Research on Farming Systems Change to Enable Adaptation to Climate Change

Undertaken for the Ministry of Environment and Tourism and the United Nations Development Program Namibia, in preparation of Namibia's Second National Communication to the United Nations Framework Convention on Climate Change

Prepared by

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LIST OF ABBREVIATIONS

AALS	= Affirmative Action Loan Schemes
AGOA	= African Growth Opportunity Act
AGP	= Average Growth Period
AgriBank	= Agricultural Bank of Namibia
COMESA	= Common Market for Eastern and Southern Africa
CSM	= Cropping System Model
DART	= Directorate of Agricultural Research and Training
DEES	= Directorate of Engineering and Extension Services
DOP	= Directorate of Planning
DSSAT	= Decision Support System for Agrotechnology Transfer
EFTA	= European Free Trade Association
EMU	= Emergency Management Unit
EPA	= Economic Partnership Agreement
EU	= European Union
EWIS	= Early Warning and Information System
FAnGR	= Farm Animal Genetic Resources
FAO	= Food and Agriculture Organization
GCM	= General Circulation Models
GDP	= Gross Domestic Product
INC	= Initial National Communication
IUCN	= International Union for the Conservation of Nature and Natural Resources
LI	= Livestock Improvement
LRD	= Livestock Research Division
MAWF	= Ministry of Agriculture, Water and Forestry
MCA	= Millennium Challenge Account
MDG	= Millennium Development Goal
MEATCO	= Meat Corporation of Namibia
MET	= Ministry of Environment and Tourism
NAB	= Namibia Agronomic Board
NAPCOD	= Namibia Programme to Combat Desertification
NBPTS	= National Beef Performance Testing Scheme
NBRI	= National Botanical Research Institute
NCA	= Northern Communal Area
NCCC	= Namibian Climate Change Committee
NCR	= North Central Region
NDP	= National Development Plan
NEPRU	= Namibian Economic Policy Planning and Research Unit
NHIES	= Namibia Household Income and Expenditure Survey

NPC	= National Planning Commission
NPFS	= National Programme for Food Security
NPGRC	= Namibia Plant Genetic Resources Centre
PWC	= Price Waterhouse Coopers
SACU	= Southern African Customs Union
SADC	= Southern African Development Community
SNC	= Second National Communication
SWAPO	= South West African People's Organization
TOR	= Terms of Reference
UNFCCC	= United Nations Framework Convention on Climate Change
UNDP	= United Nations Development Programme
USA	= United States of America
UNAM	= University of Namibia

EXECUTIVE SUMMARY

BACKGROUND

01. The United Nations Framework Convention on Climate Change (UNFCCC) provides that all Parties must formulate and implement national or regional programmes containing measures to facilitate adequate adaptation to climate change. The vulnerability of agriculture to climate change has become an important issue because of reduced productivity of the sector due to adverse changes. The "Research on Farming Systems Change to Enable Adaptation to Climate Change" study marks a major milestone for Namibia to fulfill its obligation to the UNFCCC. It provides a comprehensive source of information on Namibia's farming systems indicators at a time when Namibia is in preparation of the Second National Communication and developing its Third National Development Plan.

02. The overall purpose of the study was to assess and conduct research needs on farming systems change in Namibia to enable adaptation to climate change. The Terms of Reference (ToR) required the consultants to solicit data and views from relevant sources and principal stakeholders. Information was also obtained from a review of secondary sources. The information was to satisfy the following specific tasks:

a) Compile the farming system change through range of consultations and meetings;
b) Support further quantification of the economic and social impacts due to predicted climate changes and provide guidance to coping strategies thereof;
c) Support, through collaborating with the indigenous livestock breeds project, further development of indigenous livestock breeds by recommending appropriate selection, breeding and testing of genetic material;
d) Provide technical expertise, indigenous germplasm collection and collaboration with the Plant Genetic Resources Centres;
e) Assist the MAWF in development and use of agricultural models;
f) Uphold the capacity building component through the use of students in implementation of tasks;
g) Recommend the suitability of existing data and others suitable for inclusion in the Second National Communication; and
h) Provide recommendations about procedures and institutional arrangements required to sustain data collection and archiving.

03. The above tasks are categorized and assessed in chapters presented in this report. Chapters 1 and 2 are introductory and aim to portray the research problem and approaches used, and to present the physical environment of Namibia. Chapter 3 and 4 investigate the social and economic impacts of climate change. The predicted climate change scenarios for Namibia and the adaptations necessary to reduce climate change impacts are reviewed in Chapter 5. Chapter 6 explores germplasm collection and the use of crop modeling as avenues to addressing adaptations of crop production systems to climate change. Chapter 7 examines improvement of indigenous

livestock breeds for adaptation to climate change. Chapter 8 draws the recommendations and also outlines future research needs for adaptations to climate change.

PHYSICAL ENVIRONMENT

04. Ecologically, 22% of the country is desert and receives a mean annual rainfall of less than 100 mm; 33% is arid with a mean annual rainfall of between 100 and 200 mm; 37% is semi arid and receives between 300 and 500 mm of rain annually; and 8% is semi–humid to sub–tropical with a mean annual rainfall of between 500 and 700 mm. Evaporation ranges between 2400mm/year along the coast and in the Caprivi, and more than 3600mm/year in the eastern Karas Region.

05. Rainfall is a significant constraint to agriculture over most of the country. Not only does the rainfall regime restrict the possibilities of rainfed farming, but it also restricts surface runoff and subsurface flow, so that there are generally very few areas where irrigation can be carried out, either cheaply, or without depleting groundwater reserves.

06. Temperature conditions along the coast can be described as moderately cool (15-20^{o}C); while those of the interior are moderately warm (20-25^{o}C). Average annual maximum temperatures in the hottest months are usually above 30^{o}C over most of the country, excluding the coastal belt where it is much cooler and the arid south where mean temperatures rise to as high as 36^{o}C. July is the coolest month over much of the country with average minimums of less than 10^{o}C.

07. Namibia is a country of sunshine and boasts on average between 8 and 10 hours of sunshine per day throughout the year. Winds are southerly, and south-winterly winds dominate both the frequency (30-40%) and strength (6 - >9m/s) along the coast, whereas variable winds of the interior do not present a clear pattern.

08. The productivity of the soils are limited, and this together with the low average rainfall, as well as the extreme arid to semi-arid climatic and physiographic conditions, place severe limitations upon the country's agriculture. Over 90% of the country's soils have a clay content of less than 5%, and thus have a very low water holding capacity. They are generally deficient in most of the major and micro nutrients. If there were to be locally much less rainfall and increasing intra- and inter-annual variability, these could lead to less dry-matter production and hence, in due course, lower soil organic matter contents.

09. Higher temperatures, particularly in arid conditions, entail a higher evaporative demand. Where there is sufficient soil moisture, for example in irrigated areas, this could lead to soil salinization if land or farm water management, or irrigation scheduling or drainage are inadequate.

FARMING SYSTEMS

10. The agricultural sector has, broadly, a dual system comprising a well developed, capital intensive and export oriented *commercial sub-sector* and a subsistence-based *communal farming sub-sector*, low in technology and external inputs and highly dependent on labour. It is estimated that about 152 000, 20 300 and 16 000 households are directly involved in crop, cattle and small stock production respectively. Five major farming systems exist in Namibia and these are: small-scale cereals and livestock, small stock production, mixed cattle ranching, intensive agriculture and natural resource production.

11. Owing to climate, soil types and evapo-transpiration rates, Namibia is better adapted to livestock-based as opposed to crop-based agriculture. At the present moment, livestock contribute 70% to the agricultural economic output. The areas receiving between 250 and 400 mm rainfall allow cattle farming, and consequently mixed livestock farming based on ruminants. In areas with rainfall in excess of 400 mm, cattle farming is predominant but dry-land crop production can be initiated.

12. Crop production activities are limited, mainly due to general dry conditions (lack of water) and poor soils. Low and sometimes poorly distributed rainfall have limit rain-fed crop production to only those areas receiving 400 mm and above annually or about 34% of the country. Rain-fed crops include pearl millet, sorghum and maize.

13. Irrigated agriculture is concentrated in fertile areas with high annual rainfall or abundant water resources from rivers, streams, dams or boreholes. Horticultural production occurs across a wide range of environmental conditions, with distribution restricted primarily by access to water, water quality, soil quality and by topography. Horticulture supports more than 100 crop types, categorized into 21 commodity groups. Horticultural production systems have good potential for expansion in Namibia and are seen as a source of adaptation to climate change.

14. The development of farming systems is supported by an agricultural policy which is pro-poor and driven by a need to reduce poverty. Namibia is an active participant in trade agreements and is an active member of several trade arrangements and trading communities.

SOCIAL AND ECONOMIC IMPACTS

15. The capacity of a farming system to adapt to changing weather and climate conditions is chiefly based on its natural resource endowment and associated economic, social, cultural and political conditions. The socio-economic environment in Namibia is currently characterized by the following trends which potentially have a great influence on its ability to adapt to climate change:

- Namibia is the most arid country south of the Sahara. Rainfall is low and variable and droughts occur frequently. The inherent human carrying capacity is low.
- Due to its aridity, the environment is extremely sensitive to over utilization.

- Population growth of approximately 3% is high. The population is youthful in character with 57.4% of the population falling in the age group of between 16 and 64.
- 70% of Namibians depend on natural resources, particularly agricultural land, for much of their livelihoods.
- More than 70% of the Namibian population lives within 100km of the northern perennial rivers, while less than 15% of the population lives south of Windhoek in more than 40% of the surface area. Certain areas thus experience more land pressure as a result of population.
- Internal migration, mostly from rural areas to urban and mining centres is rife.
- The income distribution in Namibia is extremely skewed with a large part of the population living in poverty. Levels of vulnerability to natural and personal disasters are high among some sections of the population (especially female headed households, disabled people, Ovatua and Khoisan).
- Traditional management of the communal land tenure system is losing its effectiveness
- Access to credit is limited and savings mobilization is low.

17. The effect of climate change on the livestock sector is experienced through changes in quality and quantity of vegetation, availability of fodder and the occurrence of climate related animal diseases. Indirectly, these factors transcend themselves on livestock productivity parameters such as conception and calving rates, mortality rates and meat quality.

18. During periods of drought, livestock production volumes decrease, while the number of livestock marketed increases. The value of cattle and smallstock may drop due to increased supply and the deteriorating conditions of the animals. Farmers often opt to sell their animals before the value reaches unacceptably low levels. The government's livestock marketing incentive schemes during periods of droughts contributes to this situation. In fact, marketing of livestock declines immediately after periods of droughts because farmers are rebuilding their herds.

19. In times of drought the export of quality meat cuts decline leading to Namibia not meeting its quota allocation for meat exports to the European Union (EU). Since only 20% of the measured production of cattle and smallstock is consumed domestically and 80% is exported, increases in sales in years of drought will consequently result in a rise in export volumes. Climate variability and occurrences of drought are generally classified as supply-side factors and hence influence prices. There is evidence of marginal downward pressure on domestic livestock prices during times of drought and a slight upward pressure on livestock prices in periods immediately after droughts. These effects are not felt in export markets because Namibia is a price-taker in those markets.

20. The impact of climate change on the dairy sector is mainly through input shortages and prices. Input prices of dairy products increase in times of drought. Farmers have to purchase

additional fodder to feed their milk cows. Karakul sheep are very well adapted to the harsh climatic conditions of the arid and semi-desert areas of southern Namibia. Karakul production is thus less vulnerable to drought. Prices of karakul pelts are not very sensitive to drought but are more influenced by other factors such as the whims of fashion, the economic situation in consumer countries and mink prices.

21. Although the cereal sub-sector on the average contributed around 7% to total agricultural economic output, it is important in terms of its contributions to food security and export earnings. This sector is sensitive to climate variability and change, and yield tends to oscillate accordingly. The areas planted vary over time and this may present statistical problems in portraying impacts.

22. The periodic fall in cereal outputs due to drought or floods create cereal deficits, which increases cereal imports and prices. Market distortions make determining impacts on secondary markets such as millers difficult, while extreme occurrence of drought and floods puts tremendous pressure on the government budget and reliance on external sources. With climate change, these occurrences are expected to be frequent thus necessitating huge budget appropriations for the national drought relief programme/fund.

CLIMATE CHANGE TRENDS AND ADAPTATION ACTIONS

23. There is sufficient evidence suggesting significant changes in global climate over the past century, and that this phenomenon will continue throughout the 21st century due to anthropogenic activities as well as natural cycles. Climate change predictions for Namibia by the 2050s decade include:

- Expected increase in potential evapotranspiration of 4% - 8% for central and eastern Namibia, 8% - 12% for North Central Regions (NCR), and 12% - 16% for the Caprivi Region;
- An anticipated decrease of up to 5% in mean annual precipitation, with an increased variability of between 5% and 10%;
- Shortened length of the rainy season.

24. Predicted changes in climate for Namibia have implications for agricultural productivity. With changes in precipitation and hydrology, temperature, length of growing season and frequency of extreme weather events, considerable efforts would be required to prepare Namibia to deal with climate-related impacts in agriculture. The study depicts a number of adaptation strategies employed within the various farming systems:

- Advance in irrigation
- Water harvesting technologies
- Conservation agriculture systems
- Crop diversification initiatives
- Use of improved crop varieties
- Increase seed and fertilizer availability
- Increasing use of protected cultivation systems (e.g. greenhouses)

- Improve post-harvest systems
- Shared water resource management
- Early warning systems

DATA MANAGEMENT

25. Adaptation practices require extensive high quality data and information on climate, and on agricultural, environmental and social systems affected by climate, with a view to carrying out realistic vulnerability assessments and looking towards the near future. Therefore, climate change assessment must observe the impacts of variability and changes in mean climate variables (inter-annual and intra-seasonal variability) on agricultural systems. However, agricultural production systems have their own dynamics and adaptation has a particular emphasis on future agriculture.

26. Constraints in farm data management and dissemination are directly linked to low and declining investments of the public sector in data collection, analysis, dissemination and storage. There are, however, many projects and institutions currently involved in different aspects of farm data collection, generation and storage. In general though, the quality and quantity of data that is available hardly reflects the efforts and resources that are allocated to this effort. There is minimal effort to synthesize and present the available data in a manner that can be used for decision support at the farm or community level. A concerted effort to harness and co-ordinate the various efforts would contribute significantly to the compilation and dissemination of farm data.

CROP MODELING

27. There are two basic approaches for evaluating crop's and farmer's responses to changing climate: (1) structural modeling of the agronomic response of plants and the economic/management decisions of farmers based on theoretical specifications and controlled experimental evidence; and (2) reliance on the observed response of crops and farmers to varying climate. For the first approach, sufficient structure and detail are needed to represent specific crops and crop varieties for which responses to different conditions are known through detailed experiments. Similar detail on farm management allows direct modeling of the timing of field operations, crop choices, and how these decisions affect costs and revenues. The ability of simulation models to predict growth and development as affected by soil and weather conditions, agronomic practices and cultivar traits makes such models attractive tools for crop improvement.

28. The availability of data with the necessary geographic detail, coupled with human resource capacity in modeling, is currently the major limitation rather than the computational capability or basic understanding of crop responses to climate. In response, this study facilitated a capacity building initiative in the use of the Decision Support System for Agrotechnology Transfer (DSSAT) V.4 model to the Namibian situation. Nineteen participants from 9 different stakeholders attended the training.

29. The DSSAT training was aimed at preparing Namibian agricultural systems for climate change. The overall aim of such adaptation is to make the best use of climate as a resource for agriculture by enhancing the capabilities of agriculturalists, agribusiness and organizations to respond to climatic variations and climate change. Specific objectives were to promote sustainable agricultural development in Namibia; to reduce vulnerability to, and increase the capacity to respond to, climatic hazards; and to adapt to new climatic resources as they materialize.

30. Due to lack of time and some slow progress during the workshop, the application of the crop models toward climate change in adequate detail was poorly addressed. There is a need to evaluate the models with local data prior to applications for credibility purposes.

GERMPLASM MANAGEMENT

31. The role of germplasm in the improvement of cultivated plants has been well recognized in Namibia. Efforts towards crop improvement in Namibia have mainly been focused on development of improved varieties of millet, sorghum, groundnut, Bambara groundnut and cowpeas by Ministry of Agriculture, Water and Forestry (MAWF). The improved varieties have the potential to enhance farmers' yields under erratic rainfall, improve household food security and income generation.

32. Viable and effective germplasm collection, conservation and utilization can support sustainable research and development. Indigenous crops and tree species also play a major role in food security, health and environment under changing climate trends. However, there has been pressure on these resources due to over-exploitation, and habitat loss, which are made worse by related rapid loss of indigenous knowledge. Domestication and commercialization of these useful plant species remains a challenge for conservation of biodiversity.

33. The use of germplasm collections is still limited despite its wide recognition. National Plant Genetic Resources Centre (NPGRC) devotes a major effort in collecting germplasm for conservation and utilization of plant genetic resources for food production. At present, NPGRC houses 3,010 accessions, representing about 1,140 wild species and 1,870 crops.

34. The knowledge base for genetic resources conservation and evaluation, as well as for research on the collections that is necessary to support utilization among the frontline officers in MAWF, is limited. An urgent need exists for MAWF to undertake, purposely and systematically, a greatly increased strategic research effort on conservation, evaluation and enhancement of its mandated crops with research and extension personnel in the relevant agro-ecological zones.

35. Germplasm evaluation, in the broad sense and in the context of genetic resources, is the description of the material in a collection. It covers the whole range of activities starting from the receipt of the new samples by the curator and growing these for seed increase, characterization

and preliminary evaluation, and also for further or detailed evaluation and documentation. Until a collection has been properly evaluated and its attributes become known to breeders, it has little practical use. After collection of germplasm, there is need for its systematic evaluation in order to know its various morphological, physiological and developmental characters including some special features, such as stress tolerance, pest and disease resistance, etc.

IMPROVEMENT AND CONSERVATION OF INDIGENOUS BREEDS

36. Generally, experiments into the adaptability, heat tolerance and disease resistance of various livestock species and breeds are lacking, while some farm animals and chickens in particular, are least studied despite the fact that their roles in majority of households can be equated to, or may surpass that of cattle and goats. To date, the MAWF succeeded in the characterization, partial conservation and dissemination of local breeds to farmers. Farmers need technical guidance from professional breeders to help them map out their breeding strategy and long-term objectives based on a clear breeding policy guidelines.

37. There is a need for technical guidance and leadership to ensure that all Livestock Improvement Project activities will mature to be science-based, profit-oriented, and customer-driven, to enable the project to intelligently use selection and crossbreeding technologies based on sound biostatistics and economics. Part of the path is to purposely build capacity of researchers to professional postgraduate qualification levels.

38. The adaptation of the Nguni to the harsh hot areas of northern Namibia, its low feed and water requirements, good walking ability and resistance to diseases, make the Nguni a low input breed, ideal for production in communal areas where farmers do have limited resources for expensive licks and medicine needed to rear most of the exotic breeds. Despite excellent adaptation qualities to local environment, indigenous animals are threatened by rive genetic erosion and potential loss of biodiversity because of cross breeding and other climate related disasters such as drought, wild fires and floods.

39. The performance of indigenous livestock is reckoned to be poor, whereas the majority of exotic breeds are poorly adapted to most of Namibia’s harsh farming environment. In order to meet its objectives and enhance service delivery to livestock farmers, the MAWF has over the past few years improved infrastructure and facilities at some of the existing research stations, while new stations (e.g. Oshaambelo and Okapya) were established in recent years.

40. In an attempt to promote livestock production in Namibia, the MAWF initiated a programme of distributing superior quality livestock to previously disadvantaged ‘communal farmers’ at subsidized prices. However, given the fact that the mode of distribution is via auctions, well-off commercial buyers outbids the rightful targeted beneficiaries.

41. Even though the MAWF is committed to conserve and promote the keeping of indigenous stock, there appears to be conflicting messages from other stakeholders that are promoting the use of less adapted, but high yielding (i.e. birth and weaning weights) exotic breeds. Since there is limited, if at all, material gain in conserving indigenous stock to the farmers keeping indigenous animals, there is need to introduce incentives while considering *ex situ* and *in situ* conservation. At the moment, the farmers in the NCRs are responding to market forces (i.e. Meatco pays, comparatively, higher prices for young and heavier animals with better carcass quality) in their strategy of exploiting their existing gene pool by crossbreeding with exotics.

RECOMMENDATIONS

41. The study puts forward several recommendations on how adaptation to climate change can be strengthened, and these are summarized as:

- **Strategic Policy Framework**

While being cognizant of the effects of climate change, such as reduced rainfall and higher temperature regimes, few policies currently reflect the need to respond to and prepare the economy for the impacts of climate change. There is a need to mainstream climate change issues into national policies and strategies. These can be initiated and enhanced by intensified activities of the Namibia Climate Change Committee and its various working groups at both national and regional levels. Targeted strategies are needed to better ensure that decisions and investments made do not suppress the ability of farming communities and their economic sub-sectors to adapt to future climatic changes.

- **Long-term Funding for Research and Development**

Investment in research and development is required to enhance capacity in research, development and innovation to address the Namibian challenges of climate change in agriculture. Agriculture will be better able to meet the challenges of climate change if research, extension and development practitioners, industry and farmers utilize a participatory approach to research and development. A deliberate and emergent financing strategy for research and development need to be created within a stakeholder participatory planning process.

- **Research Programme Formulation and Priority Setting**

Research needs for adaptation to climate change is not sufficiently articulated within the national agricultural research programme and agenda. Programme formulation with clearly set out, widely understood, and multi-stakeholder coordinated priority setting mechanisms will facilitate the implementation, monitoring and evaluation of well-thought government initiated research programmes. A formal multi-disciplinary research programme review, evaluation, and monitoring exercise for Namibia is proposed to ensure that proper guidance is given to all research institutions, professionals and the farming community alike.

- **Coordinated Data Management**

There is no formal system for farming data (field crops, fruits, vegetables, small-stock, large-stock, economic, social, environmental, etc.) management in Namibia. The current practice is ad-hoc oriented for incoming, internal, and outgoing information among the diverse farming service providers. There is a need to maintain and enhance the collection of accurate physical, economic and social data that will enable the development of models that predict the impacts of climate change on agriculture.

- **Strengthening Communication and Awareness through Establishing an Adaptation Information and Advice Service**

Bringing climate change rather than just climate variability into focus as an additional element in normal strategic planning and climate risk management in agriculture requires awareness raising and capacity building. Efficient and planned awareness, incorporating climate change considerations in policy and programme communications, will foster an increased understanding and integration of scientific knowledge into farm management decisions and incorporate issues of climate change adaptation into education and training packages directed at agricultural industries. Sources of climate change information and advice on adaptation strategies in the farming communities are not generally available, and it is necessary to propose the formation of climate change information and advise service to satisfy this need.

- **Investment in Breeding, Biotechnology and Seed Technology Programmes**

Namibia must promptly promote the use of indigenous and locally-adapted plants and animals as well as the selection and multiplication of crop varieties adapted or resistant to adverse conditions. The selection of crops and cultivars with tolerance to abiotic stresses (e.g. high temperature, drought, flooding, high salinity content in soil and water, pest and disease resistance) allows harnessing genetic variability in new crop varieties. Biotechnology can contribute to agricultural productivity and food security. In Namibia, issues in the realm of seed science and technology including seed health and testing, are not adequately addressed and coordinated. There is for instance no seed health laboratory that farmers can resort to for diagnostics, if their crops are beset by seed borne diseases. There is lack of information on seed science issues including seed research and science-based seed testing. There is a need for technical expertise and other resources to utilize existing seed testing facilities in a coordinated fashion with the leading organized seed production and supply organizations in the crop growing Regions.

- **Empowerment and Broadening of Early Warning Systems**

There is a need for better cooperation between the Early Warning and Information Systems Unit of MAWF with the Emergency Management Unit of the office of the Prime Minister in order to better utilize the assessment of short- and long-term impact of adverse natural events on agriculture livelihoods, while contributing to disaster preparedness and mitigation of potential risks, through the establishment of a historical climate data archive with monitoring tools using systematic meteorological observations, and information tools on the characteristics of farming system vulnerability and adaptation effectiveness such as resilience, critical thresholds and coping mechanisms.

- **Strengthening of Social Protection Policies**

Given fiscal and administrative constrains, and an economic context of reducing government interventions in the economy, public actors should work together in partnership with private and informal actors to deliver effective social protection. There is a need to improve targeting and quantifying of household vulnerability. Given the close linkages between chronic and transitory food insecurity, at times exacerbated by effects of climate variability, public interventions should achieve positive synergies between social protection and pro-poor economic growth.

RESEARCH NEEDS

42. The study identified future research needs to enable adaptation to climate change in the following key areas:

- **Crop Breeding and Germplasm Evaluation**

In order to reduce possible adverse consequences to climate change, the agricultural sector should be encouraged to continue develop crop breeding and management programs for heat tolerance and agronomic drought. Collection of germplasm alone is tedious and requires harnessing sufficient human and financial resources. Henceforth, sufficient resources should be made available to adequately support the participation of extension agents in the germplasm collection activity.

- **Climate Change Monitoring**

The clearest objective at present is to prepare for changing climatic hazards by reducing vulnerability, developing monitoring capabilities, and enhancing the responsiveness of the agricultural sector to forecasts of production variations and food crises. A pilot assessment designed to monitor climate variability while enhancing adaptation of farming systems is needed.

- **DSSAT Crop Model Simulation and Validation**

Following the capacity-building initiative, there is a need for technical support in validation of the crop models with experimental data from the fields. This will allow for modeling yield changes, and changes in growing season length arising from climate change, and the identification and evaluation of alterations in agricultural practices that would lessen any adverse consequences of climate change.

- **Ricardian Approach-Based Study**

Current initiatives to model climate change impacts are limited to crops. There is a need to model the impact of climate change on farm production units, other than crops. The Ricardian model offers a rigorous alternative model for studying climate change impacts on the agricultural economy. A fully fledged fieldwork-based study, to collect data on the various parameters to be included in the model, is highly recommended.

CONCLUSION

43. The project succeeded in establishing the baseline situation in the agriculture sector in Namibia: its significance to the national economy, high level of sensitivity to key climatic variables, climate variability-induced losses in agricultural outputs in recent past, other socio-economic drivers for vulnerability of the sector, traditional knowledge and practices existing within the farming community for coping with climate variability, knowledge and information gaps for better decision making and farming system management.

44. In responding to farming systems adaptation to climate change, government and development partners have a noteworthy, enduring role in supporting the efficient allocation of resources, managing distribution of costs and benefits proportionally amongst those potentially affected, and in facilitating efficient decision-making by providing information, institutional support and policy frameworks. Developing and implementing adaptation strategies to climate change oblige the involvement and concerted efforts of many stakeholders in ensuring an efficient delivery system. Implementing adaptation measures at farm level requires that research and development, coupled with extension, is well coordinated.

CHAPTER 1: INTRODUCTION AND BACKGROUND

1.1 Introduction

Namibia is an arid country in south-western Africa with a total land area of 824 268 km^2 (NPFS, 2007). About 70% of Namibians are directly dependent on natural resources to sustain their daily lives: wood serves as building material, fuel and light, cattle is not only a source of meat, but also milk, drought power and dung for fertilization, the veld and forests of Namibia do not only provide timber but also additional food stuffs, medicinal plants, and ultimately, water is the critical resource to sustain resources as well as livelihoods. The two most predominant features of Namibia's climate are the scarcity and unpredictability of its rainfall. Climate variations, chiefly in the form of droughts and to a lesser degree floods, have a major impact on agriculture. Since a large proportion of the population lives in rural areas, drought usually has devastating effects on commercial agricultural productivity and the rural poor (Christelis and Struckmeier, 2001), causing considerable stock losses and reduced grain production (GRN, 2002).

Namibia's agro-ecological base is composed of arid and semi-arid zones having only limited development potential. The soil and terrain conditions of Namibia are generally not conducive to agriculture and food production. Indeed, considering soils, rainfall and/or water supply, only less than 5% of the land surface is considered to have medium to high potential for rainfed and irrigated crop production. In the Northern Communal Areas (NCAs), the agro-ecological base mainly supports a variety of smallholder production systems of crop and livestock husbandry based on uncertain rainfall patterns (PWC, 2005), and limited technology inputs for optimum production and marketing. By contrast, commercialized cattle ranching with some small stock (goats and sheep) ranching dominates the agricultural economy in the Regions south of the Veterinary Cordon Fence.

Water availability is the most important factor limiting agricultural production in Namibia. One of the most significant impacts of climate change is likely to be on the hydrological system, and hence on river flows and water resources of the country. This is especially important given the semi-arid nature of the country, where water resources are very sensitive to climate variability and change. As climate changes, several direct influences alter precipitation amount, intensity, frequency and type (Solomon, Qin, Manning, Alley, Bernstein, *et al.*, 2007). Warming accelerates land surface drying and increases the potential incidence and severity of droughts, which has been observed very often in Namibia. Decreased land precipitation and increased temperatures that enhance evapo-transpiration and drying are important factors that have contributed to more droughts (Trenberth, Jones and Ambenje, 2007). Average annual rainfall in Namibia varies from less than 20 mm on the Atlantic coast to 600 mm in the northeast, and only 8% of the country receives more than 500 mm in average rainfall annually (Christelis and Struckmeier, 2001). Most rain falls during the summer and agricultural drought remains a common phenomenon throughout the country.

Henceforth, irrigation development is seen by some as the best means of mitigating the effects of drought. Climate model simulations and empirical evidence all confirm that warmer climates, owing to increased water vapor, lead to more intense precipitation events even when the total annual precipitation is reduced slightly, and with prospects for even stronger events when the overall precipitation amounts increase. The warmer climate therefore increases risks of both drought – where it is not raining, and floods – where it is but at different times and/or places. For instance, the most devastating drought climaxed during the 1970/71 season the Region has ever experienced was followed a year later in March 1972 by an overnight filling of the Hardap Dam with 150mm rain in the fish river catchment area and with opened flood gates, the town of Mariental flooded (Rawlinson, 2004).

The United Nations Framework Convention on Climate Change (UNFCCC) makes a distinction between climate change attributable to human activities altering the atmospheric composition, and *climate variability* attributable to natural causes. The common conclusion of a wide range of fingerprint studies conducted over the past 15 years is that observed climate changes cannot be explained by natural factors alone (Sommerville et al., 2007). Social and economic factors add further dimensions to the impacts of climate change because they influence vulnerability and henceforth influence the relative extent of climate change impacts. Through a cross-sectional research analysis, this study aims to assess and conduct research needs on farming systems change in Namibia to enable adaptation to climate change.

1.2 Background to the Study

The UNFCCC was adopted in New York on 9 May 1992. On 16 May 1995, Namibia ratified the UNFCCC and became legally obligated to adopt and implement policies and measures designed to mitigate the effects of climate change and to adapt to such changes. Following its ratification of the UNFCCC in 1995, a country study on Greenhouse Gas inventory, an overview of Namibia's vulnerability to climate change and a mitigation study with economic scenarios, emission scenarios and mitigation options was finalized in 1998. The Namibian Climate Change Committee (NCCC) was established in 2001 to direct and verse further obligations to the UNFCCC. Namibia has since submitted its Initial National Communication (INC) in 2002 and is now in preparation for its Second National Communication (SNC).

Within the framework of the above, various studies and assessments have identified agriculture as one of the most vulnerable sectors that will be affected by climate change, and recommended that more systems be developed to match crop species and cultivars to environmental conditions, including climate, soils and farming systems (GRN, 2002).

1.3 Study Objectives

As part of Namibia's preparations for the SNC to the UNFCCC, the main task of the 'Research on Farming Systems Change for Adaptation to Climate Change' study are extracted and summarized from the ToR (Annexure A) as follows:

a) Compile the farming system change through range of consultations and meetings;
b) Support further quantification of the economic and social impacts due to predicted climate changes and provide guidance to coping strategies thereof;
c) Support, through collaborating with the indigenous livestock breeds project, further development of indigenous livestock breeds by recommending appropriate selection, breeding and testing of genetic material;
d) Provide technical expertise, indigenous germplasm collection and collaboration with the Plant Genetic Resources Centres;
e) Assist the MAWF in development and use of agricultural models;
f) Uphold the capacity building component through the use of students in implementation of tasks;
g) Recommend the suitability of existing data and others suitable for inclusion in the Second National Communication; and
h) Provide recommendations about procedures and institutional arrangements required to sustain data collection and archiving.

1.4 Methodology

The study was undertaken during the period June 2007 to February 2008 using a combination of research approaches carried out in Hardap, Karas, Khomas, Kunene, Ohangwena, Omaheke, Omusati, Oshana, Oshikoto and Otjozondjupa Regions, representing the four major farming systems in Namibia, namely: small-scale cereals and livestock; cattle ranching; small stock; and intensive agriculture. In undertaking this study, the following methods were employed:

1.4.1 Desk Review

A desk review of the recent work in the agricultural sector was conducted ahead of the fieldwork, to become familiar with the current issues in the sector and gather pertinent information on farming systems change to enable adaptation to climate change. The various secondary sources comprised technical reports, books, review papers and maps, all of which were deemed useful based upon the overall objective of this study. A list of the reviewed reports and documents are denoted in the Reference section of this report.

