridae	15	17. Schilbeidae	6
7. Gymnarchidae	1	18. Mochocidae	15
8. Amphillidae	1	29. Cyprinodontidae	3
9. Clariidae	8	20.Poeciliidae	1
10. Malapteruridae	1	21. Clamidae	1
11. Cromeridae	1		

Trends of biodiversity for food and agriculture

The assessment of overall trends of biodiversity for food and agriculture seems to be difficult since the major parameters contributed to this are not easy to measure.

1. **Shrinkage of pasture due to desertification and fire:**
Desertification is considered the most serious constraint that had affected livestock development in landless system (L 1). During the sixties “1968/69”, seventies “1972/73” and eighties “1984/85” many species of grasses were lost, some of which are of high nutritive value. Many families lost their total herds and others migrated to new areas. An example is Bani Hussien tribe (cattle herders) at the Northern Darfur who are now transferred to Kubum in Southern Darfur with the resultant displacement and tribal conflicts. Another example is the Fuga cattle (sub-breed) herders that shifted from Northern Kordofan to Western Kordofan.

2. **Reduction of the range area due to mechanized and traditional rain-fed agriculture:** The impact of climate change on rangelands was clearly reflected by the reduction of the range productivity per unit area. Watering points have been engulfed by farms (PAS, 2007).Due to the uncontrolled expansion of mechanized and traditional rain-fed agriculture on the account of grazing lands, most of the land used for grazing in the savannah belt started to shrink (Shazali and Ahmed, 1999).

3. **Diseases:**
The prevalence of diseases in Sudan limits livestock productivity through morbidity and mortality, resulting in the loss of animal products e.g. meat, milk, eggs and by-products e.g. wool, skin and hides, manure and services e.g. animal traction (FAO, 2010).Uncontrolled borders crossed by livestock & game animals from neighboring countries constitute a great hazard in disease transmission to the national livestock flocks. Game animals proved to be reservoirs of trypansomiasis which is a wasting and killing disease transmitted by tsetse flies. Livestock disease outbreaks in North Darfur have been reduced due to vaccination campaigns carried out by FAO and CAHWs through training (FAO, 2012).

4. **Policy:**
Some government policies, particularly agricultural policies and those that encourage investment in the rain-fed subsector, pricing policies and different types of fees had negatively impacted the pastoral sector (Zaroug, 2006).

State of conservation of diversity

Conservation of diversity among agricultural plant crops

***Ex situ* conservation**

The Agricultural Plant Genetic Resources and Research Center (APGRC) are entrusted with conservation of plant genetic resources for food and agriculture. More than 11000 accessions representing more than 60 crops have been acquired. A number of these crops are among those covered by the Multilateral System of Access and Benefit Sharing established by the International Treaty on Plant Genetic Resources for Food and Agriculture (Treaty). A list of germplasm holdings at APGRC is included in Appendix 5.

***In situ* conservation**

Efforts devoted to *in situ* conservation are minor and scarce of any, however date palm genetic resources grown in C5 has been maintained for generation by the local farmers in their in grown fields, following their own measures for conservation. At present, date palm genetic resources is facing serious threats such as diseases, introduction of new date palm cultivars in addition to other socio- economic factors such as building of new dams along the River Nile that has resulted in flooding of traditional areas for date palm production.

Botanic gardens and other institutes

Sudan has a National Botanical Garden that preserve limited number of indigenous and exotic plant taxa including trees, shrubs herbs and grasses.

Conservation of Natural Range plants Diversity

Conservation of the genetic resources of the natural forage plants and supervising and monitoring their use is entrusted by Range and Pasture General Directorate (RPGD) with the responsibility to establish the following projects preservation in in-situ and ex-situ reservation, nurseries and herbaria.

- National seed collection and broadcast progammes.
- Seed collection.
- Seed production.
- Fenced and guarded enclosures

***In situ* conservation or management activities or programmers forest biodiversity for food and agriculture**

Forest management has always been a tool for managing forest recourses. Any environmental activities at war and conflict affected sites should consider sound management methodologies such as inventory, planning, organization and control (Abdel Magid and Badi, 2008; Elsiddig et al, 2011). These entire components are obligatory for forest management, and it will act as a means of identifying what can be done to enhance and protect the values and aspects of recourses that are most important Table 12 shows

***Ex situ* conservation and management activities or programmes (forestry)**

The herbarium of FRC is the largest in Sudan incorporating over 7000 forest specimens with a computerized appendix.

Forest genetic resources are preserved through the following methods

a. Establishment of forest reserves: These are large areas including various tree species and are present in the five ecological zones of the Sudan. Creating reserves in each of these zones leads to conservation of several species in their natural habitats. Forest reserves are registered government property. They are surveyed, demarcated, mapped and registered in the Sudan Gazette under government name. The objective behind reservation is to ensure protective conservation and sustainable management. Local people's access to these forest lands is controlled by legislation and only permitted for limited rights such as passage, water, grass collection and deadwood gathering. In recent times the government approach has to some extent altered towards giving more rights to people to access the forest reserves through collaborative management systems. A collaborative management system inside a forest reserve provides opportunities for integrated land use on a partnership basis in which farmers and pastoralists are involved. Contracts sometimes precisely govern the relationship and define the type of use permitted (Abdel Magid and Badi, 2008; Elsiddig et al, 2011).

b. Forest plantations: In addition to natural forest reserves, forest plantations containing important tree species are established. This practice helps to conserve and improve the genetic resources by selection and breeding.

c. Forest Arboreta: These are established to conserve tree species. Trees are allowed to grow provided that they can last. They become sources of seeds and material for research. Few of these have been established, and more are needed in each ecological zone.

d. Seed collection, testing and storage: Seed centers have been established, and the staffs from different institutions were trained to collect seeds from natural stands according to specified criteria to avoid narrowing the genetic base. The seeds are cleaned, tested for germination, then stored and documented. Tree seeds centre have been established by the Forest Research Centre, Soba and three regional centers at Elobied, Gadarif and El Damazin. Also the seed center established recently gene bank in 2010, conserved about 50 accessions collected from different parts of the Sudan (Abdel Magid and Badi, 2008; Elsiddig et al, 2011).The seed center has generated integrated strategy for seed procurement, tree improvement and conservation of forest genetic resources [Brief note prepared for the authors by Dr. Abdelgabar .S. Ahmed- Director, National Tree Centre]. More of these centers are needed to cover the country's needs of germplasm conservation. Exploration of tree stands, their phrenology and their extent are determined in the forest reserves, plantations and natural unreserved forests. Then seed collection areas are demarcated and seeds are collected from trees of better form, which are surrounded by several other trees.

In situ* conservation for *AnGR

Some of the livestock indigenous breeds whose numbers are at risk cannot be genetically improved fast enough to adapt to climate change. Consequently, efforts to conserve them both in situ and ex situ need to be intensified.

A number a livestock research stations were established in various parts of the country in order to study, improve and preserve the local breeds. However, the Animal Resources Research Corporation (ARRC) runs several research stations for breeding management, artificial insemination and nutrition. Cattle local breeds (Butana, Kenana and Baggara) are studied in 3 research stations; goats in 2, sheep in 2 and camels in 2.

Livestock keepers play a great role in *ex situ* conservation in a number of ways. In the extensive production systems (L1) adaptive traits are prioritized to production traits as a hazard reduction strategy. Another strategy to conserve local breeds is to diversify livestock types. Marriage between the various multi-ethnic groups and political alliances helps in the distribution and dissemination of animal herds on the largest possible area of land and under wide environmental conditions. Agro-pastoralists used to close some grazing areas and preserve it for the time when there is drought as a coping strategy against wet season failure.

Ex situ* conservation for *AnGR

An artificial insemination center was established to disseminate this technology and now other few centers are providing this service e.g. Cimex Company and Animal Production Research Centre at Kuku.

3.2 State and trends of associated biodiversity and ecosystem services

State of Associated biodiversity

Weed flora associated with agricultural plants are diverse in Sudan. Field surveys conducted recently in some of the agricultural areas within C5 and C9 systems have resulted in documentation of more than 100 weed species belonging to more than 70 families (Appendix 3).

Plantation designs with biodiversity conservation considerations are usually rare and biodiversity under forest plantations is limited. Plantations are normally, but not always, monocultures with pure stands of one species. There are obvious risks in designing plantations as monocultures if biodiversity conservation is a supplementary goal, even if the total areas of such plantations are normally quite modest in relation to more biodiversity rich natural woodlands. However, there are situations where mixed forest plantations are raised with the partial objective of biodiversity conservation (examples can be found in the riverine forests). Institutional efforts in afforestation and reforestation programmes are restricted to the reserved forests that are almost exclusively controlled by FNC. Tree and shrub species used in afforestation and reforestation are normally indigenous in areas of less than 500 mm rainfall and exotic in more humid or irrigated areas. The most common indigenous trees used are Acacias, particularly *A. senegal*, *A. nilotica* (Sunt), *A. seyal* and *A. mellifera*. Exotic trees used are Cupressus species in mountainous areas and Eucalyptus, in areas of more than 600 mm of rainfall or under irrigation, together with bamboo (*Oxytenanthera abyssinica*) (Abdel Magid, 2001; El siddig et at, 2011).

The identified insects are 5015 species (Abdelrahman, 2014), and there are 196 species of natural enemies, 126 are predators and 70 are parasitoids (Ahmed, 1993).

Sudan is known for its rich microbial resource,. There are 383 fungal species, belong to175 genera, 42 species of a *Arbuscular mycorrizal* fungi, several yeasts plant viruses genera and species reported in the fermentation of several food types, in addition to 25 epiphytic lichen in Red Sea area.

There are lists of invasive alien species that have a significant effect on biodiversity for food and agriculture.

.Information gaps in trends in the state of components of associated biodiversity within production systems and trends in the state of regulating and supporting ecosystem services within production systems are shown in Table 7, Table 8 and Table 9.

Table 7: Trends in the state of components of associated biodiversity within production systems

Data for Table 7 is not available for all sectors

Table 8: Trends in the state of regulating and supporting ecosystem services within production systems

Data for Table 8 is not available for all sectors because changes in different production systems were not detected.

Table 9: Impact of changes in biodiversity for food and agriculture on ecosystem services

Production systems	**Changes**	**Impact of changes in biodiversity for food and agriculture on ecosystem services** (2, 1, 0,-1, -2, NK,NA)								
Code or name		**Pollination**	**Pest and disease regulation**	**Water purification and waste treatment**	**Natural hazard regulation**	**Nutrient cycling**	**S, Moil formation and protection**	**Water cycling**	**Habitat provisioning**	**Production of oxygen/ Gas regulation**
L1, L5, M1	Changes in animal genetic resources	NK	NK	NK	NK	NK	NK	NK	NK	NK
C5, C9	Changes in crop genetic resources	NK	NK	NK	NK	NK	NK	NK	NK	NK
F1/ F5	Changes in forest genetic resources	NK	2	NK	NK	NK	NK	NK	2	1
A1, A9	Changes in aquatic genetic resources	NK	NK	NK	NK	NK	NK	NK	NK	NK
	Changes in micro-organism genetic resources(associated biodiversity)	NK	NK	NK	NK	NK	NK	NK	NK	NK
	Changes in invertebrates genetic resources(associated	NK	NK	NK	NK	NK	NK	NK	NK	NK
	Changes in vertebrates genetic resources(associated biodiversity)	NK	NK	NK	NK	NK	NK	NK	NK	NK
	Changes in plants genetic resources(associated biodiversity)	NK	NK	NK	NK	NK	NK	NK	NK	NK

- Biological control by two insects: *Neochetina eichhorniae and Neochetina bruchi.* The adults feed on leaves and petioles and the larva tunnels into the petioles and the crown of the plant causes biotic stress, reduced flowers and seeds, and less vigorous growth (Abdelmoti, 2012).

Table 10: Associated biodiversity species that are in some way actively managed to help provide regulating or supporting ecosystem services.

Ecosystem service provided	Actively managed species (name) and sub-species (where available)	Production systems (code or name	Availability of diversity information (Y/N)	Source of information
Pollination	NK	NK	NK	NK
Pest and disease regulation	*Acacia nilotica, A. senegal, Eucalyputs Neochetina eichhorniae, Neochetina bruchi*	F1/ F5	Y	Annual reports research
Water purification and waste treatment	NK	NK	NK	NK
Natural hazard regulation	NK			
Nutrient cycling	*Senegal*	F1/ F2 /F5	Y	Research
Soil formation and protection	NK	NK	NK	NK
Water cycling	NK	NK	NK	NK
Habitat provisioning				
Production of oxygen/ Gas regulation	NK	NK	NK	NK

3.3 Species of associated biodiversity at risk of loss

There is very little statistical data on the exploitation of and trade in NWFPs. Unlike timber and agricultural products, there is no regular monitoring of NWFPs at the national level. The information is therefore limited to select NWFPs that are nationally important and extrapolations are often made on the basis of case studies. But just like timber, these non-timber resources can also be over-harvested, especially when local products gain access to large urban markets. Without statistics it is difficult to judge when that point will be reached.

This situation was the outcome of inappropriate use of the natural resources, particularly soil and forest vegetation. Unsound political, economic, agricultural and environmental strategies were reflected in the biased development planning. [Karrar et al 1986] state that the environmental and development policies were based on the wrong assumption that the natural resources are inexhaustible. Agriculture was given the top priority at the expense of forests and livestock. That extensive area of forests was cleared to raise crops upon lands that were unsuitable for them. Agricultural expansions ignored the link between field crop and the environmental and the human needs for forest goods and services (Abdel Magid and Badi, 2008) Table 11 demonstrates the major threats to forest biodiversity.

There is no evidence of significant threat of extinction or loss of a number of important populations in Sudan, except for the threatened lichen flora of Erkowit, Red Sea Hills.

Table 11: Main threats to associated forest biodiversity identified as at risk.

Associated biodiversity species	Degree of threat	Main threat (indicate)	References or sources of information if available
Balanites aegyptiaca	Medium	lack of natural regeneration, and	Fifth Report on biodiversity &NBAP 2015
Adansonia digitata	High	lack of natural	NBAP, 2015 NBSAP
Hyphaene thebiaca	High	lack of natural	NBAP, 2015
Borassus athiopum	High	expansion of	NBAP, 2015
Diospyrus mespiliformis	High	expansion of	NBAP, 2015
Tamarindus indica	Medium	expansion of	NBAP, 2015
Pterocarpus lucens	High	expansion of	NBAP, 2015
Cordia Africana	High	expansion of	NBAP, 2015
Pseudosedrela kotshyi	High	expansion of	NBAP, 2015
Oxytenanthera abyssinca	High	over felling,	NBAP, 2015
Albizia aylmeri	High	over felling,	NBAP, 2015
Grewia tenax	Medium	over exploitation for	NBAP, 2015
Khaya senegalensis	High	over exploitation for	NBAP, 2015
Acacia seyal	Medium	expansion of	NBAP, 2015
Acacia mellifera	Medium	expansion of	NBAP, 2015
Acacia polycantha	Medium	expansion of	NBAP, 2015
Acacia seyal var. fistula	Medium	expansion of	NBAP, 2015
Acacia seiberana	Medium	expansion of	NBAP, 2015
Faidherbia albida	Medium	expansion of	NBAP, 2015
Terminalia laxiflora	High	over felling,	NBAP, 2015
Terminalia brownie	High	over felling,	NBAP, 2015
Mangrove(*Avicennia marina* (Forsk) Vierh)	Affected at various levels	Camel Grazing,	HCENR, 2014.
Sea Cucumber (*Holothuria scabra*)	Severe	Over-fishing	PERSGA/GEF, 2004

*Other sources, Sudan National Action Plan, 2007 and the National Adaptation Programme for Action 2007

3.4 Conservation of associated biodiversity

Table 12: *in situ* conservation or management activities or programmes for associated biodiversity for food and agriculture
Information not available

Table 13: *Ex situ* conservation or management activities or programmes for associated biodiversity for food and agriculture
Information not available

3.5 State and trends of wild resources used for food

Countless studies specify that, forests have provided essential resources during emergency periods such as floods, droughts, famines, and wars. There is a wide range of forest resources used as emergency foods. Regularly they differ from resources exploited in other periods. In famine periods, roots, tubers, rhizomes and nuts are most preferred. They are characteristically energy rich, but often require prolonged processing (Abdel Magid, 2001). The contribution of NWFPs to food security and nutrition of rural people living in and near the forests should be given due recognition and attention by governments, donor agencies and financial institutions, NGOs and others when designing, implementing and evaluating development policies and programmes in forested areas (Table 14, Plate 1, 2,).

Sudanese forest fruits are used traditionally as foods as well as medicines. Doum (*Hyphaene thebaica* L), kirkir (*Randia geipaeflora*), karmadoda (*Naucleae latifolia*) and godeim (*Grewia tenax*) are some of the indigenous fruits of the Sudan. The minerals profile, essential and non-essential amino acids values of these fruits were studied by [Nawal *et al*, 2014]. These forest fruits were found containing adequate amounts of minerals. Doum and kirkir are rich in P and K, karmadoda is rich in P, K, Mg and Ca; while godeim is rich in Mg, K, Ca and Fe. Karmadoda was found rich in the essential amino acids, leucine (318.59 mg/100g), isoleucine (167.28 mg/100g) and valine (214.93 mg/100g), however, kirkir was found rich in arginine (543.71 mg/100g). karmadoda was also rich in the non-essential amino acids alanine, aspartic acid, glutamic acid, glycine, serine and proline of 237.46, 421.43, 782.76, 183.70, 156.23 and 165.98 mg/100g, respectively. As said by [Nawal *et al*, 2014], these fruits can be used in several foods as ingredients. Karmadoda can be used as a supplement for minerals and essential and non-essential amino acids.

Table 14: Wild species used for food in the country

Species (scientific name)	Species (local name)	Production systems or other environments in which present and harvested	Change in state (2,1,0,-1,-2,NK)	Differences within species identified and characterized (Y/N)	Source of information
	Bamia Sara, Waika, Efreeta	C9	NK	N	NA
Acalypha sp.	Um Imerat,	C9	NK	N	NA
Amaranthus sp.	Lissan el Tair	C9	NK	N	NA
Annona senegalensis	Gishta	C9	NK	N	NA
Boscia senegalensis	Mokheit	C9	NK	N	NA
Bracharia sp.	Um keriat	C9	NK	N	NA
Cassia obtusifolia	Kawal	C9	NK	N	NA
Cassia Senna	Sanamakka	C9	NK	N	NA
Celosia trigyna	Danabel Kalib, Danabia/Lobira	C9	NK	N	NA
Cissus quadrangularis	El salala	C9	NK	N	NA
Commelina beneghalensis	Ibrig el Faki	C9	NK	N	NA
Corchorus sp.	khudura, Molukhia	C9	NK	N	NA
Dactyloctenium aegyptium	Um Assabi	C9	NK	N	NA
Datarium senegalenses	Abu Leila	C9	NK	N	NA
Diospyros mespiliformis	Abu Sebela	C9	NK	N	NA
Grewia villosa	tamr el abid	C9	NK	N	NA
Gynandropis gynandra	Tamaleika	C9	NK	N	NA
Ipomea sp.	Tabr	C9	NK	N	NA
Lanneaschimperi	Atab-hassu/Ghallub	C9	NK	N	NA
Launaea cornuta	Moleita	C9	NK	N	NA
Leptadenia hastata	Abu Leben, Alag	C9	NK	N	NA
Parkia sp.	Um Rashad, Mudus	C9	NK	N	NA
Piliostigma thonningii	Khuf Eljamal	C9	NK	N	NA
Senna sp.	Sim el Dahib	C9	NK	N	NA
Sida alba	Um Hebiba, Um Shidayda	C9	NK	N	NA
Sorghum arundinaceum	Adar	C9	NK	N	NA
Sporobolus pyramidalis	Aish el Far, Tamara	C9	NK	N	NA
Strychnos innocua Del.	hog el fil,	C9	NK	N	NA
Oryza punctata	Roz Alwadi	C9	NK	N	NA
Adansonia digitata	Tabaldi	F1,F5	2	N	Mahir&ElDoma, 1993

Balanites aegyptiaca	Hijleej	fruits, leaves	2		Badi, 1993
Borassus aethiopium	Dalaib	fruits, sprouts	-1		Badi, 1993
Boscia senegalensis	Mokhait	fruits, seeds, leaves	1		Badi, 1993
Brachiaria obtusiflora	Um chirr	Grains	-1		Badi, 1993
Senna obtusifolia	*Kawal*	*Leaves*	2		Mahir & ElDoma, 1993
Cenchrus biflorus	*Haskaneet*	*Grains*	2		Mahir &ElDoma, 1993
Dactyloctenium aegyptium	*Koraib*	*Grain*	-1		Alamin, 1995
Diospyros mespiliformis	*Joghan*	*Fruits*	-1		Kees Vogt, 1995
Dobera glabra	*Maikih*	*fruits, seeds*	-2		Kees Vogt, 1995
Dombeya quinqueseta	*Gregdan*	*Fruits*	1		AlAmin, 1995
Echinochloa colona	*Difra*	*Grains*	1		AlAmin, 1995
Ficus sycomorus	*Jimaiz*	*Fruits*	1		AlAmin, 1995
Fimbristylis bisumbellata	*Dign-il-tais*	*Fruits*	-2		GTZ, 1995
Grewia tenax	*Goddaim*	*Fruits*	2		AlAmin, 1995
Cleome gynandra.	*Tamalaika*	*Leaves*	2		AlAmin, 1995
Hyphaene thebaica	*Dom*	*fruits, sprouts*	2		AlAmin, 1995
Maerua pseudopetalosa	*Kordak*	*Fruits*	-1		AlAmin, 1995
Sarcocephalus latifolius	*Karmadoda*	*Fruits*	2		Kees Vogt, 1995
Oryza punctata	*Roz-el-wadi*	*Grains*	-2		Kees Vogt, 1995
Randia genipifolia.	*Karkar*	*Fruits*	-1		Nawal *et al*, 2014
Sclerocarya birrea	*Hommaid*	*Fruits*	1		Nawal *et al*, 2014
Sorghum sudanense	*Adar*	*Grains*	1		Nawal *et al*, 2014
Tamarindus indica	*Aradaib*	*pods, leaves*	2		Badi and Abdel Magid, 2013
Tribulus terrestris	*Diraisa*	*Fruits*	1		Badi and Abdel Magid, 2013
Ximenia americana	*medaika*	*Fruits*	-1		Badi and Abdel Magid, 2013
Ziziphus spina christi	*sidir*	*fruits, seeds*	2		Badi and Abdel Magid, 2013
Capparis decidua	*Tundub*	*Fruits*	1		Badi and Abdel Magid, 2013
Grewia flavescens.	*Hilleo, Khlekhsan*	*Fruits*	1		AlAmin, 1995
Grewia mollis.	*Basham*	*Fruits*	1		AlAmin, 1995
Grewia villosa.	*Tikko, Gregdan*	*Fruits*	1		AlAmin, 1995
Azanza garckeana	*Gagh-gagh or Nakhgar*	*Fruits, leaves*	-1		AlAmin, 1995
Abelmoschus esculentus	*Weika, Sarra*	*Fruits*	2		AlAmin, 1995
Feretia apodanthera.	*Shagart alshai*	*Leaves*	-1		GTZ, 1995
Vangueria madagascariensis	*Kirkir*	*Fruits*	-1		GTZ, 1995
Vitex doniana	*Um-Togulgul*	*Fruits*	1		GTZ, 1995
Strychnos innocua	*Um Bikhesa, Abu gawi gawi*	*Fruits*	1		GTZ, 1995

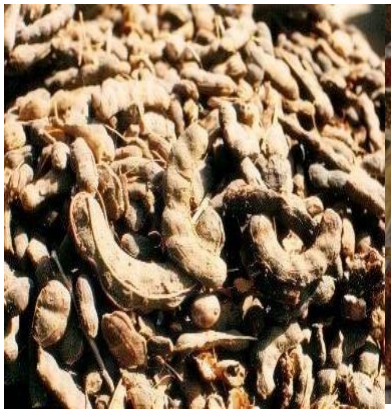
Table 14: Wild species used for food in the country in animal sector

Species (local name)	Species (scientific name)	Production systems or other environments in which present and harvested	Change in state (2,1,0,-1,-2, NK)	Differences within species identified and characterized (Y/N)	Source of information
Nile lechwe	*Kobus megaceros*	L1	NK	N	**Hilton-Taylor, C. (Compiler) (2000). 2000 IUCN Red List of Threatened Species. IUCN, Gland, Switzerland and Cambridge, UK. xviii + 61 pp.**
Grant's Gazelle	*Gazella granti*	L1	NK	N	**Hilton-Taylor, C. (Compiler) (2000). 2000 IUCN Red List of Threatened Species. IUCN, Gland, Switzerland and Cambridge, UK. xviii + 61 pp.**
Mountain reedbuck	*Redunca fulvorufula*	L1	NK	N	**Hilton-Taylor, C. (Compiler) (2000). 2000 IUCN Red List of Threatened Species. IUCN, Gland, Switzerland and Cambridge, UK. xviii + 61 pp.**
Dorcas gazelle	*Gazella dorcas*	L1	NK	N	**Hilton-Taylor, C. (Compiler) (2000). 2000 IUCN Red List of Threatened Species. IUCN, Gland, Switzerland and Cambridge, UK. xviii + 61 pp.**
Red fronted gazelle	*Gazelle rufifrons*	L1	NK	N	**Hilton-Taylor, C. (Compiler) (2000). 2000 IUCN Red List of Threatened Species. IUCN, Gland, Switzerland and Cambridge, UK. xviii + 61 pp.**
Damma gazelle	*Nanger dama*	L1	NK	N	**Hilton-Taylor, C. (Compiler) (2000). 2000 IUCN Red List of Threatened Species. IUCN, Gland, Switzerland and Cambridge, UK. xviii + 61 pp.**
Giant bush buck	*Tragelaphus scriptus*	L1	NK	N	**Hilton-Taylor, C. (Compiler) (2000). 2000 IUCN Red List of Threatened Species. IUCN, Gland, Switzerland and Cambridge, UK. xviii + 61 pp.**
Besia Oryx	*Oryx besia besia*	L1	NK	N	**Hilton-Taylor, C. (Compiler) (2000). 2000 IUCN Red List of Threatened Species. IUCN, Gland, Switzerland and Cambridge, UK. xviii + 61 pp.**
Sitatunga	*Tragelaphus spekii*	L1	NK	N	**Hilton-Taylor, C. (Compiler) (2000). 2000 IUCN Red List of Threatened Species. IUCN, Gland, Switzerland and Cambridge, UK. xviii + 61 pp.**
Roan antelope	*Hippotragus equines*	L1	NK	N	**Hilton-Taylor, C. (Compiler) (2000). 2000 IUCN Red List of Threatened Species. IUCN, Gland, Switzerland and Cambridge, UK. xviii + 61 pp.**
Nubian ibex	*Capra nubiana*	L1	NK	N	**Hilton-Taylor, C. (Compiler) (2000). 2000 IUCN Red List of Threatened Species. IUCN, Gland, Switzerland and Cambridge, UK. xviii + 61 pp.**
Barbary sheep	*Ammotragus lervia*	L1	NK	N	**Hilton-Taylor, C. (Compiler) (2000). 2000 IUCN Red List of Threatened Species. IUCN, Gland, Switzerland and Cambridge, UK. xviii + 61 pp.**
Lesser kudu	*Tragelaphus imberbis*	L1	NK	N	**Hilton-Taylor, C. (Compiler) (2000). 2000 IUCN Red List of Threatened Species. IUCN, Gland, Switzerland and Cambridge, UK. xviii + 61 pp.**

Adansonia digitata **(Gongoles)**

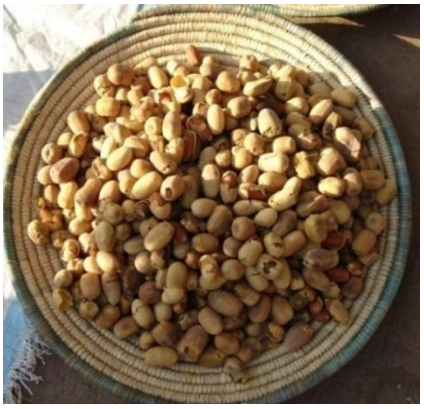
Ziziphusspinachristi **(Nabag)**

Hyphaenethebaica **(Doum)**



Tamarindus indica (Aradape)

Forest foods in local market



Teminalia chebula (Laloop)

Fig 4: Some forest foods

3.6: Wild food resources at risk

Table 15: Main threats to wild food species identified as at risk

Wild food species (scientific name)	Degree of threat	Main threat(indicate)	References or sources of information if available
Tamarindus indica	Medium	Natural and anthropogenic	Abdel Magid and Badi, 2008
Adansonia digitata	High	Anthropogenic	Badi, 1993
Sclerocarya birrea	High	Anthropogenic	Badi, 1993
Grewia tenax	Medium	Anthropogenic	Badi, 1993
Borassus aethiopium	High	Anthropogenic	Abdel Magid and Badi, 2008

3.7 *Conservation of wild resources used for food*

Table 16: *Ex situ* conservation or management activities or programmes for wild food species.

Table 17:*In situ* conservation or management activities or programmes for wild food species.

No programmes have being implemented for both In situ and Ex situ conservation for wild food

3.8 Natural or human-made disasters and biodiversity for food and agriculture

Climate change

The repeated drought conditions that hit the country in the1970s, 1980s and 1990s have seriously affected the biodiversity especially forests. Forest genetic diversity resulting in the disappearance of a large number of trees in the country repeated drought spells as in 1980s that led not only to crop failure, but losses of important germplasm in C5 and C9 production systems. On the other hand heavy rains and floods during the 1990s led to complete damage of the crops in C5 and C9 system of production Socio-political factors

These include land tenure leading to land fragmentation with the consequence of shift away from the traditional crops. This is particularly true in the production systems C5 and C9. A good example of such situation is the extensive shift since the 1960s to production of date palm in the Northern region in areas that used to be cultivated by annual food crops in the past. Migration from rural to urban areas and abandon of agriculture throughout the C5 and C9 production systems Civil war and destabilization of the life pattern leading to little or no involvement in agriculture, with consequence of total loss or reduction of the germplasm of the indigenous crops such as sorghum and pearl millet. This particularly true in L1 and C9.production systems. Other non intentional disasters such as wild fires led to the destruction of vast areas of the natural vegetation.

Expansion in oil and mineral industry

Oil drilling and traditional gold mining have become new threat to the state of biodiversity in many production systems throughout the Sudan particularly systems L1. Lands that had been source of pastures and forests are abandoned in favors of the new industries. The traditional grazing routes were blocked .Vallies and streams, the sources of water in the desert areas became at high risk of blocking and pollution.

Biotic factors

Pests and diseases that attack crops usually have damaging results on the genetic variability within the crops. They exert selection pressures on such crops leading to extinction of those susceptible strains of cultivated species. In Sudan, as it is everywhere, a number of pests are known to attack crops, in addition to a number of fungal, bacterial and viral diseases. Quarantine measures are not effective enough to restrict the introduction of new pests and diseases. The leakage and spread of the green scale insect (*Asterolecanium phoenicisin*) in Northern and River Nile states since the 1980s has led to destruction of a considerable number of indigenous date palm stands there. Insects and other pests may damage dormant seeds in the soil resulting into declined species diversity in rangelands.

Specific Threats

Threats to the indigenous germplasm

Gem plasm enhancement is an integral component of plant crops research in the Sudan. New elite cultivars are annually released for almost all production systems to replace the former ones. In the long run this is thought to have adverse effects on the local indigenous genetic resources.

Specific threats to rangeland

Seasonal wildfire out-breaks

Increased wild fire hazard is associated with low humidity, high fuel loads and the presence of moving grazers. This is the case to the destruction of10-30%ofthestandingdryforageindifferentecologicalzones, loss of seeds and erosion

Over- exploitation

The natural forest vegetation has been subjected to heavy over-exploitation for agriculture through the removal of tree cover for crop production, (Abdel Magid and Badi, 2008).

The spreading of the IAS such as mesquite (*Prosopis juliflora*) and the increase in planting of the toxic shrub *Jatropha curcas* are expected to have negative impacts on forests genetic diversity.

Pollution

Pollution from petroleum, mining, cement and other industries are expected to have negative impacts on forests genetic diversity. Forests fires are a serious problem in nearly all forest areas in the Sudan. The increase in population totally or partially

Table18: Natural or human-made disasters that has had a significant effect on biodiversity for food and agriculture in the past 10 years in the country.

Disaster description	Production system(s) affected (code or name)	Effect on overall biodiversity for food and agriculture (2, 1, 0, -1, -2, NK)	Effect on ecosystem services (2, 1, 0, -1, -2,NK)
Fire	F1 F5	2	2
Flood incident occurred in 1988 in central clay plain of Sudan	F1 F5	1	1
Pests and Diseases	F1 F5	1	1
Pollution	F1 F5	-1	-1
Climate change	L1, M1	-1	NK

3.9 Invasive alien species and biodiversity for food and agriculture

Invasive Alien Species

There are many invasive alien plant, insect and animal species in Sudan, which have been introduced accidentally or deliberately for various purposes. *These are:*

❖ ***Prosopis juliflora*** **(Mesquite)**

- This is a woody species introduced in the Sudan in the thirties of last century from South Africa and Egypt to conserve soils subject to wind erosion in eastern Sudan, then to Western and Central Sudan.
- **Mesquite"** (*Prosopis juliflora*) is a threat to biodiversity in several regions of Sudan, particularly in eastern Sudan. Its strong tendency for all elopathic-induced mono cultural growth and its prolific seed production and efficient spread by browsing animals are the major factors that have enabled this species to take over large areas of the habitats. *P. juliflora* was introduced into Sudan in 1917 from South Africa and Egypt and planted in Khartoum. The success attained in establishment and its ability to tolerate drought, fix sand dunes and capacity to furnish shade, fuel, timber, fodder and edible pods are main driving forces for its repeated introductions into various agro-ecosystems particularly in dry areas (Abdel Magid and Badi, 2008).Table 19.
- Dense of Mesquite in Sudan is found in Delta Tokar and Al Gash.
- The plant constitutes a threat to agriculture, biodiversity and may lead to deterioration of natural vegetation and pastures.
- The bulk of Mesquite infestation (> 90%) in Eastern Sudan, were agro pastoralist and subsistence cultivation constitute the main source of income. Invading Mesquite tends to form dense, impenetrable thickets. In rangelands it reduces grass cover and stocking

density. Interferes with mustering of stalk, and threatens the livelihood of traditional pastoralist. Invasion into agricultural land, along irrigation channels and water courses is also a major problem. (ELsidig et al, 1998).