1.4.2 Consultations and Stakeholder Involvement

Broad-based consultations involving the consultants, coordinating agencies and various key stakeholders were conducted for the purpose of implementing this study (Annexure B). Mobilization of this study among stakeholders was accomplished through various role players at regional and local government levels. Relevant government departments were informed by way of an introduction letter issued by the Ministry of Environment and Tourism (MET), while Regional and local authorities were contacted prior to field visits to garnish support for the study and to mobilize participation of stakeholders at Regional and local levels. Directorate of Extension and Engineering Services (DEES) and Directorate of Agricultural Research and Training (DART) Directors, in consultation with the coordinating agencies, facilitated and ensured that their staff participated in the Decision Support System for Agrotechnology Transfer (DSSAT) Crop Modeling Training Workshop.

1.4.3 Field Work

Piloting of the germplasm collection instruments was carried out in Omusati and Oshikoto Regions before the actual germplasm collection in the crop growing Regions. Group discussions were held with farmers, community activist, and research and extension personnel in the target Regions visited. The indigenous livestock improvement centres, currently under construction, were visited in Omusati and Oshikoto Regions to assess practical suitability for the development of suitable breeding management systems.

1.4.4 Capacity Building

In addition to the above initiative of building local and future leadership, and in order to enhance in-country capacity to deal with farming systems change to enable adaptation to climate change, the consultants (i) organized and facilitated a local DSSAT v4 Training Workshop, and (ii) initiated germplasm collection activities. A renowned DSSAT Crop Modeling Expert, Prof. Gerrit Hoogenboom from the University of Georgia USA, conducted the workshop for 19 participants from various institutions dealing with agricultural planning, extension, agronomic research and training in Namibia. Five undergraduate students in agriculture were taken on board of this study to, amongst others; assist with the collection of germplasm of indigenous plants from the crop growing Regions of Namibia. Following failure to streamline and coordinate the research activities of this important component with that of the National Plant Genetic Resources Centre (NPGRC), the consultants resorted to prepare the students with a basic germplasm collection technique and storage of material in the gene bank at Ogongo Campus of the University of Namibia.

1.4.5 Data Analysis and Projections

All data and inputs gathered during the desk review and consultations for this study were reviewed to describe the current state of the farming systems in Namibia. During this activity, the consultants concentrated on important variables and factors influencing crop and livestock production across all agricultural tenure systems.

Based on the perceived strength of the relationship between individual socio-economic variables and the natural environment, the consultants investigated the trends in the state of the farming environment including bush encroachment, soil erosion and carrying capacities. The socio-economic variables underlying these trends and patterns, together with the knowledge of local conditions were used to identify issues of environmental concern and progress. While the team relied heavily on readily available local and Regional scientific reviews on climate change, useful information was extracted from local weather data obtained from Namibia Meteorological Services and General Circulation Models (GCM) data generated by the University of Pretoria. This, together with the issues highlighted during the field work, consultations and those that were identified from desk review activities, provided the focus to the team in the identification and characterisation of socio-economic indicators that has a bearing on climate change and coping strategies thereof.

1.5 Overview of Report Layout

The report layout consists of eight chapters, each presenting an enquiry in a specific research problem relating to climate change issues and farming systems in Namibia, as contained in the ToR. This study is part of a series of research projects that will contribute to the preparation of Namibia's SNC to the UNFCCC.

Chapters 1 present general information about the research problem, and the research approach of the study. Chapter 2 is a description of the environmental circumstances of Namibia. The study recognizes the strong link between climate change and poverty. In portraying climate change linkages to poverty and food security, Chapter 3 examines the key selected socio-economic indicators that characterizes the state of human development in Namibia and analyze the implications and relationships of these indicators on climate change impacts.

Chapter 4 endeavors to present an overview of the agricultural sector in Namibia. It gives pertinent descriptive information about the various agricultural sub-sectors within the overall farming systems. In particular, the typical characteristics of each farming system are outlined and the relative importance in terms of contribution to total agricultural output is assessed. As a basis for performance comparison, an important distinction is made between farming in commercial and communal areas.

Chapter 5 present climate change scenarios using GCM data obtained from the University of Pretoria. The analysis of climate change scenarios looks at trends globally, regionally and trends specific to Namibia. The analysis of Namibian specific climate change scenarios and trends helps in drawing important conclusion about the likely future impacts of climate change on farming systems in Namibia, and forms the basis for recommending research needs and adaptation strategies.

As prelude to developing adaptation strategies against climate change, Chapters 6 and 7 outlines the Namibia's status at preserving and promoting the use of local genetic materials for both fauna and flora, which is believed to be best suited to local climate and offers better resilience to negative climate change offers impacts discussed in Chapters 3-5.

Finally, Chapter 8 presents a composite of recommendations, derived from the findings of the study, outlined for further consideration and development. The ToR required the consultants to solicit data and views from particularly the Ministry of Agriculture, Water and Forestry (MAWF). Together with information sourced from the review of secondary data sources, this information is structured within the entire report. Finally, the conclusion features as Chapter 9.

CHAPTER 2: OVERVIEW OF PHYSICAL ENVIRONMENT OF NAMIBIA

2.1 Introduction

The concept of sustainable development is the cornerstone on which development thinking worldwide is moving. Sustainable development implies that the three fundamental objectives of economic development, social development and environmental development be addressed at the same time within politically and culturally acceptable ways. While, Namibia has subscribed to this approach since the United Nations Convention on Environment and Development (Rio Convention) in 1992, an understanding of its physical and social context is important in developing policies and strategies that embraces climate change adaptation measures.

Agriculture, one of the most vulnerable sectors to climate change, depends heavily on natural resources. The basic climate elements directly influence the spatial distribution of crop types, livestock and wildlife species and agricultural systems, because different species require different amounts of rainfall, humidity, warmth and sunshine. This chapter aims to give an overview of Namibia's physical environment.

2.2 Geographical Features

Namibia's land surface stretches about 1,320 km between the northernmost and southernmost points (MCA, 2006). The country consists of poorly vegetated steppe-like areas dominant in southern and western Regions, the Namib Desert in the west along the Atlantic Ocean, the Kalahari Desert in the southeast, extensive savannah and woodlands in the central and north-eastern areas, and subtropical forests in the far north-eastern Regions

Ecologically, 22% of the country is desert and receives a mean annual rainfall of less than 100 mm; 33% is arid with a mean annual rainfall of between 100 and 200 mm; 37% is semi arid and receives between 300 and 500 mm of rain annually; and 8% is semi–humid to sub–tropical with a mean annual rainfall of between 500 and 700 mm (GRN, 2005). Areas defined as forests cover just less than 10% of the country (Mendelsohn and El Obeid, 2005). Five perennial rivers are found along the borders with neighboring countries; and all other rivers are peripheral.

2.3 The Average Climatology of Namibia

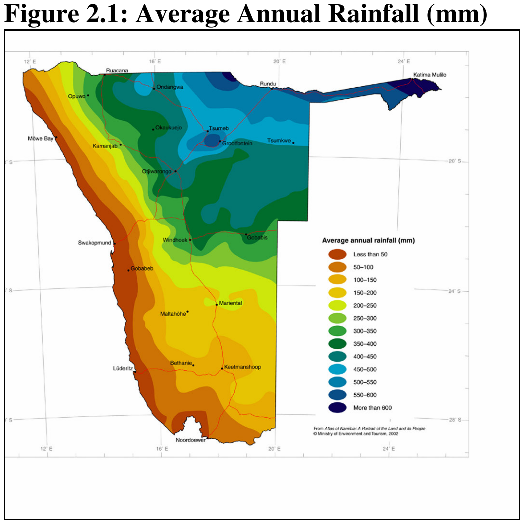
Namibia as a whole is characterized by a dry climate (Christelis and Struckmeier, 2001), and agricultural production is severely constrained by its arid climate (Werner, 2000). The arid climate is a result of Namibia lying along the edge of south-western Africa where it is placed between two climate systems (Mendelsohn and El Obeid, 2005): the Inter-tropical Convergence Zone, that feeds moist air southwards from the tropics and Indian Ocean, and the Subtropical High Pressure Zone, from which dry, cooler air to the south pushes the tropical moist air away to the north.

2.3.1 Average Rainfall in Namibia

Rainfall is a significant constraint to optimum agriculture output over most of the country due to its scarcity and unpredictability. The mean annual rainfall for Namibia is about 270mm (Christelis and Struckmeier, 2001). Figure 2.1 shows that the semi-humid to sub-tropical areas of Namibia receives a mean annual rainfall of 500-700mm, while the desert, arid and semi-arid areas receive <100mm, 100-200mm and 300-500mm respectively. Only 34% of the country is receiving on average more than 400mm of rain, which is considered to be the minimum for reliable crop production (Werner, 2000). The isohyets generally lies northwest to southeast, decreasing from northeast.

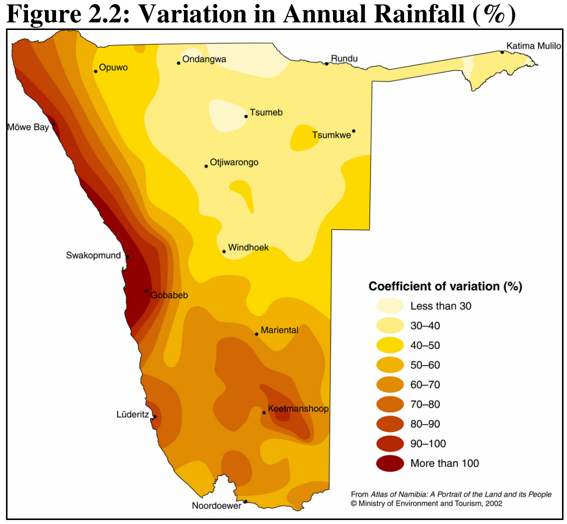
Not only does the rainfall regime restrict the possibilities of rainfed farming, but it also restricts surface runoff and subsurface flow, so that there are generally very few areas where irrigation can be carried out, either cheaply, or without depleting groundwater reserves. In addition to the high levels of variation in average rainfall, the rainfall is also highly variable between seasons (Figure 2.2). In large parts of the country, especially towards the west, the coefficient of rainfall variation is more than 40%, while it is between 20% and 40% in the remainder of the country (MCA, 2006).

Figure 2.1: Average Annual Rainfall (mm)



Source: Atlas of Namibia

Figure 2.2: Variation in Annual Rainfall (%)

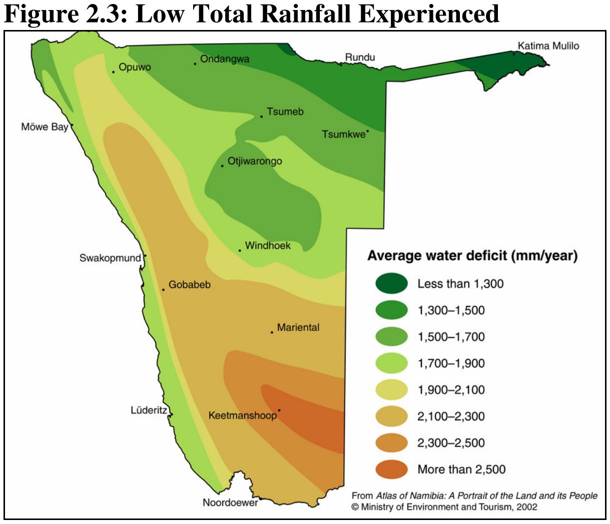


Source: Atlas of Namibia

The pattern of rainfall is highly seasonal, with a direct impact on the growth of vegetation and crops, the movements of people, domestic stock and wildlife, flooding of the rivers, and groundwater recharge. Rainfall seasonality is marked by dry seasons (March/April to September/October) and wet seasons over the rest of the year, with exceptions in the very south and the coastal areas where winter rainfall is associated with the mid-latitudinal type of weather regime and where the wet season hardly exist (Figure 2.3). As a measure of variability, Figure 2.3 shows low total rainfall (mm) experienced every 14 years. With an average of 148mm per year, Keetmanshoop usually has only two rainy months each year, Windhoek (average of 352mm) has about three wet months, and Katima Mulilo (annual average of about 628mm) can expect rain during five months from December to April (Mendelsohn and el Obeid, 2005).

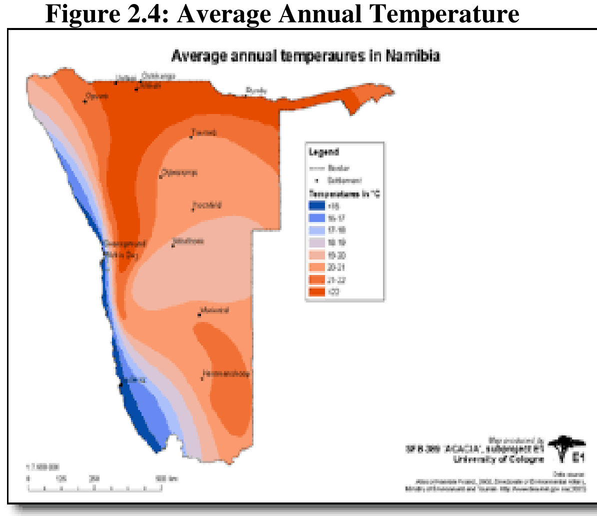
The Maize Triangle of Tsumeb, Grootfontein and Otavi receive rather more than the pattern would indicate, due to orographic effects, allowing the successful growing of maize variety of vegetables and fodder. The general pattern of the rainfall season is consistent throughout the country, though the actual amounts vary widely (Figure 2.3). Arable agriculture is thus restricted to the north of the country, and a few irrigation schemes along perennial rivers in the south and NCRs. In the NCRs, maize is restricted to the higher rainfall areas of eastern Caprivi, while elsewhere the arable crop is Mahangu. South of about 19°S, arable farming is not viable, thus this major part of the country is given over to extensive rangelands. The restricted rainfall limits the natural fodder production potential, and the carrying capacity varies between 8 LSU/ha in the north to more than 24 LSU/ha in the south.

Figure 2.3: Low Total Rainfall Experienced



Source: Atlas of Namibia

Figure 2.4: Average Annual Temperature



Source: UC, Data from Atlas of Namibia

2.3.2 Average Temperatures in Namibia

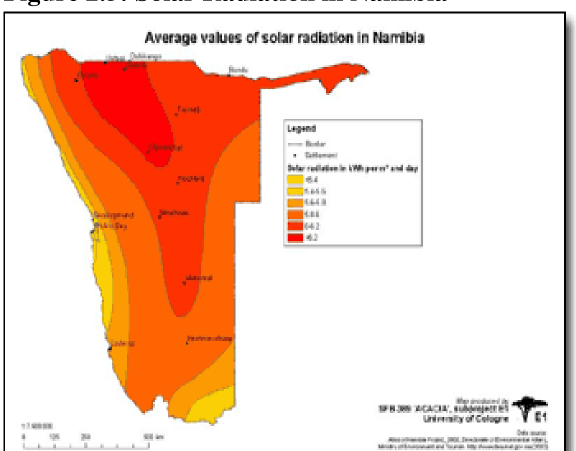
Temperatures are of interest to agriculture, and not only because of the influence it has on the water balance of the soil. There is a marked seasonal regime, with the highest temperature occurring just before the wet season in the wetter areas, or during the wet season in the drier areas (MET, 1999). Temperature conditions along the coast can be described as moderately cool (15-20^{o}C), while those of the interior as moderately warm (20-25^{o}C) (Christelis and Struckmeier, 2001). Average annual maximum temperatures in the hottest months are usually above 30°C over most of the country, excluding the coastal belt where it is much cooler and the arid south where mean temperatures rise to as high as 36°C. July is the coolest month over much of the country with average minimums of less than 10°C (MCA, 2006). Mean monthly minimum temperatures do not, on average, fall below zero, though several stations in the central and southern areas have recorded individual years with negative mean monthly minima (Figure 2.5), and individual days of frost occur widely. This may be considered to be generally advantageous to rangelands farming, particularly in terms of pest and disease control. The small stock affliction of *Oestrus ovis,* for example, is dormant in the cold season, and only becomes a problem when temperatures rise in the spring.

2.3.3 Solar Radiation and Sunshine

Solar Radiation is an important factor in the climatic regime of the country. Very few actual radiation records are available (Figure 2.6), but an extensive network of sunshine recorders does provide information on the duration of sunshine (Figure 2.6). Namibia is a country of sunshine and boasts on average between 8 and 10 hours of sunshine per day throughout the year (MCA, 2006).

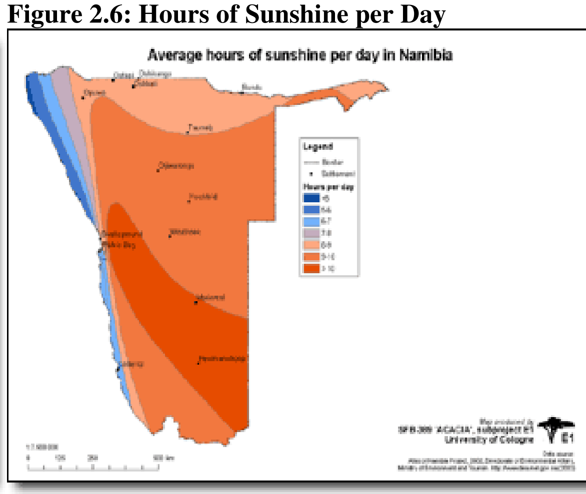
In the wetter north, the dry season receives considerably more sunshine than the wet season (Figure 2.6). The hottest months in most parts of the country are December, January, and February, while the hottest months in the northern parts occur earlier. September and October are the hottest months in the Caprivi and the NCRs respectively.

Figure 2.5: Solar Radiation in Namibia



Source: UC, Data from Atlas of Namibia

Figure 2.6: Hours of Sunshine per Day



Source: UC, Data from Atlas of Namibia

2.3.4 Wind

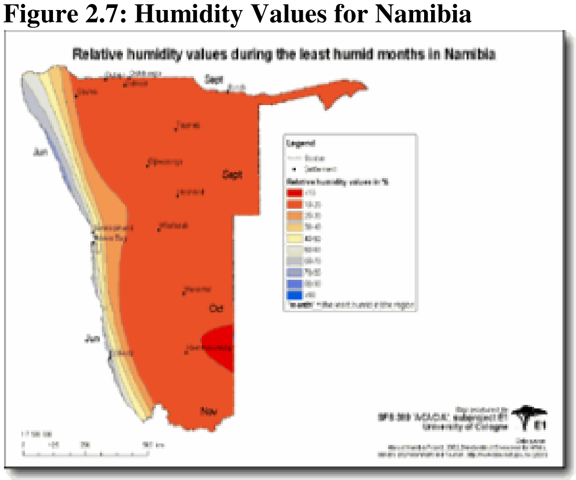
Wind is a critical resource for many agricultural activities in Namibia. Within the agronomic sector, wind aids in pollination, grain drying, winnowing, threshing and storage (Kuvare, 2006). Along the coast, the southerly and south-winterly winds dominate both the frequency (30-40%) and strength (6 - >9m/s), whereas variable winds of the interior do not present a clear pattern (Christelis and Struckmeier, 2001). For example, at Rundu during the major mahangu post-harvest period of June, July and August 2006, the daily prevailing wind velocity of <1.5m/s dominated with 47%, 63% and 39% in the mornings, and remained at 3% prevalence in the afternoon for the entire period (Kuvare, 2006).

In general, in the interior, August, September, October, November and December are the windiest months. In the drier areas, however, especially during the dry season, it is possible that some wind erosion of the soil takes place, but this is slight on a world scale. Since wind does affect the water requirement of the crop, while of it much needed for post-harvest activities such as winnowing and threshing, it does need consideration in climate change adaptation.

2.3.5 Humidity

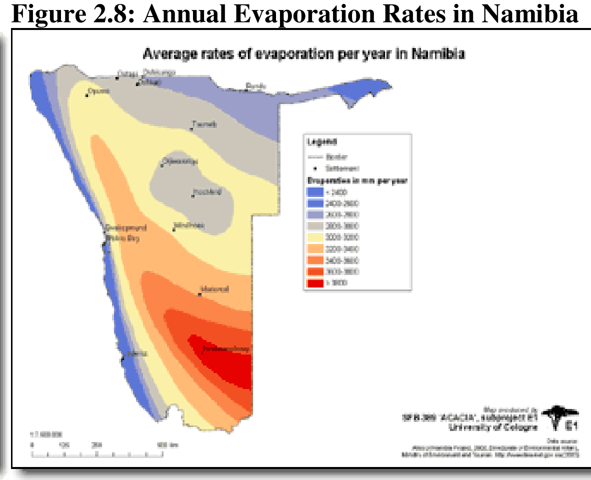
An increase in temperature would lower the relative humidity, even though no moisture had been lost. A decrease in temperature would increase the relative humidity (MET, 1999), possibly up to 100%, at which point, moisture would convert to precipitation. Humidity also does affect the water requirement of vegetation. Away from the coast, humidity levels average between 25% and 70% (Figure 2.7), presenting few problems to agriculture either in terms of excessive desiccation or of promotion of mould and other growths on stored products. For Windhoek, March is the most humid month at 51%, compared to September at 18%, while for Rundu, February is the most humid month at 72%, dropping to 33% in September (Figure 2.7). The dry season predictably indicates a lower humidity than the wet, but not excessively so, because of the lower temperatures.

Figure 2.7: Humidity Values for Namibia



Source: UC, Data from Atlas of Namibia

Figure 2.8: Annual Evaporation Rates in Namibia



Source: UC, Data from Atlas of Namibia

2.3.6 Potential Evaporation

High rates of evaporation of water at the surface from open water, vegetation and soils are a dominant and consistent feature of Namibia's climate (MAWF, 2000). Evaporation far exceeds precipitation throughout Namibia, and together with evapotranspiration is the country's biggest water "consumer" (MET, 1999). It is a major contributor to the soil water balance, hence to the growth of the vegetation, and a causal agent to agronomic drought. Potential evaporation is important for areas of water deficiency, where it is defined as the amount of water which would be evaporated from the soil and transpired from standard vegetation provided there is an adequate amount of water in the soil (MET, 1999).

Mean annual evaporation rates vary considerably across the country and also throughout the year (MAWF, 2000). Evaporation ranges between 2400mm/year along the coast and in the Caprivi, and more than 3600mm/year in the eastern Karas Region (Figure 2.8). The very hot summer temperatures and relatively cold wintertime temperatures in the south result in the largest difference between summer and winter evaporation rates (MET, 1999). For an arid country, Namibia has a large number of surface water supply dams, and hence losses to the atmosphere are high despite measures taken to minimize evaporative losses (MAWF, 2000). At all of Namibia's major dams, losses through evaporation far outstrip the quantity of water actually drawn off for water supply. Water is also lost through transpiration and seepage, although the amount is unknown (MET, 1999).

2.4 Agricultural Water Requirements

Namibia's general arid conditions coupled with increasing demand for water due to population expansion and the general economic expansion makes water a very precious commodity in Namibia. Within the context of sustainable development, balancing the demand and supply of water becomes a crucial developmental issue. This involves looking at both demand and supply interventions that emphasize efficient water use while exploring avenues for increasing water availability.

Table 2.1 below outlines the Namibian water demand and supply situation during 2000. About 45% of Namibia's water comes from groundwater sources, 33% from the Border Rivers, mainly in the north, and about 22% from impoundments on ephemeral rivers. There are more than 130 000 boreholes drilled all over Namibia to access groundwater (Ogunmokun, 2007), with an estimate of 50 000 production boreholes in use in the country (Christelis and Struckmeier, 2001). An estimated 48% of groundwater sources were used for domestic purposes, 78% for livestock, 26% for irrigation, and 36% for mining (Table 2.1).

TABLE 2.1: Use of water resources per consumer group in 2000

Consumer Group	**Demand (mm^3)**	**Source of Supply**					
		Perennial Rivers		**Ephemeral Rivers**		**Groundwater**	
		mm^3	**%**	**mm^3**	**%**	**mm^3**	**%**
Domestic	73	18	25	20	27	35	48
Livestock	77	14	18	3	4	60	78
Mining	14	8	57	1	7	5	36
Irrigation	136	60	44	41	30	35	26
TOTAL	**300**	**100**	**33**	**65**	**22**	**135**	**45**

Source: Christelis and Struckmeier, 2001.

The Namibian Agricultural Policy suggest that there is considerable potential for expansion of irrigated agriculture through the sustainable utilization of the country's perennial and ephemeral river sources. Envisaged development of irrigated agriculture under the Green Scheme Initiative will add additional demand on the use of both perennial river and groundwater as sources of irrigation water. Recent efforts to initiate rice growing in the Cuvelai basin in northern Namibia offers great potential for the utilization of Oshana water source of which otherwise the water is lost through evaporation. The volume of water used by natural ecosystems has not been estimated, but the varied wetlands including perennial and ephemeral rivers are essential for maintenance of water supply for development and as a habitat for much of Namibia's biodiversity, including several critically endangered and endangered red data species (MET, 1999).

2.5 Soils and landforms

While there is a general lack of information on the impacts of soil characteristics on infiltration and runoff (MET, 1999), the main group of soils are characterized by unconsolidated sand and shallow, weakly developed soils on bedrock. Sandy soils are always low in nutrients because they consist largely of quartz sand grains and thus contain little humus (Mendelsohn and el Obeid, 2005). More recently, the agrarian structure of the country has been divided into 11 agro–ecological zones defined by Average Growth Period (AGP), physiographic features and ecotypes (Table 2.2).

Table 2.2: Agro-ecological Zones of Namibia

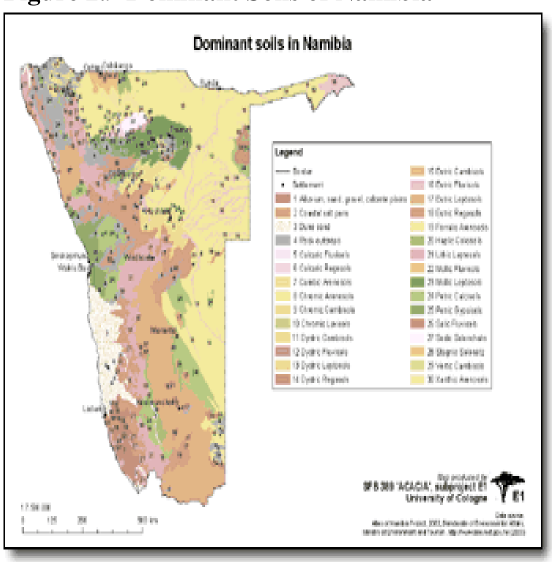
Agro-Ecological Zone	AGP (days)	Suitability for agriculture
Kunene North	8-63	Large and small stock production
Central Plateau	8-83	Small stock (goat & sheep) production
Escarpment	8-15	Large and small stock (sheep) production
Ekuma Plains & Etosha Pan	63	Large stock production
Kalahari Sands Plateau	25-135	Large and small stock production and mixed cropping in floodplains of river systems
Kalkveld	48-105	Large stock production and early maturing or short cycle crops in certain places
Namib coastal (sand) plains	0	Not applicable agriculturally
Namib desert plains	0-35	Not applicable to extensive agriculture
River Canyons	0-15	Not applicable agriculturally
Kunene South	8-25	Small stock production
Undifferentiated rocky hills and inselberg mountains	0	Not applicable agriculturally

Source: Adapted from, GRN, 2005

The Namibian soils are mainly deep Kalahari sands, covering much of northern and eastern Namibia (Figure 2.9), dominated by poor fertility (Figure 2.10) with deficiency in most of the mineral and micronutrients. In some parts of Namibia, soils have a compacted horizon with lower permeability and high sodium activity. Calcrete outcrops occur in the area bordering the Kunene Region, while black clays are associated with the floors of the Oshanas and pans.

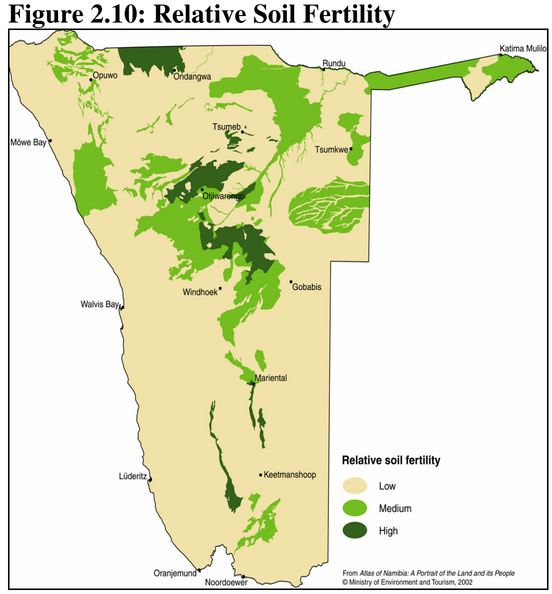
Half of the 30 major reference soil groups from the FAO soil classification system do occur in Namibia, and by far most of the soils are Regosols, Arenosols and Luvisols (Christelis and Struckmeier, 2001). Soils with a high potential for crop production occur in a few areas, but irrigation possibilities are limited (MET, 1999). The fertile soils and higher rainfall of the central savannah support crop and fodder production (Figure 2.11). Table 2.3 below summarizes the agricultural usefulness of the soils shown in Figures 2.10 and 2.11, together with a brief description of the general characteristics and limitations. Their main characteristic features include: high sand stratum, low nutrient content, low organic content, alkaline pH-conditions, typical for arid climate conditions with high evaporation rates, as well as high salinity (Christelis and Struckmeier, 2001). The poor quality soil is often more of a limiting factor to the growth and productivity of crops and indigenous plants than the arid climate (Mendelsohn and El Obeid, 2005).

Figure 2.9 Dominant Soils of Namibia



Source: UC, Data from Atlas of Namibia

Figure 2.10: Relative Soil Fertility



Source: Atlas of Namibia

Four major categories of landforms are the coastal plains and Namib Desert (covering 15% of land area), the Namib escarpment, the rocky central plateau and the Kalahari Sandveld (Barnard, 1998). Over 70% of Namibia's surface area can be classified as highly susceptible to erosion activities, making soil development very difficult in general (Christelis and Struckmeier, 2001). It is further reported that extensive physical weathering and erosion under arid and semi-arid conditions are the dominant soil forming processes throughout Namibia. Several phases of uplifting, erosion and deposition have created complex landforms as determined through geomorphology and structural geology. In areas with annual average rainfall of 300-400 mm, some form of soil erosion (wind, sheet and drill) and topsoil capping is occurring. This is likely to be correlated with the occurrence of bare soils (Motinga et al, 2004).

Table 2.3: Characteristics of Dominant Soil Types.

SOIL TYPE	AGRICULTURAL UTILITY	GENERAL CHARACTERISITICS AND LIMITATIONS
Fersiallitic	High	Well weathered tropical soils with low water-retention capacity; Potential for irrigation
Solonetzic and Palanosolic	Moderate-low	Shallow sands on clay; Highly alkaline; Periodically wet
Halomorphic	Low	Danger of salinization; Wetness; Flooding hazard
Arenosols (Littoral sands)	Low	Low water-retaining capacity; Very sensitive to wind erosion
Arenosols (Interior sands)	High	Low water-retaining capacity; Sensitive to wind erosion; Potential for irrigation
Alluvium	High	Danger of salinization; Flooding hazard; Potential for irrigation
Poorly-developed Soils	Low	Shallow; stony; steep
Lithosols	None	Rocky; Steep mountains and hills

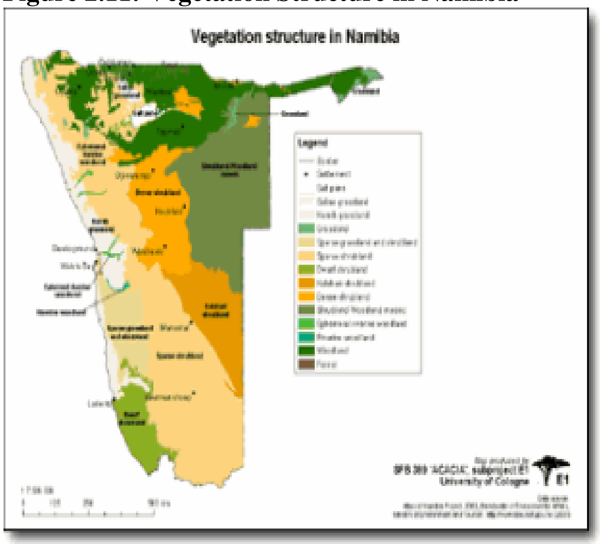
Source: MET, 1999.

2.6 Vegetation and Forests

Three major vegetation zones, namely: deserts, savannas and woodlands, are dominant in Namibia (Christelis and Struckmeier, 2001). Figure 2.11 depicts the vegetation structure in Namibia of which high land, thorn bush and mountain savannas are the most dominant ones to occur in the central highlands, with an abundance of shrub and mopane savanna in the central and southern parts, the Kalahari sandveld, and in north-western Namibia. Good grazing capacity of the country is dominant in the central highlands towards the southern Kalahari, the south-eastern strip of the Caprivi, and within the Karstfeld (Figure 2.12). Where productive perennial grasses are present bare ground is still common due to the distances between the grass tufts.