- Methods of control, Eradication with mechanical and manual initiated in New Halfa 1995 and Zeidab irrigated scheme with little success. Due to high cost of eradication and incomplete and poor follow- up, a significant proportion of cleared area is re- infested. Chemical control by 2,4-D and Trilena herbicides in Khartoum Province in Selate Projects 2014 showed successful results

.

***Eichhornia crassppes* (Water hyacinth)**

- Water Hyacinth is highly invasive species and has a tendency to cover and choke major waterways and lake surfaces, which have numerous detrimental ecological, biological, diversity, fisheries, hydroelectric, transportation and economic results.
- Method of control, Chemical 2,4-D, in 1979 Biological control by two insects: *Neochetina eichhorniae and Neochetina bruchi.* The adults feed on leaves and petioles and the larva tunnels into the petioles and the crown of the plant causes biotic stress, reduced flowers and seeds, and less vigorous growth (Abdelmoti, 2012).
- Now monitoring by satellite (Spot 6) at area from Kosti to Goda evaluate the density of the plant and to re-activate the effect of the insects (bio agent).
- Project 0f Biological control of water hyacinth between Sudan and Egypt, is going on .

Others

Jatropha curcas (jatropha)

This plant has been reported to be an eminent threat to biodiversity of rangeland, agriculture and forest ecosystem. It can become a noxious weed because f it tolerance to harsh condition. It can easily colonize large areas thus displacing and replacing native species. transforming natural protected areas into agricultural production system is disastrous to the wild life biodiversity in the region.

***Cannabis sativa* (hashish)**

South Darfur has been plagued by influx of hasish and all efforts to control that activity has been hampered by the inaccessibility of the road during the rainy season.

***Acanthospermum hispidium* (Horab Hawsa)**

As n lien toxic plant was claimed to brought by Umbarro livestock from west Africa.

***Xanthium brasilicum* (Ramtok)**

It colonizes moist sites along the flood plins of the seasonal water cannels in the Butana plain, the Gash and Toker Deltas and the central clay plain, where it invades it suppresses the nodemic desirable grazing plants

Others plants

Invasive Parasitic Weeds

Orbanche crenata

Orbanche ramose (haluk)

Invasive Insects

Palmapsis phoenicis (Green Pit Scale of date palm).

- The Green Pit Scale newly introduced, is now surpassing the former species in its population densities and damage inflicted on date palm trees and fruits.
- It is widely spreading in Northern, River Nile and Khartoum Province causing more than one million trees infested, and very high yield losses.
- Methods of Control, Quarantine regulations, Cultural practices and Chemicals, since *P. phoenicis* is under natural control in its original places, biological control through importation of suitable natural enemies can be attempted (Abbas and EL Nasr, 1992, ELhassan, 2007).

***Tuta absoluta* (Tomato leaf miner)**

- It is a devastating insect pest with strong preference for tomatoes; it can also attack potatoes, eggplant, tobacco and solanaceous weeds.
- In Sudan a severe outbreak was reported for the first time on tomato grown in green house at Khartoum state in June 2010 (Mohamed et al, 2012).
- The loss in tomato yield as a result of the pest infestation in the green houses at Khartoum state was 76%.

Parlatoria blanchardii (Scale insect of date palm)

Ceratitis capitata (Fruit fly)

Ceratitis cosyra (Fruit fly)

Bactrocera cucrbitae, B. invadens (Fruit fly)

Table 19: Invasive alien species that have had a significant effect on biodiversity for food and agriculture in the past 10 years

Invasive alien species (scientific name)	Production system(s) affected (code or name)	Effect on components of biodiversity for food and agriculture	Effect on ecosystem services (2,1,0,-1,-2, NK)
Prosopis juliflora	FI	1	1
Jatropha curcas	F5	2	2
Eichhornia crassppes	A1	NK	NK
Cannabis sativa	C9	NK	NK
Acanthospermum hispidium	F1	NK	NK
Xanthium brasilicum	C5, C9 , A	NK	NK
Orbanche crenata	C9	NK	NK
Orbanche ramose	C9	NK	NK
Palmapsis phoenicis	C5,C9	NK	NK
Tuta absoluta	C5,C9	NK	NK
Parlatoria blanchardii	C5. C9	NK	NK
Ceratitis capitata	C5. C9	NK	NK
Ceratitis cosyra	C5. C9	NK	NK
Bactrocera cucrbitae	C5. C9	NK	NK

10. Gaps and priorities

- Lack of adequate research, surveys and institutions in plant biodiversity conservation.
- Lack of clear policy for the conservation of the local genetic resources of plants at the national level.
- Complete absence of *in situ* conservation activities in most plant biodiversity sectors
- Lack of a national frame work with legislative and institutional instruments on agro-biodiversity issues including access and benefit sharing matters. Although the country has been a party to the CBD since1995 and to the ITPGRFA since 2002, yet there are no national legal frame works that are necessary to internalize such international frameworks.
- Lack of sustained harmonized efforts between and within the different institutions, groups and individuals engaged directly in activities of relevance to plant agro-biodiversity conservation and utilization in the country.
- Information related to agro-biodiversity is not quite extensively published or easy accessed.
- Efforts to disseminate knowledge on the strategic importance and values of the different components of biodiversity in general and specifically on plant agro-biodiversity are fragmented, non-sustainable and sometimes poorly conducted through the media.
- Lack of understanding of concepts of integrated environmental management processes.
- Weak institutional capacities in terms of manpower and research (especially in terms of stock assessment).
- Weak governance and inadequate management capacity in fisheries,
- Market demand for undersized fish and under-investment in the fisheries sector.
- The combination of these factors results in environmental degradation, overfishing, use of illegal gears; trade in undersized, immature fish and poor post-harvest facilities and practices. This leads to reduced catches and exports, reduced incomes, reduced revenue to government and reduced food security.
- Poor organization of fishers and their poor socio-economic status has limited their political influence and effective participation in the development process.
- Complete lists of Microorganism and Invertebrates in Sudan are not available.
- In Sudan there have been no monitoring activities related to associate biodiversity.
- There are many of obstacles to effective adoption strategy for managing IAS include:
  - No national policy and legislation on the management of IAS in Sudan, although issue are covered in sectoral policies and legislation
  - Information on IAS is scattered and in complete and public awareness programs is weak
  - Range of pathways through which IAS enter the country, has many social , economic and biolgical impact

Gaps, constraints and targets associated with wildlife utilization and ecosystem services

- Except the Dinder National Park and Jebel Al Dair, most protected areas are not well managed due to the lack of human resources and logistics as well as insecurity.
- The disputes and the negative public attitude towards protected areas (e.g. the Rahad Game Reserve) are due to conflicts of interest between the park policies and the local community to use the natural resources.
- There seems to be no control over the national hunters. As far as Safari hunters are concerned, they are always accompanied by wildlife personnel. The role of companions is to make sure that international hunters do not exceed their bag and possession limits.
- Absence of corridors among protected areas may hamper genetic diversity.
- The role of research in wildlife policies is overlooked. The bag and the possession limits issued by WCHA are not research-oriented.
- Hunting licenses are issued without prior information to the trend of the target species in the field. The role of Wildlife Research Center is to address such research problem.
- Inappropriate coordination between Wildlife Research Center and Wildlife Conservation General Administration to adopt strategy for wildlife management in the country.

Priorities and action required

- Encourage and facilitate conduction of research on different aspects of biodiversity, special attention should be paid for surveys and assessment of different biodiversity aspects such as composition, distribution, and threats. Improve capacity and initiate capacities where it does not exist for conservation of plant biodiversity both *in situ* and *ex situ.*
- Adoption/and development of clear policy that regulate conservation and sustainable use of biodiversity.
- Establishment of a mechanism for harmonization between different sectors involved on plant biodiversity conservation.
- Development of an information system concerned by managing data on biodiversity issues
- Effective IAS management requires inistitutional, human and physical resources, raising capacity.
- strengthening the biological control methods is important. and the training is priority.
- Development opportunities exist in capture fisheries and aquaculture in the marine waters of the Red Sea but freshwater aquaculture is the most likely source of increased production through the adoption of proven technologies.
- Clear and measurable mechanisms of poverty reduction must be incorporated into sector strategic and action plans at all levels.
- Improvements in sustainable harvests should be possible through the establishment of responsible co-management.
- A new partnership is needed between fisheries and business development specialists to develop an approach tailored to meet the needs of the fisheries sector in Sudan.

CHAPTER 4

The state of use of biodiversity for food and agriculture

4.1 The use of management practices or actions that favor or involve the use of biodiversity for food and agriculture

Since the initiation of agricultural research in Sudan, which dates back to early 1900s, breeders have been engaged in acquirement and use of plant genetic resources from local and exotic sources. This has resulted in breeding and release of improved cultivars for different crops under the major groups such as cereals, oil crops, food legumes, fruits and vegetables. Appendix 6 shows the varieties that were released for different crops for food and agriculture. However despite the numerous numbers of the released varieties question on how many are used is raised.

Cereals

Sorghum (*Sorghum bicolor* L)

A large number of accessions from the local germplasm were screened for phonological adaptations mainly earliness. The screened lines were further evaluated for yield potential and yield components. Breeding work in sorghum resulted in releasing many varieties which were resistance to Striga, the most anxious weed that threats sorghum productivity, in collaboration with ASRECA, in addition to high yielded variety (Elwafer). Sorghums genetic resources from Sudan have impacted sorghum improvement efforts globally. Recently the ARC on its work plan for 2015- 2019 focus mainly on increasing sorghum productivity per unit area since at least one third of the total cropped area in Sudan is annually devoted to sorghum, About 93 % of the total sorghum area is situated in C9(the rain-fed crop production system).

Millet (*Pennisetum glaucum* (L.)

In spite of the importance of pearl millet, it did not receive much attention for improvement, prior to 1974 when a proper breeding millet program was initiated in North Kordofan. Local collection from landraces and a large number of introductions were grown in C9 (the rain fed crop production system) of Western Sudan and C5 (irrigated crop production system) at Gezira Research Station. So far, three improved varieties have been released. However, these improved varieties were not available to the farmers due to the difficulty of maintaining and increasing seeds because of the high out crossing habit of pearl millet.

Wheat (*Triticum* aestivum L)

With the initiation of Wheat Varieties Improvement Program in Sudan in 1921, some introductions from Australia (Feration, Firbank) and Iraq (Rustom 141) were tested and recommended for distribution. In the 1940s a variety, called Hindi 62 was recommended for both Northern state and Gezira area (Snow, 1943-Khalifa). Thereafter, in the 1950s, more emphasis was given to introductions. This became more important especially when

some international agencies such as FAO, CIMMYT and ICARDA, started to cooperate with national programs. Since then, hundreds and sometimes thousands of advanced lines were introduced every year and screened and hybridized for adaptation to Sudan conditions resulting in the release of a number of varieties for production in the different agro ecological zones of Sudan between 1960 and 2007.In 2013, research was carried on the ARC and at University of Khartoum aiming to improve tolerance to heat, moisture stress, pests and diseases and quality and grain yield.

Maize (*Zea mays*)

Maize variable local old cultivars are still used in the northern, central, western and southern parts of the country. Maize varieties are traditionally maintained by farmers year after year by mass selection. Breeding efforts to improve maize are still limited though presently a number of cultivars and hybrids were released using exotic introduced germplasm. In the ARC the general objectives of the maize research program are: To maximize maize productivity under C9 (rain fed crop production system), C5 (irrigated crop production system) and to increase the income of resources – poor farmers and to introduce maize in C5 (irrigated crop production system) and C9 (rain fed crop production system) to become an alternative cash crop.

Rice (*Oryza sativa*)

Rice in Sudan is grown on a limited scale, mainly on the banks of the White Nile River. The development of new aerobic rice cultivars considered as a sustainable rice production option in Sudan. The outcome of the breeding efforts in this area is four irrigated cultivars that were released in 2010. Aerobic rice varieties (Kosti 1, Kosti 2, wakra and Umgar) are newly released (2012) for commercial production in the Sudan.

Grain legume genetic resources: The main outputs of the legumes program now in the ARC are: Improve varieties of winter food legumes (Faba bean, chickpea, common bean, Lentils) with higher yields, better quality and disease resistance, heat tolerant and high yield potential and good quality cultivar of faba bean, chickpea and lentil genetic sources in collaboration with International Center for Agricultural Research on Dry Areas (ICARDA), and best crop management practices (sowing date, planting density, fertilization, etc.) determined and recommended.

Faba bean (*Vicia faba*)

It is grown in the Northern and Darfur regions. The varieties grown by farmers are primarily landraces named after locality of production such as Aliab, Zeidab and Agabat. Breeding work in faba bean has been started in the ARC since early 1960s. Between 1979 and 1988, the Nile Valley Regional Program (NVRP) was initiated which involved ARC, ICARDA and the International Fund for Agricultural Development (IFAD) to improve other winter legumes besides faba bean and wheat. Breeding for high seed yield, yield stability, better seed quality, resistance or tolerance to biotic and abiotic stress was the primary objectives of that program. The methods used to achieve this goal included germplasm introduction, selection, hybridization and

to a lesser extent mutation breeding. More than 2000 accessions have been imported since the mid 1960s from different places including Europe, Egypt, former USSR, Ethiopia and ICARDA and tested for seed yield.

Field bean (*Phaseolus vulgaris* L.)

Breeding programs carried out on field bean aimed at screening cultivars for high yield potential, screening for some stress conditions especially, salt toxicity and curly top disease and testing the adaptability of previous genotypes to different climatic zones in the Sudan. Many lines were selected from the local types grown in 1960s.These selections were tested for yield for a number of years and one of them that continuously proved to be superior in yield and salt tolerance was released in 1969 under the name Ro/2/1. There was international collaboration with CIAT in Colombia and East Africa in supplying the Sudan with field bean germplasm.

Chick pea (*Cicer arietinum* L.)

Germplasm collection and identification of lentil seeds started at Hudeiba Research Station in the early 1970s in collaboration with ALAD/ICARDA. More than thousand lines were introduced from ICARDA and about 16 lines were retained and found to be adapted and promising to Sudan conditions. Most of these lines were from Egypt (60%) with white flowers and brown seed testa color. These lines were evaluated and most of them were early, with high seed protein content of more than 25% and seed yields of around one ton/ha. These lines together with the local cultivars were included in a variety of yield trials. As the result of that a variety was released in 1993. Additional germplasm received from ICARDA, local materials were evaluated under farm conditions in the late 1990s, and a cultivar was released in 1998.

Oil crops genetic resources

Sesame (*Sesamum indicum)*

Out of a big collection of sesame landraces made in 1950s and 1960s, a number of improved cultivars were released suitable to the C9 (rain fed crop production system) farmers. In the mid 1970's a joint breeding program between the Agricultural Research Corporation and the University of California, Riverside, was started with the financial support from UNDP. This led to the release of one variety in 1985, which was a high yield, white-seeded, practically single- stemmed. The recent programs in the ARC aims to enhance and develop new varieties and also regeneration, evaluation and recommendation of Improved production package, in addition to identification of the major pests and diseases and development of protection strategy**.**

Sunflower (*Helianthus annuus*)

Sunflower is an important oil crop in Sudan, in the recent year's sunflower has evolved as an important research program in the ARC, dealing mainly with development of new single-cross hybrids. Comprehensive researches on the crop resulted in the release of a number of open pollinated and hybrid varieties. The research in the ARC is targeting the germplasm enhancement, new hybrids and ops development, evaluation and release for different eco-systems by development and improved production packages in addition to identification of key pests and diseases, and development of integrated plant protection strategies.

Groundnut (*Arachis hypogea*)
Is another important oil crop grown in central, eastern and western regions of Sudan? Mainly sesame is grown for its oil seed, which is important cooking oil in Sudan. Farmers' varieties previously grown in that area were of the runner type locally known as "Abu Hibailat", which is a type believed to be available at present only in some remote and isolated areas, with a high risk of disappearance. Due the efforts made by the scientists at the ARC, a number of improved cultivars were released.

Soy bean (*Glycine max* L.)
Research on soybean in Sudan started as early as 1930. Soybean varieties were tested at Gezira Research Farm during the period from 1973-1977. Results of field trials indicated that Sudan has great potential for growing soybeans in both C5 and C9 crop production system. Nevertheless, most of the early introduced varieties had poor agronomic performance. Currently, the ongoing soybean research program at the Agricultural Research Corporation (ARC) is focusing on developing improved soybean varieties and generating suitable production packages. Although ARC succeeded to release two soybean-improved varieties, the up scaling and promotion of these varieties need great efforts from all stakeholders along the soybean value chain.

Safflower (*Carthamus tinctorius*L)
Traditionally safflower is being grown for flower to extract dyes, which are being used to color foods and textiles. However, for the last fifty years, this crop had been primarily cultivated for production of high-quality vegetable oil in semi arid regions in Asia, Australia, Americas and Europe. Safflower, which has many usage areas and certain superior characteristics than other oil plants, may play a significant role to fill the gab of vegetable oil shortage. In order to promote safflower-growing areas and to increase production, high quality seed plants with high yield must be identified firstly.
The program in the ARC now is targeting genetic enhancement and evaluation of promising Safflower for C5 and C9 (irrigated and rain-fed crop production systems).

Fiber crops genetic resources
Cotton (*Gossypium spp.)*
Sudan has been for years a leading country for cotton production in Africa. Cotton production decreased significantly during the last years. Although Sudan relied on cotton for a substantial part of the export earnings, the challenge was how to persuade cotton growers to continue to grow cotton, when it is such a difficult and unrewarding enterprise. Recently, a Chinese Center for Agricultural Technology has been established in Al Faw in Gedarif state as a donation from the Chinese government. The center works under the Ministry of Agriculture, with the goal to transfer the Chinese agricultural technologies to Sudan including genetically modified (GM) crops. In 2009, this centre introduced Bt cotton varieties resistant to American boll worm for testing. In 2012, a cultivar which is genetically modified Chinese Bt cotton genotype (G. hirsutum) carrying Cry1A gene conferring resistance to American boll worm was released for commercial production in Sudan, which was named "Chinese1". In June of the same year, it was cultivated on about 20,000 acres of land in rain-fed areas, and in another 50,000 acres of field under irrigation.

Vegetables genetic resources

Tomato (*Lycopersicon esculentum)*

Tomato is among the most the important vegetables in Sudan, where it is used for salad and paste; exist in some parts of the country especially in the Northern, Kordofan and Darfur states. Tomato breeding program was developed to improve the crop during winter, summer and autumn. Different level of progress has been achieved for the three types. All released cultivars of winter time developed from introduced material as commercial cultivars or source for genetic tolerance. Two of these released cultivars in 1993 were resistant to Tomato Yellow Leaf Curl Virus (TYLCV). Whereas, in 1999 another tomato cultivar found to be resistant to TYLCV was released. Only one cultivar of summer tomato which is tolerant to heat was also released in 1999. In 2009 two cultivars that were tolerant to heat and TYLCV were released.

Onion (*Allium cepa*)

A very important vegetable crop produced almost all over the Sudan. In 1987 three onion cultivars were released and all of them are of indigenous nature. A fourth onion variety was also released in 1993. Recently in 2007, a new onion cultivar that was developed from a foreign onion germplasm introduced form Yemen, and now the output in the ARC is to improvement of the yellow onions.

Garlic (*Allium sativum*.)

Garlic is one of the most important field crop in Sudan and a high value crop grown in Northern Sudan where its production is favored by relatively longer and cooler winter season. It grown in specific location confined in El-hassa area in Barbar and Selaim basin in Dongla as C5 (irrigated crop) and in Darfour as C9 (rain fed crop).

Potato *(Solanum tuberosum*)

All potato materials are introductions. Five potato cultivars were released, in 2004. Farmers in Sudan grow local cultivars of Sweet potato as well as some introductions. Two sweet potato cultivars were released recently in 2009 by the ARC, but now in 2015 the research activities are for improvement of potato yield and quality for consumption and processing,

Okra (*Abelmoschu sesculentus*)

Okra is used as fresh and dry form in Sudan. The Efforts have started to utilize the great natural variability found in C9 (the rain-fed) and C5 (irrigated) types of okra. Some lines from these types showed outstanding performance compared with introduced varieties. Three lines were selected for their high yield and superior market qualities. The three lines were released by the ARC in 1987 under the names Raiba, Higairat and Sennar. Farmers depend almost completely on the use and production of local landraces of okra, All okra germplasm used in breeding programs of Sudan are of local origin.

Melon

Among the most important cucurbits grown in Sudan are melon (*Cucumis melo*) and watermelon (*Citrullus lanatus*. Four cultivated types of melons are grown in Sudan: Sweetmelon (*C. melo cantalupensis*), snake melon (*C. melo flexuosus*), a salad melon known locally as (Tibish), and a melon type used for its edible seeds known locally as (Seinat). True wild melons known locally as (Humaid) and belong to the group *C. meloagrestis*. Recent studies proved that germplasm of the true indigenous types of melons such as humaid, tibish and seinat included material which could be used as sources of resistance to known virus and fungal diseases.

Squash *(Cucurbita pepo)*

Genetic materials used in squash breeding program are introductions. Egyptian cultivar, Eskandrani which is commonly grown is susceptible to fungal and viral diseases. Whereas a recently released Sudanese squash cultivar is resistant to some of such diseases.

Fruit genetic resources

Citrus

Certified virus-free bud wood of a number of varieties of grapefruit, orange and mandarin , in addition to rootstocks and indicator plants were introduced by the ARC from National Citrus Collection in USA since 1995 and the Agronomic Research Institute (IVIA), Valencia, Spain in 2002. A cooperation program between the ARC and the Horticultural Sector Administration of the Ministry of Agriculture and Forests was then initiated using such material for improving citrus production and germplasm conservation. Thirteen grapefruit (*Citrus paradise*) introduced cultivars were evaluated by ARC during the 1970s and early 1980s resulting into six cultivars being officially released in 1987.

Banana (*Musa* spp**)**

In 1994, efforts to promote banana production in the Sudan have been initiated resulting in development of a national research program to address the issue of banana improvement. These efforts started effectively through support from International Atomic Energy Agency (IAEA). It included mutation breeding, introduction of new banana germplasm and evaluation of new banana cultivars and mutant clones.

In 2000, five new banana cultivars were introduced from South Africa for evaluation. Four new banana clones were also recently introduced from RSA, as part of CFC project implementation for banana improvement in Sudan. As a result of the improvement activities since 1994 high yielding cultivars were officially released by the ARC in 2002.

Research work on banana focuses on fertilizer and irrigation. Post- harvest physiology of banana has also been carried out by the Food Research Center at Shambat. The most recent activities on Banana are improving production packages for banana, development of a package for banana pests and diseases management and transference of these packages to farmers.

Mango (*Mangifera indica L*)

The mango cultivated in Sudan categorized into three groups: True Indian cultivars, Egyptian seedling cultivars of Indian origin such as Zibda, Alphons, Malgoba and Hindibesinara, and Sudanese seedling cultivars of Indian origin of high quality including Shendi, Taimoor, Nailm, Mabroka, Debsha and the famous sort Abu Samaka.

The activities in the ARC recently (2015):

- Enhancement of mango germplasm for yield and quality.
- Evaluation of poly embryonic mango root stock under heavy clay alkaline saline soil.
- Establishment a collection of the best mango cultivars.

Date Palm (*Phoenix dactylifera* L)

Date production process offers employment to both skilled and unskilled labor thereby generating income. The long term gain derivable from this is the alleviation of poverty at both national and universal level. The date crop in the midst of the deserts and Savannah, serve useful purpose in the area of shed provision. Recently there is a private introduction of soft date's informal cultivars from Gulf State and North African countries such as Tunisia.

The research activities in the ARC now include:

- Date Palm germplasm enhancement for yield and quality.
- Development of Compatible mutagenic males with different introduced tissue culture female cultivars
- Improvement of date palm pollination habit.

Grape (*Citrus paradisi Macf*)

The evaluation of different grape vine cultivars under Sudan conditions is a priority for Fruit research program in the ARC, the focus of this program will be for yield potential and improving quality.

Guava *(Psidium guajava L)*

One of the main goals of the fruit research program is to improve yield and quality and vegetative propagation of Guava, in addition the program is aiming to compare the yield potential and quality of the local guava germplasm with the introduced cultivar.

Forage crops:

The National Seed Administration was involved in the production of seed of the major fodder crops alfalfa and ‘Abu Sabeen’ well as Sudan grass, clitoria, lablab, phillipesara and maize; following the re-organization of the Ministry of Agriculture and Forestry, these have been transferred to the recently established seed companies.

Fodder sorghum

The private sector companies have been playing a considerable role in the introduction of a number of fodder varieties especially hybrid cultivars, which resulted in the official release of six hybrid sorghum cultivars since 1991.Recently a new cultivar of Abu Sabeen was released under the name Kambal for commercial production in Khartoum and Nile State as a (C5) irrigated forage cultivar.

Pearl millet (*Pennisetum glaucum* L.)
Two hundred pearl millet accessions were obtained from the Genetic Resources Unit (GRU) of the Agricultural Research Corporation (ARC) to screen for glabrous leaved accessions at the flowering stage. According to the results obtained it was launched as an irrigated forage crop in Sudan by the National Crop Husbandry Committee on 20/ 6/2013, while fourty accessions (depending on their dry matter) were selected from the top ranking 25 accessions of the three seasons for further evaluation.

Natural range genetic resources
Quality seed of improved varieties is an essential input for fodder crop production and pasture establishment. Production and collection of range species seed is undertaken for rehabilitation of degraded rangeland. Fodder crop seed production is mainly undertaken by farmers, and farmers with small holdings play a crucial role in the informal seed supply system.

Plant Biotechnology aspects related to use of biodiversity
Agricultural biotechnology

In Sudan, there are several biotechnology laboratories supporting agricultural research and working towards solving problems facing priority crops, through enhancing the conservation and use of agro-biodiversity. Mainly, the Agricultural Research Corporation (ARC) and research institutions such as the National Center for Research (NCR) are the leading institutions in the biotechnology research. The Commission for Biotechnology and Genetic Engineering, which is one of the institutions of the NCR, is the focal point in Sudan for the International Center for Genetic Engineering and Biotechnology (ICGEB). In Sudan, several Bio-techniques have been adopted to improve and preserve plants and crops. Most existing techniques are plant cell and tissue culture and DNA molecular makers.

Plant cell and tissue culture:
Tissue culture proved to be very successful in Sudan. It can also be used for conservation and storage of genetic resources for crops with special importance or those threatened by extinction. There are many programs in Sudan on plant tissue culture amongst them:

- Improvement of economic crops such as tomato, potatoes, elite Sudanese wheat, elite Sudanese sorghum landraces, elite Sudanese sesame genotypes, banana and ginger using callus production and regeneration technology.
- Production of valuable secondary metabolites through callus or root suspension culture in species such as (*Vernonia amygdalina*), (*Moringa oleifera*), (*Proboscidea parviflora*), (*Azadirachta indica*), (*Striga hermonthica*) and (*Solanum dubium*).

Biodiversity management practices

There are no records, data or research regarding application of management practice in the different production system in Sudan. The same could be applied to the percentage of the production area where the management practices implemented, or the effect of the practice on productivity and biodiversity. The conclusion is obvious absence of studies on biodiversity and its components as shown in (Table 20)

Integrated Pest Management (IPM)

There is Integrated Pest Management (IPM) methods by cultural practices and chemical control of Green Pit insect in Date palm tree.

Integrated Pest Management (IPM) practices in Vegetable, wheat and cotton in the Gazira Scheme from 1979 to 1996 was strongly change in production area quantity under the practice (significant increase (2) and effect on biodiversity for food and agriculture is strongly increasing (2) by this practices.

Research in, *Salmonella,* root-nodulating bacteria (*Rhizobium), Streptomyces* spp. *Bacillus* and *Lactobacillus*, *Brucella* spp., *Helicobacterpylori*, *Staphylococcus* spp., Clostridium spp. and others are ongoing.

Home gardens

The home garden (jubraka), is a C5, are principally used for growing early maturing field crops to meet household d consumption needs before the normal crop maturation time. Traditional home gardens (HGs) are considered to harbor high levels of plant diversity and have been therefore characterized as sustainable agro-ecosystems suitable for on-farm conservation of plant genetic resources. The *jubraka* represents the most common type of small-scale farming system in the semi-arid zone of Sudan and is distributed from Darfur up to the Kordofan province, southern Sudan. Typically, the *jubraka* (pl. *jabreek*; an alternative term exists in the eastern Nuba Mountains: *najad*) is a rain-fed cropping system of about 0.5 -1 feddan that surrounds homesteads and has the capability to supply food throughout the year.

Table 20: Management practices that are considered to favor the maintenance and use of biodiversity for food and agriculture

Production system …… [*insert code or name*]			
Management practices	**Percent of production area or quantity under the practice (%)**	**Change in production area or quantity under the practice (2,1,0,-1,-2, NK,NA)**	**Effect on biodiversity for food and agriculture (2,1,0,-1,-2, NK,NA)**
Integrated Plant Nutrient Management (IPNM)	NK	NK	NK
Integrated Pest Management(IPM)	NK	2	2
Pollination management	NK	NK	NK
Landscape management	NK	NK	NK
Sustainable soil management practices	NK	NK	NK
Conservation agriculture	NK	NK	NK
Water management practices, water harvesting	NK	NK	NK
Agro-forestry	NK	NK	NK
Organic agriculture	NK	NK	NK
Low external input agriculture	NK	NK	NK
Home gardens	NK	NK	NK
Areas designated by virtue of production features and approaches	NK	NK	NK
Ecosystem approach to capture f fisheries	NK	NK	NK
Conservation hatcheries	NK	NK	NK
Reduced-impact logging	NK	NK	NK

Diversity based practices that involve the enhanced use of biodiversity for food and Agriculture

Absence of information and research on biodiversity aspects and component make it difficult to estimate the precise and accurate levels of enhancement of biodiversity through the implementation of biodiversity based practices (Table 21) indicate this lacking of information

Table 21: Diversity based practices that involve the enhanced use of biodiversity for food and agriculture

Production system …… [*insert code or name*]			
Diversity based practices	**Percent of production area or quantity under the practice**	**Change in production area or quantity under the practice**	**Effect on biodiversity for food and agriculture (2,1,0,-1,-**
Diversification	NK	NK	NK
Base broadening	NK	NK	NK
Domestication	NK	NK	NK
Maintenance or conservation of landscape complexity	NK	NK	NK
Restoration practices	NK	NK	NK
Management of micro-organisms	NK	+1	+1
Poly culture/Aquaponics	NK	NK	NK
Swidden and shifting cultivation agriculture	NK	NK	NK
Enriched forests	NK	NK	NK

4.2 Sustainable use of biodiversity for food and agriculture

The state of use of plant biodiversity for food and agriculture

The rural inhabitants of the Sudan constitute 67% of the population their livelihood depends on the natural resources. This situation has put intensive pressure on these resources, and has led to serious degradation in the biodiversity and the rest of ecosystems including the plant agro-biodiversity.

The state of use of staple crops

The staple food crops in Sudan are mainly sorghum, wheat and pearl millet. The period 2009-2013 witnessed remarkable fluctuations in the production of grain, sorghum and millet (produced in system C9), which was caused mainly by the rainfall fluctuations. Wheat production on the other hand remained stable since it is mainly grown in the irrigated crop production system (C5).

Sorghum

The production of sorghum increased by 140.3% from 1,883 thousand metric tons in 2011/2012 to 4524 thousand metric tons in 2012/201, that is explained by the increase of 14.2% in the cultivated areas from 8098.7 thousand ha to 9251.3 thousand ha, the productivity increased by 37.8%, from 81.1 Kg/ ha to 111.8 kg/ha. The Ministry of Agriculture reported that the cultivated area was 10531.5 thousand ha in season 2014/ 2015 and the harvested area was 8800 thousand ha with productivity reached 123.9 Kg/ ha.

Pearl millet

The production of pearl millet increased by 188.6%, from 378 thousand metric tons in season 2011/2012 to 1091 thousand metric tons in season 2012/2013, as a result of an increase of 40.5% in the cultivated area, from 2676.9 thousand ha to3761.8 thousand ha, and a rise of 35.2% in productivity from51.3 kg/ha to 69.3 kg/ha. In 2014/ 2015 Ministry of Agriculture reported that the cultivated area was 4131.5 thousand ha and the harvested was 3310.1 thousand ha while the productivity reached 66.4 Kg/ ha.

Wheat

The wheat production decreased by 18.2% from 324 thousand metric tons in season 2011/2012 to 265 thousand metric tons in season 2012/2013, due to a reduction of 26.9% in the cultivated area from 187.4 thousand ha to 137.0 thousand ha, despite a rise of 7.2% in productivity from321.4kg/ha to 344.5 kg/ha. Wheat production in 2014/ 2015 recorded 237.0 thousand ha cultivated area and 224.8 thousand ha harvested areas while the productivity estimated by 371.4 Kg/ ha (Fig below).

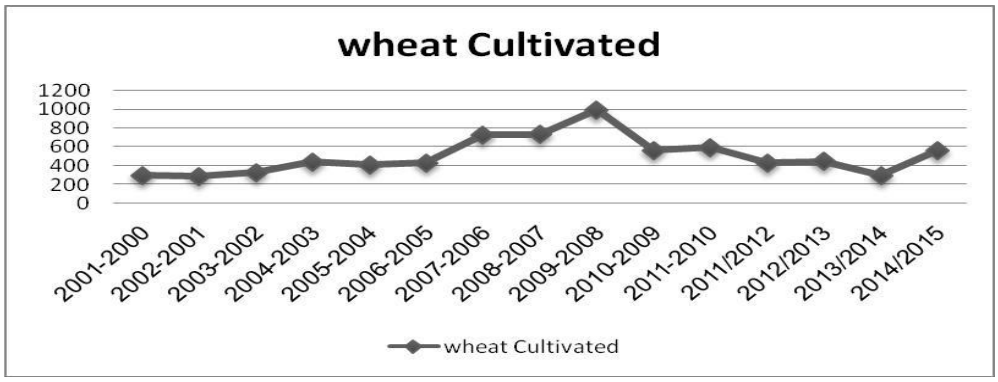


Figure 5: Wheat Cultivated Area in Sudan 2000- 2015

Production of Oil crops

Groundnuts

The production of groundnuts increased by 71.2%, from 1,032 thousand metric tons in 2011/2012 to 1,767 thousand metric tons in 2012/2013, this is explained by the increase in the cultivated area from 2098.0 thousand ha to2731.5 thousand ha, in addition to 28% rise in productivity from 112.6 kg/ ha to 144.1 kg/ ha. In 2014/ 2015 the cultivated area was 2696.2 thousand ha and the harvested area 2184.0 thousand ha while the productivity was estimated by 151.3Kg/ ha.