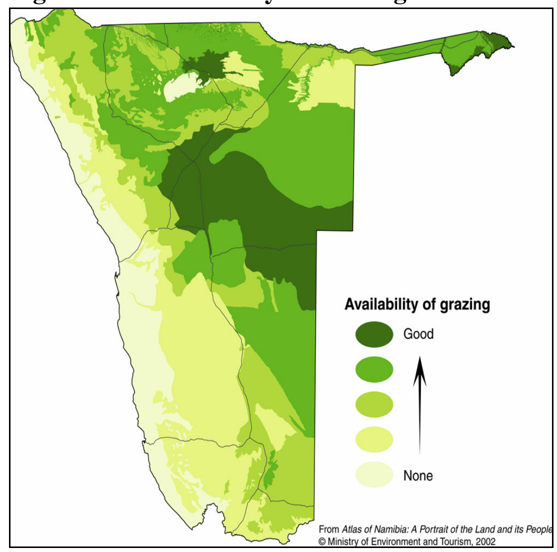
About 10% of all plants species in Namibia are trees which are considered to be woody plants that normally grow to 1m or more in height (Mendelsohn and El Obeid, 2005). Major forest zones occur predominantly in high rainfall areas, stretching from the Kunene-North Region to eastern Kavango and most of the Caprivi Region. Forests (including community and strategic forests), whose major products are timber, thatch grass, poles, droppers, dry wood used in crafting, and fuel wood accounts for about 20 000 km^2 of land.

Figure 2.11: Vegetation Structure in Namibia



Source: UC, Data from Atlas of Namibia

Figure 2.12 Availability of Grazing



Source: Atlas of Namibia

CHAPTER 3: CLIMATE CHANGE AND NAMIBIA'S SOCIAL ENVIRONMENT

3.1 Introduction

In Namibia, as in many countries in Sub-Saharan Africa, the effects of climate change are inextricably linked to poverty. This is certainly so, because 70% of its population relies heavily on subsistence agriculture for their livelihoods. The colonial history of Namibia has created a skewed income distribution (Gini Index 74.3[1], UNDP, 2007), partly because large tracks of arable land, the primary means of production and livelihoods is owned by a small number of the population. Agricultural land comprises 69.6 million hectares, and is sub-divided into communal and commercial farmland (Adams and Wolfgang, 1990). About 41% of agricultural land is owned by roughly 4000 white commercial farmers, compared to about 45% occupied by 70% of the population living on communally owned land (Fuller, 2001). However, since independence previously disadvantaged communal farmers have started to buy into commercial farming areas through Agribank's' Affirmative Action Loan Schemes (AALS).

Climate change induced drought and floods has serious social and economic implications for Namibia. The attainment of noble human development efforts as contained in National Development Plans 2/3, Vision 2030, and the Millennium Development Goals (MDG) are undermined by climate change. While many other factors affect the social and economic circumstances of Namibians, either individually or collectively, climate change is said to be an emerging important parameter for the 21st century. This chapter, therefore, focuses on creating an understanding of the impacts of climate change on the social and economic circumstances of Namibia.

3.2 Conceptual and Analytical Frameworks

The impact of climate change on farming can be conceptualized within the framework of its impact on household food security and poverty. Understanding the interactions between climate change and poverty is critical to understanding local and global trends of climate change impacts. Such an understanding is, in turn, vital to the development and implementation of effective strategies to mitigate the effects of climate change. Figure 3.1 illustrates a conceptual framework on how climate change affects the farming households in Namibia. While the impact of climate change is felt across all farming communities, being rich or poor, communal or commercial, its impact transcend it more on the poor people living in marginalized areas.

3.3 Non-Climatic Social Stressors in Namibia

Livelihood systems in Namibia currently experience a number of interlocking socio-economic stressors, other than climate change and climate variability. In discussing the social impacts of climate change it is important to note that a complex interaction of such stressors affects the

[1] Gini Index was obtained from UNDP Human Development Report 2007/2008. A value of 0 represents absolute equality, and a value of 100 absolute inequality.

social status of Namibians and climate change induced impacts adds only one dimension to this status. Table 3.1 below outlines non-climatic stressors that affect livelihoods in Namibia.

Figure 3.1: A Conceptual Framework for Climate Change Effects on Farming Households in Namibia

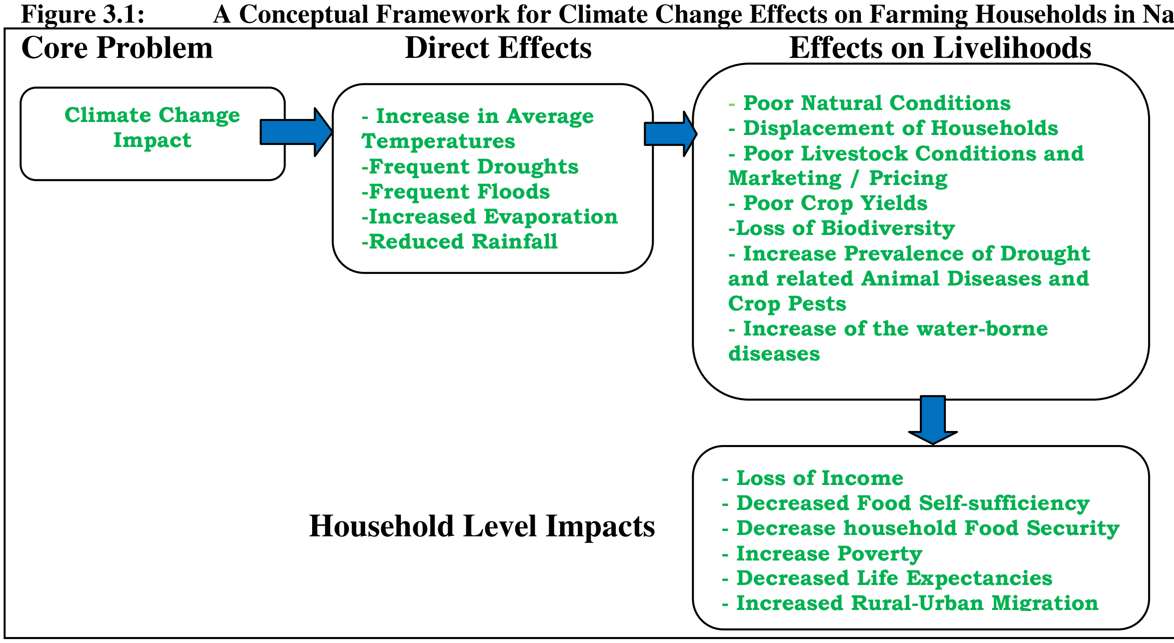


Table 3.1: Non-Climatic Stressors that Affect Livelihoods in Namibia

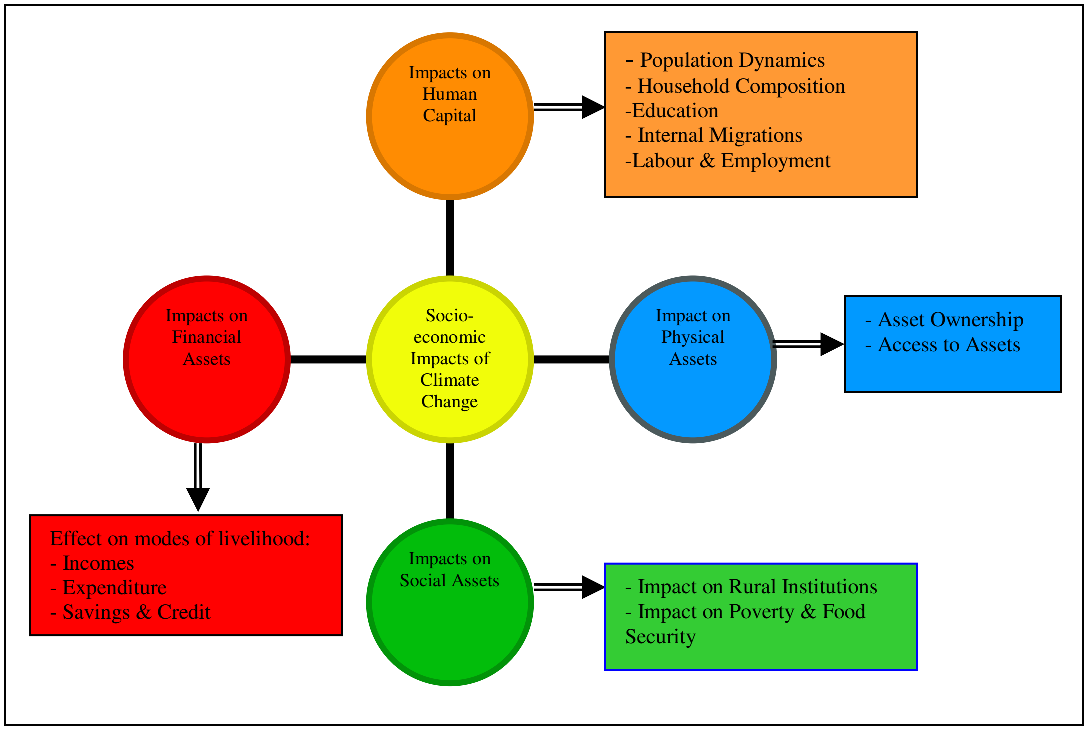
Stressors
• Poverty and inequality • Human Health and Welfare including HIV/AIDS • Land issues including equitable access to land and sustained productivity • Devolution and governance • Improve access to existing knowledge and generate new knowledge regarding issues that affect sustainable development • Limited human resources and capacity • Unsustainable natural resource management and loss of wildlife and biodiversity • Gender Equality and Women's Empowerment • The need for a stable macro-economic environment • Population growth and settlement patterns • Increasing competition for shared resources

Source: Adapted from Karuaihe et al (2007)

3.4 Climate Social Stressors

Socio-economic impacts of climate change are four fold; they affect the physical, human, financial and social assets of humans (Fig. 3.2). This study adopted the above analytical framework to discuss the socio-economic impacts of climate change in Namibia.

Figure 3.2: An Analytical Framework for Socio-Economic Impacts of Climate Change



3.4.1 Impacts on Human Capital

Human capital consists of skills, knowledge, the ability to work under good health, in pursuing of livelihood strategies. The social demographic situation in a country informs the context within which climate change impacts are felt. This section therefore explores and analysis the demographics of the Namibian population and points out how identified characteristics makes the Namibian society susceptible to negative climate change occurrences.

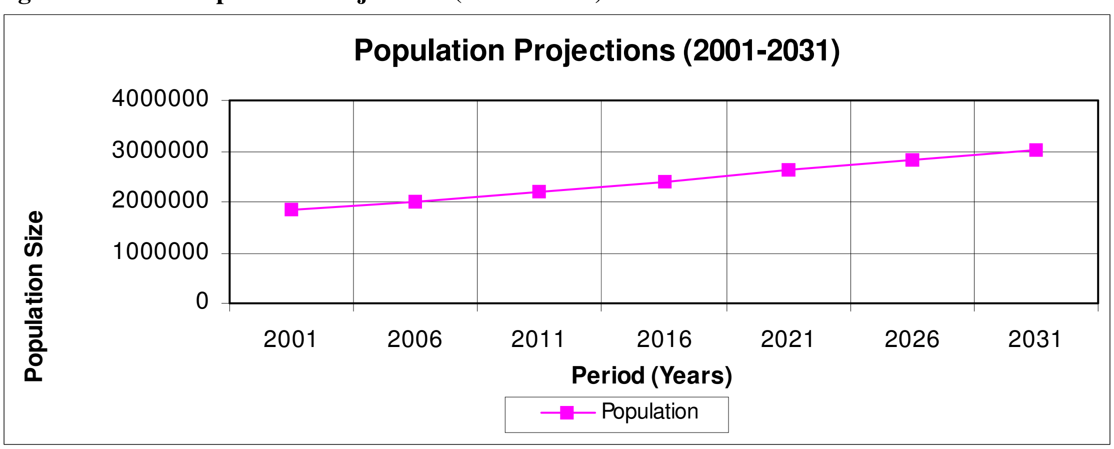
3.4.2 Population Size and Growth

The status of a population, growth and the underlying factors influencing the dynamics of a population, such as fertility and mortality are important players in the human development equation. A country's population influences access to resources, resource allocation and the general pressure on resources. The impacts of climate change, which in Namibia takes the form of frequent drought, rainfall variability, occurrence of floods, increasing temperatures, and water low availability, on population is determined by its size relative to resource endowment, access and distribution.

In Namibia, especially in rural areas, people rely heavily on the use of renewable natural resources. In the absence of meaningful economic growth and diversification, population growth has a major impact on the natural environment. Increases in cultivated land, the loss of prime arable land to non-farm use, the clearing of new land, the fragmentation of land holdings and the intensification of agricultural and livestock production all contribute to increasing pressure on finite natural resources. More than 70% of the Namibian population lives within 100 km of the northern perennial rivers, while less than 15% of the population lives south of Windhoek in more than 40% of the surface area (MET, 1999).

The succession of decennial censuses in Namibia since 1970 provides a basis for analyzing the population growth trend. Estimated at 0.74 million in 1970, the population increased to 1.03 million in 1981, 1.41 million in 1991, 2 million in 2005, and estimated at 2.3 million by 2015 (NPC, 2004 and UNDP, 2007). The implied annual growth rates are 2.9% from 1970 to 1981, 3.0% from 1981 to 1991, and projected to decline gradually to 1.2 for the period 2005 to 2015 (ibid). Namibia's population is projected by NPC (2006) to reach 3.03 million by the year 2031, also using the medium- variant projections with a projected average annual growth rate of 1.2 and average of 4 births per woman by 2015 (Fig. 3.3). There is thus sufficient evidence of growing population and hence an imminent pressure on the natural resources, particularly agricultural production systems, as a direct result of population growth. Climate change will further exacerbate this situation by inhibiting the production capacity of Namibia's farming systems.

Figure 3.3: Population Projections (2001 – 2031)



Source: Data from NPC, 2006

There are indications in Namibia that the population will continue to grow based on three factors, namely; fertility, mortality and migration. At the root of the high rate of population growth are the high level of fertility and a declining rate of mortality over the years. Infant mortality declined from 57 per 1000 live births in 1991 to 46 in 2005; and life expectancy at birth stood at 50.9 years for males and 52.2 for females in 2005.

Namibia's population is youthful in character, with 57.4%[2] of the population falling in the age group of between 16 and 64, which is considered to be the economically active age group. Only 39.1% and 3.5% of the population falls under the age groups 0 to 15 and 65 and above respectively (ibid). Furthermore a comparison with Switzerland, which is considered to be at an advanced stage in the population lifecycle, reveals that Namibia's is at early stages of the cycle and that further population expansion is a 'norm' (Table 3.2). The age structure, according to experts has a high potential for continuous population expansion.

Table 3.2: Population by Age Comparisons

Percent distribution of the de facto population by age group

	Namibia			Switzerland
Age group	**1992**	**2000**	**2005**	**2005**
< 15	42.9	42.6	39.1	14.5
15-64	50.7	51.9	57.4	66.8
65+	5.3	5.2	3.5	18.7
Missing/don't know	1.1	0.3	-	-

Source: NDH, 2000 and UNDP, 2007

3.4.2 Internal Migration and Population Density

Mobility existed from the beginning of human development. The primary reason why people migrate is to find more favourable environment to secure a living. Decisions by farmers, as households or individuals, to migrate as is practiced in Kunene-North, are influenced by such factors as environmental deterioration, economic constrains, and natural disasters. Migration is in many cases a form of creative and constructive adaptation of people to changing circumstances, and these circumstances may as well be caused by climate change.

In Namibia, historic and current labour migration patterns shows that because of the distribution of Namibia's population and natural resources, strong pressures for migration remain, and indeed have perhaps intensified since independence (NEPRU, 1999).

Namibia's internal migratory movements continue to be a major force in the dynamics of Namibia's population, influencing the rate of urban population growth and the spatial distribution and density of the population (NPC, 1994). Initially induced by the defunct migrant labour laws

[1] Calculated based on data from UNDP Human Development Reports 2001, 2002 and 2007

and reinforced by the structure of the economy, the pattern of migration in the country is largely from the rural to the urban areas and the mining centers, dominated by able-bodied men and women in search of wage employment. In rural areas the proportion of female-headed households increased to 43%, suggesting that married men migrate in large numbers from the rural areas to the cities leaving their wives behind to take care of the household.

The average population density for Namibia is estimated at 2.2 people/km^2, making Namibia one of the most sparsely populated countries on the continent (NPC, 1994). However, certain parts of Namibia are not easily inhabitable by people. Human settlements and people densities increases in areas were either economic activities and or natural resources (arable land, water and grazing) offers livelihoods to the people. The effect of migration and population densities increases pressure on natural resources and makes people particularly vulnerable to adverse climate change effects. The historic conglomeration of people in communal lands makes households in these areas especially vulnerable. For example 60% of the population lives in the NCAs, where the population densities are about 5 per square kilometer.

3.4.2.1 Implications on Climate Change and Adaptation Planning

The point can hardly be overemphasized that the projected population will have significant implications for the country's overall plan for social and economic development. In particular, the effects of climate change on poverty and the formulation of adaptation policies and strategies relies on an understanding of the population dynamics. As already illustrated here with the results of different population and labour force projections a **laissez-faire** population policy, particularly regarding the prevailing high rate of fertility, is bound to be negative on the economy and society in the long-run. In order to take rational decisions about adaptation options in the face of climate change, an integrated approach is thus warranted.

Depending on whether the economy creates employment, the impact of population growth, migration and increases in population densities can be associated with rising levels of unemployment, increasing dimensions of the youth problem, and the potential degradation of the ecological environment. Climate change interlocks with these social stressors and puts tremendous strain on government to tackle climate change and provide, at the same time, for rising demand for health, education, housing and land, among others. At farming household level, rural-urban migration may impact household labour supply for food production, household income and consumption levels and their ability to invest in production technologies (including technologies for adaptation to climate change).

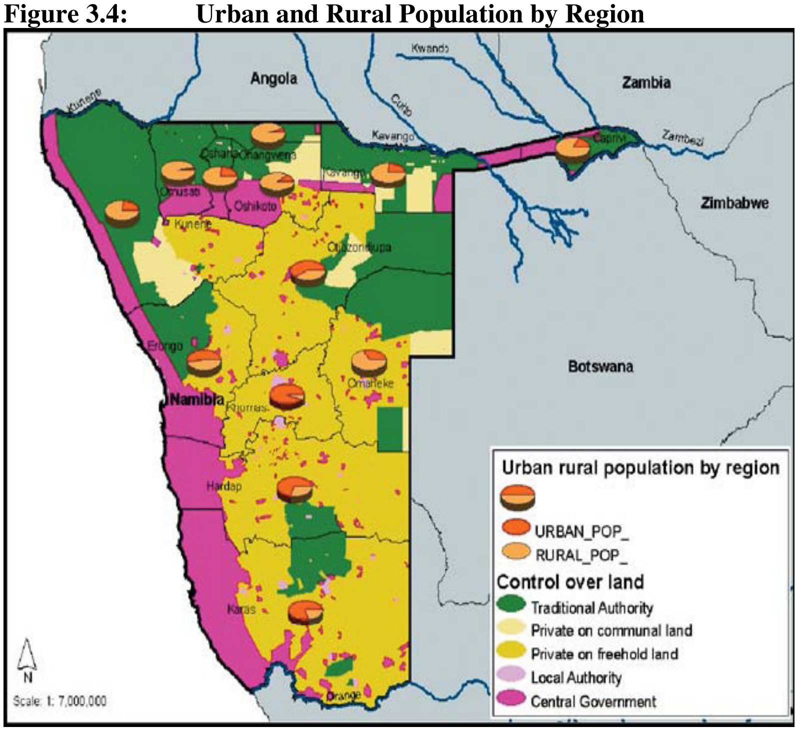
3.4.3 Household Composition

The 2003/4 Namibia Household Income and Expenditure Survey (NHIES) estimated that there are 1 830 000 people in Namibia and estimated 371 678 households (NPC, 2006). A total of 65% of the population and close to 60% of the households lived in the rural areas, whereas 35% of the population and just fewer than 41% of the households lived in urban areas (ibid). About 60% of the population, comprising of 52% households, lives in the northern Regions of Caprivi, Kavango, Ohangwena, Omusati, Oshana and Oshikoto (ibid).

The average household size in Namibia is 4.9 persons (NPC, 2006). On average rural households are larger than urban households, 5.4 compared to 4.2 persons per household (ibid). The national average household size has decreased from 5.7 persons since the previous survey in 1993/94 (ibid). The decline has been particularly marked in rural areas (ibid). In Namibia 59% of households are headed by males and 41% by females (NPC, 2006). A larger proportion of households in urban areas are headed by males, 62% compared to 38% headed by females (ibid).

The National Population and Housing Census in 2001 revealed that 73% and 27% of the population inhabit the rural and urban areas respectively. In addition, 51% of the population comprises females who reside mainly in rural areas (NPC, 2003). Because of the high rural-urban migration, urban areas have more people in the economic active age group of 15-59 years. Two thirds of Namibia's population lives in rural areas, where land is communally owned. Women comprise 43% of communal farmers and 53% of those engaged in communal agriculture. Women head approximately 48 percent of rural households.

Figure 3.4: Urban and Rural Population by Region



Source: MCA, 2006

3.4.4 Education

The level of education attained by a household has an important bearing on the quality of household human capital. In our analysis of educational status/achievements of Namibia several indicators are used, namely; literacy and school enrolment. To show the effect of education on the quality of life is illustrated through its effect on household consumption and income. Literacy (defined as ability to read and write) in Namibia is fairly widespread; the percentage of the population 15 years and over who are literate is at 85% in 2005 (UNDP, 2007). This represents a slight improvement from 77% in 1991 (NPC, 1994). Although the literate rate is commendable in Namibia post-literacy programmes are needed to ensure progression in the use of knowledge and skills acquired.

There is a strong correlation between educational attainment of the head of household and consumption in the household (Table 3.4). In Namibia were the self-employment culture is not rife having a job and earning a salary or wage is seen as key. Securing a job requires that one has a qualification and skill and once educational attainments becomes important. The higher the educational attainment of the head of household is correlated to higher income and consumption per capita. In households were the head has no formal education the income/consumption per capita is N$ 3 003/N$ 2 910, compared to N$ 11 383/N$ 10 993 in households where the head has attained a secondary education and N$ 36 503/N$ 35 329 in households where the head has a tertiary education (Table 3.4).

Table 3.3: Annual Income and Consumption according to Educational Attainments

Category	Household (%)	Population (%)	Average Household Size	Total Income			
Namibia							
Income	100	100	4.9	16 176	100	43 521	8 839
Consumption	100	100	4.9	15 639	100	42 078	8 546
No formal education							
Income	27.4	23.8	5.7	1 507	9.3	17 057	3 003
Consumption	23.8	27.4	5.7	1 461	9.3	16 530	2 910
Primary							
Income	33.4	31.4	5.3	2 682	16.6	23 016	4 382
Consumption	31.4	33.4	5.3	2 591	16.6	22 234	4 233
Secondary							
Income	30	34.2	4.3	6 254	38.7	49 270	11 383
Consumption	34.2	30.0	4.3	6 040	38.6	47 584	10 993
Tertiary							
Income	8.4	9.9	4.2	5 635	34.8	152 375	36 503
Consumption	9.9	8.4	4.2	5 454	34.9	147 477	35 329
Not Stated							
Income	0.7	0.8	4.2	97	0.6	34 167	8 054
Consumption	0.8	0.7	4.2	93	0.6	32 852	7 744

Source: Adapted from NPC, 2006

The educational attainment of a household has certain implications pertaining to climate change, and the. Firstly, educational attainment increases household income through easier access to waged/salaried employment and thus resilience to climate change. Secondly, it is assumed that higher levels of education attainment may facilitate adoption of new technologies because of increased ‘flexibility’, as educated people are associated with ‘early adopters’.

3.4.5 Effects on Labour Force and Employment

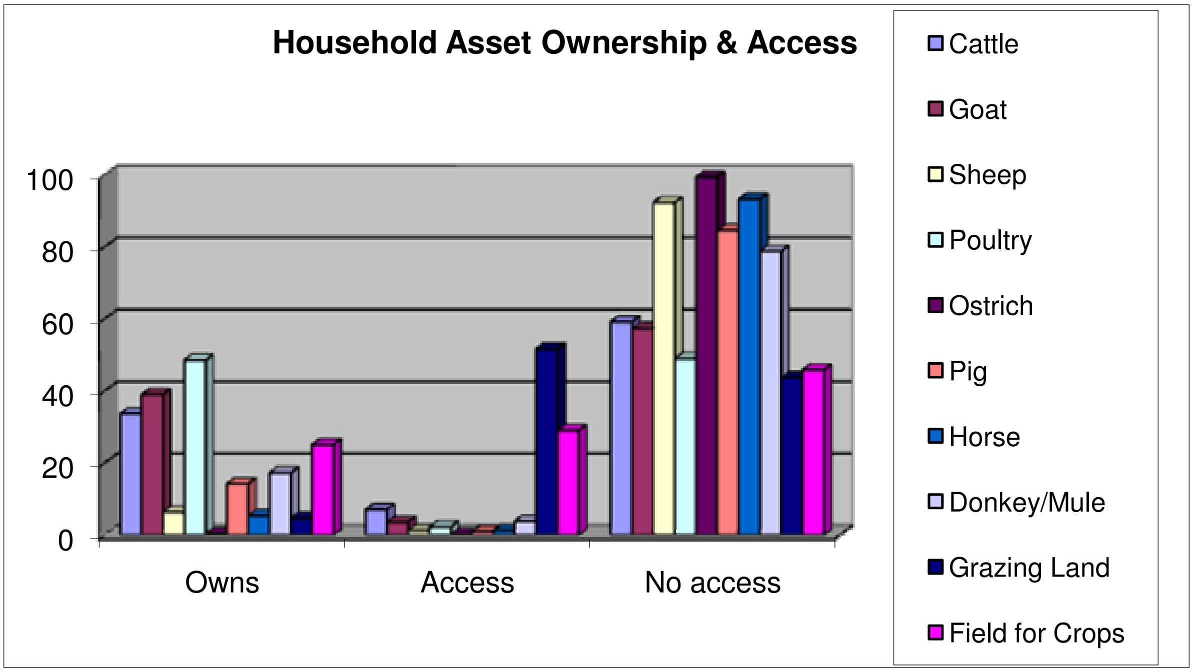
The average percentage unemployment rate (% of total labour force) is 33.8% for the period 1996 to 2005 (UNDP, 2007). Of the total people employed in Namibia 31% are employed in the agriculture, 12% in industry and 56% in services. Although only 31% of Namibians work formally or semi-formally in agriculture a lot more are self-employed in agriculture and related industries i.e. over 60% of the population practice some form of agriculture for a livelihood. This situation makes the effects of climate change on agriculture and subsequently on labour obvious.
The vast majority of farm workers both on communal and commercial farms is unskilled and lives under precarious situations. On average farm workers in Namibia spent N$ 250 per month on food while their average income is N$ 350 per month, thus spending 70% percent of their income on food that confirms the high levels of poverty among farm workers (LaRRI, 2004). This makes farm workers highly vulnerable to economic shocks associated with loss of agricultural production due to climate change. For example, the most likely rational action that a livestock farmer will take if faced by drought is to downsize his herd (e.g. sell off male animals) or increase feeds by cutting other less important costs. the need to cut on costs may point to reducing the number of labour on the farm. According to Wolfgang (2004) labour costs accounts for 16 – 18% of total costs on an average commercial farm and farmers are likely to start cutting costs on the labour side.

The scourge of HIV/AIDS further exacerbates the impact of climate change on labour as it affects the general health of farm workers, their ability to care for their families (which results in withdrawing from schools) due to loss of income and general loss of labour due to death.

3.5 Impacts on Physical Household Assets

Almost, 50% of households own poultry, 39% goats, 34% cattle (NPC, 2006). Grazing land is owned by 5% of households and 25% own fields for crop (ibid). The proportion of households owning or having access to both animals and land are reported to be higher in rural areas compared to urban areas (ibid). Generally higher percentages of male headed households own animals compared to female-headed households, except in case of poultry and field for crops (NPC, 2006). Households where the main source of income is reported to be commercial farming, 64% and 48% own grazing land and field crops and 88% own cattle (NPC, 2006). On the other hand, households where the main source of income is subsistence farming 86%, 66% and 50%, own poultry, goats and cattle respectively (ibid). The percentage of households that own cattle has declined slightly from 37% in 1993/94 to 34% in 2003/04 (NPC, 2006). The percentages of households that own poultry also show a decline from 61% to 49% over the same period (ibid). Fewer households own field crops in 2003/04 as compared to 1993/94 (ibid).

Figure 3.5: Farming Households' Asset Ownership and Access



Source: Data from NPC, 2006

Table 3.4: Household Ownership/Access to Animals/Land by various Categories[3]

Category	Ownership/Access	Cattle	Sheep	Pig	Goat	Donkey/Mule	Horse	Poultry	Ostrich	Grazing Land	Field for Crops
Namibia	Owns	33.7	6.4	14.3	39	17.3	5.4	48.6	0.4	4.7	25.1
371 678	Has access	7.1	1.3	1.1	3.6	3.9	1.3	2.3	0.2	51.7	29.1
	No access	59.2	92.3	84.6	57.4	78.8	93.3	49.1	99.4	43.6	45.8
Urban	Owns	23.9	5.2	3.5	23.3	7.3	4.1	18.3	0.5	5.6	10.9
150 533	Has access	3.5	1	1.3	3.4	2.3	0.6	3	0.1	25.4	13.3
	No access	72.6	93.8	95.2	73.3	90.4	95.3	78.7	99.4	69	75.8
Rural	Owns	40.4	7.2	21.6	49.7	24.1	6.2	69.2	0.4	4	34.8
22 1148	Has access	9.5	1.5	1	3.7	4.9	1.8	1.9	0.3	69.6	39.9
	No access	50.1	91.3	77.4	46.6	71	92	28.9	99.3	26.4	25.3
Female	Owns	26.7	4	16.8	37.7	13.3	2.2	51.8	0.1	3.1	27.2
15 051	Has access	6.1	1	0.6	2.9	3.8	0.6	1.7	0.2	53.1	32
	No access	67.2	95	82.6	59.4	82.9	97.2	46.5	99.7	43.8	40.8
Male	Owns	38.5	8	12.6	40	20	7.6	46.4	0.6	5.8	23.6
219 709	Has access	7.7	1.5	1.4	4	3.9	1.8	2.7	0.3	50.6	27.1
	No access	53.8	90.5	86	56	76.1	90.6	50.9	99.1	43.6	49.3
No Formal Education	Owns	35.3	6.3	19.3	46.2	23.6	5.8	63.7	0.3	3	30.7
88 375	Has access	9.5	1.7	0.7	3.4	5.6	1.6	1.9	0.1	67.1	39.7
	No access	55.2	92	80	50.4	70.8	92.6	34.4	99.6	29.9	29.6
Tertiary Education	Owns	34.9	9.4	6.9	29.3	8.2	7.4	25.8	1.9	9.3	14.5
36 980	Has access	1.6	0.3	0.4	8	0.9	0.3	0.4	0.1	31	15.4
	No access	63.5	90.3	92.7	62.7	90.9	92.3	73.8	98	59.7	70.1

[3] Created using 2003/2004 NHIES data, NPC (2006).

3.6 Impacts on Social Assets

3.6.1 Impact on Rural Institutions

In Namibia, traditional institutions such as kinship systems, traditional political structures, co-operatives, trading groups, conservancies and mutual assistance groups are involved in many aspects of rural development and poverty alleviation. Climate change and poverty are highly correlated, and impoverished people are simply too busy scraping a living to care about participating in organizational and voluntary life.

According to a study on the impacts of HIV/AIDS on the farming sectors in Namibia the participation of elderly people in rural institutions is already curtailed by them having to provide support to the young, thereby subverting the role of this critical institution in traditional African society (UCCB, 2001). The impact of climate change is therefore expected to worsen the situation.

3.6.2 Impacts on Poverty and Food Security

3.6.2.1 Poverty

Namibia represents a typical dualistic economy where abject poverty exists alongside extremes of wealth. For example, the richest 10% of the households in Namibia has more than 50 % of total income of private households. The GINI index is 74.3 (UNDP, 2007), which makes Namibia one of the most unequal societies in the world. There is a wide disparity in infrastructural development between the impoverished northern parts of the country, where most of the population lives, and the central and southern Regions.

The percentage of the Namibian population below the income poverty line is estimated at 34.9%[4] for the 1U$ a day category and 55.8% for the 2 U$ a day category (UNDP, 2007). The human poverty index, which is a composite index measuring deprivations in three basic dimensions, namely; a long and healthy life, knowledge and a decent standard of living, is estimated at between 24.7% (NPC, 2004) and 26.5% (UNDP, 2007).

The share of food consumption of total consumption is used as a crude poverty measure. If 60% or more of the household's total consumption is spent on food, then the household is considered "poor", while a household is considered "severely poor" if 80% or more of household consumption is spent on food. In Namibia, 4% of households fit the above definition of severely poor. The proportion of poor households is 24%. Table 3.6 below illustrate household food consumption ratio.

Based on Table 3.5 and consumption based definition of poverty, more people are classified as 'poor' and 'very poor' in rural areas than in urban areas. Climate change is expected to worsen the situation.