Sesame Seeds

Sesame is grown in Sudan in C9 (rain fed crops production system) by subsistence, semi-commercial and commercial farmers. It is a crop that contributes with a considerable portion to the export trade of Sudan. The production of sesame seeds increased by 200.6% from 187 thousand metric tons in 2011/2012, to 562 thousand metric tons in 2011/2013, the reason is the expansion of the cultivated area by 13.5% from 1688.2 thousand ha to 2580.3 thousand ha, in addition to an increase of 13.5% in productivity from 40.3 kg/ ha to 45.8 kg/ha. Sesame cultivated area increased to be 3262.2 thousand ha in 2014/ 2015 and the harvested area was2659.7 thousand ha, the productivity increased to be 60.5 Kg/ ha.

Sun flower:
Sun flower production decreased by 6.5% from 92 thousand metric tons in 2011/2012, to 86 thousand metric tons in 2012/2013, as a result of a reduction of 4.3% in the cultivated area from 145.0 thousand ha to 138.7 thousand ha, and a decline of 11.9% in productivity from 162.6 kg/ha to 143.3 kg/ha. The general trend for the production of the main oil seeds during the period 2009-2013, was notable fluctuations, which attributed to the rainfall fluctuations and distribution.

Cotton:
Cotton production declined from 288 thousand tons in 2011/2012, to 131 thousand tons in 2012/2013 with percentage of 54.5%. The decline explained by the reduction in the area under cultivation from 164.7 thousand ha in 2011/2012, to 74.4 thousands ha in 2012/2013, decrease that estimated by 54.8%. The period 2009-2012 witnessed a continuous rising trend in cotton production; that trend sharply reversed in 2013 due to the problems experienced at the Gezira Agricultural Scheme.

Production of horticultural crops
Vegetables:
Various vegetables are grown in Sudan, in both crop production system (C5 and C9), in a total area of about 370.000 ha, relatively about 3% of the total cultivated area in the country, producing in average about 3.4 million ton of vegetables. The most important vegetable are Onion, tomato followed by Potato, Okra, egg plant, watermelon, cucumber, pumpkin and number of leafy vegetable.

Fruit producing plants
Several fruit producing species are grown in Sudan. Some of them are ancient in the country while others were introduced not long time ago. The most well known fruit producing species in Sudan include date palm, banana, guava, citrus fruit trees and mango**.** The estimated total fruit production in Sudan is about 1.9 million ton in an area of about 186.000 ha. The Total production area of mango was estimated by 29.9 thousand ha while the production raised 640.8 thousand tons in season 2013 while for banana was 31.5thousand ha for 900 thousand tons. For lemon the area was 18.5 thousand ha which caused 264 thousand tons that was almost about the area of grapefruit (14.8thousand ha) while the productivity recorded by 211.8 thousand tons, which was not the case for orange (147 thousand tons for 12.4 thousand ha). The recorded area for guava was 8.4 thousand ha and the production estimated by 140 thousand tons, the date palm growing area was 36.8 thousand ha producing about 438.5 thousand tons.

Production of forages plants
The Range Plants General Directorate (RPGD), based on recent survey on the Live stock grass land based production system (L1) estimated that total livestock feed availability in the country was 66.6 million tons on dry matter basis (DM) represents different feed sources from rangelands and agricultural sources the table below).

Available animal Feed Supply from rangelands and agriculture feed

Feed type	Dry Matter (million tons)	Energy (million Mega Joule)	Digestible protein (million tons)
Herbaceous plants	48	432720	1.9
Browsing	5.2	39150	0.03
Fodder crops	3.4	44386.292	0.68
Crop residues	8.3	53086.2	0.0003
Agro-industrial by products	1.4	14485.3	0.314
Cereals (sorghum, maize and millet)	0.1	1822.7	0.007
Total	66.6	585650.492	2.9

Grass lands (grazing)

The most important feed source, they provide feed during wet season (August to December). During the short wet season grasses grow and mature rapidly producing abundant biomass where herbs and grass characterized by succulence with high crude protein content, low fiber in the beginning of the wet season. The nutritional inadequacy of the dry season grazing imposes a major constraint on sustainable livestock production under traditional systems where grazing constitutes the only source of feed for livestock.

Browse species (fodder trees and shrubs)

These sorts of fodder trees and shrubs are important components of the natural rangelands as national herd at different ecological zones under traditional pastoral production system depends mainly on grazing and browsing. In the drier areas where *Acacias* are predominant, fruits (seedpods), twigs, flowers and leaves are main browse materials. In the wetter areas to the south where broad-leafed plants are dominant, livestock depend heavily on tree foliage.

Wild food production

Although consumption and use of wild food plant species is very common in Sudan, yet the topic did not received the necessary attention, record, data or research on production, productivity or any conservation measures are very limited and fragmented.

- Several plant species, existing in the wild flora are used, on a limited scale, as food plants by some indigenous communities. Examples of such species include *Brachiaria obtusiflora*, known locally as "Um chirr", *Cassia obtusiflora* known locally as "Kawal", *Echinochloa colona* known locally as "Difra", *Oryza punctata* known locally as "Roz el wadi", and *Sonchus* spp. known locally as "Moleita". These underutilized species contribute substantially to household food and livelihood security. Some of them have potential for more widespread use, and hence the promotion of food security, agricultural diversification and income generation, (Higher Council for Environment and Natural Resources, 1998).

- Traditionally, forests of Sudan have been managed by forest-based communities to satisfy their needs for forest products. An accumulated indigenous knowledge with respect to the local use of trees and forests to provide food and other non-wood materials has been recognized. Local communities have explored the use of different parts of trees as food, medicines, fibers and other uses. The majority of the acacia species produce leaves during the small rainy season, while others like *Ziziphus* spp. and Balanites aegyptiaca as well as *Hyphaene thebaica, Boscia* spp. are evergreen plant species found in large quantity in the dry areas. These species yield a reliable source of green browse all through the year. The survival of the pastoralists and agropastorlists depends on the sustained yield of the green browse for their livestock during the dry season. Besides the well-known specie *Faidherbia albida*, is a dependable supply of browse for livestock (Abdel Magid and Badi, 2008).
- The small farmer communities neighboring the Dinder Park receive direct economic benefit from the vegetation communities of DNP, predominantly from making use of several species of wild plants and animals for subsistence use as well as for commercial purposes, i.e. selling on to users in neighboring towns and further away. (Lindsay et al, 2010 and Abdel Magid and Awad, 2005)
- ***NWFP use and the national economy***
  The importance of NWFPs at the national level lies in the huge numbers of people involved in gathering, hunting, processing, trading and other aspects of their production and use. Most rural people use some forest products, and many obtain part of their income from forest-product activities. The lack of information about the numbers involved in subsistence use, or about the value of that use at the household level, makes it impossible to arrive at even rough estimates of the economic contribution of that component of production and use Table 20.
- **Livestock & state of their utilization**
  Cattle: Meat, milk, by-products (hides, hair, manure, blood etc.), traction, transport.
  Sheep: Meat, milk, by-products (skins, hairs, manure ….etc).
  Camels: Meat, milk, recreation, transport, traction and other by-products
  Goats: Meat, milk and other by-products. Available meat and milk for domestic consumption in 2009: Annually about 41 kg of meat and 26.3 kg of dairy products are available per capita for domestic consumption (IGAD, 2013).
- **Major Animal Products:**
  The most important animal products are milk, meat, poultry meat, skins & hide and to some extent hair and wool and animal power.

a) Meat:

Pastoral nomadic and semi-nomadic agropastoralism systems (L1) are the main sources of meat that provide all domestic needs and enough supplies for export. The country is self-sufficient in meat and livestock off take is estimated at 31,695,252 heads/yr. The slaughter by products like blood, bones and condemned parts are used for animal feed industry.

b) Milk:

Most of the milk is produced by pastoral nomadic and semi-nomadic agropastoralism systems (L1) but most of it doesn't find access to urban areas due to poor roads infrastructures. Most of the marketable amounts of milk in urban markets come from the dairy cooperative and commercial dairy farms in mixed systems (M1) and landless (L5).The country is insufficient in milk and milk off take is estimated at 10,292,040

tons/yr covering 70% of domestic needs. Livestock improvement programmes are aimed towards enhancing and improving milk productivity in all dairy animals.

c) **Poultry meat**
Unlike other countries the prices of white meat are higher than the prices of red meat .At the urban and per urban areas where landless systems dominate (L5) poultry industry relies on foreign breeds and hybrids while in the remote areas local types provide all the available supplies of the market. Most of the marketable production in urban markets is generated from (L5) system.

d) **Table eggs:**
The local breeds of hens are available in all animal production systems. They are the main sources of eggs at the local markets in rural areas. Farmers in large commercial farms (M1 & L5) and even some householders use exotic breeds. Most of the marketable production in urban markets is generated from (L5) system. Production is highly affected by the high temperature and high prices of grains and super concentrates. Success depends on good management and provision of poultry feed at reasonable prices. Egg off take is estimated at 55,594,000 dozens/yr.

e) **Fish meat:**
The production of fish is hindered by poor infrastructure, unavailable or expensive inputs and the inefficacy of the traditional system used. Fish off take is estimated at70, 000 tons/yr.

- **Range & Animal Feed Rangelands:**
Rangelands cover an estimated area of 96.4 million (M) ha composed of 53.4 M ha of grassland and 43.0 M ha of woodlands containing scattered trees and shrubs (Afri-cover 2003). This vast area encompasses different ecological zones extending from desert and semi-desert in the north to the low rainfall wood savanna (LRWS) to the south and south west. Nearly 80% of all rangelands are located in semi-desert and LRWS ecological zones which are characterized by variable and unpredictable rainfall. Rangelands are estimated to have a total production of 34.8 million tons of dry matter.
Total available feed is 50 million tons (dry matter) composed of 34.8, 14.1, 0.5 and 0.2 million tons of forage from rangelands, crop residues, irrigated pastures and concentrates, respectively.

The state of use for fisheries:

Fish and fish products are highly appreciated in Sudanese diet for their indispensable nutritional value, and they thus contributed significantly to the food and nutrition security of the population (FAO, 2014). The information on the fisheries of Sudan is partially available. However, the country is endowed with considerable fishery resources, centered on the Red Sea, with a coastline of about 853 km long stretching to an Exclusive Economic Zone (EEZ) of 91,600 km^2, including a shelf area of 22,300 km^2, River Nile and its tributaries (Blue Nile, White Nile, and Atbarah Rivers), as well as several reservoirs (Gebel Aulia, Sennar, Roseires, Khashm El Girba, Merewe) and lake (Nubia).
Estimates of the potential production in Sudan (before secession) have been made and they range from 70,000 tons per year to over 300,000 tons per year. The FAO reports that, in 2006, the total fish catch for all of Sudan (both the south and the north) reached

an estimated 64,550 tons, broken down as follows by subsector: 57,000 tons (accounting for 88.3% of the total) originating from inland waters; 2,000 tons (3.1%) from aquaculture; and 5,550 tons (8.6%) from the Red Sea.

The state of use for Microorganism

Sudan is known for its rich microbial resource, and the scientific research in this field is focusing on enhancing the use of locally isolated microbes. There are 383 fungal species, belong to175 genera, 42 species of a Arbuscular mycorrizal fungi, several yeasts plant viruses genera and species reported in the fermentation of several food types, in addition to 25 epiphyteic lichen in Red Sea area.

The Desert locust ***(****Schistocerca gregaria)*, the tree locust *(Anacridium melanorhodon,)* although they are serious pests, they are used as wild food in some parts of Sudan

Honey: It can be collected from bee colonies found in forests or from man-made hives which attract and keep bees. Many natives are engaged in collection of honey from Feral bee nests, a method which is quite destructive. Wherever there is abundance vegetation exists, feral indigenous bee colonies are found nesting in tree cavities, rock crevices, termite mounts, soil cracks and in tree branches. In the Central and Northern States, the bee population is confined to the riverine belt. Given its expansiveness and vegetative diversity, the country offers wide opportunities for honey and other honeybee by products. Even in the semi-desert zone and the open savannah, the Acacia spp. are bountiful, providing extended flowering period starting from July through to February.

Numerous favored forest foods have particular harvest seasons that do not necessarily be compatible to food short periods. In these cases, foods are gathered for as long as they are available. Home gardens (intensively managed farm systems integrating tree and herbaceous crops) are extensively well thought-out to make use of variations in the timing of the harvest of different tree crops component, with the purpose of supply foods and saleable produce during the period between harvests of staple crops (Abdel Magid and Badi, 2008). Table 22 illustrates the main practices associated with wild foods and Table 23 highlighted the effect of the lack of biodiversity for food and agriculture on production.

Major practices that negatively impact associated biodiversity and/or wild foods in the Sudan

Numbers of practices that have negative impact on plant biodiversity practiced in Sudan, but there is no adequate research, surveys or data to trace this impact. In (Table 22) number of these practices where references are available were mentioned, while some are absent due to lack of references.

Table 22-a: Major practices that negatively impact associated biodiversity and/or wild foods in the country (animal).

Types of practices	Major practice (Y/N)	Description	Reference
Over-use of artificial fertilizers or external inputs	N	Artificial fertilizers are used in many farmer fields, but there is no specific study or survey to conclude its negative effect on biodiversity	No
Over-use of chemical control mechanisms (e.g. disease control agents ,pesticides, herbicides, veterinary drugs ,etc.)	Y	High crops yields are attained through the adoption of good husbandry practices including weed control. As a result of weeding, 29 herbaceous fodder plant species are controlled in central Sudan as weeds.	Fifth national report submitted to the CBD, 2014
Inappropriate water management	Y	In Sudan the main water resources challenges include: - Erosion and sedimentation (Sudan difficulties in managing the water resources in reservoirs and irrigation canalization due to sedimentation). - Natural disasters: (a) Flood devastation range from loss of lives to widespread crop destruction and other economic activities. (b) Drought and desertification. (c)Watershed degradation: poor cultivation practices,	Assessment of the level of implementation of Integrated Water Resources Management. In Sudan. Applied Training Project Publications. Dr.
Practices leading to soil and water degradation	Y	Vast areas of rangelands were shifted to several investment activities such as sugar industry in White Nile State, petroleum explorations in Kordofan states, and mining in Butana area and other states. In addition to reduction of land area, the highly polluted drain waters may affect range plants and cause death to livestock in some cases.	Fifth national report submitted to the CBD, 2014
Over-grazing	Y	Overgrazing to the extent that extensive stretches of forests land lie bare of vegetation. As a result of grazing selectivity, some highly palatable forage plant species such as *Chrosophora brochidiana*, which livestock prefers its flowers and twigs preventing the plant to complete its life cycle, became decreases. Conversely, unpalatable ones are increasing and becoming dominant. Overgrazing has occurred in many parts of the semi-desert and savannah zones as a result of over stocking of livestock, poor distribution of water sources, amount of available vegetation and blockage of livestock routes during the wet season.	El siddig et at, 2007. Fifth national report submitted to the CBD, 2014
Uncontrolled forest clearing	Y	Due to horizontal expansion of mechanized farming in central clay plains. 241 of trees or shrubs species are considered seriously threatened, which showed marked retreat in their distribution and/or regeneration due to climatic conditions and also due to the intensity of their removal for wood, fodder or clearance for cultivation. Also endangered are 43 exotic shrubs or tree species. The natural forest vegetation has been subjected to heavy over-exploitation for agriculture, felling for fuel and	Abdel Magid and Badi, 2008 Biodiversity stocktaking report (2014)
Fishing in protected areas			
Overharvesting	Y	heavy over-exploitation for agriculture through the removal of tree cover for crop production, felling trees for fuel wood and building poles	Abdel Magid and Badi, 2008

Table 22-b: Major practices that negatively impact associated biodiversity and/or wild foods in the country (AQGR)

Types of practices	Major practice (Y/N)	Description	Reference
Over-use of artificial fertilizers or external inputs	**N**		
Over-use of chemical control mechanisms (e.g. disease control agents, pesticides, herbicides, veterinary, drugs, etc.)	Y	Serious pesticide contamination has been found in Gazira canals and Kassala horticulture zone leads to frequent fish kill. Disease control agent, pesticides, herbicides, veterinary drugs, etc (PPD)	UNEP Randa *et al.*, 2014
Practices leading to soil and water degradation	Y	Major environmental problems associated with dam construction include silt loss for flood recession agriculture, dam sedimentation, severe riverbank erosion and the degradation of downstream habitats.	Hamid *et al.*, 2009).
Fishing in protected areas	Y	Weaknesses in institutional capacity and law enforcement.	Hamid *et al.*, 2009).
Over-harvesting	Y	Population of some species are decreasing due to overexploitation (using of destructive fishing gears , the violation of fishing period and illegal fish trawling especially in red sea).	Hamid *et al.*, 2009).

Table 22-c: Major practices that negatively impact associated biodiversity and\or wild food in the country.