[4] The figure represents a weighted average for the period 1990 to 2005

Table 3.5: Rural and Urban Households by Food Consumption Ratio

Category	Food consumption ratio %					Total Consumption (Million N$)	Total Number of Households
	80-100	60-79	40-59	00-39	Total		
		(Per cent of households)					
Namibia	3.9	23.9	27.4	44.8	100	15 639	371 678
Rural vs. Urban							
Urban	0.6	6.0	18.3	75.0	100	9 764	150 533
Rural	6.1	36.0	33.6	24.3	100	5 875	221 145

Source: Adapted from NPC, 2006

While the effects of climate change on poverty is obvious, the objective measurement of impact has not been done in Namibia. Progress in attaining the MDG 1, i.e. to eradicate extreme poverty, is shown in Table 3.6 below. Uncertain weather patterns and rainfall posses a special threat to the attainment of this noble goal. Although poverty incidence in relation to projected figures is on the decline, the rural-urban differences are large and persistent.

Table 3.6: Progress in the Attainment of MDG 1 Goals

Goal	Objective	1992	2003	Projections 2006
Eradicate extreme poverty and hunger	Proportion of households living in relative poverty	38%	-	28%
	Proportion of households living in extreme poverty	9%	-	4%

Source: NPC, 2005

3.6.2.2 Food Security

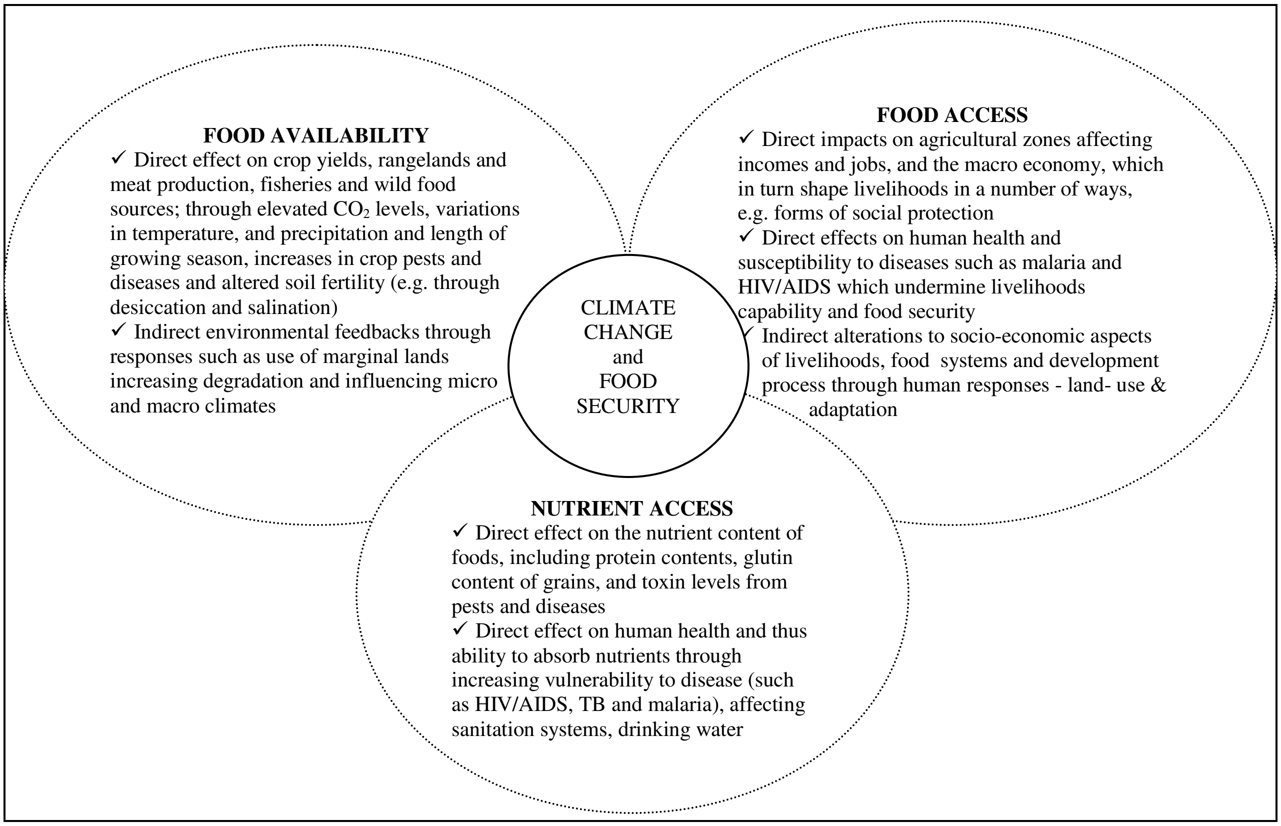
The key recognition in linking climate change to food security is that there are multiple factors, at all scales, that impact on individual and household's ability to access sufficient and nutritious food: these include household income, human health, government policy, conflict, globalization, market failures, as well as environmental issues (Devereux and Maxwell, 2001; Marsland, 2004; Misselhorn, 2005). Building on this recognition, three principal components of food security may be identified (Boko et al, 2007):

i. the *availability* of food (through the market and through own production);
ii. adequate purchasing and/or relational power to acquire or *access* food;

iii. the acquisition of sufficient nutrients necessary from the available food, which is influenced by the ability to digest and absorb *nutrients* necessary for human health, access to safe drinking water, environmental hygiene and the nutritional content of the food itself (Swaminathan, 2000; Hugon and Nanterre, 2003).

The abovementioned principal components of food security are illustrated in figure 3.6 below.

Figure 3.6: Climate Change and Food Security



Source: Boko et al, (2007)

The realization of the ideal of adequate access to sufficient nutritious food which meets dietary needs and food preferences for an active and healthy life is one of the most daunting challenges facing Namibia, and one of the central objectives of the MDGs. Two indicators are crucial in assessing progress in the attainment of food security goals, namely; dietary energy supply and food availability.

- ***Dietary energy supply*:**

Vast discrepancies and inequalities exist at the household level with regard to reliable access to the level of food supplies sufficient to maintain a healthy and active life. This situation is exacerbated by the country's harsh and fragile environment and occurrence of droughts leading to household food insecurity. According to the FANRPAN (2006), Namibians derive 53% of their calorie needs from grains Close to 90% of the households do not grow enough staple food to meet daily calorie needs. Over 70% of the household produce half, or less than half, of the food they need to survive (ibid). While Namibia has showed improvements in dietary energy supply, using the percentage of population undernourished indicator of 34% in 1990/92 to 24% in 2002/04 (UNDP, 2007), the situation still reveals excessive levels of vulnerability of households to famine. This starvation takes place in seemingly normal communities, because affected households are interspersed with unaffected households and thus to an outside observer there is no sign of hunger.

- ***Food availability and affordability***

Food security and nutrition planning in Namibia are based on knowledge that in the past, food accessibility through a combination of domestic production and foreign imports has not been a major problem in the country, since the strength of the country's per capita income enables Namibia to access any amount of food on international markets, and also Namibia is close to South Africa, one of the greatest food producers in the world (Southern Consultants, 2005). Affordability, on the other hand, is a major problem at the household level, as most people are poor to afford the available food.

3.6.3 Social Protection in Namibia

Social protection policies and safety nets take various forms in Namibia. For rural households leaving in farmlands, social protection measures has been in the form of production-based entitlements (e.g. provision of inputs, seeds and tools), employment-based transfers (e.g. food-for-work projects), trade-based entitlements (e.g. consumer subsidies or food price interventions through Namibian Agronomic Board and Meat Board) and transfer-based entitlements (e.g. supplementary feeding or cash transfers or vouchers that boost the purchasing power of the food insecure).

Despite the existence of these social protection measures in Namibia, they have been short-term instruments to reduce chronic poverty or to protect households against risks to their livelihoods. Social welfare or 'safety nets' instruments are often applied discretely making them administratively complex and hence there is a need to move towards an integrated approach to social protection that addresses vulnerability in a comprehensive and systematic way. The study puts forward some recommendations with regard to how social protection systems can be improved, which are largely and consensually also contained in the Poverty Reduction Strategy document for Namibia.

3.7 Impacts on Financial Assets

3.7.1 Impact on Income

About 28% of all households obtained their main household income from farming activities (MCA, 2006), though with great Regional differences ranging from 1% to 56% for Karas and Oshikoto and Karas Regions respectively.

The 2003/2004 National Household, Income and Expenditure Survey (NHIES) estimated household incomes, using total income, average household income and income per capita as indicators.

The aggregated total income in Namibian households over the survey period was N$ 16 176 million (Table 3.7). While the average annual household income for Namibia is N$ 43 521 with an income per capita of N$8 839, the result reveals large disparities between urban and rural areas. While rural areas accounts for 60% of all households in the country and 65% of the population, they only account for 38% of total income. Female headed households which account for 41% of all households, only command 29% share of total income. The average income in male headed households is N$ 51 912 compared to N$ 31 402 in female headed households.

Table 3.7: Annual Income by Categories of Households

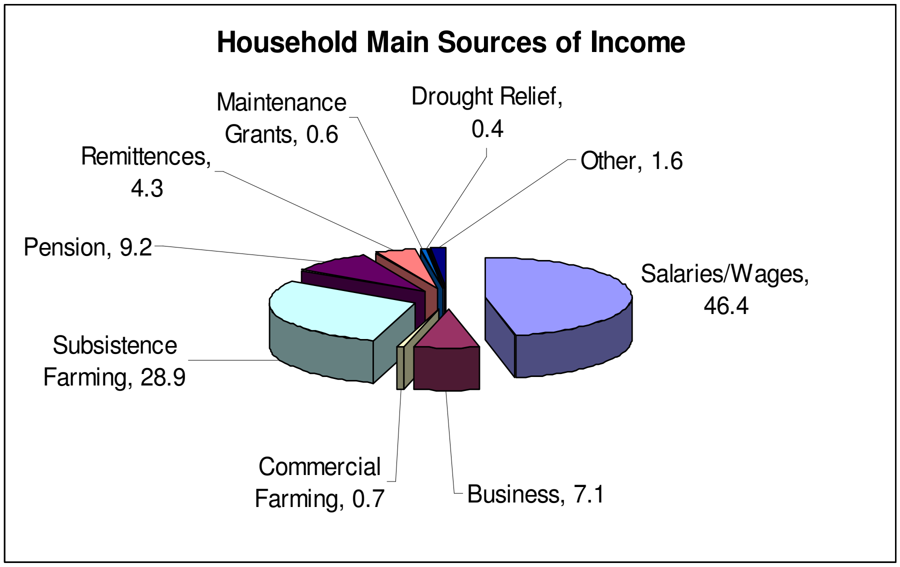
Category	House-Holds	Population	Average Household Size	Total Income		Average Household Income	Income per capita
	%	%		Millions N$	%	N$	N$
Namibia	100	100	4.9	16 176	100	43 521	8 839
Rural vs. Urban							
Urban	40.5	34.7	4.2	10 028	62.0	66 620	15 810
Rural	59.5	65.3	5.4	6 147	38.0	27 798	5 141
Sex of head of household							
Female	40.5	40.8	5.0	4 724	29.2	31 402	6 320
Male	59.1	59.0	4.9	11 406	70.5	51 912	10 570
Marginalized groups							
Khoisan	1.3	1.5	5.6	74	0.5	14 914	2 642
Type of Farming							
Subsistence	28.9	36.5	6.2	2 422	15.0	22 570	3 631
Commercial	0.7	0.5	3.3	680	4.2	246 946	74 451

Source: Adapted from NPC, 2006

Figure 3.7 below indicates that subsistence farming as a source of income constitutes 28.9% of total household sources of income, second from wages and salaries which constitute 46.4%. While there are considerable variations in sources of income at Regional level, Figure 3.7 highlights the relative importance of the climate change vulnerable subsistence farming as a source of livelihoods. A comparison of household sources of income between urban (Fig. 3.7) and rural (Fig. 3.8) households reveals striking differences and reiterates the fact that rural households are especially vulnerable to climate change.

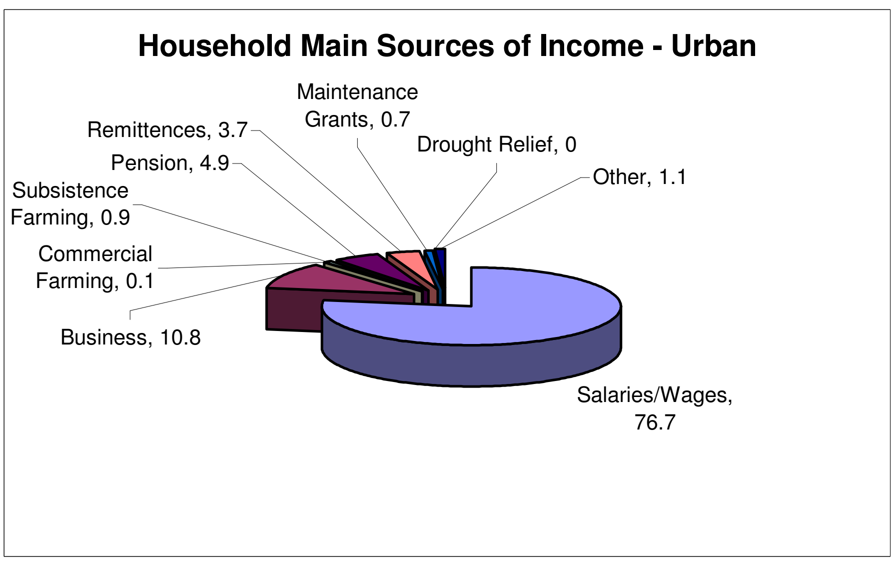
The majority of urban dwellers (76.7%), compared to only 25.7% rural households receive salaries/wages. Salaries and wages do not generally decline in climate induced extreme events such as drought. Rural households relies more on non-farm 'handouts' such as, in order of importance, pensions, remittances, maintenance grants and drought relief.

Figure 3.7: National Household Main Sources of Income (%)



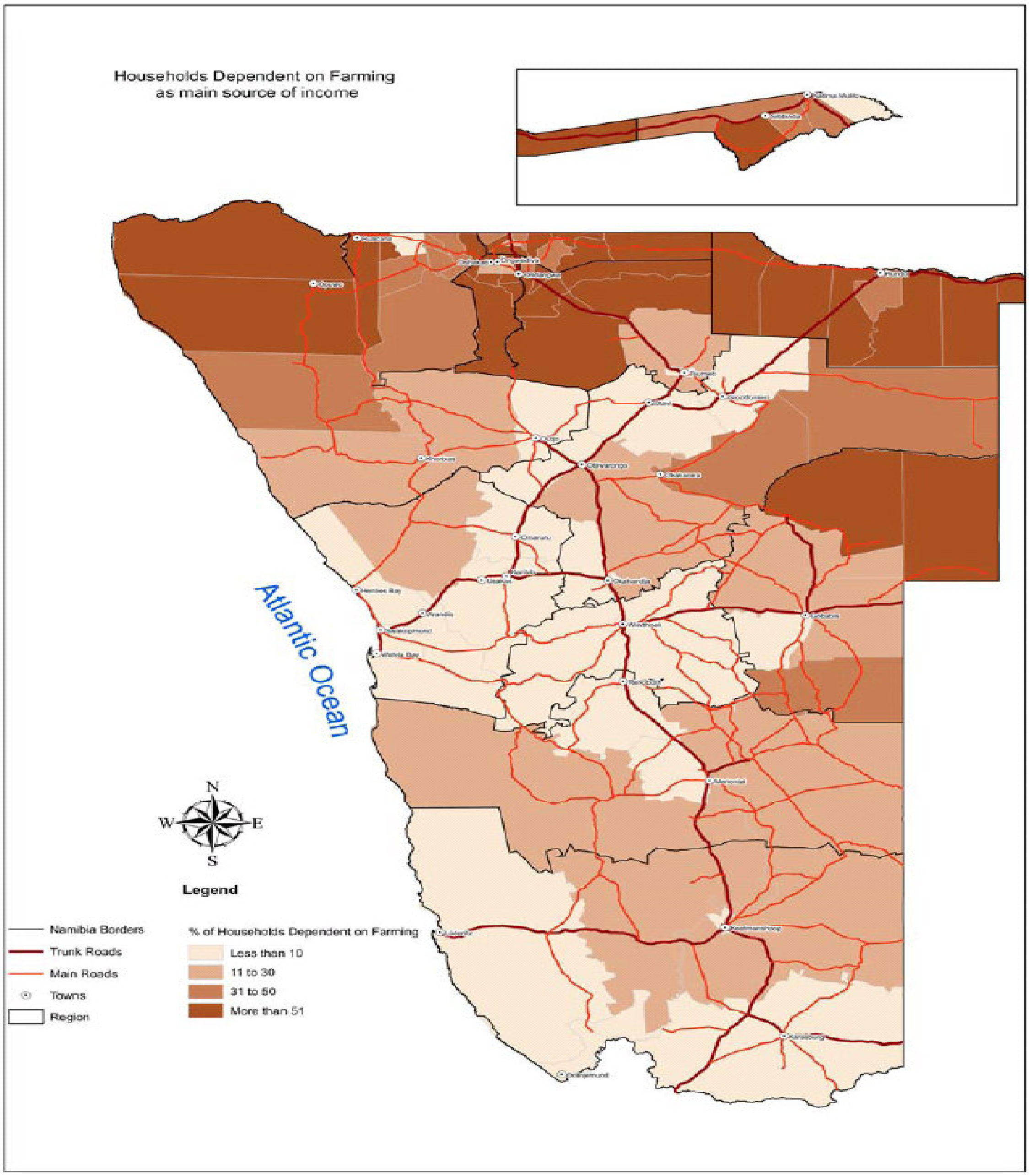
Source: Data from NPC, 2006

Figure 3.8: Household Income – Urban



Source: Data from, NPC, 2006

Figure 3.9: Households Dependent on Farming as Main Source of Income



Source: MCA, 2006.

While the so called 'handouts' may appear insignificant they form the very means of livelihood security for the very poor households dependent on farming (Figure 3.9). The next section examines some categories of off-farm income and their role in the livelihoods of rural households in the light of climate change shocks.

3.7.1.1 Role of Remittances and Pensions

Farming should ideally be seen as economically viable business entities that sustain livelihoods in their own right. The situation in Namibia belies this assertion, because government interventions are inevitable due to poor farming situations of the majority of farmers, especially communal farmers. Farming units in communal areas are small and yields are low due to poor rains and soils. Farmers therefore tend to resort to off-farm income for their sustenance. According to Mendelsohn (2006), the average value of food produced by most farmers in the *Small-scale cereals and livestock* farming system amounts to less than N$ 5 000 per year. By comparison and on average, over three-quarters of all their cash and income in-kind is derived from sources unrelated to their farms. A family member who is a teacher might have an annual income of between N$ 40 000 and N$ 60 000, and social pensions (now at N$ 4 440 per year) often exceed the value of produce on the smallest farms (Mendelsohn, 2006). There seem to be evidence that freehold farmers likewise depend more and more on tourism activities, trophy hunting, and game meat sales. This situation may be true in light of the fact that game is generally better adapted to drought than domesticated animals. Also, about one quarter of freehold farmers are part-time farmers, and as such, substantial amounts of investments on farms comes from off-farm income. In fact, as a direct consequence of this, farm size tends to correlate to the amount of off-farm income a household receive. A study of remittances in Lesotho, where remittances from migrant labourers in South Africa are a major source of national income, demonstrates that remittances have a strong poverty-alleviating effect (Gustafson, Bjorn and Negatu, 1993).

Within the context of climate change two considerations are important. First, remittances and pensions remain indispensable sources of income. The NHIES 2003/4 estimated that Namibian households received a total of N $ 94 million during the review period. To put the figure in perspective, it is equivalent to about one-third of the amount that Namibia received as cash grants from foreign aid, and about two-third of the amount that the government disbursed as pensions.

3.7.2 Effect of Climate Change on Savings and Credit

Data on the effects of climate change on farm household savings and credit are rare to find in Namibia. It is however expected that climate change will alter household expenditure mix that will affect levels of savings. In most instances, climate change occurrences erode household income levels, and will thus lead to reduced savings. The situation in Namibia is more severe for full-time farmers compared to part-time farmers, because of the cushioning effect of off-farm income.

Granting credit to farmers to invest in measures that will enhance their resilience to climate change may prove to be difficult. Firstly, the actual cash benefits (as opposed to social benefits) may not be enough to meet interest payments. For example, restocking indigenous breeds with a low carcass mass will not give farmers enough revenue in the short to medium-term to repay their loans. Secondly, formal commercial banking sector is seldom interested in providing small loans to farmers without collateral (the most venerable group to climate change), as the cost of administration and bad debt remove all potential for profit. Thirdly, the informal sector may give loans, but they cover their risks by extortionate interest rates that are not appropriated for medium term investments.

Loan repayment performance among farmers may be low if faced by drought, generally because of poor agricultural output. Levels of loan default may rise as a result of drought and other climate change shocks. Furthermore, delays in payment of loans results in escalation in interest on arrears. As with savings, full-time farmers are more severely affected than part-time farmers because of the cushioning effect of off-farm incomes. There is further evidence of escalating interest rates for the agricultural sector. For example, Grobler (1999) estimated a weighted interest rate increase for the agricultural sector from 14% in 1994 to 20% in 1998. Total agricultural debt per hectare during the 1990's more than doubled in nominal terms (because of AALS); at current prices it rose from N$ 12.99 to just over N$ 30 per hectare, disrupting farmers' cash flows (ibid). The impacts of climate change are therefore likely to worsen the financial position of indebted farmers.

In Namibia, AgriBank is a major lender for the agricultural sector and faces severe credit risks when there is drought or floods. This is so because AgriBank loan portfolio is in agriculture and the occurrence of drought is typically covariate – all eggs are in one basket. There is however efforts from AgriBank to diversify its loan portfolio to sectors whose performance may not necessarily fluctuate with climate (such as aquaculture). While access to credit can be viewed as good for farmers to finance innovations that enhance their resilience to climate change impacts this argument is not exhaustive. Conflicting appropriations of loan funds may undermine efforts to mitigate negative impacts from climate change. There is a danger that loans under the National Agricultural Credit Programme (NACP) from AgriBank will go disproportionately for the purchase of livestock in areas which are already degraded or affected by climate change shocks. According to NAPCOD (1996), there are indications that very high proportions of loans, 70% in Kavango, went to livestock purchases. Even more disturbing is that one-third of loans under Special Agronomic Loans Scheme, which was essentially meant to be a scheme for crop producers, were derailed for livestock purchases.

3.7.3 Effects on Household Expenditure

The average annual household consumption is estimated at N$ 42 078 and the per capita consumption is N$8 546 (NPC, 2006). While rural areas account for 60% of all households in the country and 65% of the population, they only account for 38 per cent of total consumption (Table 3.8). Female headed households which account for 41% of all households, only command a 29% share of total consumption. The average consumption in male headed households is N$ 50 100 compared to N$ 30 500 in female headed households. Similarly, consumption per capita in male headed households is 40% lower in female headed households (Table 3.9). Households in Namibia spend 24% of their total expenditures on food and beverages, 21% on housing, 16% on transport and communication and 20% on consumption of 'other' goods and services. Education and health make up a very small proportion of total household consumption, 2% and 3%, respectively. Urban households spend a smaller proportion of their consumption on food and beverages (16%) than rural households (39%). However, urban households spend a large proportion of their consumption on housing (24%) compared to 17% for rural households.

Table 3.8: Annual Consumption by Categories of Households

Category	House-Holds %	Population %	Average Household Size	Total Consumption Millions N$	%	Average Household Consumption N$	Consumption per capita N$
Namibia	100	100	4.9	15 639	100	42 078	8 546
Rural vs. Urban							
Urban	40.5	34.7	4.2	9 764	62.4	64 863	15 393
Rural	59.5	65.3	5.4	5 875	37.6	26 568	4 914
Sex of head of household							
Female	40.5	40.8	5.0	4 584	29.3	30 465	6 132
Male	59.1	59.0	4.9	11 010	70.4	50 113	10 204
Marginalized groups							
Khoisan	1.3	1.5	5.6	72	0.5	14 505	2 570
Type of Farming							
Subsistence	28.9	36.5	6.2	2 315	14.8	21 530	3 470
Commercial	0.7	0.5	3.3	619	4.0	224 850	67 789

Source: Adapted from NPC, 2006

Table 3.9: Annual Consumption Composition by Categories of Households' Spending

Category	Food/ beverages	Housing	Clothing/ footwear	Health	Education	Furnishing/ equipment	Transport communication	Other N$	Total Millions
Namibia	24.3	21.3	5.9	1.8	2.7	8.4	16.0	19.6	15 639
Rural vs. Urban									
Urban	15.7	23.7	6.3	1.9	2.9	8.3	18.3	22.9	9 764
Rural	38.7	17.2	5.2	1.5	2.3	8.7	12.3	14.0	5 875
Sex of head of household									
Female	30.6	23.4	6.6	1.9	2.4	8.3	10.0	16.7	4 585
Male	21.7	20.5	5.6	1.7	2.8	8.5	18.3	20.8	11 010
Marginalized groups									
Khoisan	62.3	17.2	3.8	0.5	0.3	5.3	4.6	5.9	72
Type of Farming									
Subsistence	52.4	18.1	5.8	1.3	2.6	6.0	7.1	6.9	2 315
Commercial	9.6	14.9	1.9	1.9	2.2	15.9	28.6	25.1	619

Source: Adapted from NPC, 2006

CHAPTER 4: CLIMATE CHANGE AND THE AGRICULTURAL ECONOMY

4.1 Introduction

Climate change can have impacts at both national and household levels. On the overall, climate change can affect the national economy through its impacts on agriculture, fisheries, ecosystems (biodiversity and tourism), coastal zones, and the health, energy and water sectors. As for the agricultural sector, the forward and backward linkages of agriculture to the wider economy and the occurrence of climate induced shocks may affect the Gross Domestic Product (GDP) both directly through reduced agricultural output, and by weakening the balance of payments position of the country. In addition, the sector is a supplier of raw materials to industries, like: meat processing, milling enterprises, etc. and a fall in agricultural output may have knock-on effects. Those industries serving the sector, like input providers, may also suffer if drought leads to a fall in demand for their goods and services.

It is important to note that considering country-level production impacts of climate change in the absence of consideration of the global impacts can generate highly skewed results. Agricultural exporting countries, whose productivity is reduced by climate change, may find themselves with a financial bonanza if world agricultural prices rise because of climate change. These same countries may suffer significant economic losses if climate change turns out to be generally beneficial to world agriculture even if agricultural productivity in their country benefits. This feature of the agricultural economy is well known and reflects what an inelastic demand for food is, in aggregate. Therefore, no absolute implications for food availability, price or farm financial success can be drawn from local and country-level estimates of production impacts of climate change unless one assumes that production changes around the world will generally balance to leave little impact on global production and prices. A country may attempt to carry out a set of policies that maintains a neutral effect on the country's agricultural sector *vis-à-vis* the rest of the world, but maintaining such policies will generally entail significant economic cost through subsidization of domestic agricultural production and/or consumption or through import or export controls. There are many different ways on how these costs may be borne given by Reilly (1996) as higher food prices, government expenditures, lost efficiency in the producing sector, lost export opportunities depending on how the policies are structured.

Based on how global economic linkages and geographic dispersion and variability of climate change occurrences affects country-level economic impact assessments, this study relies on implicit assumptions about certain factors in order to portray the Namibian situation.

4.2 Farming Systems in Namibia

Based on the agro-ecological zones of Namibia, five major farming systems are given by Mendelsohn (2006) as: small-scale cereals and livestock; small stock production; mixed cattle ranching; intensive agriculture and natural resource production (Table 4.1). Other integrated forms of farming systems in which fish (integrated aquaculture), bees (apiculture), and forest products (silviculture) contribute significantly to household livelihoods exist, but these are poorly documented in literature. The agricultural sector has, broadly, a dual system comprising a well developed, capital intensive and export oriented *commercial sub-sector* and a subsistence-based *communal farming sub-sector*, low in technology and external inputs and highly dependent on labour (GRN, 2004). Mendelsohn (2006) estimates that about 152 000, 20 300 and 16 000 households are directly involved in crop, cattle and small stock production respectively.

Table 4.1: Farming systems in Namibia

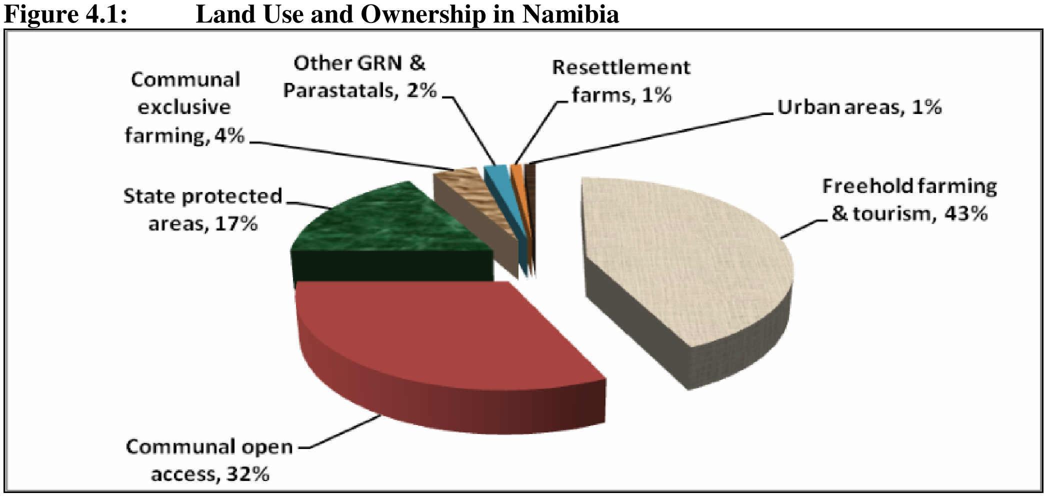
Farming system	Main commodities	Land area	Use of production
Small scale cereals and livestock	Mahangu, sorghum, maize, goats and cattle	Small exclusive farms and open grazing in communal land in the northern Region	Domestic consumption supplementing income from non-farming activities
Cattle ranching	Cattle	Large freehold farms, exclusive farms in communal land and in open grazing in northern Kunene	Beef, mainly for commercial sales to South Africa, Europe and Namibian consumers
Small stock	Sheep and goats	Large freeholds farms and open grazing in communal land in the southern and western Regions.	Mutton and goats for commercial sales to South Africa and Namibian consumers

Source: Adapted from, GRN, 2005

4.3 Land Use Systems in Namibia

About 78% (or 64 million hectares) is designated as crop and livestock (including wildlife) farming area taking various forms such as freehold farming and tourism (356 533 km^2), communal open access (263 832 km^2), communal exclusive (35 602 km^2) and resettlement areas (7 731 km^2). State protected areas (e.g. mining) and government farms accounts for about 137 212 km^2 and 15 827 km^2 of land respectively, whereas town lands accounts for 7 275 km^2 of land (Sweet, 1998; Mendelsohn, 2006). Figure 4.1 below shows the distribution of land among various land uses and ownership.

Figure 4.1: Land Use and Ownership in Namibia



Source: Data from Mendelsohn, 2006

4.3.1 Commercial Farming Sector

The main activity in the *commercial sub-sector* is cattle ranching, with limited areas of cropping, carried out in free-hold farms covering about 44% of the country's landmass (GRN, 2004). There are an estimated 4 200 commercial farmers, each owning on average, nearly 8 000 ha south of the VCF. The sub-sector employs more than 30 000 farm workers equivalent to supporting about 150 000 people – assuming a family size of 5 persons per farm worker. The sector includes producers of maize, wheat and other crops such as grapes and ranchers of cattle and small stock (NPFS, 2007).

4.3.2 Communal Farming Sector

Between 60% and 70% of Namibia's population practice subsistence rain fed arable agriculture and livestock (cattle, goats and to a lesser extent sheep) farming on communal land, which is state owned and constitutes approximately 36% of the total land area. The communal sector produces about 30% of grain consumption requirements, and keeps about 60% of cattle and 40% small stock population in Namibia (NPFS, 2007). Agriculture in the communal areas is vital for the livelihood of most rural households. Distant markets limit the development of farming in the communal areas and agricultural incomes are low and variable (PWC, 2005). Although communal-tenure farming is an important direct provider of staple food for many rural households, it makes limited contribution to the cash income of most of these households.

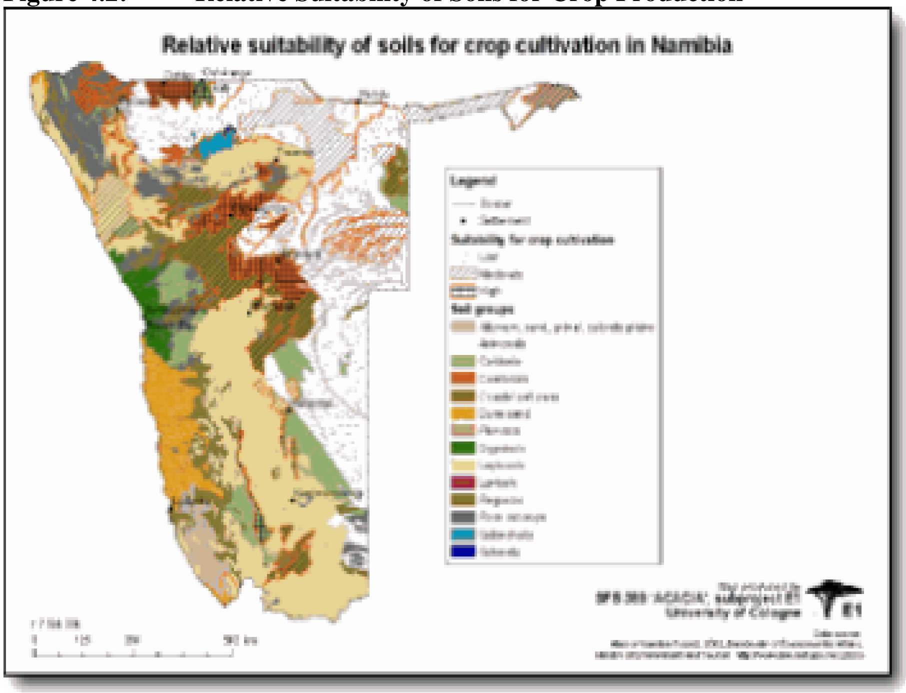
4.4 Livestock Farming

In Regions with rainfall lower than 250 mm, the vegetation can only support small ruminants such as sheep and goats (Duggal, 1989). The areas receiving between 250 and 400 mm allow cattle farming, and consequently mixed livestock farming based on ruminants (ibid). In areas with rainfall in excess of 400mm, cattle farming is predominant but dry-land crop production can be initiated (ibid). At the present moment, livestock contribute 70% to the agricultural output (MAWF, 2007), and serve various roles to communities including cash, wealth, sustenance & food security (through milk, meat and by-products), draught power, manure, employment, skins, dowry, ecosystem health and exchange for other farm produce. Owing to climate, soil types and evapo-transpiration rates, Namibia is better adapted to livestock-based as opposed to crop-based agriculture (Table 4.1). While livestock production is generally acknowledged as the most important agricultural economic activity in Namibia, the importance of staple cereal crops like Mahangu and maize both in the commercial and communal areas is underscored.

4.5 Crop Production

Crop production activities are limited, mainly due to general dry conditions (lack of water) and poor soils (Figure 4.2). Geographic distribution of crops will thus be influenced, mainly, by suitability of soils and availability of water (rainfall and perennial and ephemeral streams). With the high degree of unreliable rainfed cropping, it is evident that the upper limit of available land has been reached in much of Namibia, resulting in high cropping intensities and a dominant role for irrigation under the Green Scheme Initiative. For example, in the Kavango Region, the increase in arable land is achieved only at the expense of ecological cost of deforestation (Kuvare and Mbai, 2006), which may have direct relevance to climate change.

Figure 4.2: Relative Suitability of Soils for Crop Production



Source: UC, Data from Atlas of Namibia

4.5.1 Rain-fed Crop Production

About 1% of the total surface area of Namibia is suitable for seasonal and permanent crop production (Christelis and Struckmeier, 2001). Low and sometimes poorly distributed rainfall have limited high yielding rain-fed crop production to only those areas receiving 400 mm and above annually or about 34% of the country. Such production is associated with a high risk of crop failure due to the erratic nature of the rainfall. Of the cereals, a large amount of the rain-fed maize is produced in the commercial sector, while pearl millet (Mahangu) and to a small extent sorghum is almost exclusively grown by an estimated 150 000 subsistence communal farmers mainly for own consumption.

4.5.2 Irrigated Crop Production

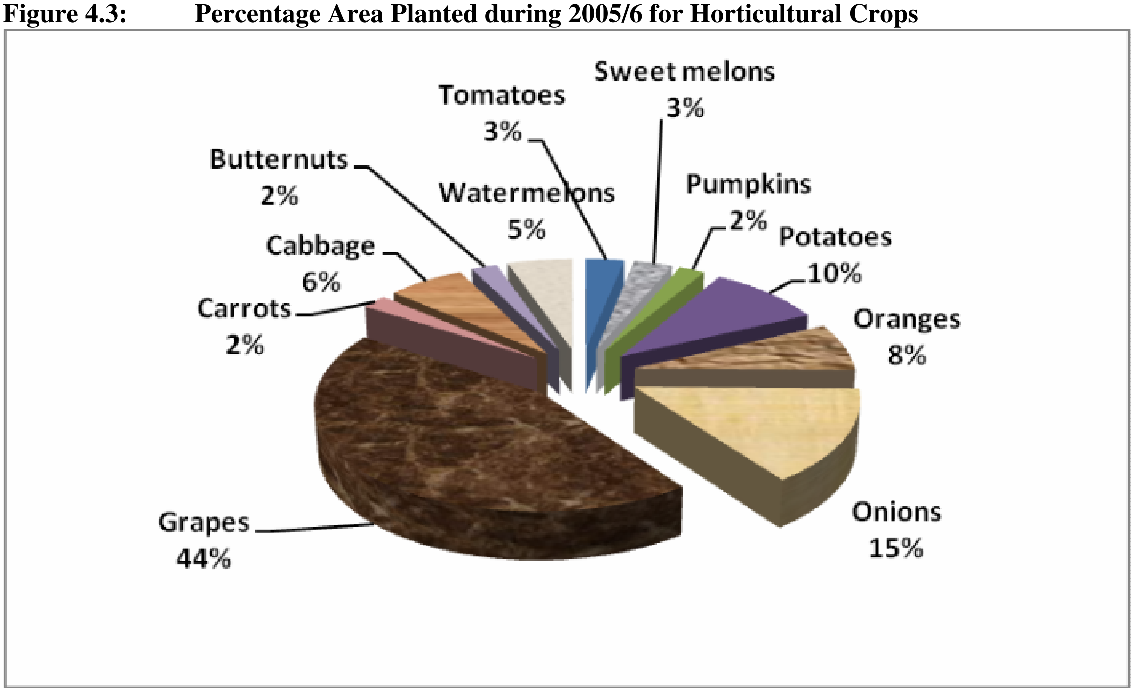
Specifically in terms of irrigation, there is significant potential in communal-tenure farming for increased agricultural productivity, which can be achieved through well-planned interventions, including adaptations and adoptions of improved farming techniques (PWC, 2005). Due to the arid nature of the country, dry land, rain-fed crop production, which is practiced by the majority of small-scale and mostly subsistence farmers, is unreliable in ensuring food security, at household and national level (MCA, 2006). In response, Namibia commenced with a strategic process to promote the development of irrigation, resulting in the approval and implementation of the Green Scheme Policy in 2003 and 2004 respectively.

To date the total agricultural area under irrigation consists of about 8,600 hectares. Considering existing national water and land resources, the arable development potential through irrigation in Namibia is estimated at 43,500ha (PWC, 2005). This area leaves sufficient development potential not only to cover the subsidization of existing food imports, which in terms of cereals, crops and horticulture products amounted to N$450 million in 2004, but also to enhance the exports of high value horticulture products such as grapes, dates, mangoes and some vegetable produce (ibid).

Irrigation is practiced mainly in the maize triangle, Hochfeld area and within the Green Scheme Projects in Kavango Region (i.e. Mashare, Musese, Sarasungu, Shadi Kongoro, Shitemo, and Vungu Vungu Irrigation Projects) and Etunda in Omusati Region. Limited irrigation takes place along the Ruacana-Outapi canal and Olushandja dam. In the south, the Hardap and the Naute Irrigation Schemes produces a winter wheat crop and some table grapes and dates, which have boosted the volume growth of high value commercial crops. Along the Orange River, individual farmers and companies and farmers' cooperatives produce table grapes, dates and other high value horticultural crops for export. In this regard, the few perennial rivers are pivotal to cropping systems in Namibia.

Horticultural production systems have greater potential for expansion in Namibia. Currently the system supports more than 100 crop types, categorized into roughly 21 commodity groups. Figure 4.3 below shows the fragmentation of various horticultural products in Namibia in terms of area planted.

Figure 4.3: Percentage Area Planted during 2005/6 for Horticultural Crops



Source: NAB, 2007

Horticultural production occurs across a wide range of environmental conditions, with distribution restricted primarily by access to water, water quality, soil quality and by topography. Major production areas are concentrated in fertile areas with high annual rainfall or abundant water resources from rivers, streams or reticulated irrigation scheme areas.

Future expansion in the horticultural sector would be constrained by access to viable markets and to water resources rather than by environmental limitations. Although accountability for food safety and environmental compliance will be increasingly important to future markets, the complexity of the industry inhibits close liaison and coordinated planning. Access to water resources is considered the key industry risk. However the relatively high water use efficiency of many horticultural crops, compared with other irrigated agriculture, means that horticulture is well placed to compete for increasingly expensive water entitlements. Land is not expected to be a limiting factor, though it was reported that in recent times the horticulture industry is competing with the staple crop industry for productive soil and water resources. Wherever expansion does occur, it will probably be achieved through the re-allocation of existing agricultural land to horticulture rather than clearing new land.

The scale of horticultural investments is likely to increase in the future, as technology and plant breeding become more integrated with consumer markets and supply chains serving domestic and export markets. Climate change adapted technology will be increasingly important to expansion of horticultural industries by providing rapid access to information on markets and innovations, and assistance in farm management and environmental practice.

4.6 Sectoral Policies Related to Agriculture

Poverty reduction has been the overarching policy goal across many economic sectors of Namibia. In the wake of concerns that commercial sectors would be nationalized, Namibia has instead implemented pragmatic policies to maintain private sector leadership in the economy, to encourage foreign investment and to avoid over-reliance on international loans. Namibia pursues a policy of product diversification to expand the base of agricultural development by relying on market forces to determine the direction of diversification. Initiatives encouraging the diversification of smallholder crop-based systems will promote the integrated production of legumes and livestock, while sustainable production, harvesting, and marketing of indigenous veld products will also be actively promoted (NPFS, 2007). The various policies and guidelines governing the agricultural sector are outlined below:

- Namibia's Vision 2030 visualizes the NDPs as the main vehicles for achieving its objectives and realizing the long-term Vision. The NDP3 for the period 2007/08 to 2011/12, themed "*Accelerated Economic Growth through Deepening Rural Development*", is currently under finalization. The broad thrusts and goals of the NDP3 are derived from the Vision 2030, the 2004 SWAPO Party Manifesto, the directions from the November 2005 Cabinet Retreat, the MDGs, and the lessons learned from implementing both the NDP1 and NDP2.

- The overall goal outlined in the *National Agricultural Policy* is to increase and sustain levels of agricultural productivity, real farm incomes and national and household food security within the context of the country's fragile ecosystem. The broad objective of this Policy as highlighted in the NDP2 is to enhance and contribute to sustainable and equitable economic growth by: "Enhancing agricultural production at the household and national level; Promoting on- and off-farm livelihood opportunities; Reducing the volume and value of agricultural imports; and Increasing the volume and value of agricultural exports".

- Other key national instruments governing the agriculture and land components with the integration of sustainable development and natural resource use principles are the Drought Policy, Namibia's Green Plan, Water Policy and the National Land Policy.

- The Poverty Reduction Strategy is chiefly directed towards agricultural expansion and strengthening food security, equitable and efficient delivery of public service and strengthening non-agricultural and informal sectors. The NPRAP outlines poverty reduction programmes and projects in accordance with the NDP2 and the Public Investment Programme.

- Green Scheme Policy is under implementation since October 2004. The mission of the Green Scheme is to create an enabling, commercially viable environment through effective public-private partnerships. The premise is to attract and enable large scale commercial farming enterprises to establish commercially viable entities in remote undeveloped rural areas, and act as Service Provider to small-scale farmers, ensuring their successful and long-term sustainable settlement.

4.7 Agricultural Trade Agreements

Trade agreements serve to provide and enhance acquisition of agricultural and related products that Namibia cannot produce, while exports would earn Namibia revenue and foreign currencies through sales. In Namibia, cross-border sales are organized by private traders, but the government exercise control and enter into agreements to protect or enhance the value of farm produce in three principal ways:

- By promoting exports, and therefore local production.
- Through restrictions on imports to protect and support local production against foreign competition.
- By limiting the export of raw products to encourage local processing.

Exports are mainly promoted through trade agreements that aim to give exporters free, cheaper or preferential access to markets in countries with which Namibia has links. Namibia is party to many southern African and international trade agreements and communities including:

- The Southern African Development Community (SADC) Free Trade Agreement;
- The Common Market for Eastern and Southern Africa (COMESA);
- The EU – African, Caribbean and Pacific countries (or Cotonou) agreement;
- The EU's Economic Partnership Agreements (EPA);
- African Growth Opportunity Act (AGOA);
- The Common Monetary Area and;
- The World Trade Organization.

As a member of the Southern African Customs Union (SACU), Namibia also benefits from participation in the SACU/Mercosur agreement with Argentina, Paraguay, Uruguay and Brazil, the SACU/European Free Trade Association (EFTA) agreements, and negotiations to establish free or preferential trade agreements with China, the USA and India. Namibia has a free trade agreement with Zimbabwe and is negotiating a preferential trade agreement with Angola.

4.8 Agricultural Output and Growth

Despite the marginal contribution of the agricultural sector to the GDP, it remains central to the lives of the majority of the population. Directly or indirectly, it supports over 70% of the country's population (NPFS, 2007). Presently, livestock and grain production represents the foundations for the growth of agricultural incomes, exports and rural employment, consequently contributing to import substitution and household food security.

The agricultural sector is estimated to have grown at an average rate of 2.2% per year, during 2000-2005, which is below the NDP2 target of 5% real growth. In the same period, the agricultural sector contributed only 5.2% per annum to total GDP compared to the NDP2 target of 10% of GDP (NPFS, 2007). Even in 2005, agricultural sector accounted for only 5.95% of GDP at current market prices (MAWF, 2007). Most growth in agricultural GDP was due to the positive contribution from the commercial sub-sector which grew at a rate of 8.3% per annum unlike the subsistence sub-sector, which experienced negative growth of 3.1% per annum (ibid). Overall growth in the sector fluctuated and was negative in most years. This poor performance of the agricultural sector can be attributed to episodes of drought and currency appreciation among other constraints (NPFS, 2007).

Namibia is a net importer of most of the agricultural, forest and fisheries related products. Meat and fish are the exception as they are produced in abundance within the country. Regarding meat and fish and their related products, Namibia export mainly to the Angolan, European Union and South African and, to a limited extent, the United States of America's markets. Namibia exports about 100 000 tonnes of beef and about 15 000 tonnes of goat meat and mutton annually (Meat Board, 2007). About 65% of the beef is exported to the EU, while the rest is exported to South Africa and Angola (ibid). Almost all the exported goat meat and mutton goes to South Africa.

In 2005, total agricultural output was estimated at N$1.13 billion out of which 66.8% and 33.2% was contributed by the commercial and communal sub-sectors respectively. In 2005, agricultural exports accounted for 6.1% of total exports and livestock and animal products accounted for 71.3% of agricultural exports (NPFS, 2007). Namibia imports approximately N$105 million of vegetables and another N$55 million of fruit on an annual basis which is about 58.2% of total agricultural and forestry products. Of the current local production, only about 50% reach local markets. The remaining produce is exported to South African fresh produce markets and eventually re-imported for own consumption. This in effect means that locally produced horticultural products are re-imported into the country (PWC, 2005).

Namibia has experienced a positive growth in agricultural output over the past decade or two. Agricultural contribution to GDP as depicted in Table 4.3 below has grown from 4.5% in 2001 to about 7% in 2005.

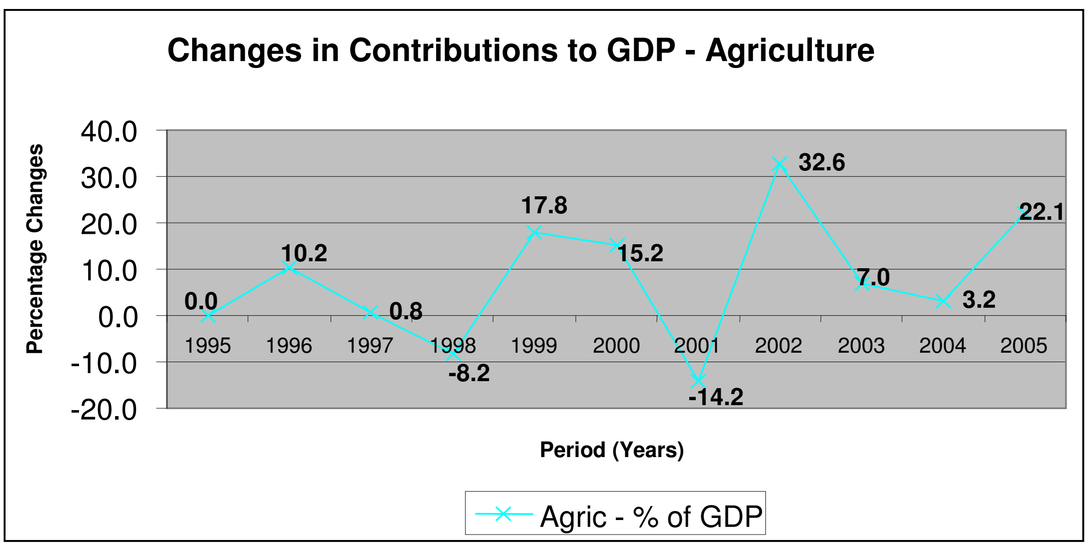
Table 4.3: Contribution of Agriculture and Fisheries Sectors to GDP

Sector/sub-sector	2001	2003	2005
Agriculture and Forestry	*4.5*	*5.8*	*7.0*
Commercial	2.8	4.3	5.0
Subsistence	1.7	1.5	2.0
Meat processing	<1.0	<1.0	<1.0
Fishing	*5.7*	*5.6*	*4.9*
Fish processing	1.9	2.8	1.6
Mining and Quarrying	*14.7*	*9.5*	*10.2*
Diamond mining	11.5	8.4	7.7

Source: MAWF, 2007.

Due to the fragile ecosystem and aridity, Namibia's agricultural output has been sensitive to climate variability and change. Trend of changes in the contributions of agriculture to GDP over time shows evidence of climate change on the performance of the sector to GDP (Figure 4.4). During periods of relative drought, the contribution of agriculture declined considerably.

Figure 4.4: Changes in Contribution of Agriculture to GDP



Source: Data from NPC, 2007

4.9 Relative Climate Induced Impacts on Agricultural Performance

4.9.1 Impacts on Livestock Sector

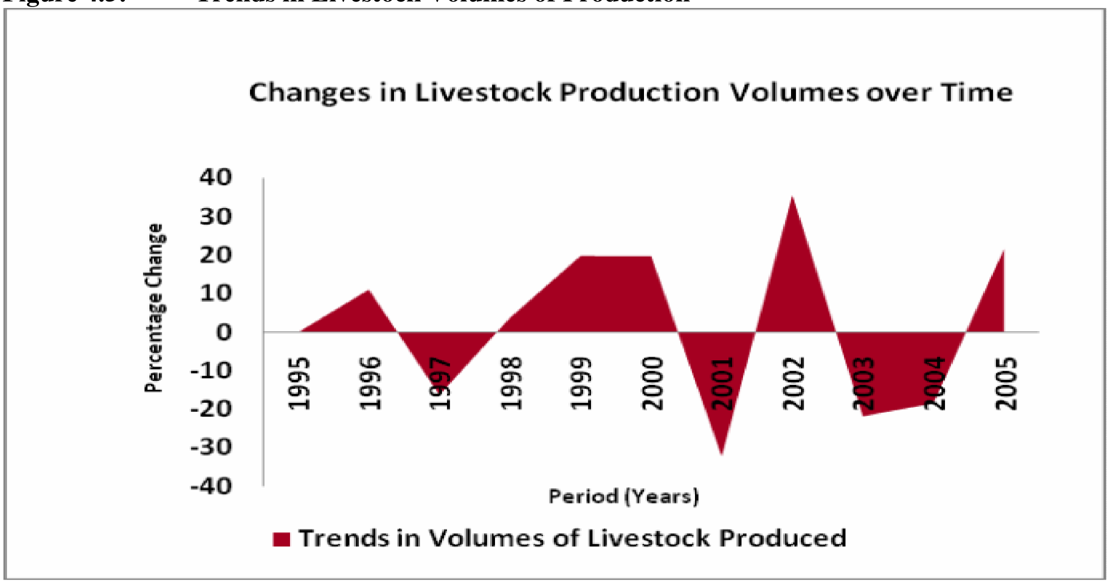
Livestock production is the dominating agricultural activity in Namibia. Cattle ranching and small stock farming systems alone occupies a total of 58.5 million hectares of land and contributed 59% to the Gross Agricultural Production in 2004 (Mendelsohn, 2006).

Climate change has three main impacts on the economics of livestock production, as discussed below:

4.9.1.1 Impacts on Livestock Production Volumes

The effect of climate change on the livestock sector is experienced through changes in quality and quantity of vegetation, availability of fodder and the occurrence of climate related animal diseases. Indirectly the aforementioned factors transcend themselves on livestock productivity parameters such as conception and calving rates, mortality rates and meat quality. Occurrence of climate induced drought affected livestock production volumes in Namibia (Figure 4.5).

Figure 4.5: Trends in Livestock Volumes of Production



Source: Data from MAWF, 2007

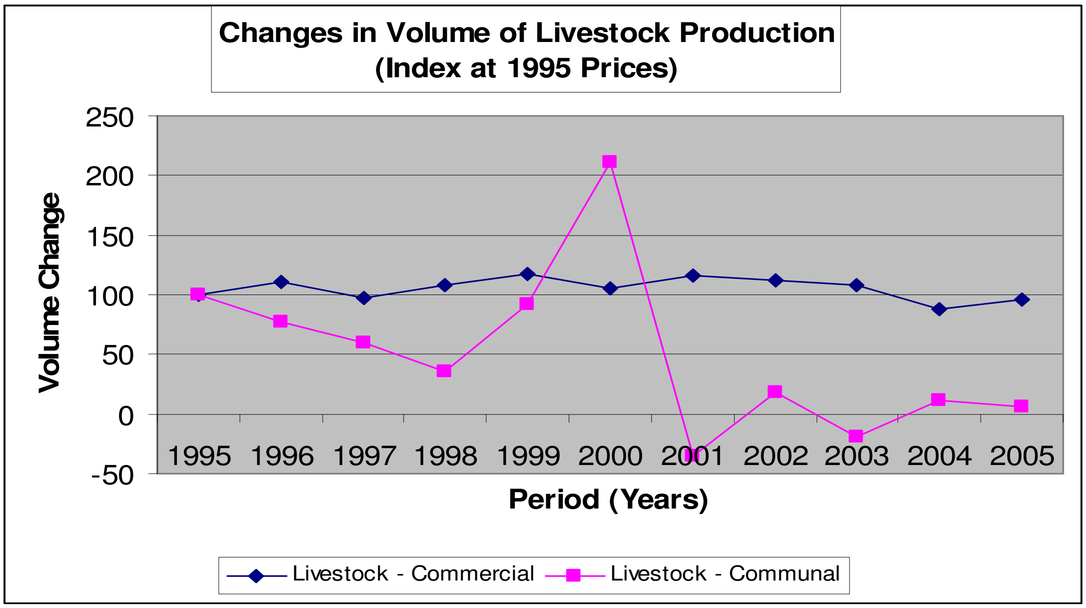
Changes in livestock production volumes for the periods 1995 to 2005 expectedly conformed to prevailing climatic conditions, because in years of relative drought 1996/7, 2000/1 and 2003/4 livestock production declined. According to Moorsom and Pfouts (1993), in a period of normal rainfall, calving rates are 60% to 70%, whereas in a period of drought this rates may fall as low as 25-30%. For goats, the normal kidding rate is 160% and this rate falls to 50% to 80% in a period of drought (ibid). An indicator of how drought affects meat quality is imbedded in exports of quality meat cuts to the EU. In times of drought, the export of quality meat cuts decline leading to Namibia not meeting its quota allocation for meat exports to the EU. There is no quantitative information on the fall of conception rates in the cattle and other small-stock sub-sectors. Instead, changes in total sales measure the effects of drought on output of cattle and small-stock.

The relative impacts of drought on livestock production volumes between communal and commercial farmers' show greater fluctuations for communal farmers. Figure 4.6 highlights greater susceptibility of communal livestock production to climate variability, hence more vulnerability.

4.9.1.2 Effects on Livestock Marketed and Exports

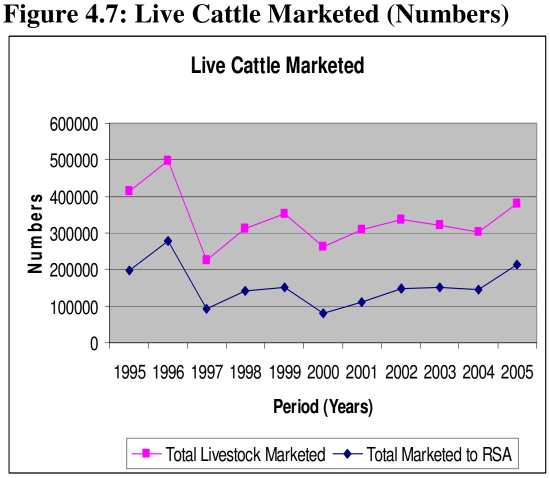
At face value, it is expected that a decline in livestock production volumes leads to a decline in the number of livestock marketed. However, in reality how this unfolds is determined by several market factors and farmers marketing decisions. In periods of drought in Namibia, the number of cattle and small stock marketed can be expected to rise. During drought, the value of cattle and small stock may drop due to increased supply and deteriorating conditions of the animals. Farmers may therefore tend to sell their animals before the value reaches unacceptably low levels. Also, government livestock marketing incentive schemes during periods of droughts contributes to this situation. In fact, marketing of livestock declines immediately after periods of droughts, because farmers are rebuilding their herds. These assertions are illustrated in Figures 4.7 and 4.8 below.

Figure 4.6: Changes in Volumes of Production between Communal and Commercial Farmers



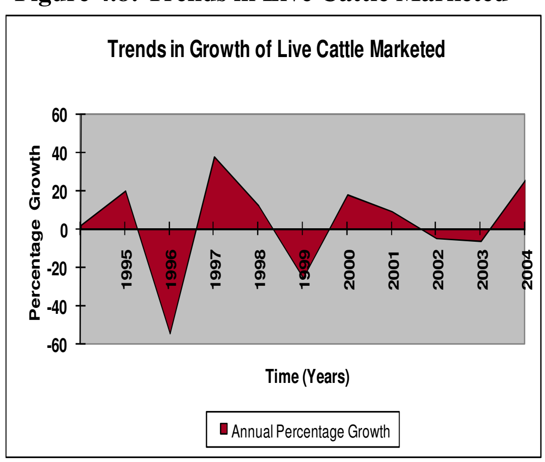
Source: Data from MAWF, 2007

Figure 4.7: Live Cattle Marketed (Numbers)



Source: Data from MAWF, 2007

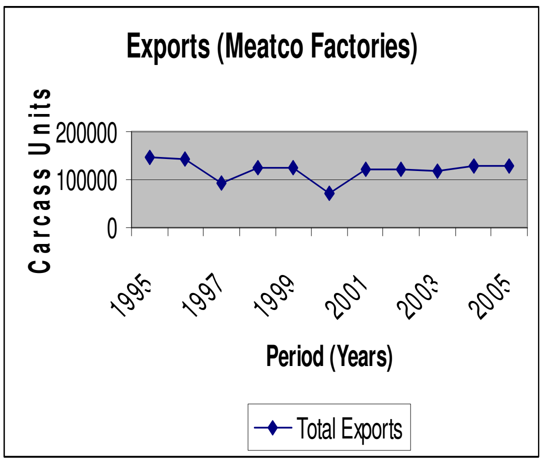
Figure 4.8: Trends in Live Cattle Marketed



Source: Data from MAWF, 2007

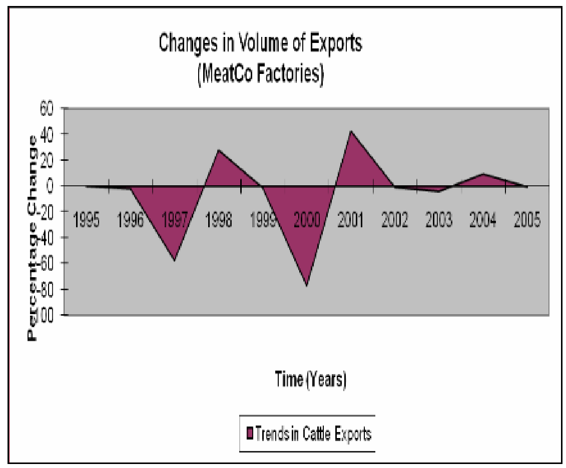
The number of live cattle marketed peaked during the drought experienced in the summer of 1996 with a total of 497963 numbers of livestock marketed (Figure 4.7). To a lesser extent, the 2000/1 and 2003/4 drought also shows an increase in the number of livestock marketed. During the periods following the drought, the number of livestock marketed declined because farmers were restocking. This effect transcends itself on the export market of cattle. Since only 20% of the measured production of cattle and small stock is consumed domestically and 80% is exported, increases in sales in years of drought will consequently result in a rise in export volumes. For example, export data from the Meat Corporation of Namibia (MeatCo) Factories reflects relative decline in exports as a direct result of drought (Figures 4.9 and 4.10).

Figure 4.9: Export Volumes – Meatco Factories



Source: Data from MAWF, 2007

Figure 4.10: Changes in Export Volumes (Meatco)



Source: Data from MAWF, 2007

Exports to overseas, notably the EU, has certain requirements in terms of the quality of cuts. During times of drought, the condition of slaughter animals are not that good and hence exports to the EU may drop. Consequently, Namibia cannot exploit the lucrative EU market for high quality beef cuts in full. It is worthwhile to note that while climate change may impact production volumes and export quantities other factors such as trade barriers (quotas and tarrifs), government policies (such as requirements to sell a certain percentage of sheep to local butchers before getting an export allowance) and prices (both product and input) affects export quantities.

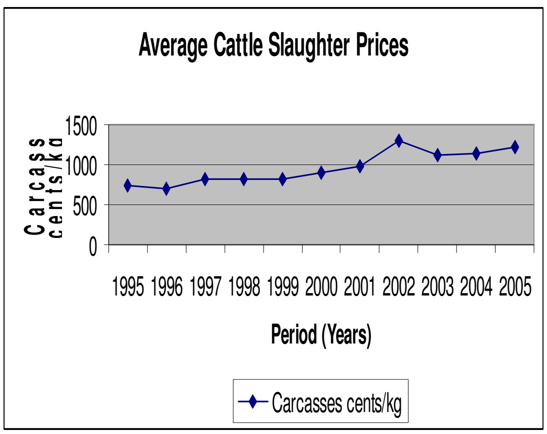
4.9.1.3 Effects on Livestock Prices and Output

Prices are generally determined by a number of factors, namely demand-side and supply-side factors. Climate variability, and the occurrences of drought, are generally classified as supply-side factors, i.e. they influence production levels. There is evidence of marginal downward pressure on domestic livestock prices during times of drought and a slight upward pressure on livestock prices in periods immediately after droughts (Figures 4.11 and 4.12). While prices did not fluctuate much over the years, farmers received lower total value for their cattle and small stock because of the lower average grades arising from the poor condition of the animals.

The increase in domestic supply to the RSA open and controlled markets during drought did not put a downward pressure on prices in RSA, because Namibia is a price-taker as it supply about 5% of the total meat consumed in RSA. On the other hand, prices of domestic sales to Meatco was not influenced either, chiefly in that Meatco prices are based on the RSA prices. At the moment no data on prices offered at informal markets, auctions and individual buyers are available.

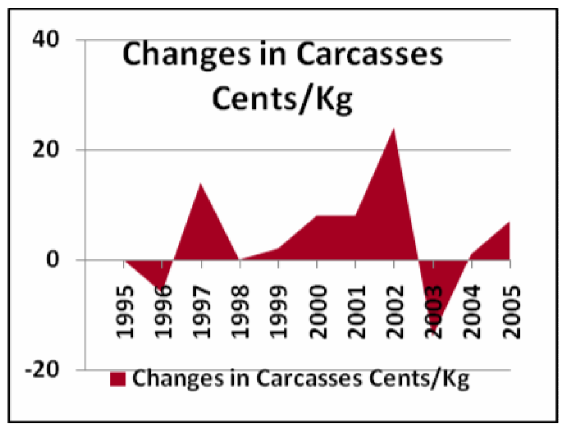
The preceding analyses show that market conditions in the RSA have an influence on Namibian livestock prices, especially cattle and small stock. For example, prices of maize (mostly yellow maize) in RSA affect demand for life export of livestock (mostly weaners for feedlots) to that country. Changes in maize prices in South Africa may also be affected by climate change as maize shortages in South Africa raises demand for maize and increases prices, thus leading to lower demand for life export of Namibian weaners to South Africa.

Figure 4.11: Trend in Prices of Slaughter Cattle



Source: Data from MAWF, 2007

Figure 4.12: Changes in Carcass Prices



Source: Data from MAWF, 2007

4.9.1.4 Impacts on Meat Processing Industry

The meat processing sector in Namibia is controlled mainly by two companies Meatco and Hartlief. Meatco supplies chilled and frozen cuts and Hartlief supplies processed meat. Hartlief uses 75 to 80% pork meat in its production process. Since 70% of the Namibian demand for pork meat is imported from the RSA, Hartlief's inputs are not much affected by drought occurring in Namibia. During the 1992/93 drought, Meatco experienced an increase in supply which could be handled within the existing processing capacity. However, a major problem Meatco encountered was the failure to meet the demand for high quality cuts, for export to the EU.