Types of practices	Major practices (Y\N)	Description	Reference
Over-use of artificial fertilizer or external input	N	No data	
Over-use of chemical control mechanisms	Y	Disease control agent, pesticides, herbicides, veterinary drugs, etc (PPD)	Randa *et al.*, 2014

Table 23: Effect of the lack of biodiversity for food and agriculture on production, food security and nutrition and livelihood

No information is available**.**

4.3 The contribution of biodiversity for food and agriculture to improving productivity, food security and nutrition, livelihoods, ecosystem services, sustainability, resilience and sustainable intensification

- Agriculture is a multifunctional sector that comprises all activities that use the ecosystem available. It produces diverse products and provides many valuable services to the society with a reasonable level of integration and coordination between all sub-sectors, the producers and the service providers. This in addition to the need for rational use for the natural resources. Sustainable agricultural development is achieved by increasing production from all agricultural ecosystems with all components without sacrificing the environmental balance; improvement of productivity, sustainability in production and sustainable of intensification for food security and nutrition, improvement of socio-economic conditions, improvement of livelihoods.
- There are many different kinds of food gathered from forests. Forest foods may also be smoked, dried or fermented, making them available over extended periods of time. Some species are important as predominantly rich sources of vitamins, minerals, proteins and fats. For example, many forest fruits and leaves are good sources of Vitamin A (Falconer and Arnold, 1991).The few species which provide edible gum and oils are *Acacia mellifera*, *Acacia senegal*, *Adansonia digitata*, *Balanites aegyptiaca*, *Hyphanea thebacia* and *Ximenia americana*. Most of the oils extracted from seeds of these species are sold either locally or are exported. Gum extracted from the bark of several acacia species provides food for livestock of the pastoralists and agropastorlists.Forest fauna are also contributing to food security through the provision of different kinds of bush meat. During the periods of drought that hit the Sahel, the fruits of *Cordia africana* and the fruits of *Boscia senegalensis* were used extensively by local people as famine foods. Forestry was making the difference between being and not being for rural communities at these critical moments. (Falconer and Arnold, 1991; Elsiddig et al, 2007; Abdel Magid and Badi, 2008).
- Nomadic pastoralists from different ethnic backgrounds find dry season grazing in the vicinity of and within the park; livestock corridors in both Gedaref and Blue Nile States lead directly towards the park from wet season areas.
- The fisheries sector has successfully mobilized the rural community through providing work opportunities in various activities related to fish production, processing and marketing. Establishment of small-scale family oyster farms along the northern Sudanese coast have contributed to the stability and improvement of the socio-economic status of these multiethnic communities, which have very limited alternative income generating opportunities (FAO, 2008). Small-scale fish-farm owners in urban areas around Khartoum and other towns belong generally to comparatively well-off middle class citizens. Some of them self-finance their business, while others obtain bank loans to start or develop their farms. There is no known association for this category except possibly personal membership in the Fisheries Trade Chamber or similar. Semi-industrial fish farming in freshwater (e.g. finfish) and marine waters (e.g. shrimp) is practiced by capable investors. Those in the last two categories hire fishermen, workers and expertise for short consultancies or full-time work (FAO, 2008).
- No information available on the proportion of the population that uses wild food on a regular basis for food and nutrition.

4.4 The adoption of ecosystem approaches

Sudan has begun to change its management strategy away from traditional marine resource management approaches towards an Ecosystem Approach to Management (EAM). This included policy, strategy development and implementation. Table 24 shows adoption of and importance assigned to ecosystem approaches. Commercial fishing for Sea Cucumber was closed in 2009 based on evidence provided to all red sea states from the regional conservation organization (PERSGA).

Observation: The state is now collecting catch data as well as gaining a better understanding of the operational costs and benefits of the fishery (Johnstone consult ltd, Bulgaria, 2009).

Table 24: Adoption of and importance assigned to ecosystem approaches in production aquatic systems in the Country.

Production system **Code or name**	**Ecosystem approach adopted (name)**	**Extent of adoption (2,1,0,NA)**	**Importance assigned to the ecosystem approach (2,1,0,NA)**
Self-recruiting capture fisheries, tropics	Commercial fishing for sea cucumber was closed in 2009	1	1
Self-recruiting capture fisheries, tropics	The Red Sea state is now collecting catch data as well as gaining a better understanding of the operational costs and benefits of the fishery.	1	1

4.5 Gaps and priorities

- A numerous number of the released varieties are not used by the ultimate stakeholders.
- With respect to the sustainable use of biodiversity for food and agriculture it is obvious that there is no harmonization between different sectors.
- Regarding each sector there is no documentation for the ongoing research or even archive for the past research.
- In addition to lose the seed materials and a lot of released varieties had been lost and not adopted by the farmer and the stockholders.
- Enactment of necessary national legislations for conservation and sustainable use of biodiversity taking into consideration the matters related to access and benefit sharing as well as protection of the local communities, farmers and pastoralist rights to biological resources and their indigenous knowledge, practices and technologies; including issuance of a national legislation on PGR.
- Some areas of research do not cover either because there are no specialized breeders to work in or a few of them work in specific areas and crops that cannot cover the needs, such as the vegetables.

- Lack of equipments and specialized labs especially in the horticultural sector.
- Lack of building capacity for the most of the breeders.
- Seed production system is inefficient.

The problem in livestock sector is that;

- The accuracy of the entire calculation rests on an estimate of the size of the country's livestock population, and there has been no attempt to count the national herd since 1975.
- Indigenous breeds especially dairy cattle (Kenana and Butana) are currently under severe pressure as to the indiscriminate introduction of foreign breeds (Friesian).
- There is overgrazing in some areas, particularly around settlements, while vast areas are under grazed because of lack of water for the animals.
- Expansion of agriculture, particularly mechanized farming, into traditional grazing land, has led to reduction in grazing areas and in many instances to the blocking of traditional migration routes and water points, causing conflicts between transhumant and settled farmers.
- Prevalence of diseases, particularly infectious, tick borne diseases and parasites had led to high mortalities in cattle.
- Difficulty of marketing and processing milk from 90% of the milking animals in nomadic and other traditional systems which are far from the centers of consumption.
- Lack of infrastructure such as research, extension, roads, education, and health services and livestock markets.

With respect to management practices, sustainable use, improving livelihood, food security and adoption:

- Lack of understanding of concepts of integrated environmental management processes.
- Weak institutional capacities in terms of manpower and research (especially in terms of stock assessment).
- Weak governance and inadequate management capacity in fisheries,
- Market demand for undersized fish and under-investment in the fisheries sector.
- The poor organization of fishers and their poor socio-economic status has limited their political influence and effective participation in the development process.

Priorities

- Producers need to be consciously aware of the importance of AnGR for positive response and cooperation.
- AnGR use, preservation and development require the allocation of sufficient funds, capacity-building herder's extension and above all the will to do the required research.
- Rehabilitation of research units, supply them with their immediate needs and support with qualified experts and technicals.
- Development opportunities exist in capture fisheries and aquaculture in the marine waters of the Red Sea but freshwater aquaculture is the most likely source of increased production through the adoption of proven technologies.
- Clear and measurable mechanisms of poverty reduction must be incorporated into sector strategic and action plans at all levels. Improvements in sustainable should be possible through the establishment of responsible co-management

CHAPTER 5

The state of interventions on conservation and use of biodiversity for food and agriculture

5.1 National policies, programmes and enabling frameworks that support or influence conservation and sustainable use of biodiversity for food and agriculture and the provision of ecosystem services

Twenty six Policies include laws and, legislations as well as regulations, certification procedures and other mechanisms that incentivize conservation and sustainable use of biodiversity for food and agriculture.
Twenty seven Programmes include initiatives and actions implemented and organized at all levels from community and stakeholder groups to national and regional organizations, as well as local implementation of international programmes.

Policies, programmes and enabling frameworks that Support the integrated conservation and sustainable use of biodiversity for food and agriculture across sectors

Polices

- Although national legislations, in various areas, within the period 1900 to 1990, are huge, the laws relating to the agricultural sector do not exceed twelve acts such as Plant Diseases Act (1913), Cotton Act (1924), Protection of Farmers in the Gash and Tokar Delta Act (1928), The Seizure of the Transplants of the Date Palm Act (1947) and Control of Crops Act (1972). However, there are a number of regulatory and legislative and administrative frameworks known in the country that are directly relevant to aspects of biodiversity conservation and sustainable use, including the following:
- Sudan Interim Constitution refers to the Environment and Natural Recourses, in Article 11, states that: People of the Sudan shall have the right to a clean and diverse natural environment, and the State and the citizens have the duty to preserve and promote the country's biodiversity. According to this constitution, the State shall not pursue any policy, or take or permit any action, which may adversely affect the existence of any species of animal or vegetative life, their natural or adopted habitat.
- The Civil Transaction Act of the country: provides regulating access to grazing land. The Act (Section 565) specifies that: All fallow land is grazing lands; it stipulates the right of government to impose temporal or spatial restrictions on grazing in these areas or to allocate land for grazing for the benefit of an entire community or for the protection of wildlife (De Wit, 2001).
- Rangelands Rationalizations, Conservation, and Fodders Resources Development Act was issued to become effective by February 2015. At state level, local orders were issued to organize the utilization and protection of the grazing resources through the local administration (Altayeb, 2006).

- A proposed national legislation on plant genetic resources (PGR) in Sudan has been drafted in 2011 by a task force of technical and legal experts formed by the Ministry of Agriculture. This draft legislation has been developed in order to attain the following objectives:
    - *Conservation* of PGR.
    - *Sustainable use* of PGR for food security and other public goods.
    - Facilitated access to PGR for *conservation* and sustainable use.
    - Equitable and fair sharing of benefits arising from the use of the PGR.
    - Protection of farmers' and community rights related to PGR.
    - Capacity building and transfer of technology related to PGR.
    - Protection of traditional knowledge, techniques and practices related to PGR.
- A national Biosafety Law for the year 2010 was issued as a fundamental and step in the establishment of effective national system of biosafety in Sudan, to adjust operations of treatment and trade in genetically modified organisms and its products at all levels. The law aims to ensure the integrity of trading of genetically modified products, and its safety in terms of environment and health.
- Forest Policy, (2006) support biodiversity conservation and its sustainable use (Ministry of Agriculture and Irrigation, 2012).The policy provides guidelines for rehabilitation. As a result local communities become aware of the importance of the resources. Converting policy into action always faces limitations at the local implementation level due to a lack of experience.
- National *Biosafety* Framework issued in 2005. It has become a basic document in which many relevant stakeholders participated. It covers the main guidelines in biosafety issues, to be followed in Sudan
- The Environment Protection Act (2001): is policy-oriented framework legislation for the protection of environment and natural resources in the country. The Act includes a provision of compliance with international conventions. Section 18 of the Act stipulates certain directives to guide the activities of various concerned authorities. These directives include, among them: "Preservation of animals and other living beings from extinction induced by illegal hunting or any other threat by human".
- Biosafety Legislation**:** Sudan is a party to the Convention on Biological Diversity (CBD), since 1996, and acceded to the Cartagena Protocol on Biosafety since 2005.
  In 2010, Sudan has issued a National Biosafety Law, dealing with the application of modern biotechnology, in accordance with the national, regional, and international commitments. This law contributes to ensuring an adequate level of protection in the field of safe transfer, handling, and use of living modified organisms resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity, but unfortunately the law does not cover issues dealing with AnGR.
- Sudan has a number of international obligations that are relevant to the fisheries sector and the National Fisheries Policy.
- UN Convention on the Law of the Sea (1994).
- Protocol Concerning the Conservation of Biological Diversity and the Establishment of Protected Areas.

- Protocol concerning Regional Cooperation in Combating Pollution by Oil and other Harmful Substances in the Red Sea.
- Protocol concerning the Protection of the Marine Environment from Land-Based Activities in the Red Sea and Gulf of Aden.
- The Ramsar Convention.
- The Nile Basin Initiative (NBI).
- The FAO Code of Conduct for Responsible Fisheries (CCRF).
- UN Framework Convention on Climate Change and Kyoto Protocol to the Convention.

- **Fisheries legislations**
- Freshwater Fishing Law (1954), amended (1960) and (1995).
- Marine Fisheries Ordinance (1937): This old ordinance aimed at regulating fishing and use of marine resources in territorial waters and was in use until its amendment in 1975, and renamed Marine Fisheries Regulation. The major amendment included banning of spear guns in fishing, collection of corals and ornamental fish without permission or dumping of wastes in water, in addition to regulation of marine engineering and coastal development activities.
- **Governance and Decentralization of Forestry in Sudan**
  The first forest legislation was enacted in 1901 followed by consecutive revisions in 1908 and 1917. Forest policy 1932 was declared to resolve the conflict between the central and local government authorities over the management and administration of the forest resources. The policy was supported by the enactment of the Central Forest Ordinance and the Provincial (recite local government) Forest Ordinance 1932. The forest policy was reviewed in 1986 to reinstate central government control of forest resource management and address the environmental crisis. In 2005 a new forest policy proposal was formulated through extensive community consultation process by the project (TCP/SUD/2903 Revision of Forest Policy, Legislation and Institutional Reorganization in collaboration with FNC, Sudan). (Abdel Magid and Warrag, 2011).

Programmes

- **FAO Plan of Action for North Sudan (*Emergency response and rehabilitation for food and agriculture August 2010 – August 2012*)**

  In this Plan of Action (PoA), FAO outlines its emergency and rehabilitation programme for North Sudan in 2010–12. The programme relies heavily on a *disaster risk management approach* to the complex situation in North Sudan. It aimed at improving preparedness and to make short-term responses in food and agriculture more effective. PoA contained six areas; one of which is reduced livestock production and productivity.

- **Reduced livestock production and productivity**

The livestock subsector faces numerous constraints, including a heavy disease burden, low productivity exacerbated by drought and insecurity, the lack of adequate marketing infrastructure, and poorly organized and informed livestock owners and traders.

The priorities in North Sudan are:

(i) vaccination and treatment of livestock; (ii) training and equipping of CAHWs and consolidation of the community-based animal health system; (iii) establishment of fodder banks and improvement of livestock supplementary feeding, especially during the dry season (animal feed preparation, balanced animal feeding); (iv) construction/rehabilitation of water points along migratory routes; (v) pasture and rangeland rehabilitation (pasture seed broadcasting, enclosure establishment);

- **Achievement of FAO'S ongoing emergency and rehabilitation programme in North Sudan**

- The efforts by FAO and other actors in disease prevention through vaccination of animals in North Darfur have led to a drop in the incidence of disease outbreaks. CAHWs had played significant role in vaccination campaigns which had an overall positive impact on the health of livestock. The role of CAHWs is well recognized by local communities:
- They participated in public health services by inspection of slaughterhouses and meat markets.
- They also offered veterinary drug sales free-of-charge services to poor livestock owners or offer services on a loan basis to those who can't afford to pay immediately.
- FAO also has encouraged alternative sources of income by training the most vulnerable groups in cheese-making or other food processing techniques.

- **Advancements and innovations in science and technology**

- Biotechnology is applied in vaccine production since 1930. Bacterial vaccines such as anthrax, hemorrhagic septicemia and black leg, and viral vaccines such as rabies, new castle and PPR, all are produced in Sudan by the General Animal Resources Research Corporation (ARRC).
- DNA technology has been exploited to some extent for characterization of some domestic and wild livestock breeds. In Animal Production Research Center (APRC) at Kuku, Khartoum there is ongoing collaborative work with ARS-USDA in USA that dealing with characterization and sequencing of Sudanese goat populations.
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- **Projects support conservation of farm animal species**

- Phenotypic Characterization and Genotyping by Sequencing for Sudanese Goat Populations. Collaborating Institute: USDA/ARS Bovine Functional Genomics Laboratory. Ongoing 2014 -215
- Profiling Fecundity Genes in Sudan Desert and North Riverine Sheep. Collaborating Institute: IAEA. Appropriated 2 014 – 2015
- Polymorphism and Sequencing of GDF9 and BMP15 in Sudan Desert and Taggar Goats. Collaborating Institute: ILRI. Appropriated 2015-2016.
- Phenotypic & Genetic Characterization of AnGR in Arab World. Collaborating Institute: ACSAD. Appropriated 2015-2016.

- Characterization & Inventory of FanGRs Biodiversity in Sudan. Collaborating Institute: HCENR. Proposed 2015-2016.
- Nubian Ibex (*Capra nubiana*) in Northeastern Sudan: Survey and Genetic Characterization
- Collaborating Institute: Wildlife Conservation General Administration. Proposed 2014 – 2015.
- Wildlife Genetic Resources Survey in Red Sea State.

- **Projects support conservation of aquatic species**
  The *Sudan Productive Capacity Recovery Program (SPCRP)* – Funded by the European Commission (EC) is a four-year program (2009–2013) worth US$24.83 million with an overall objective of strengthening the capacities of state government administrations and non- state actors operating in the agriculture sector. The EU also funded the project titled "*Technical Assistance to the Fisheries Sector in Red Sea State*" over the period from May to October2010. This intervention was comprised of 225 person-days of in-country technical assistance plus costs for international travel (Scanagri, 2010).

- **The updated National Biodiversity Strategy and Action Plan (2015-2020).**

a) Support the conservation and sustainable use of associated biodiversity:

(1) ***Multilateral agreements for conservation of associated biodiversity include:***
Sudan is a party to a number of global and regional multilateral agreements of relevance to conservation and sustainable use of wildlife genetic resources. These include:

- The African-Eurasian Water bird Agreement (AEWA) - 1999.
- The Regional Convention for the Conservation of the Environment of the Red Sea and the Gulf of Aden (PERSGA) - 1982.
- The Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES) - 1973.

(2) GEF-UNDP project 2000-2005 succeeded in developing a management plan for Dinder National Park (DNP) involving all stakeholders and based on the concept of biosphere reserves. The DNP succeeded in raising awareness among neighboring communities, establishing Village Development Committees (VDCs), and adapting models for alternative livelihoods.