4.9.1.5 Impacts on Dairy Industry

The impact of climate change on the dairy sector is mainly through input shortages and prices. Input prices of dairy products increases in times of drought. Farmers have to purchase additional fodder to feed their milk cows. In April 1993, input prices of Bonmilk had increased by 12% (Van der Linden et al., 1995). This price increase was passed on to the consumer and Bonmilk was therefore not financially affected by the increase in input prices (ibid). Rietfontein experienced an increase of 15% in input of which only 10% was passed on to the consumer. The remainder was partly covered by increased total output resulting from advantages associated with economies of scale.

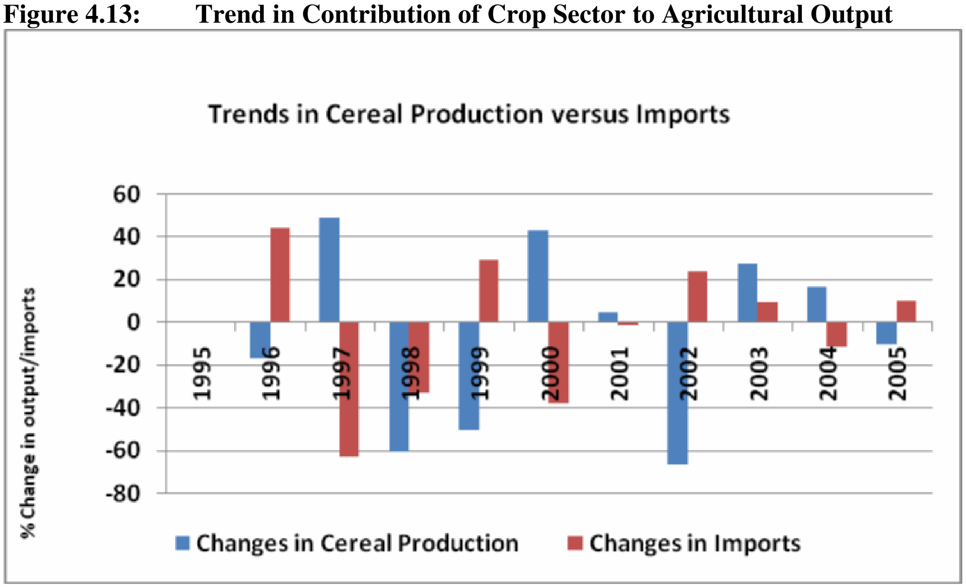
4.9.1.6 Impacts on Karakul Industry

Karakul sheep are very well adapted to the harsh climatic conditions of the arid and semi-desert areas of southern Namibia. Karakul production is thus less vulnerable to drought. Prices of karakul pelts are not very sensitive to drought, but are more influenced by other factors such as the whims of fashion, the economic situation in consumer countries and mink prices. As for the depression of the karakul industry in the 1980s, much of the blame was put on a fall in world karakul pelt prices and to a lesser extent on the droughts that occurred in the same period. In recent times, the activities of animal welfare organizations may pose considerable threat to the karakul industry.

4.9.2 Impact on Cereals Sub-sector

The crop production sub-sector forms an important part of the agricultural sector (Figure 4.13). Although the sector on average contributed around 7% to total agricultural output, it is important in terms of its contributions to food security and export earnings. The sector has shown potential for growth over the years, from 5.2% to 9.9%, mainly due to the introduction of the Green Scheme Initiative and diversification into high value crops such as grapes, dates, etc. Further improvement in production technologies and full utilization of irrigation capacities also ensures growth in this sector.

Figure 4.13: Trend in Contribution of Crop Sector to Agricultural Output



Source: Data from MAWF, 2007

With regard to climate change, irrigated agriculture is not significantly affected by variations in rainfall unless[5] if the source of irrigation water is affected. For example, in Figure 4.14 below, irrigated wheat to agricultural output did not show huge variations compared to the contribution of rain fed maize, pearl millet and sorghum.

[5] Moorsom et al (1993) reported that irrigated wheat production declined by 50% because only 50% of the Hardap dam's normal capacity could be used.

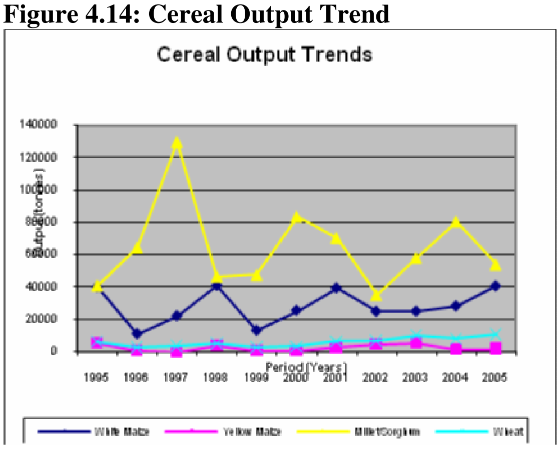
4.9.2.1 Impact on Cereal Production

For cereal crops, such as maize, pearl millet and sorghum, the negative impacts of climate change have the effect of reducing yield and thus quantity and quality of marketable produce. Climate variability and change has a threefold impact on the cereal sub-sector, notably:

- When there are shortages of rainfall during the growing season (January, February and March), agronomic drought takes its course and crop failure will occur. Excessive rainfall may result in crop failure, because of field flooding.
- When rain is delayed, the growing season is shortened and yields become lower. Typically maize needs about 120 days, sorghum 90 days and millet 85 days to grow from seed to a harvestable crop.
- Drought generally deteriorates soil condition and a lack of appropriate farm practice interventions e.g. irrigation and drainage may lead to a smaller area being planted and hence low yields.

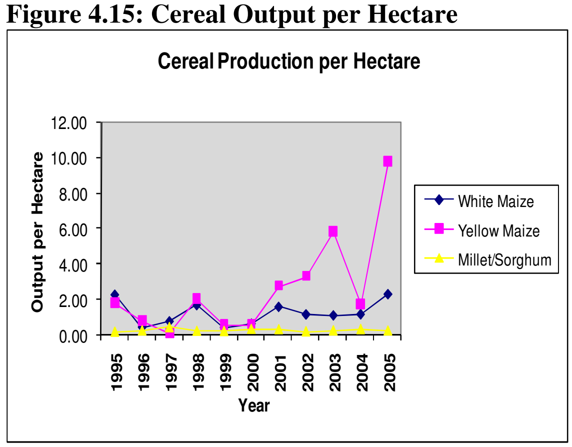
In Namibia, there is considerable evidence that suggest that real output in maize and pearl millet tend to oscillate with occurrences of droughts or alternatively flooding of fields. The fluctuations in cereal output over time (Figure 4.14) did not occur in regularity occurrences of drought, but due to variations in the area planted for the various categories of cereals. To account for this, Figure 4.15 on cereal production per hectare over time shows clearly that cereal output per hectare fluctuated in tandem with occurrences of droughts which may be due to climate change. Low cereal output per hectare was experienced during the periods 1995/1996, 1996/1997, 2000/2001 and 2004, all seasons in which Namibia experienced considerable drought.

Figure 4.14: Cereal Output Trend



Source: Data from MAWF, 2007

Figure 4.15: Cereal Output per Hectare



Source: Data from MAWF, 2007

4.9.2.2 Effects on Cereals Marketed and Imports

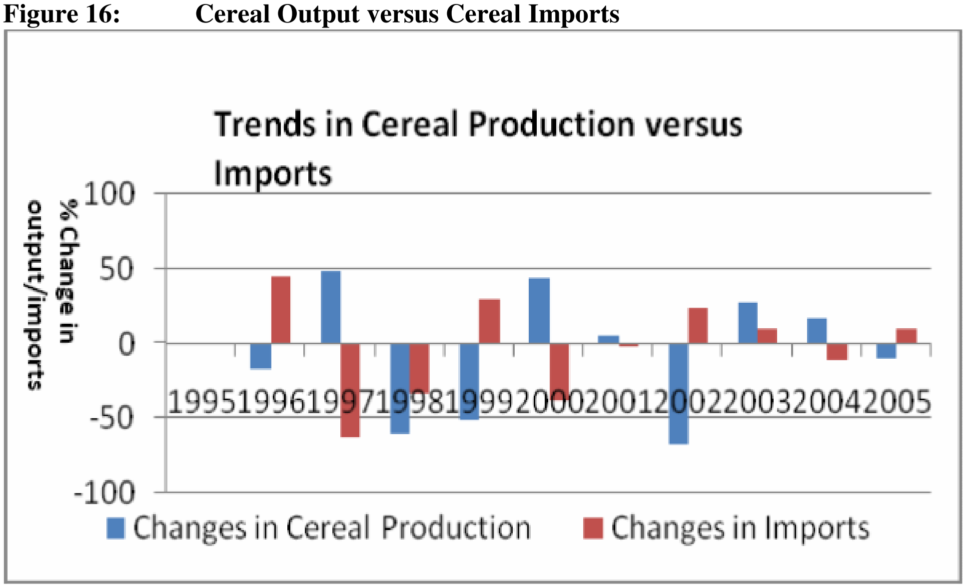
The occurrence of drought results in market shortages and increased demand and prices, *ceteris paribus*. Due to storability of both maize and pearl millet a degree of flexibility exist for farmers in making marketing decisions – farmers can time the most suitable time to market his produce, when prices are high. Increasing farmers' access to market information and their ability to store their produce can thus enhance food security while allowing commercial farmers to hold to their produce longer in order to catch better prices.

Namibia is not self-sufficient in the production of most cereal crops. It is not likely that Namibia will become self-sufficient in these products in the near future since only a small part of Namibia is suitable for agronomic production and prospects for expansion of staple crop production are limited. Thus, Namibia is likely to remain dependent on imports of all important cereals to meet domestic consumption needs. The periodic fall in cereal outputs due to climate variability create cereal deficits, which increases cereal imports.

Figure 4.16 below illustrate the relationship between changes in cereal output and cereal imports. If local cereal production is low, than imports of cereals become inevitable, especially during the drought years. However, the relationship between local production and imports, as seen in Figure 4.16, is not a perfect one (direct inverse proportionality) because other factors, especially price, also determines the levels of imports. The economic impacts of changes in cereal output due to climate variability are thus obvious, certainly because cereals form a major part of the diet of Namibians. Increased imports of cereals due to low local production as a result of climate change will result in weakening the balance of payments in trade, decline in the contribution of agriculture to GDP and thus weaker economic growth and food security situation.

In the preceding analysis of the impacts of climate change on cereal markets, it is important to note that several other factors come into play in determining the market outcome of cereals. For example, changes in household incomes, changes in livestock industries that use maize as animal feed, the international markets, trade barriers, etc. have considerable influence on market outcomes.

Figure 16: Cereal Output versus Cereal Imports



Source: Data from MAWF, 2007

4.9.2.3 Effects of Drought on Secondary Markets of Crop

The occurrence of droughts has forward effects on secondary markets. According to Van der Linden (1995) the demand for services from the milling companies increases in times of drought. For example, AGRA, a leading input retailer in Namibia, experienced an increase in demand of between 10-15% during the 1992/93 period of drought (ibid). Two reasons are cited for this, firstly, cereal shortages causes an increase in demand for cereals from subsistence farmers. Secondly, food aid raised demand for milling activities, because donated cereals for food aid were locally processed. It, therefore, appears that while domestic supply of cereals to mills drops in times of drought the impact on major millers is not significant. It is reported that during the 1992/3 period of drought, Namib Mills employed 35-40% more workers than in a year of normal rainfall. Millers have even benefited from increased imports since the lower price and quality of imported (yellow) maize was not reflected in lower consumer prices.

4.9.2.4 Effects on Prices

Producer prices for controlled crops will normally not directly fluctuate in resonance with climate variability because of government market interventions. Prices for controlled crops are set by the Namibian Agronomic Board in consultation with producers, processors, consumer lobby groups, and the Ministry of Trade and Industry. Although price-fixing is common, marginal fluctuations in prices do occur because of value addition. Normally, producer prices are set before land preparations and serves to entice farmers to produce. For the three cereal crops (maize, wheat and pearl millet) being investigated in this section, only maize and wheat are controlled crops. Pearl millet is yet to be made a controlled crop, thus data on its prices could not be obtained. The ten year (1995 to 2005) average price per ton for maize was N$ 1 163. There is a general inflationary upward trend in cereal producer prices.

Consumer prices for un-controlled cereal crops, say pearl millet, is expected to go up during drought but the increase is suppressed by increase in imports which tend to be less costly than the domestic products. Moorsom *et al.* (1993) reported that consumer prices in rural areas tend to be higher than those in urban areas during drought. In 1992, prices of maize in rural areas were approximately 50% higher than in urban areas (ibid). The other factor that affects consumer prices for uncontrolled cereals is the amount of reserves that a country has given that most cereals are storable. If sufficient reserves exist, than prices will remain stable even during the periods of drought.

4.9.3 Impacts on Government Budget

4.9.3.1 Expenditure, Revenue and Aid

Financing drought relief is constrained by available financial resources. Government is already facing a budget deficit and is likely, in years of drought, when the demand for government assistance increases, to rely on additional external resources.

During the drought of the early 1970's the only drought relief given was in the form of subsidies for transport of fodder, on which R615 000 was spent in 1970/71; R1,130,000 in 1971/72; and R1,000,000 in 1972/73 (Van der Linden *et al.*, 1995). During the drought of the early 1980s, large amounts were spent on drought relief; R20.5 million in 1982/83 and R24.7 million in 1983/84 (ibid). In contrast, the amount spent on drought relief in 1986/87 was not significantly higher than in years of normal rainfall. This can be explained by the discontinuation of subsidies and the change of drought relief policy in 1987 (ibid). For the 1992/93 financial year, the total drought relief assistance budgeted was N$133.57 million of which N$80.51 million was allocated to MAWF, R40.60 million to DWA under MAWF, and N$12.46 million to MoHSS (ibid). These amounts greatly exceed the expenditures of 1990/91 and 1991/92 when drought relief was budgeted at N$9.45 million and N$2.00 million respectively (ibid).

From the preceding outlay on Government budget appropriations on the drought relief programme, it is clear that government carry a heavy burden on expenditure. The specific impacts of drought on government can be outlined as follows:

- Decline in corporate income tax revenue from farmers.
- Decline in corporate income tax revenue from industries experiencing adverse primary or secondary effects from drought.
- Increase in corporate income tax revenue from industries experiencing secondary effect from drought (e.g. milling companies)
- Decline in sales tax revenue (VAT) due to a decline in purchasing power of households with drought correlated incomes.
- Increase in sales tax revenue due to a price increase of selected agricultural products (e.g. fruits and vegetables)
- Increase in revenue from the southern African Customs Union due to a higher level of food imports.

The net effect on Government revenue of these factors cannot be quantified. Data on tax revenue is presented in an aggregated form and does not show the composition of revenue from each source of taxation. Furthermore, the possible decline in purchasing power cannot be quantified on the basis of presently available data.

4.9.3.2 Additional Expenditure on Drought Relief

As discussed in the earlier section, foreign aid remains a meaningful contribution to drought relief. However, the demand on government budget in times of drought remains significant. Several options exist for government to meet additional expenditure on drought relief:

4.9.3.3 Reallocation of funds

When drought occurs, drought relief assistance is considered a high priority in Namibia because of extensive bargaining through Regional government structures. In Namibia additional budgets are kept and allocated during a fiscal year. When emergency situations occur, of which drought is only one, budgets are verimented from less important expenditure items. For example, in the 1992/93 period of drought, the construction of the Trans-Caprivi road from Rundu to Katima-Mulilo was put on hold to meet additional expenditure of drought relief.

4.9.3.4 Borrowing and Foreign Aid

While borrowing can be considered an option in Namibia, where drought is a recurrent problem, this option may not be viable. Interests and loan repayments will accumulate and place a heavy burden on the government budget. Foreign aid can be sought, but secure sources of foreign aid depend heavily on the priorities set by donors. The total monetary value of the foreign aid received for drought relief could not be determined. Since most foreign donations for drought relief were given in kind, these donations are not recorded in the state revenue account/budget. The foreign donations, however, saved Namibia a considerable amount of money.

4.9.3.5 Drought security fund

Namibia has a drought relief fund, established through recommendation of a draft policy and strategy. The establishment of such a fund may be plausible because government will not be confronted with unexpected large financial outlays in a year of drought. However structural problem and lack of clear cut policies on how to best target the most vulnerable groups remain pertinent problems with the fund.

4.10 Predicting Economic Impacts of Climate Change in Namibia

Models that predict impacts of climate change at farm level for the different farming systems are rare to find in Namibia. This situation makes it difficult to develop specific climate change remedies for the different farming systems in Namibia. While efforts to develop crop modeling have commenced with the inception of this study, there is a need to develop models for livestock farming systems. An attempt to model farm business performance under different farming scenarios was made by Schuh *et al*. (2006) using gross margin analysis. In their model, Schuh *et al*. (2006) examined the economics of land use for different land-based development schemes in Namibia. Their approach does not analyze farming systems based on Namibia's agro-ecological zones, but included a selection of farming systems defined as; (1) small scale commercial farming units, (2) green scheme, (3) communal conservancies, (4) community forests, and (5) resettlement schemes.

Schuh *et al*. (2006) further made a sensitivity analysis based on different performance scenarios. Although their economic models were not based on climate change scenarios, the models provide a first attempt to depict typical farm business performance situations in Namibia and thus provide a basis for analyzing climate change impacts at farm level. There are however more rigorous models for analyzing the economic impacts of climate change on farming systems. For example, the commonly used Ricardian approach/model captures many farming parameters that determines farm business performance and is thus highly recommended. The development and use of the Ricardian approach or model will require a fully fledged study that will capture data on the various farming parameters for the different farming systems and scenarios.

CHAPTER 5: CLIMATE CHANGE SCENARIOS AND FARMING SYSTEMS ADAPTATION

5.1 Introduction

Africa is one of the most vulnerable Regions in the world to climate change (Desanker, 2002; Boko et al., 2007), which has a major influence on all aspects of Namibian life. Farming systems in Namibia are expected to be most affected by climate changes because they are highly dependent on climate variables such as temperature and precipitation. This will further be exacerbated by (i) the semi-arid nature of the country, (ii) the frequency of droughts and floods, and (iii) the scarcity of water, which is characterized by a high spatial variability of rainfall. Climate affects the availability of water, where and when crops can be grown, the availability of pastures for grazing, the distribution and abundance of animals and plants, and the potential for using wind and solar energy for agricultural practices (Benhin, 2006).

5.2 Climate Change Trends

Climate change scenarios present coherent and systematic descriptions of possible future climates, given a set of clearly articulated assumptions, which may then be used as input into climate change impact assessments (Hulme and Viner, 1998). In considering indicators of climate change it may be useful to consider their predictions and to devise indicators which can tell whether these changes are indeed occurring and, if so, whether to the predicted extent (MET, 1999). As part of Namibia's preparation for the SNC to the UNFCCC, a vulnerability assessment study by the DRFN will provide detailed climatic changes observed over Namibia and the changes projected to occur towards the middle of the century. This section examines a set of climate change scenarios predicted by scientists on various studies conducted elsewhere with coverage on Namibia, and provides a review of adaptation strategies prevailing within the Namibian farming systems.

5.2.1 Trends in Global Climate Change

It is now generally accepted that observable changes in climate are linked to anthropogenic activities as well as natural cycles. While the exact nature of the changes in temperature, precipitation, and extreme events is not known by fact, there is a global agreement about the following general trends:

- Global mean surface temperature is projected to increase between 1.5 °C and 6 °C by 2100 (Desanker, 2002); 1.7°C by 2050s decade (Hulme, 1996); 1.7^{o}C as early as the 2030s decade or delayed until the end of the twenty-first century (Hulme, 1998).
- The magnitude of global warming over the next 110 years may vary from 1.4^{o}C to 3.4°C of the climate sensitivity, or from 0.9°C to 5.2°C if the IPCC range of possible values for the climate sensitivity is considered (Hulme and Viner, 1998).
- Average surface temperature increased 0.6 ± 0.2°C in the 20th century, and will persist with an increase of 1.4°C to 5.8°C by 2100 (Cosbey, 2005).
- Global temperatures have increased by over 0.5°C since the nineteenth century (Hulme, 1996); 0.2°C of this warming had already been realized globally by the 1986-95 decade (Hulme and Viner, 1998).

- Sea levels are projected to rise by 15 to 95 centimeters by 2100 (Desanker, 2002);
- Future warming across the African continent ranging from 0.2°C per decade to more Hulme *et al.,* 2001; than 0.5°C per decade (Desanker and Magadza, 2001), with the greatest warming over the interior of semiarid margins of the Sahara and central southern Africa (Desanker, 2002).

5.2.2 Trends in SADC Regional Climate

Various scientists observed a similar rate of warming for the SADC Region during the present century. The following studies are of particular interest and are discussed briefly:

a) Hulme (1996): The six warmest years this century in southern Africa have all occurred since 1980 and the warmest decade has been 1986-95. Rainfall in the Region is variable from year-to-year and droughts have always occurred from time-to-time. The last twenty years, however, have seen a trend towards reduced rainfall and, during the early 1990s, two or three serious droughts occurred. The decade 1986-95, as well as being the warmest this century, has also been the driest.

b) Desanker (2002): The historical climate record for Africa shows warming of approximately 0.7°C over most of the continent during the 20th century; a decrease in rainfall over large portions of the semi-arid Region south of the Sahara; and an increase in rainfall in East Central Africa. Over the next century, this warming trend, and changes in precipitation patterns, is expected to continue and be accompanied by a rise in sea level and increased frequency of extreme weather events.

c) Hulme and Viner (1998): While most of tropical Africa sees increases in rainfall intensities, the frequency of moderate to heavy rainfall events increases over northern Africa but decreases over large parts of southern Africa.

These climate change scenarios suggest that, with global warming, increases in inter-annual rainfall and temperature variability predominates in the semi-arid areas, although the responses may be quite localized to agro-ecological zones.

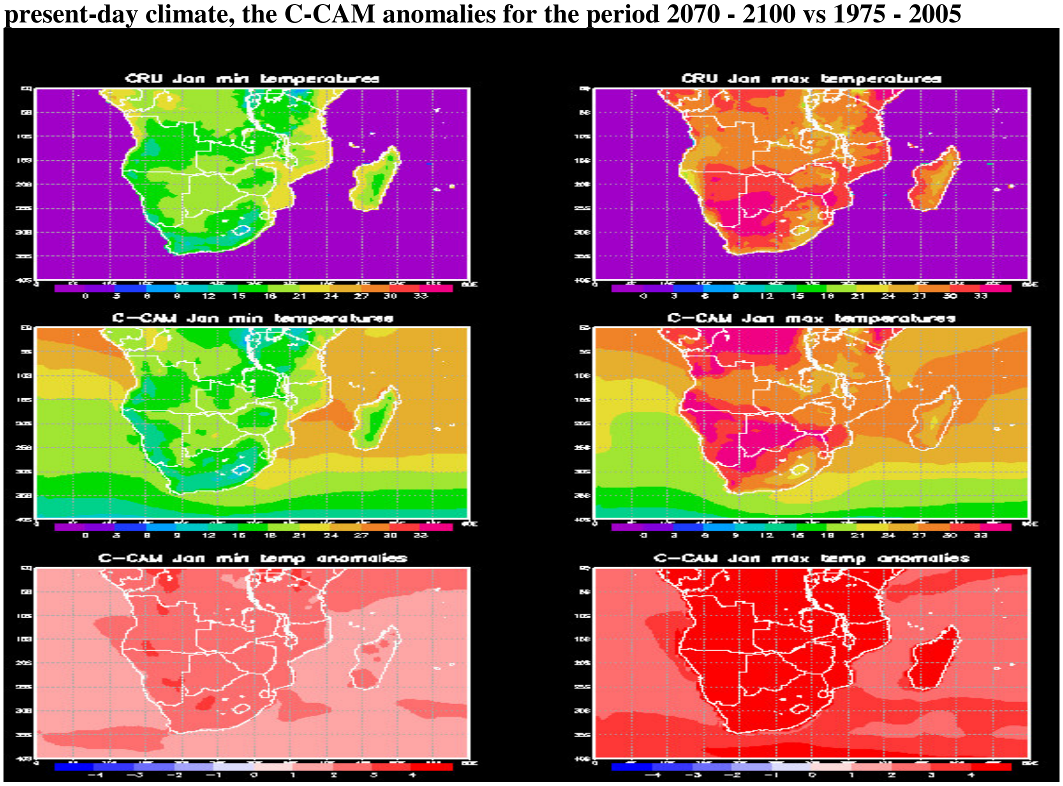
5.2.3 Selected Trends over Namibia

MET (1999) quoted certain predictions for Namibia by the 2050s decade. These include an expected increase in Potential Evapotranspiration of 4% - 8% for central and eastern Namibia, 8% - 12% for NCRs, and 12% - 16% for the Caprivi Region. With respect to rainfall, a decrease of up to 5% in Mean Annual Precipitation is anticipated, with an increased variability of between 5% and 10%. In addition, it was suggested that the length of the rainy season will shorten.

A realistic climate change scenario that is of high enough spatial resolution to be of use in impact studies on climate change on water resources has been developed for the period 2070 - 2100 using the C-CAM model. Based on a comparison of the C-CAM simulation for the period 2070 - 2100 to the simulation for the period 1975 – 2005, Engelbrecht (2005) presented climate change results with coverage for Namibia summarized as follows:

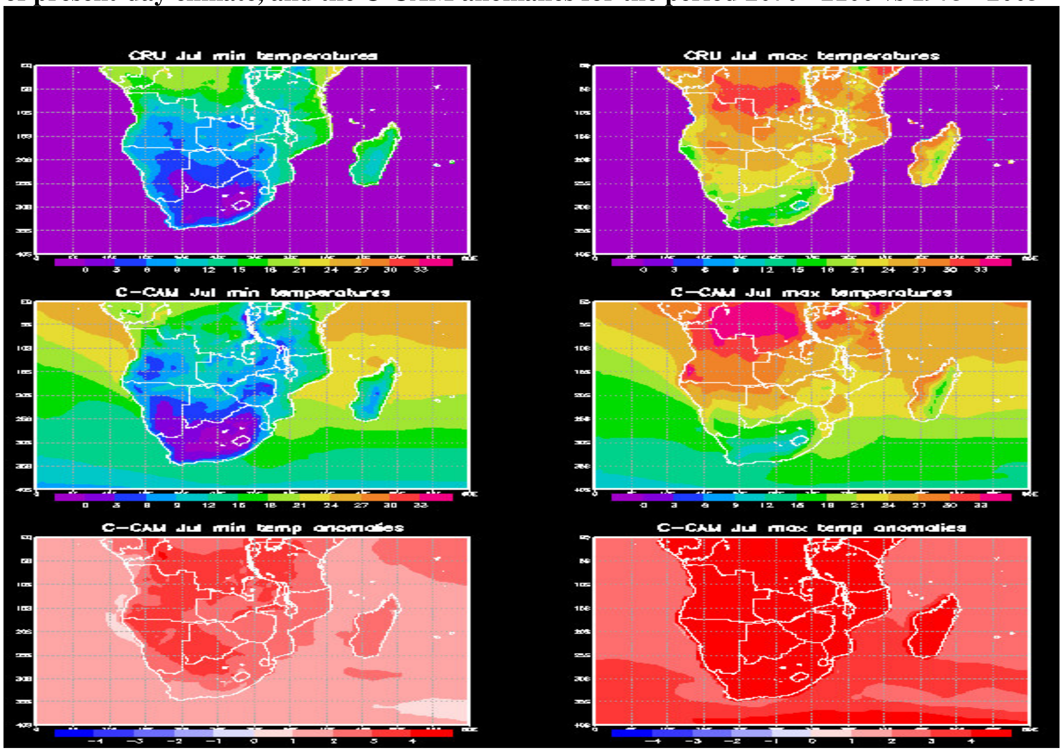
- Most of southern Africa is simulated to experience an increase of between 2°C and 3°C in the January means of daily minimum temperatures over the next 100 years (Figure 5.1).
- An increase of more than 3°C in January means of daily maximum temperatures are simulated for much of Angola and northern Namibia.
- A mean change of between 2°C and 3°C in minimum and maximum July screen-height temperatures are simulated for most of southern Africa (Figure 5.2).
- Large portions of the western subcontinent are simulated to warm by more than 3°C in the July screen-height temperatures.
- In the future, climate enhanced moisture advection of stronger mid-level highs to the west is simulated to lead to an increase in rainfall of about 10% - 20% over some parts of Namibia - with future rainfall fields expressed as a percentage of the present-day monthly rainfall fields - which receive between 40% - 60% of their annual rainfall in the months February to April, the simulated increases are of great importance (Figure 5.3).
- In the late summer most of southern Africa is simulated to become drier, with some parts of Namibia and the western interior of South Africa experiencing significantly wetter conditions in the future climate. More intense subsidence under stronger mid-level high pressure systems has been postulated to induce the above-mentioned drier conditions (Engelbrecht, 2004). The same systems may be responsible for enhanced moisture advection and increased rainfall over Namibia.

Figure 5.1: January screen-height temperatures from the CRU data set, the C-CAM simulation of present-day climate, the C-CAM anomalies for the period 2070 - 2100 vs 1975 - 2005



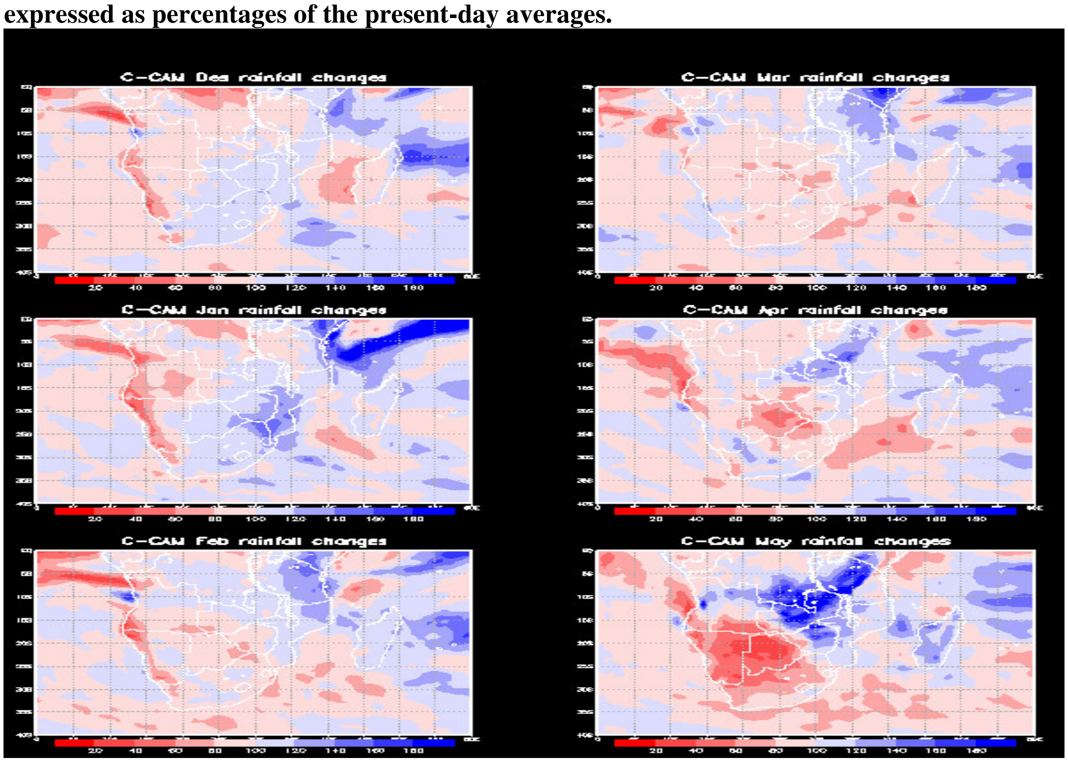
Source: Extracted from Engelbrecht (2004)

Figure 5.2 July screen-height temperatures from the CRU data set, from the C-CAM simulation of present-day climate, and the C-CAM anomalies for the period 2070 - 2100 vs 1975 - 2005



Source: Extracted from Engelbrecht (2004)

Figure 5.3 C-CAM simulations of changing average December - May precipitation patterns for the period 2070 - 2100 vs 1975 - 2005, with the monthly average rainfall totals of the future climate being expressed as percentages of the present-day averages.



Source: Extracted from Engelbrecht (2004)

5.3 Sensitivity of Namibia's Farming Systems

Agriculture is totally dependent on weather and climate (Bazzaz and Sombroek, 1996). Climate change impacts on the Namibian people is significant, given the heavy dependence on natural resources of Namibian agricultural community, and the importance attached to biodiversity in terms of consumptive use (food, fuel, shelter, medicine) and non-consumptive use (eco-tourism industry). Climate change in respect of its impact on the present agricultural systems is likely to add further incremental stress to the Namibian ecosystems that is already under severe pressure because of population growth, endemic droughts, unequal land distribution, increasing subsistence needs and a very limited coping ability of the poor communal farmers.

The droughts of 1992/3, 1996/7, 2000/1 and 2003/4 exposed the vulnerability of Namibia's food security and water resource base to climatic extremes. Hulme and Viner (1998) found that there is a clear tendency toward increases in dry season length, most marked for Southern Africa, in this context as the number of months with rainfall below a certain threshold (number of months below 50 mm and number of months below 100 mm). Similarly, higher temperatures in arid conditions, entails a higher evaporative demand (Brinkman and Sombroek, 1996).

5.3.1 Browsing and Grazing Resources

Veld fires contribute to climate change, both by causing loss of the scarce vegetation and soils that serve as carbon stocks, and by releasing of minima carbon to the atmosphere by burning. As global warming increases at current rates, reported at $1.4 \pm 5.8^{o}C$ by 2100 (Cosbey *et al*. 2005), forest and savannah fires are likely to get more intense and extensive, and may result in significant ecosystem changes that would affect biodiversity in the form of accelerated species loss, or changes in species composition. An average of 43% of Caprivi and 34% of Kavango land are burnt each year over 5 years (Mendelsohn and El Obeid, 2005), while the southern parts only burn land when there is an abundance of dry grass following wetter summers. In Southern Africa, changes in the fire and grazing regimes during the past century are thought to have increased woody plant density over large parts of the Region (Desanker, 2002).

Observations show that land degradation is a widespread problem, owing to floods in the Caprivi and extreme rainfall events in the Kunene, which cause erosion in slope cultivation and grazing areas. To determine the ultimate effects of climate change on vegetation, grazing and livestock and related industries, further research should be done on the likely future extent and effects of land degradation, the quantification of rainfall variability, and the consequences of improved land use practices.

5.3.2 Wildlife Resources

Climate change of the magnitude that is predicted for the twenty-first century could alter a range of African antelope species (Hulme, 1996), which represent 90% of the 80 species in the world (Desanker, 2002). These species are of key livelihood components in mixed wildlife-livestock farming systems of Namibia.

5.3.3 Crop Species

The most certain aspects of future climate change impact in Southern Africa are seemingly the strong effects on staple crops, suggesting faster growth and higher yields per unit of water required. This is largely due to the relatively modest changes in climate compared to the substantial accumulation of carbon dioxide in the atmosphere, while yield quality (the percentage of nitrogen in the grain) may suffer from shorter growing seasons. The ongoing DSSAT modeling exercise would render significant results outlining a clear perspective for Namibian crops. However, rain-fed agriculture is highly vulnerable to changes in climate variability, seasonal shifts, and precipitation patterns. In fact, any amount of warming will result in agronomic drought due to increased water stress.

Overall, the pattern of declining maize production in the commercial areas, especially among the Maize triangle farmers, indicates that maize is no longer a suitable crop this area's bioclimatic and socio-economic conditions. There is a trend towards cultivating the more profitable drought resistant food crops and animal fodder that requires fewer inputs.

5.3.4 Food Imports

Poonyth *et al*. (2002) use a Ricardian model to explore the South African agricultural sector's performance with respect to climate change and conclude that rising temperatures will be detrimental to agriculture, and the effects will be even worse if farmers do not adapt appropriately. Adverse effects of climate change on agriculture would have severe implications not only for South Africa, but also for Namibia because South Africa is the SADC Region's major source of food. For example, 50% of the maize (the main staple) in the SADC Region is produced in South Africa. Adverse effects in South Africa could therefore destabilize the whole region (Benhin, 2006). Given the heavy dependency of Namibia on imports such as fruits and vegetables, these problems will be exacerbated by the inability of Namibian farming communities to cope with increased demand for food products.

5.3.5 Animal Production Systems

Sunshine and average day length do affect livestock performance. For instance, short day-length reduces bird activities and intake and, subsequently, egg production in poultry. Farm animals such as goats and sheep are seasonal breeders and, without human intervention, their conception rates as well as kidding and lambing rates are affected.

5.3.6 Disease Prevalence

Most of southern Africa is simulated to become drier in late summer, however, with some parts of Namibia and the western interior of South Africa experiencing significantly wetter conditions in the future climate. Changes in rainfall will affect the presence and absence of vector- and water-borne pathogens. It can be expected that small changes in temperature and precipitation will boost the population of disease-carrying mosquitoes and result in increased malaria epidemics (Desanker, 2002) in the malaria prone areas of the NCRs. The floods experienced in the northern Namibia pose disease impacts on the predominantly farming communities. Increased flooding could facilitate the breeding of malaria carriers in formerly arid areas (Desanker, 2002). Livestock production in

Namibia is determined by moisture, and changes to its climate could have dramatic effects on the distribution of animals themselves, in addition to patterns of infectious diseases.

5.4 Adaptation Strategies and Actions in Namibia

While local societies have always responded to environmental, social, economic and technological change, the potential rapidity of climate change could test the limits of our ability to adapt. The farmer's risk on extreme events and abrupt changes in climatic patterns, such as the floods in the crop growing regions, is increasing. Natural resource based industries such as agriculture, are particularly vulnerable to these risks, and thus the need for Namibian to increase the adaptive capacity of production systems to deal with climate change risks as a priority.

Madison (2006) differentiates between 'internal' and 'external' adaptations: the former dealing with the adaptations envisaged by the Ricardian approach, and the latter being adoption of technologies from elsewhere because of favourable agro-ecological conditions. According to Klein (2002), adaptation to climate change can be 'reactive' - when undertaken in response to impacts of current climate change or variability, or it can be "anticipatory" - when implemented before impacts are observed. The following adaptation strategies and actions are currently employed in Namibia.

5.4.1 Irrigation

Irrigated agriculture is a possible means for vulnerable agricultural populations to adapt to climate change. However, it should be noted that in some smallholder farms, irrigated vegetable production systems do not, in themselves, necessarily address farmers' sensitivity to climate hazards, as the interaction of market uncertainty and price volatility with climate risk may in some cases actually exacerbate the vulnerability of these farms. However, irrigated agriculture is increasingly been practiced along reliable permanent water sources, and where soil conditions allow for crop suitability, due to low and unreliable precipitation necessary for rain fed farming.

5.4.2 Conservation Agriculture

Conservation agriculture and organic agriculture that combine zero or low tillage and permanent soil cover are promising adaptation options promoted in Namibia. Although the three fundamental components of conservation agriculture are the combination of minimum tillage, crop rotation, and the use of soil cover, there are many different techniques using hand tools, draught animal power or mechanical equipment. In NCR, dry planting (minimum tillage) is practiced by some farmers as a crop management strategy, most of it is done with the hand hoe. However, the size of the land dry-planted by each household depends on the labour available for land preparation and for the subsequent weeding. Conservation tillage practices on trial and used in the NCR provide for better mahangu and cowpea yields, a lower workload, and improved soil structure over time. Land use planning approaches are being developed that stress participatory approaches for identifying priority areas at district and national level, and identifying where investments are most suitable in relation to natural resources.

5.4.3 Crop Diversification

Namibian policies pursue economic diversification that creates alternative income opportunities outside agriculture whilst alleviating poverty. As part of its policy of crop diversification, government is encouraging cultivation of high-value non-traditional crops such as table grapes, dates, paprika, mushrooms, cotton, oriental tobacco, lucerne and variety of fruits and vegetables. Rice cultivation in the oshanas is being promoted in the NCRs by screening cultivars for salinity tolerance, and imparting knowledge and skills in rice cultivation are the major outputs to date.

The National Botanical Research Institute (NBRI) hosts the Succulent Cultivation Project and the Useful Plants Development Project that is investigating options for succulent cultivation in rural communities, with special attention being given to the cultivation of *Hoodia*, a species with massive potential in the nutriceutical industry; the cultivation and value addition of Devil's claw for export purposes; and the establishment of the Wild Silk Project as a financially sustainable mechanism to remove *Gonometa* cocoons from pasture land to reduce livestock and game mortalities. Jatropha cultivation is currently being practiced as pilots in very small amounts, and being discussed as an option to rural farming.

5.4.4 Use of Improved Crop Varieties

One of the adaptation strategies employed by Namibian farmers is the use of different varieties of seed within the same field in one season, as practiced in parts of the NCRs with Okashana 1 (early maturing and drought resistant) and the Traditional varieties of Pearl Millet. The use of improved Okashana 1 variety is widespread among the mahangu growers in Namibia. However, post-harvest management of the variety, particularly the shelf-life and storability characteristics, is poorly developed and needs further assessment.

Over the years, Namibia has developed several varieties of crops. Three mahangu, one sorghum, two cowpea, one groundnut, and one Bambara nut variety were developed by DART, in addition to two millet varieties that were developed by farmers- Kantana and Maria Kaherero. In addition to the varieties developed by DART, work has also focused on the evaluation of germplasm of other crops, including cotton, sweet potato vines and more recently indigenous melons. However, there is no official mechanism for variety release covering all crops. There is also no official variety list in place in Namibia. Farmers' options for suitability of varieties to climate conditions are therefore limited, and they had to rely on South African guidelines.

5.4.5 Seed Availability

Variability in seasonal rainfall can lead to major shortages in food supply from rainfed crop production in Namibia. Quality seed of improved varieties is an important agricultural input, and unavailability of seed is one of the reasons why under disaster conditions, the normal cycle of food production may collapse. Access to quality seed is important in ensuring the resilience of the production base, which provides the inherent capacity of a country to respond to, and mitigate the impacts of a disaster. While there is no formal seed industry in Namibia, the Government has an agreement with the Northern

Namibia Farmers Seed Growers Cooperative (NNFSGC), which requires the cooperative to keep a strategic seed reserve of 100 tonnes of mahangu seed. This is commendable, and the cooperative should be supported to maintain this important seed reserve.

5.4.6 Protected Cultivation Systems

Protected cultivation systems are on an increase in Namibia, notably plastic tunnels and net houses in Oranjemund, Rehoboth, Swakopmund, Omaruru, Okahandja and Windhoek areas. While the production of a quality product is guaranteed due to favourable growing conditions, it is an exact and expensive venture involving high technology. Apart from the fact that soil-borne diseases can be avoided, plant growth can easily be manipulated by using a balanced nutrient feed. In recent years, household level hydroponics systems have been promoted in the Khomas and Kavango Regions.

5.4.7 Shared Water Resource Management

Changes in runoff and its variability provided an impetus to Namibia to fully participate and engaged in the SADC development of a shared water resource strategy to regulate inter-basin water transfers. Namibia is party to Permanent Commissions managing the Kunene, Kavango and Orange Rivers.

5.4.8 Early Warning Systems

Early warning management, contingency and response plans are inadequate and this leaves the Government, at times, ill-prepared to deal with large humanitarian emergencies despite the presence of local early warning mechanisms in form of the Early Warning and Information System (EWIS) and Emergency Management Unit (EMU), and others in the SADC Region. EWIS focuses largely on rainfall and cereal production, but provides few guidelines on emergency responses. Cattle production and wildlife, both in commercial and communal land, are often affected by diseases and drought, and this leads to loss of income for farmers and range degradation. This can affect related industries such as tourism and the beef market.

Frequent droughts and floods result in crop failure and food shortage particularly for the rural communities. Often, disease and pest outbreaks or floods turn good potential crop yield to nothing. At such times, the farming communities rely on the Government to declare a disaster situation which normally takes unnecessary time to become a reality. There is a need for improvement in responsive preparedness for Namibia.

5.4.9 Drought Animal Power

Due to unreliable rainfall regimes, coupled with short intensities and poor water-holding capacity of soils, agronomic drought in NCRs is common. In response, smallholder farmers increasingly shift from traditional broadcasting planting methods to the use of draught animal power in an attempt to make use of the available soil moisture termed the ‘window-of-opportunity’, for planting Mahangu in order to increase productivity and cope with moisture stress.

5.4.10 Drought Mitigation Measure

In order to avoid the disruptive effects of financing emergency assistance from other budget lines, to speed up the mobilization of funds, and to accommodate funds from different sources, Namibia established a National Disaster Management Fund to finance its obligations to food security, agriculture and water supply in disaster drought years. Within the National Drought Policy and Strategy, the distribution of free seeds for replanting after drought for communal farmers has been replaced by an input voucher scheme, the details for which have yet to be determined. The Government commits itself to encourage and support the development of private sector seed production and distribution capacity, and take responsibility for ensuring the maintenance of an adequate reserve of seed to meet emergency needs nationally. Other measures on drought mitigation includes support for on-farm risk minimization through promotion of early maturing and high value crops, small-scale irrigation, rainwater harvesting and improved post-harvest technologies. In the context of food security, Namibia promotes improved food storage and preservation with strategic food reserves being developed at the household level, and those at the national level maintained by the private sector.

5.4.11 Livestock Management

Mobility and herd accumulation remains the most important adaptation to spatial and temporal variations in rainfall, and in drought years many communities make use of cattle posts as fall-back grazing areas unused in ‘‘normal’’ dry seasons because of distance, land tenure constraints, or water availability problems. Livestock producers classically keep a combination of small stock and large stock herds of various breeds to take advantage of different ecological and market niches. Shifts in the balance of livestock species can occur as responses to climate variability and changes in the environment, market conditions, and availability of labor. A small proportion of livestock producers now hold some wealth in bank accounts, and others use informal savings and credit mechanisms at local community level. Both communal and, chiefly, commercial livestock farmers also use purchased supplementary feed for livestock. As a coping strategy, they intensify animal disease management through indigenous and scientific techniques, and they increasingly use powered boreholes due to insufficient natural breeze for adequate water extraction.

5.5 Requirement for Improvement

With changes in precipitation and hydrology, temperature, length of growing season and frequency of extreme weather events outlined above, considerable efforts would be required to prepare Namibia to deal with climate-related impacts in agriculture. Adaptation practices require extensive high quality data and information on climate, and on agricultural, environmental and social systems affected by climate, with a view to carrying out realistic vulnerability assessments and looking towards the near future. Climate change assessment must observe impacts of variability and changes in mean climate (inter-annual and intra-seasonal variability) on agricultural systems. However, agricultural production systems have their own dynamics and adaptation has a particular emphasis on future agriculture.

CHAPTER 6: GERMPLASM COLLECTION AND CROP MODELING FOR CLIMATE CHANGE ADAPTATION

6.1 Introduction

The vulnerability of agriculture to climate change has become an important issue because of reduced productivity of the sector due to adverse changes. Climate change presents a challenge for researchers attempting to quantify its impact due to the global scale of likely impacts, the diversity of agriculture systems, and the decades' long time scale. Mendelsohn and Dinar (1999) identified three broad strategies to uncover the impact of climate change on agricultural productivity: agronomic modeling, agro-economic modeling and the Ricardian technique. Crop simulation models' ability to predict growth and yield as influenced by growing environment, agronomic practices and crop traits immediately suggest the possibility of using models to identify desirable traits or combination of traits potentially leading to the specification of crop ideotypes (White, 1998). In response, this study facilitated a capacity building initiative in the use of the DSSAT V.4 model.

6.2 DSSAT Model

Intensification and commercialization of the Namibian agricultural sector will continue to require farmers to have access to the necessary tools to assess competitiveness between different enterprises and technological options for the various farming systems, in order to make informed decisions relevant to climate change adaptation. Successful and sustainable increased production of the small-scale farming sector also depends on systematic decision support services, and a widespread information system on production opportunities.

As plant type and plant productivity are major determinants of food production, it is critical to understand and quantify the response of the most important crops to changing environmental conditions (Bazzaz and Sombroek, 1996). Anticipated changes in temperature and rainfall patterns will affect the production of crops in both communal and commercial farming sectors. Of the many crops which are cultivated in Namibia, maize and mahangu were selected to form the subject of crop modeling programme in relation to climate change. The crops were selected both in recognition of their importance in local livelihood security and their strategic importance to national development and food production.

6.2.1 Training Purpose and Coverage

The overall goal of the training workshop was to familiarize the participants with systems analysis and computer modeling for applications in climate change and climate variability, sustainability and food security. The DSSAT training was aimed at preparing Namibian agricultural systems for climate change. The overall aim of such adaptation is to make the best use of climate as a resource for agriculture by enhancing the capabilities of agriculturalists, agribusiness and organizations to respond to climatic variations and climate change. Specific objectives were to promote sustainable agricultural development in Namibia; to reduce vulnerability to, and increase the capacity to respond to, climatic hazards; and to adapt to new climatic resources as they materialize.

The specific topics that were covered included:

a) Introduction to crop modeling and decision support systems
b) Introduction to systems analysis
c) Modeling of crop development
d) Modeling of crop growth and yield
e) Genetic coefficients and potential yield
f) Modeling water-limited production
g) Modeling nitrogen-limited production
h) Experimental data collection for model evaluation
i) Application of the crop models for real-world problems

Table 6.1: Representation by Institutions for DSSAT Training

Institution	Participants
Directorate of Agricultural Research and Training, MAWF	9
Directorate of Planning, MAWF	2
Directorate of Engineering and Extension Services, MAWF	4
University of Namibia, Crop Science Department	1
Ministry of Education, Ogongo Agriculture College	2
Green Scheme Agency	1
*Namibia National Farmers Union	0
Desert Research Foundation of Namibia	1
*Namibia Meteorological Service	0

*No representative sent

The software that was used in the workshop was the DSSAT and the Cropping System Model (CSM). DSSAT includes crop models for more than 25 different crops, data entry programs and application programs. In imparting knowledge on the use of DSSAT and CSM, the training sessions relied on using a combination of lectures and hands-on exercises, at approximately 50-50. Table 6.1 shows the number of participants by institution. Each of the trainees was provided with a licensed DSSAT V.4 and the book “Understanding Options for Agricultural Production”.

6.2.2 Level of Participation by Trainee

The participants participated actively in all activities, although there were some issues about timeliness. Once they seemed to understand the software and the approach of modeling, they were keen on learning more about the system and the potential for applications in Namibia. The participants also actively collaborated to help solve some of the computer exercises. A comprehensive list of participants is attached in Annexure C.

6.2.3 Lessons Learned

The DSSAT V.4 model seem particularly suitable for studies of yield potential and adaptation to both rainfed and irrigated environments. There was a wide range in the background of the participants, ranging from technicians with less than three years of university education versus well qualified agriculturalists with post-graduate qualifications. This sometimes created some difficulties with respect to understanding and the synthesis of the material, especially the lectures.

There was also a conflict with respect to the location. The workshop was held at the University of Namibia in Windhoek. Many of the participants still tried to attend to some of their regular office duties during the workshop, causing them to be late and/or absent for sessions. For future workshops, it would be good to organize this on a location away from office in order for the participants to be fully dedicated to the training. It might also be good to provide the participants with a notebook computer that can be used for homework and related issues.

6.2.4 Crop Yield Simulations

Crop modeling simulation experiments are performed for baseline long-term climate and General Circulation Model (GCM) doubled CO_2 climate change scenarios with and without the physiological effects of CO_2. This process will involve, among others, the following tasks (Fischer, Frohberg, Parry and Rosenzweig, 1996):

1. Defining geographical boundaries for the major crop production regions;
2. Describing agricultural systems (e.g. rainfed and/or irrigated production, number of crops grown per year);
3. Gathering data on regional and national rainfed and irrigated production of major crops:
4. Obtain observed climate data for representative sites within these regions for a specified baseline period;
5. Specifying the soil, crop variety, and management inputs necessary to run the crop models at the selected sites were specified;
6. Validating the crop models with experimental data from field trials, to the extent possible.
7. Running the crop models with baseline data, and GCM climate change scenarios, with and without direct effects of CO_2 on crop growth.
8. Execute rainfed and/or irrigated simulations as appropriate to current growing practices.
9. Identify and evaluate alterations in farm-level agricultural practices that would lessen any adverse consequences of climate change, by simulating irrigated production and other adaptation responses, e.g. shifts in planting date and substitution of crop varieties.

Table 6.2, summarizes the results of the large number of studies of the impact of climate change on potential crop production for Africa and Latin America. While it does not provide the detail on the range of specific studies, methods and climate scenarios evaluated, it provides an indication of the wide range of estimates with particular reference to Zimbabwe and South Africa. The general conclusion of global studies that tropical areas may more likely suffer negative consequences is partly supported by the results in Table 6.2.

Table 6.2: Comparison of Latin American and African crop yield for 2xCO2, GCM equilibrium climates

Region	Crop	Yield Impact (%)	Countries Studied and Comments
Latin America	Maize	-61 to increase	Argentina, Brazil, Chile, Mexico. Range is across GCM scenarios with and without CO^2 effect.
	Wheat	-50 to -5	Argentina, Uruguay, Brazil. Range is across GCM scenarios, with and without the CO_2 effect.
	Soybean	-10 to +40	Brazil. Range is across GCM scenarios, with CO_2 effect.
Africa	Maize	-65 to +6	Egypt, Kenya, South Africa, Zimbabwe. With CO_2 effect, range across sites and climate scenarios.
	Millet	-79 to -63	Senegal. Carrying capacity fell 11-38%
	Biomass	Decrease	South Africa; agro-zone shifts

Source: Adapted from Reilly, 1996

6.2.5 Future DSSAT Workshops

A necessary condition for confidence in a model simulation of climate change is that the model should be able to adequately simulate the present-day climate. The long-term mean circulation patterns and surface fields should be simulated well, as well as variability on many time scales from diurnal through seasonal to decadal and beyond (Battisti, 1995; Renwick *et al*. 1999). Thus, a full model validation is a comprehensive task. Due to lack of time and some slow progress during the workshop, the application of the crop models toward climate change in adequate detail was poorly addressed. There is also a need for evaluation of the models with local data prior to applications for credibility purposes.

In light of the foregoing, two additional workshops could address local data collection, model evaluation with local data, and applications, especially for climate change. It might also help to develop a local network for support, and serve as a basis for inter-agency cooperation within agricultural research and extension.

6.3 Namibian Crop Germplasm

Assembly of germplasm is the most important among all activities of genetic resources. Germplasm has been collected from different agro-ecological systems of Namibia, and acquired as introductions from the international germplasm collection centres. The role of germplasm in the improvement of cultivated plants has been well recognized in Namibia. However, the use of germplasm collections is still limited despite this wide recognition. The National Plant Genetic Resources Centre (NPGRC) of Namibia, housed at the NBRI conducts explorations and collections of germplasm throughout Namibia. The NPGRC is also involved in the evaluation and characterization of local germplasm.

6.3.1 NPGRC Collections

At present, the NPGRC houses 3010 accessions, representing about 1140 wild species and 1870 crops. The main crop housed is pearl millet (*Pennisetum glaucum*), with some accessions also of sorghum (*Sorghum bicolor* subsp. *bicolor*), melon (*Citrullus lanatus*), cowpea (*Vigna unguiculata* subsp. *unguiculata*), Bambara nut (*Vigna subterranea*), groundnut (*Arachis hypogaea*) and maize (*Zea mays*). Wild species collection was focused mainly on useful species or species of conservation concern. Wild crop relatives include watermelon (*Citrullus lanatus)*, cowpea (*Vigna unguiculata*), and rice (*Oryza longistaminata* and *O. barthii*). Plants of national importance are also collected and conserved for plant genetic resources for the future use.

In addition to the NPGRC facilities at the NBRI, the MAWF in conjunction with Unam, invested in the establishment of a gene bank, biotechnology and tissue culture laboratories, as well as plant breeding and seed technology facilities at Ogongo Campus. Due to limited resources, limited research activities have taken place over the past years, except for devils' claw, Ombidi and Mutete for genes banking and conservation.

6.3.2 Multiplication and Characterization

The NPGRC has multiplied about 670 crop accessions, representing 36% of all crop accessions. The remaining 1200 accessions to be multiplied are mainly of pearl millet. Multiplication is done in collaboration with research stations of MAWF, mainly in northern Namibia. Germplasm evaluation, in the broad sense and in the context of genetic resources, is the description of the material in a collection. It covers the whole range of activities starting from the receipt of the new samples by the curator and growing these for seed increase, characterization and preliminary evaluation, and also for further or detailed evaluation and documentation. Until a collection has been properly evaluated and its attributes become known to breeders, it has little practical use. After collection of germplasm, there is need for its systematic evaluation in order to know its various morphological, physiological and developmental characters including some special features, such as stress tolerance, pest and disease resistance, etc.

6.3.3 Material Distribution and Collaboration

The demand for germplasm material has been increasing steadily over the years, mainly for research purposes on crops. A large number of requests for seed of wild plant species are also received, but these can very seldom be complied with, since the NPGRC's wild species collection is not yet representative of the diversity found in Namibia. The NPGRC distributes small amounts of seed only for non-commercial purposes (e.g. academic research, botanic gardens) to local farmers or established institutions. The NPGRC collaborates with the Millennium Seed Bank Project of the Royal Botanic Gardens, Kew's Seed Conservation Department (UK). This concentrates on collecting seed of wild plants of conservation concern. Nationally there is informal collaboration with many institutions, initiatives and projects, like the Agronomy Research Section of the MAWF, the MET, the Indigenous Plant Task Team and the National Biodiversity Programme. The NPGRC uses the documentation programme common to the SADC Plant Genetic Resource Centre (SPGRC) Network.

6.4 Knowledge Base in Genetic Resource Conservation

A rapid assessment showed that the knowledge base for genetic resources conservation and evaluation, as well as for research on the collections that is necessary to support utilization among the frontline officers in MAWF, is limited. This study also found that the knowledge base is insufficient at best for *ex situ* conservation, the method of conservation and storage that is essential for crop improvement. Even so, the knowledge base for *ex situ* conservation is much better than for *in situ* conservation. Also, a fundamental lack of understanding exists about the complementary roles of *ex situ* and *in situ* conservation of plants. An urgent need exists for MAWF to undertake, purposely and systematically, a greatly increased strategic research effort on conservation, evaluation and enhancement of its mandate crops with research and extension personnel in the relevant agro-ecological zones.

6.5 Indigenous Crop Germplasm

Genetic diversity gives plant breeders access to genes that could be used to develop new plant varieties adapted to local conditions such as drought resistance, early maturity, and pest and disease resistance. In ensuring that the plant breeders will have genetic resources for use in plant breeding programs, a comprehensive programme approach that encompasses collection, conservation, characterization, evaluation, documentation and distribution of plant genetic resources must be implemented. Collection of germplasm as a standing activity is not advisable. Large efforts were made by Government and other institutions such as Unam to collect and conserve a diversity of crops and plants, e.g. pearl millet, before it is lost forever. This study envisions a strategic research agenda that would include the following major elements:

a) Germplasm management and gene bank management, including eco-geographic studies of biodiversity of target crops and wild relatives, collecting methods, conservation and handling, including seed physiology and seed health studies aimed at storage of Namibia's strategic crops.

b) Strategic research on the collections themselves, using an interdisciplinary team approach to understand the genetic makeup of the collections, search for specific traits needed in local production systems, find sources of resistance to pests and diseases of economic importance, locate sources of tolerance to Namibian abiotic problems, and support genetic enhancement for raising farm productivity.

c) Strategic research in genetic enhancement using conventional and non-conventional means coming from the new science to transfer needed traits into suitable genetic backgrounds to produce parental materials for use in crop improvement.

6.6 Plant Selection for Stress Tolerance

Through various collaborative research and support programmes, the MAWF and NPGRC conducted germplasm evaluation and breeding for adaptation, early maturity, and drought-resistance. Recommended grain crops include groundnut (*Arachis hypogaea* L.); cowpeas [*Vigna unguiculata*]; bambara nuts; sorghum [*Sorghum bicolor* (L.)]; pearl millet [*Pennisetum glaucum* (L.)]; and maize [*Zea mays* (L.)]. There is a need for a comprehensive list of crop varieties that are adapted to the low rainfall, high evaporation, low soil fertility and pest and diseases often experienced in the crop growing areas of Namibia. These efforts of evaluating adapted crops with improved yield potential could assist farmers to achieve self-sufficiency in food production under changing climate regimes.

6.7 Breeding of Mahangu Varieties

For decades, Okashana 1 was promoted jointly by ICRISAT and MAWF, and nowadays farmers grow this open-pollinated cultivar on almost 50% of the national pearl millet area. Success in the release of Okashana 1 resulted from the introduction of genetic material improved by ICRISAT breeders, early involvement of local farmers in participatory selection, rapid cultivar release responding to farmers' preferences, and the commitment of MAWF to high-quality seed multiplication and dissemination.

Later, ICRISAT developed Okashana 2, a variety derived from a Zimbabwe local landrace IP 16504 (SDGP 1514) crossed with ICMV 87901 and ICMV 88908, which was released in Namibia during 1998. Kangara, another variety released in Namibia in 1998, was derived from two landraces IP 17527 and IP 17531 and S2 progenies of SADC white grain composite. The same variety was also released as PMV 3 in Zimbabwe during 1998.

6.8 Summary

Although there have been some studies of climate change impacts on African crops (Benhin, 2006), it is still not very clear how staple crops of strategic importance to Namibia, i.e. mahangu and maize, will be affected and what adaptation options are available to the country. Because each crop and crop variety has specific climatic tolerances and optima, it is not possible to model world agriculture in a way that captures the details of plant response in every location with varying current climatic, soil and socio-economic conditions. The availability of data with the necessary geographic detail, coupled with human resource capacity in modeling, is currently the major limitation rather than the computational capability or basic understanding of crop responses to climate.

The DSSAT training initiative under the project appears to be an effective tool to: engaging relevant key players in the sector in discussions on climate change impacts and the implications for the sector; and enhancing the technical capacity of these key stakeholders that facilitates decision making.

For responsive achievement of outputs, the research work discussed above will require considerable more resources and staff, as well as a detail research action plan. The strategic germplasm research envisioned by this study will require specialists from many disciplines working in three areas that are closely linked in a continuum of (a) germplasm conservation and management; (b) systematic evaluation of collections for resistance or tolerance to biotic and abiotic stresses, along with identification of novel traits; and (c) genetic enhancement.

CHAPTER 7: IMPROVEMENT AND CONSERVATION OF INDIGENOUS LIVESTOCK BREEDS IN NAMIBIA

7.1 Introduction

The use of indigenous livestock cannot be overemphasized especially in the smallholder settings where livestock assumes various livelihood roles including food (e.g. eggs, meat, milk) and non-food roles (e.g. Draught Power, manure, feathers/hair, hides, skins, sacrificial ceremonies, dowry). Despite these roles, the performance of indigenous livestock is reckoned to be poor in comparison with exotic breeds. However, the majority of exotic breeds are poorly adapted to Namibia's harsh farming environment. In addition acquisition of high performing exotic breeds in most communal areas is limited to a few wealthier farmers because of the high purchase prices and transportation costs. Indigenous animals are, therefore, the mainstay to the existence of majority of rural people.

7.2 Livestock Improvement Initiatives

7.2.1 Pre-independence: Before 1990

The potential of indigenous stock was realized about a century ago when Von Francois started promoting livestock breeding in newspapers (Rawlinson, 1994). In 1968, the National Beef Performance Testing Scheme (NBPTS) was initiated followed by the enactment of the Livestock Improvement Act (Act 25 of 1977) in 1977. Along with the NBPTS came new livestock breeding stations i.e. Omatjene (1968), Okomumbonde (1980) and Mile 46 (1984) and Sachinga. The earlier established stations of Neudamm (1928), Sonop (1953), Uitkomst (1960) and Sandveld (1965), realigned their programmes to fit into this NBPTS. In the south, Gellap-Ost (1938) and Kalahari (1958) were mandated to performance testing and improvement of small stock (sheep and goats).

Generally, each of the stations had its own mandate of species and breeds of livestock improvement. However, their principal objective was to address the needs of the farming communities by providing them with necessary training and, improved (through breeding and selection) breeds. It is of interest to note that the research stations were unevenly distributed in the whole of Namibian territory, and because of their locations they represented, to a larger extent, farmers in the south, central and eastern parts of the country. Thus, improvement of livestock in the region was unheard of and, the NCR Region was usually perceived as a crop production area. Generally, livestock breed improvement activities of the colonial time are reported to have been biased and the political climate favoured the white farmer.

7.2.2 Post-independence: After 1990

In 1993, the MAWF operationalized the Livestock Improvement Act of 1977 (Rawlinson, 1994). Since then, livestock improvement activities were refocused to increase the number, productivity and quality of indigenous animals through provision of improved cattle and goats to smallholder farmers throughout the country, thereby augmenting their participation in livestock production as a means of improving and/or diversifying their income.

7.2.2.1 On-farm Activities

The rapid population growth which for the past three decades hovered around 2.7% per annum (NPC, 2003; UNDP, 2007) and, the concomitant increase in demand for agricultural produce including livestock products (e.g. meat, eggs, milk, etc.) necessitated the rearing of high performing and fast-growing livestock breeds with good carcass merits. As a result, majority of farmers, both in the communal and commercial farming areas, endeavored to crossbreed their local breeds with exotic breeds to exploit heterosis while improving such qualities as birth, weaning, yearling and carcass weight and milk yield. However, a large proportion of farmers crossbred their local breeds randomly not knowing that indigenous animals possess other good traits and may outperform exotic breeds when in adverse farming environments. For example, indigenous goats and cattle possess unique qualities including high disease and tick resistance, good reproductive and mothering ability, low maintenance requirements, excellent physiological and morphological adaptation which makes them drought and heat tolerant and, high survival rate (Els, 1997; Thawana and Visser, 1999; Motinga *et al.*, 2004).

7.2.2.2 Farm Animal Genetic Resources (FaNGR)

Despite these qualities, indigenous animals are threatened by rive genetic erosion and potential loss of biodiversity because of cross breeding and other climate related disasters such as drought, wild fires and floods. In 1995 the MAWF's Livestock Research Division (LRD), with support from SADC, UNDP and FAO, initiated the Management of Farm Animal Genetic Resources (FAnGR) Project. The overall objective of the FAnGR project was to identify, characterize, conserve and improve farm animals to maintain biological diversity as a means of creating more sustainable livestock production and hence improved food security, rural livelihoods and income in Namibia. Seven broad themes are pivotal to the FAnGR Project and these include:

- Characterization and conservation of animal biodiversity;
- Information gathering, sharing and dissemination;
- Developing and promoting indigenous breeds;
- Breeds inventory and monitoring;
- Networking and advocacy;
- Capacity building; and
- Policy development.