- A GEF project with a total budget of about US $ 4 million is approved to upgrade management of protected areas in Sudan.

(3) The Sudan Community Watershed Management Project (CWMP) is approved with funding from World Bank; CIDA FINIDA aimed at strengthening the knowledge base and human resource capacity for cooperative action on watershed management.

b) Address food security and nutrition with explicit reference to biodiversity for food and agriculture, associated biodiversity and/or wild foods:

c) Address the *maintenance of ecosystem services* with explicit reference to biodiversity for food and, associated biodiversity and/or wild foods

d) Improve resilience and sustainability of production systems with explicit reference to biodiversity for food and agriculture, associated biodiversity and/or wild foods:

(1) Development of newly Agriculture Sector Investment Plan1 (2012) one of its main Strategic Objectives is Development and protection of natural resources sector to ensure its renewal and sustainability

(2) National Agricultural Investment Plan (NAIP) within the Comprehensive Africa Agriculture Development Program (CAADP), is now prepared contains supporting policies for biodiversity.

(3) Programme National Adaptation Programme of Action (NAPA) -July 2007

Enhancing resilience to increasing rainfall variability through rangeland rehabilitation and water harvesting in the Butana area of Gedarif State

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The main goal of the project is to enhance the resilience of local communities in the *Butana*area to current and future rainfall variability through rangeland rehabilitation and the widespread introduction of water harvesting and storage techniques

The main activities will include the following:

- Mapping of the vulnerable fodder production areas in the region and identifying suitable sites for water harvesting technologies;
- Evaluating the potential of various water harvesting and utilization techniques relative to local climatic conditions.

INTERNATIONAL & REGIONAL AGREEMENTS& COOPERATION

Sudan has endorsed Global Plan of Action for AnGR at FAO meeting 34.Now the country is activated this endorsement by joining Genetics Project.

The overall objective of this project is to: enhance the contribution of livestock to food security and economic growth in Africa.

The specific objective is to strengthen the capacity of countries and Regional Economic Communities (RECs) to sustainably use and Conserve Animal Genetic Resources through institutionalizing national and regional policy, legal and technical instruments.

The project approach is to:

- Facilitate and fast track the implementation of the Global Plan of Action (GPA) for Sustainable use of AnGR.
- Build capacity for effective formulation and implementation of policies and strategies for the management of AnGR and create awareness for inclusion into national and regional agricultural investment priorities (CAADP & NEPAD).
- Build consensus on methodology and tools for the characterization and inventory of AnGR.
- Partners with other projects and global forums to create access to and also disseminate information.

Table 25: Obstacles to developing and implementing legislation that would protect associated biodiversity identified in the country

Component of associated biodiversity	Obstacles to legislation for protection of associated biodiversity
Fisheries resources	Conflict between the States & Federal legislation
Fisheries resources	Conflict within the States fisheries management plans.
Sustainable forest management	The average number of cases against forest offenders during the last five years range between 1 625 and 2 025 per annum, most of the offenders were from the regular forces and other armed groups. The effectiveness of protection methodologies are revised periodically in cooperation and coordination with the agencies concerned.
Sustainable utilization of Forest products	The deteriorating security situations and tribal conflicts facilitate the forests deterioration process and the unauthorized trafficking of forest products
Microorganisms	lack of national culture collection in the country

5.2 Polices, programmes and enabling frameworks governing exchange, access and benefits

Table 26: Polices and programmes governing the access to its genetic resources of associated biodiversity established in the country

Component of associated biodiversity	Intend use	PIC and benefit sharing required
Vertebrate	A fish was introduced to control water hycine	Y
Invertebrate	Insect predators and parasitoids to control cotton boll warm	Y
Microorganism	Introduction of inoculating bacteria to help legumes root inoculation	Y

5.3 Information management

Recently Sudan issued a new act, named the "National Centre for Information, 2010", that repealed the previous one passed in 1999. In this Act, by "information" it is meant, all data of different kinds of systems that are processed by all means, including electronic means of access to facts, opinions, or concepts, which have been collected in all the natural sciences and human affairs. In this act, it is stated that the provisions of this law are sovereign over any other laws, and it shall prevail in case of conflict with the provisions of any other law to the extent that removes this inconsistency.

Among the objectives of the Center, it has considered information on different kinds of systems, its technology and organization in the country in coordination with the competent authorities.

Linkages between sector information systems at national level and national information system in AQGR are:
Weak or absent information systems
Lack of information links between States and Federal government

Documentation of crop PGRFA

There is no national documentation system for the Plant Genetic resources for Food and Agriculture (PGRFA) in Sudan. Information on PGRFA holdings is only available with institutes and individuals holding such materials. At present the PGR program in the ARC is using a gene bank documentation system operated through a gene bank data management tool called SESTO for documenting and accessing both the passport and management data. The SESTO system will provide a good tool that could be accessed through the internet by all users for information on passport data related to collections held by the Agricultural Plant Genetic resources Conservation and Research Centre (APGRC) in the ARC. Those passport data of the collections held by the APGRC, which are documented using the SESTO, are uploaded and can be accessed through the EAPGREN Data Portal (http://www.eapgren.org/eapgren), which is a regional web-based data portal for the Eastern Africa Plant Genetic Resources Network (EAPGREN) of which Sudan is a member among eight countries. Such data are also made available and accessible in the internet through the web-site of the Agricultural Research Corporation (ARC), Sudan at the link http://www.arcsudan.sd/genetic.html

Documentation on forest and range PGRFA

Nearly about 7000 forest specimens and 403 specimens of range plants were collected and have been preserved in as herbarium material within different institutes in the country as a documentation tool.

Table 27: National information system on associated biodiversity in the country
No information system is available

5.4 Stakeholder participation and ongoing activities that support maintenance of biodiversity for food and agriculture

The most important stakeholder groups and NGOs

Ministry of Agriculture, Ministry of Animal Resources and Fisheries, Ministry of Health, Ministry of Environment, Forests and Construction Development, Sudanese Standards and Metrology Organization-Higher Council for Environment and Natural Resources, and civil society organizations like the association of consumer protection.
In aquatic sector the most important stakeholder groups and NGOs

- Federal Fisheries Administration
- State Fisheries Administration
- Fisheries Research Center
- Marine Conservation Society
- Sudanese Environmental Conservation Society
- Fisheries companies and firms
- Fisheries trade chamber and Fishermen unions and cooperatives.
- UN bodies (FAO, OIE, UNDP, WFP, UNEP, UNIDO… etc)
- International funds (World Bank, GEF etc).
- International Humanitarian Agencies.

Incentives or benefits to support activities for the conservation and sustainable use of biodiversity (AQGR)

- The Zakat Chamber has provided 100 wooden boats to fishermen in the south-central coast area free of charge in 2010.
- The Ministry of Social Affairs (Red Sea State) and the Farmer's Bank have initiated a one million SDG project to supply 100 fishing boats to register coastal fishermen in forms of cooperatives or associations in a group of 4 fishermen per boat

Table 28: landscape based initiatives to protect or recognize areas of land and water in your country of particular significance for biodiversity for food and agriculture
No information is available because no work has been done.

5.5 Collaboration between institutions and organizations

Existing linkages and collaboration between plant, animal, forest and aquatic production sectors in national programs and policies governing conservation and sustainable use of biodiversity for food and agriculture:

There are a number of government institutions and departments involved in activities pertaining to *in-situ* and *ex-situ* conservation of BFA. However, these institutions are working in un-coordinated manner that lack a unifying umbrella frame. This usually results in duplication of work and oftentimes arouses conflicts. As a matter of fact and

according to its mandate, Higher Council for Environment and Natural Resources is supposed to coordinate between these different institutions. This is handicapped by continuous change in affiliation, lack of structural set-up and infrastructure, and financial constraints. The most important of these institutions are Range and Pasture Administration (RPA) of the Ministry of Agriculture and Forests, Horticultural Sector Administration of the Ministry of Agriculture, and the Agricultural Plant genetic resources Conservation and research Centre (APGRC) of the Agricultural Research Corporation. However, the latter is the only body in the country that is fully engaged in matters related to conservation and enhancement of utilization of the PGRFA. It already developed a recognized image in this domain at national, regional and international levels. Other institutions and departments of relevance include also the Agricultural Extension and Technology Transfer Administration, Seed Administration Unit and the Plant Quarantine Department in the Ministry of Agriculture.

In the aquatic sector:

- ❑ Coordination between institutions responsible of environmental conservation and fisheries sector is weak.
- ❑ PERSGA provided technical and financial support to the development of the marine environment, including ecological and biological studies in Dungunab Bay and Makawar Island, and offered training opportunities to technical staff in the areas of conservation management of marine parks and reserves.

Future actions planned in addressing Aichi Targets

- ❑ Sudan National Biodiversity Strategy and Action Plan (NBSAP) (2011-2020);
- ❑ The Quarter Century Strategy of the Sudan (2003-2027) calls for:

- An enhanced role for fisheries in poverty alleviation, food security, human health and environment;
- Adopting scientific research and technology advancement as vehicles for increasing productivity efficiency;
- Rational utilization, conservation and development of aquatic and fisheries resource through sustainable production management, restocking of depleted fish stocks and pollution control;

Regional and/or international Agreements and initiatives targeting the conservation

Sudan ratified the Convention on Biological Diversity (CBD) in 1995, as well as the International Treaty on Plant Genetic Resources for Food and Agriculture in 2002 and Cartagena Protocol on Biosafety in 2005

In the aquatic sector:

- ❑ Nile Basin Initiative (NBI): The NBI is a nine-nation inter-governmental organization dedicated to equitable and sustainable management and development of the shared water resources of the Nile Basin. Indian Ocean Tuna Commission (IOTC) Sudan has been a member of the IOTC since 1996

Table 29: Regional and/or international initiatives targeting the conservation and sustainable use of associated biodiversity

Initiatives	Scope (R:regional, International)	Description	References
Eastern Nile Watershed Management Project	R	The project includes the following three components: Community Watershed Management. Knowledge for Cooperative Action. Project Management.	Eastern Nile Watershed Management Project (Ethiopia, Sudan and Egypt) (2012). POLICY BRIEF. Website: www.nilebasindiscourse.org
PERSGA - 'The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden'	R	An intergovernmental organization dedicated to the conservation of the coastal and marine environments in the region.	PERSGA, 2002

5.6 Capacity development

Table 30: Higher education programs specifically targeting the conservation and sustainable use of associated biodiversity genetic resources in the country

Institution	Program	level	Enrolment		
University of Bahri	Natural resources (fisheries, wildlife, forestry, animal science, veterinary, geology…etc)	B.Sc., M.Sc.	NK	NK	NK
Sudan University of Science and Technology	Agriculture, veterinary, forestry, animal production, water resources, fisheries & wildlife	B.Sc., M.Sc., Ph.D.	NK	NK	NK
Elnilein University		B.Sc., M.Sc.	NK	NK	NK
Ahlia University	Environmental sciences	B.Sc., M.Sc.	NK	NK	NK
University of Khartoum	Zoology, Environmental sciences, Agriculture, veterinary, forestry, animal production, fisheries & wildlife	B.Sc., M.Sc., Ph.D.	NK	NK	NK
University of Red Sea	Marine sciences, Oceanography	B.Sc., M.Sc.	NK	NK	NK
Sinnar University	Environmental resources (Science)	B.Sc.	NK	NK	NK
Sudan Academy of Sciences	Fisheries sciences, Aquaculture, fish technology, fish disease	M.Sc., Ph.D.	NK	NK	NK
Gezira University	Agriculture, veterinary, animal resources,	B.Sc., M.Sc., Ph.D.	NK	NK	NK
Islamia University	Agriculture, water resources	B.Sc., M.Sc., Ph.D.	NK	NK	NK
Kordofan University	Agriculture, wildlife, Animal production, rangelands	B.Sc., M.Sc., Ph.D.	NK	NK	NK

5.7 Knowledge generation and science for the management and sustainable use of biodiversity for food and agriculture

- **Plant sector**: The Agricultural Plant Genetic Resources Conservation and Research Centre (APGRC) is one of the centers under the Agricultural Research Corporation (ARC) of Sudan. It is responsible for development of plans and conducting activities related to conservation and enhancement of sustainable use of plant agro biodiversity in Sudan. It is one of the research progammes of the Agricultural Research Corporation (ARC) in Sudan. It is the only programme in the country with the mandate of collection, conservation, characterization, evaluation and documentation of the local genetic resources for food and agriculture (PGRFA). The overall general objective of the APGRC is to conserve the plant agro-biodiversity in Sudan against deterioration and loss, and to enhance its sustainable use in research, genetic improvement, training, and germplasm restoration into the original farming systems, while at the same time protecting the rights of all parties on materials and associated information.

- **Aquatic sector**

Major institutions directly involved in research on the conservation and sustainable use of associated biodiversity (AQGR).

- ❑ **Higher Council for Environment and Natural Resources (HCENR):** Its responsibility is drawing and coordinating national policies and plans as well as proposing legislation for environmental protection and conservation of natural resources.
- ❑ **Agricultural Research Corporation (ARC):** The Corporation's mandate is adaptive research in the different agro- ecological environments.
- ❑ **Animal Resources Research Corporation (ARRC)**: Primary mandate is animal health research. It is also responsible for animal production, fisheries and wildlife research;
- ❑ **National Centre for Research (NCR)**: Has one of its several components an Institute for Natural Resources and Environmental Science.

5.8 Gaps and priorities

Major gaps in policies and legislations of relevance to plant agro biodiversity include the following:

- Lack of a national framework with legislative and institutional instruments on agro-biodiversity issues including access and benefit sharing matters. Although the country has been a party to the CBD since 1995 and the ITPGRFA since 2002, yet there are no national legal frameworks that are necessary to internalize such international frameworks.
- There is no national policy and legislation on the management of Invasive Alien Species (IAS) in Sudan, although issues of IAS are covered in sectoral policies and legislations. The Plant Quarantine Acts prevents the importation, culturing, distribution and selling of any plant forms without an official permit from the Plant Protection Directorate. The existence of a wider range of IAS in Sudan indicates that enforcement of the Act is weak probably due to weak border control and poor quarantine measures.

- In the area of rangelands Sudan's institutional and policy framework has provided little attention and support to sustainable management of this renewable resource. Recent agricultural investment efforts have forced small holder farmers and agro-pastoralists groups into marginal lands which are mainly used for grazing thus increasing competition with pastoralists. The abolishment of the Local Administration, the traditional leadership and effective governing body of natural resources utilization and protection, by the government deprived communities of their local authority to control their lands and resources without providing an effective alternative.
- Institutions in increasing awareness and technology transfer. Efforts should be made to strengthen State institutions, national NGOs, CBOs and other community organizations dealing with impacts of climate change, natural resources protection and utilization. These efforts should be extended to ensure coordination and complimentary activities in all actions pertinent to the management and development of these resources as well as increasing the resilience of communities.
- Sufficient financial resources allocated directly related to management of biodiversity component ecosystems. Advantaged prioritization and allocation of biodiversity component ecosystems.
- Lack of strategy and plan of action for fisheries development and integrated coastal management.
- Rather poor and irregular monitoring and research activities, which handicapped proper planning and institutional backstopping
- Insufficient infrastructure and institutional capacities.
- Extension, training and public awareness programs are rather lacking or poorly attended to.
- The Sudan is lacking in many areas of basic information as to animal genetic resources and development. Areas such as national recording schemes, breed societies and clubs, regulations and legislation are very poor
- There are no tangible official policy strategies and programmes targeting the preservation and development of AnGR specifically.
- A legal framework is an essential instrument for preventing the chaotic mixing of AnGR .
- The policies tailored to the use preservation and development of AnGR need to be distinct, specific and clear-cut and addressing producers concerns.
- Inadequate access of fisheries research and management proposals to regional and international for abroad training that limited their experience.
- Limited skilled manpower.
- Insufficient credit schemes for fishermen communities and small scale investors.
- Civil war disturbances that jeopardize fisheries development programs in some parts of the country.
- Links with a number of International and regional framework that related to biodiversity, including Conventions, Organizations and Net works.
- Raise the awareness on the total value microorganism biodiversity and ecosystem and strengthen in institution capacity, by narrowing the gap information in the field of biodiversity and ecosystem planning and development.

- Raise awareness of public to conserve biodiversity and ecosystem.
- Accessibility of reliable information helps in decision making and achieving polices for management AIS.
- Multidisciplinary research and participation of producers is required and supporting research and technology transfer.
- Integrated Pest Management is the only methods that controls the pests and conserve the biodiversity and the environment in agriculture.

CHAPTER 6

Future agendas for conservation and sustainable use of biodiversity for food and agriculture

6.1 Enhancing the contribution of biodiversity for food and agriculture

A number of future actions and programmes have been proposed in this respect. There are planned actions as priorities to improve the conservation and sustainable use of biodiversity for food and agriculture to enhance improvement of food security and nutrition, rural livelihood, productivity, supporting ecosystem function, support sustainability and intensification.

Conservation and sustainable use of biodiversity for food and agriculture

The following are the proposed plans to be implemented in order to ensure the conservation and sustainable use of biodiversity for food and agriculture:

- Survey the different ecosystems and agro ecological zones including those related to cultivated plant species, natural range plants, wild food plants and weeds within the different production systems.
- Establishment of a national information system with information sharing mechanisms on the state of *in-situ* and *ex-situ* conditions, with due consideration to establishing an early warning system as part of the national information system.
- Capacity building of the existing institutions, specifically the Agricultural Plant Genetic Resources Conservation and Research Centre, in terms of coordination, human resources and physical infra-structure.
- Strengthening breeding capacities in research institutes and universities in terms of human resources and physical capacities to ensure effective and wider coverage of germplasm enhancement.
- Ensure the proper maintenance and propagation of the improved varieties of cultivated plants.
- Establishment effective seed propagation and supply systems at formal and informal levels to ensure wider distribution and utilization of the officially improved varieties.
- Establish effective linkages between conservation and use of the conserved genetic resources. Initiate and support on-farm conservation activities for cultivated plant species.
- Revision the current national strategies, policies and legislation for animal, forestry and agricultural sectors.
- Development of agricultural policies based on sustainability and conservation of resources
- Interventions for the sustainable use of NWFP (forestry) include improvement of management practices including; in-situ conservation of NWFP, agro forestry systems, conservation and introduction of forest laws, conservation measures and reforestation activities, controlled grazing and browsing, introduction of energy saving systems at household levels and introduction of community-based forest management systems. This will be most effective with an integrated land management practice which also aims at increasing agricultural security and productivity.

- Involvement of forest dwellers, who are both sufferers and instruments of destruction, and who will tolerate the burden of any new management system .in the programmes of forest recourse preservation
- Coordination of efforts to study how indigenous and introduced fodder and multi-purpose trees and shrubs can be utilized within the farming areas and in rangelands to fill the gap of supply in the dry season and complement the dry grass with nutritious browse and pods.
- The Future agendas for Sudan's AnGR Policy should consider the following issues:

- The policies for the use of conservation and development of AnGR need to be distinct, specific and clear-cut and addressing producers concerns.
- Allocation of sufficient funds for research, training and capacity-building of herders.
- Health condition of the national herd.
- Increase in the livestock exports.
- Improvement of local breeds.
- Increase of livestock productivity.
- Development of animal breeding patterns to suit the traditional sector.
- The delineated livestock migration routes should be officially registered and directly linked to State Range and Pasture Administration. Which in the future should carry the responsibility of management and improvement and the body to refer to in case of violation..

In the AQGR, the proposed future agendas for conservation and sustainable use of biodiversity for food and agriculture are:

- Restructure and strengthen fisheries institutions.
- Develop national standards and codes of practice.
- Undertake economic valuations of the fisheries sector.
- Increase external financial support from outside the fisheries sector.
- Expand and integrate commercial aquaculture into irrigated agriculture.
- Maximize benefits from culture-based fisheries.
- Maximize benefits from Mari-culture.
- Adopt a business development approach to fisheries.
- Implement local fisheries management plans.
- Improve fish quality and value addition.
- Promote increased availability and access to fish in domestic markets.
- Control fishing activities, especially in newly formed reservoirs

6.2 Strengthening the conservation and management of associated biodiversity and wild foods

- Initiate a national research programmes for the development of the wild food including domestication activities.
- Establishment of *in-situ* conservation sites for wild plant species including wild relatives of crops and natural range plants.

Targets and priorities for wildlife conservation may involve the following:

- Establishment of more protected areas to cover more than 17% of the country area;
- Establishment of at least one protected area in each State.
- Sustainable access of using the natural resources by the indigenous and the local community.
- Prevention of species extinction
- Introducing ecosystem-based fisheries management to the parks, which represents a significant challenge to the park management that if successfully addressed, will greatly benefit the fishing communities dependent upon the resources of Dungonab Bay (MPA) by promoting sustainable fisheries, and permanently increasing catch levels in the medium to long term.
- Systematic revision of the MPA proposed management plans developed by PERSGA in the early-to-mid 2000s.
- The neglected habitats and species groups of mangroves, sea-grasses, Sea-weeds, turtles and birds should be monitored.
- The Regional Environmental Monitoring Program initiated by PERSGA for the water quality should continue to record the physical environmental variables.
- The paucity in taxonomists should be addressed and rectified to bridge the gap in knowledge of aquatic biota.
- Initiation of activity on conservation of microorganism and vertebrates.
- Adoption of Integrated Crop Management (ICM) and integrate of Pest Management (IPM) policies to support diversity production systems.
- Improve institutional collaboration in the management of microorganisms and vertebrates.
- Develop effective systems and tools for monitoring, evaluate and management of |Invasive Alien Species.
- Strengthen quarantine measures and border control to insure that intentional introductions are subject to appropriate authorization.
- Strengthen and management of well coordinated multidisciplinary research in associated biodiversity and wild life.
- Eradication of Invasive Alien Species, if possible, or control by IPM and biological control methods and introduce the bio agent from the origin countries
- The management of |Invasive Alien Species (IAS) has to be considered in national action plan.

6.3 Improving stallholder involvement and awareness

Formation of Resource Management Organizations at village, clan/tribe and State level composed of key stakeholders with responsibility for designing, implementing, and managing natural resource development activities.

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ANNEXES

ANNEX 1: Lists of participants to Sudan country report

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ANNEX 2: Wild Plants used as Food in Sudan

Scientific name	Vernacular name	English name
Abelomoschus spp	Bamia Sara, Waika, Efreeta	Wild okra
Acalypha sp.	Um Imerat,	Chaff flower
Amaranthus sp.	Lissan el Tair	African spinach
Annona senegalensis	Gishta	
Boscia senegalensis	Mokheit	Shepherd's tree
Bracharia sp.	Um keriat	Bread grass
Cassia obtusifolia	Kawal	
Cassia Senna	Sanamakka	
Celosia trigyna	Danab el Kalib, Danabia/Lobira	Cock's Comb
Cissus quadrangularis	el salala	
Commelina beneghalensis	Ibrig el Faki	water grass
Corchorus sp.	khudura, Molukhia	Jews Mallow
Dactyloctenium aegyptium	Um Assabi	Egyptian grass
Datarium senegalenses	Abu Leila	Sweet datock
Diospyros mespiliformis	Abu Sebela	Monkey
Grewia villosa	tamr el abid	Mallow raisin
Gynandropis gynandra	Tamaleika	African Spider flower
Ipomea sp.	Tabr	Bindweed
Lannea schimperi	Atab-hassu/Ghallub	
Launaea cornuta	Moleita	
Leptadenia hastata	Abu Leben, Alag	
Parkia sp.	Um Rashad, Mudus	
Piliostigma thonningii	Khuf Eljamal	Camel's foot
Senna sp.	Sim el Dahib	
Sida alba	Um Hebiba, UmShidayda	
Sorghum arundinaceum	Adar	
Sporobolus pyramidalis	Aish el Far, Tamara	
Strychnos innocua Del.	hog el fil,	Monkey ball
Oryza punctata	Roz Alwadi	

ANNEX 3. Weed species Dominant in White Nile State

Weed species	Family
Aristolochia bracteolate Lam.	Aristolochiaceae
Aristida adscensiois L.	Poaceae
Abelmoschus esculentus L.	Malvaceae
Abutilon glacum (Forst.f.) Schlecht.	Malvaceae
Acalypha indica L.	Euphorbiaceae
Brachiaria eruciformis (J. E. Smith) Griseb	Poaceae
Brachiaria reptans L.	Poaceae
Cynotis axillaries	Commelinaceae
Cynodon dactylon (L.) Pers.	Poaceae
Cucumis melo var. *agrestis* Naud.	Cucurbitaceae
Cyperus rotundus L.	Cyperaceae
Corchorus olitorus L.	Tiliaceae
Corchorus fasicularis Lam.	Tiliaceae
Chloris virgata SW.	Poaceae
Cymbopogon nervatus (Hochst) Chiov.	Poaceae
Cadaba rotundifolia Forsk.	Capparidaceae
Celosia argenta L.	Amaranthaceae
Digera muricata (L.) Mart	Amaranthaceae
Dinebra retroflexa (Vahl.) Panzer.	Poaceae
Dichanthium annlatum (Forsk) Stapt.	Poaceae
Datyloctenium aegyptium (L.) Beauv.	Poaceae
Euphorbia aegyptiaca Bioss.	Euphorbiaceae
Eclipta prostrate (L.) L., Mart.	Asteraceae
Echinocloa colona (L.) Link.	Poaceae
Euphorbia acalyphoidis Hochst. ex Boiss.	Euphorbiaceae
Farsetia longisiliqua Dence.	Brassicaceae
Heliotropium sudanicum F.W. Andr.	Boraginaceae
Indigofera oblongifolia Forsk.	Fabaceae
Ischaemum afrum (J. F. Gmel.) Dandy.	Poaceae
Ipomoea cordofana Choisy.	Convolvulaceae
Leucas urticifolia (Vahl) Benth.	Laminaceae
Leptadenia heterophylla (Del) Dence.	Asclepiadaceae
Momordica balsamina L.	Cucurbitaceae
Merrimia emarginata (Burn.f.)Hallier f.	Convolvulaceae
Ocimum basilicum L.	Laminaceae
Oxygonum atriplicifolium (Meisn.) Mart.	Polygonaceae
Phyllanthus maderaspatensis L.	Euphorbiaceae
Phyllanthus niruri L.	Euphorbiaceae
Panicum hygrocharis Steud.	Poaceae
Portulaca oleracea L.	Portulaceae
Portulaca quadrifida L.	Portulaceae
Polygala erioptera DC.	Polyglaceae

Rhynchosia minima var. *minima* (L.) DC.	Fabaceae
Rottboellia exaltata L.f.	Poaceae
Sorghum arundinaceum (Desv.) Stapf.	Poaceae
Sonchus cornutus Hochst.ex Oliv. & Hiern.	Asteraceae
Sonchus oleraceus L.	Asteraceae
Setaria pumila (Poir.) Roem. & Schult.	Poaceae
Solanum dubium Fresen.	Solanaceae
Sesbania sesban (L.) Merr.	Fabaceae
Sinapsis arvensis	
Thunbergia annua Hochst. ex Nees	Acanthaceae
Tribulus terrestris L.	Zygophyllaceae
Xanthium brasilicum Vell.	Asteraceae
Zaleya pentandra (L.) Jeffery.	Aizoaceae

ANNEX 4: Weed species dominant in New Halfa Agricultural Scheme

Weed species	Family
Aristolochia bracteolate Lam.	Aristolochiaceae
Abelmoschus esculentus L.	Malvaceae
Abelmoschus ficulneus L	Malvaceae
Abutilon glacum (Forst.f.) Schlecht.	Malvaceae
Acalypha indica L.	Euphorbiaceae
Alysicarpus rugosus ssp. *Rugosus* (Willd.) DC.	Euphorbiaceae
Brachiaria eruciformis (J. E. Smith) Griseb	Poaceae
Brachiaria reptans L.	Poaceae
Cynotis axillaries	Commelinaceae
Cynodon dactylon (L.) Pers.	Poaceae
Ctenium elegans Kunth.	Poaceae
Cucumis melo var. *agrestis* Naud.	Cucurbitaceae
Calatropis procera (Ait.) Ait. F.	Asclepiadaceae
Cyperus rotundus L.	Cyperaceae
Cassia tora	Fabaceae
Corchorus olitorus L.	Tiliaceae
Digera muricata (L.) Mart	Amaranthaceae
Dinebra retroflexa (Vahl.) Panzer.	Poaceae
Desmodium sp	Fabaceae
Euphorbia aegyptiaca Bioss.	Euphorbiaceae
Eclipta prostrate (L.) L., Mart.	Asteraceae
Echinocloa colona (L.) Link.	Poaceae
Indigofera oblongifolia Forsk.	Fabaceae
Ischaemum afrum (J. F. Gmel.) Dandy.	Poaceae
Ipomoea cordofana Choisy.	Convolvulaceae
Momordica balsamina L.	Cucurbitaceae
Merremia emarginata (Burm. F.) Hall. F.	Convolvulaceae
Ocimum basilicum L.	Laminaceae
Oldenlandia strumosa (A. Rick) Hiern.	Rubiaceae
Phyllanthus maderaspatensis L.	Euphorbiaceae
Phyllanthus niruri L.	Euphorbiaceae
Rhynchosia minima var. *Minima* (L.) DC.	Fabaceae
Sorghum arundinaceum (Desv.) Stapf.	Poaceae
Sonchus cornutus Hochst.ex Oliv. & Hiern.	Asteraceae
Setaria 110arbor- fusca (Schumach.) Stapf & Hubbard.	Poaceae
Solanum dubium Fresen.	Solanaceae
Sesbania sesban (L.) Merr.	Fabaceae
Thunbergia annua Hochst. Ex Nees	Acanthaceae
Tribulus terrestris L.	Zygophyllaceae
Tephrosia uniflora Pers.	Fabaceae
Vigna trilobata	Fabaceae
Xanthium brasilicum Vell.	Asteraceae
Zaleya pentandra (L.) Jeffery.	Aizoaceae

ANNEX 5: *Germplasm Holdings at the* APGRC

scientific name	crop name	No of Accessions
Abelmoschus esculentus	Okra	545
Allium cepa	Onion	97
Ammi visnaga	Tooth pick weed	2
Anethum graveolens	Dill	16
Arachis hypogaea	Peanut, Groundnut	132
Beta vulgaris	Chard, beet	17
Cajanus cajan	Pigeon pea	71
Capsicum spp	Hot pepper	386
Carthamus tinctorius	Safflower	2
Carum carvi	Common Caraway	9
Cassia	senna, cassia	17
Cicer arietinum	Chickpea	35
Citrullus spp	Watermelon	417
Corchorus olitorius	Jewsmallow	59
Coriandrum sativum	Coriander	31
Cucumis melo	Melon	433
Cucurbita spp	Pumpkins and squashes	124
Datura stramonium	datura, thornapple	14
Eruca sativa	Rocket Sallad	48
Foeniculum vulgare	Fennel	8
Gossypium spp	cotton	97
Helianthus annuus	Sunflower	2
Hibiscus sabdariffa	Roselle	180
Hordeum vulgare	Barley	8
Lablab niger	Hyacinth bean	38
Lagenaria siceraria	Bottle gourd	37
Lupinus spp	Lupins	19
Lycopersicon esculentum	Tomato	238
Medicago	alfalfa	5
Musa spp	Banana	359
Nigella sativa	Black cumin	7
Oryza sativa	Rice	9
Pennisetum glaucum	Perl millet	1455
Phaseolus vulgaris	Kidney Bean	73
Pimpinella anisum	Anise	5
Pisum sativum	Peas	10
Portulaca oleracea	Purselane	24
Raphanus sativus	Radish	31
Ricinus communis	Castor bean	12
Sesamum indicum	Sesame	369
Solanum melongena	Eggplant	21
Sorghum bicolor	Sorghum	4960
Trigonella foenum- graecum	Fenugreek, Sicklefruit	36
Triticum aestivum	Wheat	201

Unidentified taxa	Unidentified taxa	149
Vicia faba	Faba bean	124
Vigna radiata	Mung bean	7
Vigna subterranea	Bambara groundnut	58
Vigna unguiculata	Cowpea	307
Zea mays	Maize, Corn	286
Total		11590

ANNEX 6: Released varieties from plant genetic resources for food and agriculture in Sudan

Crop	Scientific name	No. of varieties		Date	Institutes involved
		Released	Maintained at APGRC		
Bread Wheat	*Triticum aestivum*	25	0	1940- 2013	ARC
Cane Sugar	Saccharum officinarum	13	0	1998- 2013	KSC
Chickpea	*Cicer arietinum*	5	4	1986- 1998	ARC
Cotton	*Gossypium hirsutum*	38	0	1913- 2012	ARC
Cowpea	Vigna unguiculata	3	0	2000	ARC
Common bean	*Phaseolus vulgaris l.*	5	0	1998- 2003	ARC
Faba bean	*Vicia faba*	13	0	1971- 2013	ARC
Garlic	*Allium sativum*	1	0	1995	ARC
Groundnut	*Arachis hypogaea*	12	5	1960- 2007	ARC
Lentil	*Lens culinaris*	3	4	1993- 1998	ARC
Maize	*Zea mays*	20	0	1975- 2015	ARC
Millet	*pennisetum glaucum*	5	0	1970- 2013	ARC
Okra	*abelmoschus esculentus*	3	0	1987	ARC
Onion	*Alli um cepa*	5	0	1987- 2007	ARC
Pea	*Pisum sativum*	5	0	1989- 2011	ARC
Pigeon pea	*Cajanus cajan*	1	1	2000	ARC
Potato	*Solanum tuberosum*	15	0	2004- 2013	ARC
Rice	*Oryza sativa*	4	0	2010	ARC
Roselle	*Hibiscus sabdariffa*	2	0	2012	ARC
Sesame	*Sesamum indicum*	14	0	1964- 2012	ARC
Sorghum	*Sorghum bicolor*	45	1	1957- 2013	ARC/ICRISAT/ ASSCO/ UG
Soybean	*Glycine max*	2	0	2012	ARC
Sunflower	*Helianthus annuus*	26	0	1991- 2015	ARC/ ASSCO/ UK
Sugar Beet	*Beta vulgaris*	2	0	2012	ARC
Squash	*Cucurbita pepo*	2	0	2009	U of G
Sweet potato	*Ipomoea batatus*	2	0	2009	ARC
Tomato	*Lycopersicon lycopersium*	10	0	1993- 2011	ARC/ ASSCO/ UG
Watermelon seed	*Citrullus lanatus*	1	0	2009	ARC
Sweet orange	*citrus sinensis*			1995	ARC