During implementation, the FAnGR project was designed to complement other existing projects within the MAWF including the Livestock Improvement (LI) Project. With the exception of phenotypic and genetic characterization of indigenous breeds, most of the activities of the two projects are interrelated.

7.3 Livestock Breed Characterization

Characterization of livestock requires both phenotypic description and genetic analyses of the population and/or breed(s) in question. Phenotypic descriptions of indigenous breeds uses colour and/or colour patterns, shape and size of ears, horns and humps, stature etc., whereas through use of micro-satellite analysis of the hair and/or blood samples of indigenous stock, genetic distances and variability as well as the percent heterozygosity and level of inbreeding are determined (Thawana and Visser, 1999; Els, 2002; Mburu et al., 2003; Hannote and Jianlin, 2005). Even though genetic analysis is the most reliable way of characterizing livestock, the level of expertise and facilities required and the cost of analysis hinders its utilization in Namibia. As a result, most institutions in other developing countries use phenotypic descriptions and/or socio-geographical criteria to characterize stock. In the case of Namibia, financial support from the SADC/UNDP/FAO and MAWF enabled the LRD to conduct both the phenotypic and genetic characterization of indigenous stock.

7.3.1 Cattle Characteristics in Namibia

The cattle breeds found in Namibia can be grouped into beef, dual-purpose and dairy breed, of which the majority are beef type as given in Table 7.1.

Table 7.1: Cattle Breeds Found in Namibia

Type	Breeds
Beef	Aberdeen Angus, Afrikaner, Bonsmara, Brahman, Beefmaster, Charolais, Drakensberger, Gelbvieh, Hereford, Indigenous Nguni, Limousin, Red Poll, Santa Gertrudis, Shorthorn, Simbra, South Devon and Sussex.
Dual-purpose	Braunvieh, Pinzgauer, Simmentaler and Dexter.
Dairy	Holstein Friesians, Jersey.

Source: Adapted from Els (2000).

Majority of the exotic breeds and their crosses occur in the central part of the country on commercial farms, where they are reported to have adapted well provided good management is assured. The indigenous Nguni cattle, which are ecotypes of the well known Sanga breed, occur in large numbers in the NCAs. The different ecotypes of Sanga in Namibia have developed phenotypic characteristics that typify their adaptability to their different environments.

7.3.1.1 Nguni Cattle Breeds

The Kunene Nguni is characterized by its long slender legs, very respiratory conformation, large variation in horn shapes, and larger than normal hooves. They are well adapted to walking long distances between the water points and available grazing, often going two days without water. With the exception of the Ovambo Nguni found in Ohangwena, the Ovambo Nguni is believed to be the smallest of the Nguni cattle in Namibia. Els (2002) reported that the Ovambo Nguni, with their small well balanced and muscled-bodies, are well adapted to the Shona and Mopane veld types.

The Kavango ecotype is believed to be the largest of the Nguni cattle types and possesses the heaviest bone structure. The Caprivi Nguni is characterized by its fine bone structure, even in mature animals. Previous research had indicated that the Caprivi Nguni has high nitrogen retention in its body, which enables it to better digest poor quality grazing. This might be one of the reasons why they are so well adapted to the highly leached soils of the Caprivi (Els, 2002).

Using Wright’s measure of differentiation amongst breeds, Els (2002) indicated that the lowest rate of gene migration was between the Ovambo and the Kavango and the highest between the Caprivi and the Kunene ecotypes. The genetic distances between the types correlate with the rates of migration between the populations. The Nem values indicate the rate of migration (gene flow) between populations. The largest genetic distance was reported to exist between the Kavango and Ovambo (0.185) and the smallest between the Caprivi and Kunene (0.061) populations. Historically, the Ovambo and Kavango populations split first, and much later the Kavango and Kunene populations, which are on land the furthest apart. The reason for these small differences is the fact that all four populations have the Ovambo Nguni as common ancestor (Els, 2002).

7.3.1.2 Adaptability Characters of Nguni Cattle

Findings from the FAnGR research support the current line of thought that the Sanga cattle of Namibia are four ecotypes of one breed. The fact that these different ecotypes have developed adaptive traits to their specific environments, should not be forfeited, but should be used to their full potential to benefit livestock production in their respective areas. Indeed, a number of commercial farmers have acquired Nguni cattle from breeders and research stations in Namibia and South Africa, and are using them for beef production, either through pure breeding or crossbreeding with exotic breeds. This is because Nguni cattle are:

- hardy, with strong legs and good walking ability;
- tick resistant and tolerant to internal parasites;
- highly fertile with a long productive lifetime;
- an excellent dam line for crossbreeding;
- of good mothering ability; and
- having minimal calving problems.

According to Els (1997), the adaptation of the Nguni to the harsh hot areas of northern Namibia, its low feed and water requirements, good walking ability and resistance to diseases, make the Nguni a low input breed, ideal for production in communal areas where farmers do have limited resources for expensive licks and medicine needed to rear most of the exotic breeds. It is evident that natural selection has trimmed the Nguni cattle down in size and conformation, lining it up with the environment.

7.3.2 Characteristics of Goats in Namibia

Motinga *et al.* (2004) reported that indigenous goats in Namibia amounted to 1.1 million in 2003. The different goat populations, with local names, are the Caprivi, Kavango, North Central, and Kunene indigenous goats. The Kunene goats are reported to be the largest, followed by the Caprivi and Kavango goats, whereas the Ovambo goat is the smallest of all the indigenous goats. The performance of the different populations in comparison with the commercial Boer goats is indicated in Table 7.2 below.

According to Thawana (2000) indigenous goats play a vital role as a source of proteins, income generation through the sale of meat, milk and other by-products such as hides, skins, dung (for fuel and manure) and hair. The importance of these indigenous goat populations lies in their unique qualities such as high disease resistance, low maintenance requirements, good reproductive ability and high survival rate. Besides, these goats thrived and survived the harsh semi-arid climate and frequent droughts for centuries.

However, the accelerated crossbreeding of indigenous goats with, for example the Improved Boer goat, to gain on heterosis and improve various qualities as shown in Table 7.2 poses a major threat to indigenous goats. It is therefore of vital importance to look into ways in which the valuable indigenous goat genetic resources of Namibia could be better utilized, conserved and/or improved to meet the needs of the growing population.

Table 7.2: Performance of Indigenous Goats Compared to the Improved Boer Goat

Parameters	Caprivi	Kavango	North Central	Kunene	Boer Goat
Mature body weight (kg)					
Ram	41.83	40.50	40.00	51.14	58.00
Ewe	29.27	31 .42	29.95	36.82	45.71
Birth weight (kg)	2.12	2.01	1.98	2.38	2.92
Weaning weight (kg)	11.73	11.87	13.50	15.29	17.76
Aver. Daily Gain (g/day)	100	100	120	130	150

Source: Thawana and Visser, 1999

7.3.3 Characteristics of Sheep in Namibia

The main sheep breeds farmed in Namibia are the Blackhead Persian, Damara, Dorper, Karakul, Mutton Merino, Redhead Persian, Van Rooy and various crossbreeds. In addition, in communal areas indigenous sheep including the Namaqua Afrikaner and Nguni are found, though in low numbers. In 2003, Dorper sheep amounted to 65% and Karakul sheep to 8% of the country's total sheep flock, with 27% of the national flock registered as other breeds. Each breed has its own characteristics and production potential and their adaptation to various local environments is not well studied.

Of the sheep found in Namibia today, the Damara is indigenous, while breeds such as the Karakul, Persian and Dorper have adapted well to the harsh semi-arid conditions. The hardy and well-adapted Karakul is ideal for production in the arid conditions of Namibia. It is free ranging and environment friendly, and even during times of drought it can survive with less feeding as it can consume a diverse diet than most other sheep breeds (Kamupingene et al., 2006). The multiple uses of Karakul products, in the form of pelts or fur, high quality meat and wool provide for its economic viability particularly to communal farmers.

7.3.4 Characteristics of Pigs in Namibia

Despite the fact that the pig industry in Namibia is very small, a total number of approximately 40 000 pigs are reported to exist in Namibia. The largest portion of the pig population in Namibia consists of indigenous pigs and more than 50% of the pig population in Namibia, is found in the NCAs. According to Els (2000), the body color of indigenous pigs is mostly mottled brown, black and white, but uniform solid colors also do occur, with the following characteristics:

- adapted to harsh environments;
- fertile;
- low maintenance requirements;
- tasty meat;

- excellent lard producers; and
- outstanding scavengers for food.

These, relatively small, hardy, low maintenance, stress tolerant pigs are ideally suited for pig production in the communal areas, and can even play a role in the commercial sector, in the production of lard (Els, 2000). It is reported that indigenous pigs were never subjected to selection for growth, litter size and lean body mass. Therefore, they have low growth rates and deposit fat very quickly. This is a survival mechanism that enabled them to survive under the rearing system used in the communal areas where pigs have to fend for themselves.

Though the indigenous pigs were never selected for fertility, they are highly fertile. Under traditional rearing systems, sows furrow on average once a year, towards the end or after the rainy season. Results obtained at Mashare Agricultural Development Institute have indicated that with improved management and nutrition, and weaning at eight weeks of age, indigenous sows can produce two litters per annum. Litter sizes vary from four to eleven. This is due to no selection for litter size. Survival of the piglets during the first few days after birth is highly dependent on the milk production of the sow. Age at first furrowing is dependent on body condition of the sow and varies from 315 – 679 days, while average inter-furrowing period may vary from 173 – 388 days (Els, 2000)

7.3.5 Characteristics of Chicken in Namibia

Of the chickens, three lines are known *viz.* Ovambo, Naked neck and Venda. Phenotypically, these birds have a variety of feather colour and patterns and, stature. One of the well known characteristic of indigenous chickens is that they can look after themselves for they are better scavengers for food. Indigenous chickens are dual purpose (meat and eggs) whereas exotic breeds are genetically improved to broilers (meat) or layers (eggs) only (Petrus, 2007; pers. comm.). Indigenous chickens become broody and can incubate their own eggs. They have excellent mothering ability as they are able to look after their own chicks.

Exotic breeds in general only lay their eggs and are unable to look after their chicks. Due to this broodiness, the indigenous chicken hen only lay between 100 and 150 eggs per year (when collected and not left for natural incubation), in comparison the exotic layers can lay between 220 and 300 eggs per year from the age of 20 up to 72 weeks of age after which they are slaughtered. In order to reach this high production level, the exotic layers also need 16 hours daylight, which must be supplied artificially.

Indigenous chickens are well adapted to the environment, especially in connection with heat tolerance. In general exotic breeds cannot tolerate heat and die easily from heat exhaustion (Van Niekerk, 1998; Motinga et al, 2004). Thus, although indigenous chickens have lower reproduction levels, it also has much lower input levels (labour, costs and risks) than exotic breeds, which makes it more suitable for small scale farmers situated in isolated areas (Van Niekerk, 1998).

7.4 Improvement and Development of Breeds

In the early part of the century, livestock improvement was considered an art (Haris, 1998). During the middle part of the century, the art was partially transformed into a science. At varying times and degrees, developed scientific principles have been implemented in stud breeding sub-sector for various species and classes of livestock (e.g. beef and small stock), but with differences owing to the biology and the potentials of the class. Industrialization of breeding for specified classes followed opportunities for larger organizations to merchandize genetically improved products. For extensively managed classes of beef, goat and sheep, breeders have usually not focused on the economics of production but instead have focused on the pragmatic “what will sell” in the show-oriented purebred industry. Successes in selling the “right type at the right time” delayed the acceptance of the need to breed adapted stock.

In less than four decades ago, breeding and selecting suitable breeds for farming gained momentum when some individual breeders realized the need to optimize the opportunities provided for by the environment, the human management component and the breeds themselves within the extensive livestock farming system. In spite of production aims and personal choice, the breeds’ ability to adapt to and to produce under arid farming conditions differ. Important production criteria to consider in Namibia are growth rate, body mass, walking ability, hair cover, maternal instinct (mothering ability), and heat resistance, resistance to internal and external parasites, feeding needs and grazing habits.

To that effect, livestock breeding stations such as the Kalahari and Gellap-Ost succeeded in breeding and developing the Kalahari Red and the Gellaper respectively. Preliminary findings indicates that these breeds’ performance (e.g. birth and weaning weights) compares well to the renowned improved Boer goat and Dorper, while further experiments into the heat tolerance and disease and parasite resistance of these breeds are being conducted (Beukes, Namwandi and Van der Merwe, 2007; pers. comm.). There is a need for further support in this endeavor.

At Omatjene and Sandveld Research Stations, through selection, the indigenous Nguni cattle was improved and higher birth and weaning weights as well as heavier carcasses have been realized while preserving such qualities as heat tolerance and disease resistance. Generally, experiments into the adaptability, heat tolerance and disease resistance of various livestock species and breeds are lacking, while some farm animals and chickens in particular, are least studied despite the fact that their roles in majority of households can be equated to, or may surpass that of cattle and goats (Mate 2007; pers. comm.).

7.5 Capacity Building

Recent advancement in animal breeding systems stimulated data collection and analyses to estimate parameters of heritability, genetic correlations and phenotypic variances amongst animals. As statistical methodologies evolved, estimation shifted to phenotypic and additive genetic variances and covariance, the characters of which are pivotal to breeding and selection of livestock. However, application of these techniques and their associated technologies still lagged in Namibia because of the affordability of some of the breeding technologies, and to a reasonable degree, due to the lack of trained and skilled personnel to breed animals, collect and analyze livestock data. For example, Motinga *et al.* (2004) reported that the LRD is understaffed. Through field visits of this study, it was observed that the majority of livestock breeding stations are administered by non-degree holders, most of whom are not animal breeders by profession. There is a need for technical guidance and leadership to ensure that all LI Project activities will mature to be science-based, profit-oriented, and customer-driven, to enable the project to intelligently use selection and crossbreeding technologies based on sound biology, sound statistics and sound economics, with these all systematically combined. Part of the path is to purposely build capacity to professional postgraduate qualification levels.

7.6 Development of Livestock Research Stations

In order to meet its objectives and enhance service delivery to livestock farmers, the LRD has over the past few years improved infrastructure and facilities at some of the existing research stations (e.g. Neudamm, Sachinga), while new stations (e.g. Oshaambelo and Okapya) were established during the years 2005–2007.

7.6.1 Livestock Acquisition and Distribution

In attempt to promote livestock production in Namibia, the MAWF initiated a programme of distributing livestock to previously disadvantaged ‘communal farmers’ at subsidized prices. However, given the fact that the mode of distribution is via auctions, well-off commercial buyers directly and indirectly (i.e. by buying through other farmers) out competes the rightful targeted beneficiaries. Therefore, the LRD introduced (2007) another way of distributing livestock by, *first*, sensitizing and selecting recipients with the assistance of extension staff and traditional authorities. The LRD has thus far started, on a nation-wide basis, distributing cattle (i.e. Simmental, Nguni, and Afrikaner) and small stock (i.e. Kalahari red, Boer goat and Damara sheep) acquired from MAWF’s research/breeding stations.

According to Mate (2007, pers. comm.), the LRD is promoting and intents to distribute adapted breeds (e.g. Nguni) especially in the NCRs. However, majority of farmers in the NCR feels that they are being treated unfairly as their counterparts south of the Veterinary Cordon Fence can apply for any animal of their choice including the less adapted and large frame Simmental. This has resulted, to a larger extent, rejection of the Nguni which the LRD is promoting in the harsher and forage-poor areas of the NCR.

7.6.2 Conservation of Indigenous Livestock

It is believed that the present population of the world inherited a wide variety of genetically diverse livestock populations from our ancestors. There is concern, however, that due to current high rates of extinction and/or dilution of indigenous stock, our descendants will inherit a far less genetically rich and diverse selection of livestock breeds and thus agricultural options, unless appropriate action is taken to conserve them. The International Union for the Conservation of Nature and Natural Resource’s (IUCN) World Conservation Strategy has defined the need for conservation as: “*The management for human use of the biosphere so that it may yield the greatest sustainable benefit to* *present generations while maintaining its potential to meet the needs and aspirations of future generations. Thus conservation is positive, embracing preservation, maintenance, sustainable utilization, restoration and enhancement of the natural environment*" (IUCN, 1980).

Even though the MAWF is committed to conserve and promote the keeping of indigenous stock, there appears to be conflicting messages from other stakeholders that are promoting the use of less adapted, but high yielding (i.e. birth and weaning weights) exotic breeds. Since there is limited (if at all) material gain in conserving indigenous stock to the farmers keeping indigenous animals, there is need to introduce incentives while considering *ex situ* and *in situ* conservation as elaborated below.

7.6.1 *Ex Situ* and *In Situ* Conservation of Livestock

Ex situ preservation involves the conservation of animals in a situation removed from their normal habitat. It is used to refer to the collection and freezing in liquid nitrogen of animal genetic resources in the form of living semen, ova or embryos. It may also be the preservation of DNA segments in frozen blood or other tissues.

In situ conservation is the maintenance of live populations of animals in their adaptive environment or as close to it as is practically possible. For domestic species the conservation of live animals is normally taken to be synonymous with *in situ* conservation. Both *ex situ* and *in situ* conservation are practicably workable for Namibia, and the MAWF and other stakeholders may consider these as options to conserve the genetic material of indigenous animals that is rapidly eroding.

It is worth noting that *ex situ* and *in situ* conservation are not mutually exclusive. Frozen animal genetic resources or captive live zoo populations can play an important role in the support of *in situ* programmes. The key advantages and disadvantages of the major systems are given in Table 7.3 with a view to identifying the relative strengths and areas of mutual support.

Table 7.3: Options Offered by Ex Situ and In Situ Conservation Techniques

Factor	Ex Situ	In Situ
Initial cost	Relatively high	Low-high
Maintenance cost	Low	Relatively low-high
Initial genetic drift	Relatively high	Low
Annual genetic drift	None	Moderate-high
Applicability to species	No	Yes
Safety/reliability	Good-bad	Moderate
Local access	Moderate-poor	Moderate-good
International access	Good	Not good
Population monitoring	None	Good
Environmental adaptation	None	Good
Selection for use	None	Good

Source: Henson, 1992.

7.6.2 Cryogenic Preservation

The relative cost of collecting, freezing and storing frozen material, as compared to maintaining large scale live populations, has been estimated to be very low (Smith, 1983). In particular, once the material has been collected, the cost of maintaining a cryogenic store is minimal. Such banks require little space and few trained technicians. A very large number of frozen animals from a large number of populations can be stored in a single facility. Cryogenically preserved populations suffer no genetic loss due to selection or drift. The method places a sample in suspended animation, and that sample remains genetically identical from the time of collection to the time of use with negligible effects of long term radiation. Frozen animal genetic resources can be made available to livestock breeding and research programmes throughout the world.

The principal disadvantages of cryogenic preservation lie in the availability of the necessary technology and access to the frozen populations. Cryogenic stores are not expensive to run but they do have annual capital maintenance requirements. In particular, cryogenic stores will require a guaranteed supply of liquid nitrogen which must be imported. Such cryogenic stores in Namibia will have no intrinsic value with respect to financial income, unless material can be sold for research and development.

There is, however, a potential danger in cryogenic storage, from large scale loss of material due to serious accidents. This could be due to human error, power failure, and loss of liquid nitrogen, fire, flood, storm, earthquake or war. Such risks can be reduced by keeping duplicate stores at different research stations. Cryogenically preserved populations are not easily available for comparative trials or for research projects, as it takes a number of years to regenerate a cryogenically preserved population to review or re-evaluate it in changed circumstances, or to utilize it as a breeding population. Cryogenically preserved populations are not able to adapt speedily through gradual selection, to changes in the climate or disease background of the local or global environment (Henson, 1992).

7.8 Summary

The livestock improvement and conservative initiative is in a nascent stage. To date, the MAWF succeeded in the characterization, partial conservation (*in situ*) and dissemination of local breeds to farmers. Despite that, majority of farmers focus on immediate or short-term benefits as opposed to long-term benefits by crossbreeding their indigenous stock, while some farmers pester the LRD to provide them with adapted breeds. As a result, it is clear that the farmers are not quite focused on what end-product they require. Farmers need technical guidance from professional breeders to help them map out their breeding strategy and long-term objectives based on a clear breeding policy guidelines. However, the conflicting messages from the different stakeholders make it difficult for the successful implementation of the indigenous breed improvement programmes. At the moment, the farmers in the NCRs are responding to market forces (i.e. Meatco pays, comparatively, higher prices for young and heavier animals with better carcass quality) in their strategy of exploiting their existing gene pool by crossbreeding with exotics. There is an opportunity for the MAWF to engage with key livestock improvement institutions (e.g. Meatco, Karakul Board, Meat Board, NNFU, etc.) in order to exchange ideas on the best techniques to improve and conserve indigenous stock among farmers.

It is the opinion of this study that conservative improvement of indigenous animals would eventually result in hardy, adapted and high yielding herds/flocks for rural farmers. The MAWF urgently need to initiate a monitoring and evaluation system for the LI Project. Such a system may involve systematic project evaluation in form of impact assessment and/or report backs from participating farmers. The latter would ensure that farmers keep simple and updated records that would serve as an objective guide in future interventions.

Changes in the social fabric occur, and questions arise as to what incentives will be required to ensure that the farmers conserve their breeds voluntarily, and whether the focus should be on pure breed conservation or indigenous gene pool conservation. Consideration into using research stations for *in situ* conservation as well as acquisition and establishment of facilities necessary for ex situ conservation of indigenous livestock will be pivotal in the near future. Training and research institutions, particularly UNAM, possess a wealth of expertise and resources which can be harnessed to accelerate livestock improvement through, mainly, capacity building and advisory services.

CHAPTER 8: RECOMMENDATIONS AND RESEARCH NEEDS

8.1 Introduction

Findings presented in this report show that the Namibian agricultural sector is vulnerable to climate change. Through the combination of indigenous knowledge and technological advancements, Namibian farmers have developed adaptive management systems in response to these varying climate regimes. A variety of adaptation options need to be considered and implemented in order to further reduce vulnerability and enhance resilience to climate change.

8. 2 Recommendations

Developing and implementing adaptation strategies to climate change requires the involvement of many stakeholders and concerted efforts in ensuring an efficient delivery system. The following are highly recommended:

8.2.1 Strategic Policy Framework

While cognizant of the effects of climate change, such as reduced rainfall and higher temperature regimes, few policies currently reflect the need to respond to and prepare the economy for the impacts of climate change. There is a need to mainstream climate change issues into national policies and strategies. This exercise should embrace research and development and involve public consultations as a basis for promoting adaptation to climate change. The NCCC, as the central coordinating organ should steer activities that encourages a national dialogue on climate change and adaptation. There is a need to enhance and intensify the activities of the NCCC and its various working groups at both national and regional levels. Active participation of policy makers and administrators, along with farmers and scientific staff, for effective formulation and implementation of farming systems strategies is essential. Targeted strategies are needed to better ensure that decisions and investments made do not condense the ability of farming communities and their economic sub-sectors to adapt to future climatic changes.

8.2.2 Long-term Funding for Research and Development

As the impacts of climate change are increasingly felt, there is an immediate need to enhance efforts to integrate adaptation into core policy-making. Investment in research and development is required to enhance capacity in research, development and innovation to address the Namibian challenges of climate change in agriculture. Doing so requires mobilizing the full range of resources within and outside the current funding stream. Developing of opportunities, tools and knowledge to enhance decision-making by farmers is vital. Investment priorities and policies must take into account the immense diversity of opportunities and problems facing small farmers. The resources, on which they draw, their choice of activities, and indeed the entire structure of their lives, are linked inseparably to the biological, physical, economical and cultural environment in which they find themselves and over which they only have limited control. Agriculture will be better able to meet the challenges of climate change if research, extension and development practitioners, industry and farmers utilize a participatory approach to research and development. A deliberate and emergent financing strategy for research and development need to be created within a stakeholder participatory planning process.

8.2.3 Research Programme Formulation and Priority Setting

It is essential that research is maintained efficiently and focused on national needs and policy objectives. Farming systems research needs for adaptation to climate change is not sufficiently articulated within the research programme and agenda of DART. An exemption is the indigenous livestock improvement and the fruit tree planting projects. Priorities are equally unclear to agronomy research initiatives with respect to the multiplicity of commodities claiming current attention. Programme formulation with clearly set out, widely understood, transparent and multi-stakeholder coordinated priority setting mechanisms will facilitate the implementation, monitoring and evaluation of well-thought government initiated research programmes. A formal multi-disciplinary research programme review, evaluation, and monitoring exercise for Namibia is proposed to ensure that proper guidance is given to all research institutions, professionals and the farming community alike.

8.2.4 Coordinated Data Management

There is no formal system for farming data (field crops, fruits, vegetables, small-stock, large-stock, economical, social, environmental, etc.) management in Namibia. The current practice is ad-hoc oriented for incoming, internal, and outgoing information among the diverse farming service providers.

Based on the findings, it is clear that under the current conditions, the public sectors' capacity to establish sustainable farm data systems is a distant mirage for most of the agricultural sub-sectors. This is aggravated by the views in some quarters that trends and policy impacts at the farm level are well-known and thus significant investment in data collection are not warranted. Nevertheless, there are several on-going efforts by MAWF, donor funded projects, NGOs and farmer associations and service providers in support of developing and maintaining farm data systems, as is the case with NAB. There is a need to maintain and enhance the collection of accurate physical, economic and social data that will complement the development of models that predict the impacts of climate change on agriculture.

There is general recognition that progress can be made in improving farm data systems by better utilization of existing resources. For instance:

- Co-ordination and networking between all the stakeholders would mean that the currently available resources allocated to farm data management could be utilized more efficiently.
- Re-orientation and re-balancing data systems to focus on user needs, rather than the current supply driven orientation, would ensure higher collaboration in collection and dissemination of information.
- Tapping of local resources, for instance, sharing the accomplishments on farmer organizations and NGOs can complement public efforts.
- Use of typology groups or farming systems information rather than information from individual farms could reduce costs of data collection and enhance the usefulness of the data and its dissemination.
- Effort to harness and synthesize the prevailing farm data would go a long way in filling the current data gaps for advisory services in farm decision support systems.

8.2.5 Strengthening Communication and Awareness

Identification of farming systems adaptation options for climate change is just beginning, and efforts to enhance national understanding of how to move forward on adaptation are needed. At the same time, a long-term strategy for adapting to climate change needs to be developed. Bringing climate change rather than just climate variability into focus as an additional element in normal strategic planning and risk management in agriculture requires awareness raising and capacity building. Efficient and responsive activities to enable adaptation to climate change, incorporating climate change considerations in policy and development programmes, will foster an increased understanding and integration of scientific knowledge into farm management decisions and incorporate issues of climate change into education and training packages directed at agricultural industries.

8.2.6 Extension Method and Approach

While Namibia has adopted the farming system research and extension approach, the introduction of the farmer-to-farmer extension concept among rural farming communities was recently proven efficient and appropriate in technology adoption among small-scale farmers. Against this background, and with established community technology promoters, it is strongly recommended that improvement and transfer of innovations and technologies for adaptation to climate change be done through the farmer-to-farmer extension approach. The underlying benefit is that the social and economic dimensions of the potential beneficiaries of technology adoption are readily understood by the fellow farmer trainer, considered to have the same needs to significance of the technology options in their livelihoods.

8.2.7 Establish an Adaptation Information and Advice Service

It is proposed that the work of providing farmers with information relevant to their adaptation needs, and advising on the technology in use elsewhere, should be undertaken under the framework of the NCCC. Farmers need help, and are looking for easily accessible one-stop source of information and advice on adaptation technologies in general and, in particular, on adopting profit-enhancing farming practices. Sources of climate change information and advice on adaptation strategies in the farming communities are not generally available, and it is necessary to propose the formation of climate change information and advise service to satisfy this need.

As a basic requirement, the development of farming systems adaptation to climate change extension materials will require the active participation of MAWF, NMS and MET (climate change coordinating organ), and the farmers themselves to make the materials relevant to the farmers’ culture, language, learning experience and farming style. The material must be field tested with farmers who had not been involved in on-farm trials, and modified iteratively several times to make them suitable for the wider farming community.

8.2.8 Invest in Breeding, Biotechnology and Seed Technology Programmes

Namibia must promptly promote the use of indigenous and locally-adapted plants and animals as well as the selection and multiplication of crop varieties adapted or resistant to adverse conditions. The selection of crops and cultivars with tolerance to abiotic stresses (e.g. high temperature, drought, flooding, high salinity content in soil and water, pest and disease resistance) allows the harnessing of genetic variability in new crop varieties if national programmes have the required capacity and long-term support to use them. To strengthen its capacity to implement these plant breeding programmes and develop locally-adapted crops, it is recommended that Namibia engage with FAO to take advantage of the Global Initiative on Plant Breeding Capacity Build progressive launched at the International Treaty on Plant Genetic Resources for Food and Agriculture in 2007.

Biotechnology can contribute to agricultural productivity and food security. However, mechanisms for handling any adverse effects of biotechnology need to be put in place. The potential and perceived risks of biotechnology, especially genetic engineered products, to human health and the environment are not well understood in Namibian society, and there is need to put in place appropriate mechanisms and capacity to address them.

In Namibia issues in the realm of seed science and technology including seed health and testing are not adequately addressed and coordinated. There is, for instance, no seed health laboratory that farmers can resort to for diagnosis, if their crops are beset with borne diseases. Within DART, there is lack of information on seed science issues such as seed research and science-based seed testing. There is a need for technical expertise and other resources to utilize existing seed testing facilities, e.g. at Unam Ogongo Campus, in a coordinated fashion with the leading organized seed production and supply organizations in the crop growing regions.

8.2.9 Empower and Broaden Early Warning Systems

There is a need for better cooperation between the Early Warning and Information Systems Unit of MAWF with the Emergency Management Unit in order to better utilize the assessment of short- and long-term impact of adverse climatic events on agriculture livelihoods, while contributing to disaster preparedness and mitigation of potential risks. A unified and empowered early warning and risk management system, both in human and technology needs, is obvious and efficient contributors that can facilitate adaptation to climate change through the establishment of:

- A historical climate data archive, inclusive of climate impacts on agriculture;
- Monitoring tools using systematic meteorological observations;
- Climate data analysis that determines the patterns of inter-annual and intra-seasonal variability and extremes;
- Information tools on the characteristics of farming systems' vulnerability and adaptation effectiveness such as resilience, critical thresholds and coping mechanisms, required to identify opportunities for particular adaptation measures and practices; and
- Crop and weather insurance indices to reduce the risk of climate impacts for lower-income farmers.

8.2.10 Strengthen Social Protection Policies

Given fiscal and administrative constrains, and an economic context of reducing government interventions in the economy, public actors (government and donors) should work together in partnership with private and informal actors (communities, farmer-based organizations, etc.) to deliver effective social protection. There is a need to improve targeting and quantifying of household vulnerability. Given the close linkages between chronic and transitory food insecurity, public interventions should achieve positive synergies between social protection and pro-poor economic growth. This can be achieved by supporting people through short-term crisis while reducing their long-term vulnerability.

The following further recommendations as per the Poverty Reduction Strategy for Namibia need to be implemented:

- Maintain fiscal sustainability while ensuring that poor elderly are covered, adopt indicator-based criteria (such as ownership of a vehicle, or a single family home, all income tax assesses, contributors to social security; etc.) to exclude the clearly non-poor individuals from eligibility to the social pension program.
- Support and harmonize current efforts in the Ministry of Works, Transport and Communication and MAWF to foster cash-based labour-intensive public works programs, by identifying and removing obstacles to their expansion.
- Reduce the number of complexity of grant-based transfer programs to three: a basic social pension program, a combined blind person and disability pension program, and a child maintenance grant.
- Continue measures aimed at reducing inter-regional disparities in grant coverage.
- Re-orient the distribution of social workers towards where the needs and clients actually are. If limitations to moving professional staff between regions cannot be overcome, consider other options of reaching the underserved northern regions (including the use of para-professionals).

8.2.11 Financing of Climate Change Adaptations

There is a role for government and development partners to assist in the provision of credit for investments in specific projects that facilitate adaptation to climate change. This may be most suitable if linked to low-cost rural banking and farmer saving schemes with strong local social control on the allocation, administration and repayment of loans. Existing loan schemes, such as low-cost renewable energy schemes may be expanded to cater for an array of environmentally friendly and climate change adaptation technologies. Special arrangements, e.g. by government loan guarantee and voucher schemes, may be made to encourage access to credit by marginalized groups and women.

8.3. Future Research Needs

Research needs for the agricultural sector include how Namibia can and will respond to reduced yields due to climate variability. More detailed adaptation studies in strategic locations will help to satisfy this need. The following areas of research are of prime importance:

8.3.1 Crop Breeding and Germplasm Evaluation

In order to reduce possible adverse consequences to climate change, the agricultural sector should be encouraged to continue to develop crop breeding and management programs for heat and drought tolerance. This will be immediately useful in improving productivity in marginal rainfed crop production areas. Another important activity is to enlarge, maintain, and screen important crop genetic resources at established seed banks. Collection of germplasm alone is tedious and requires the harnessing of sufficient human and financial resources. Resources should be made available to adequately support the participation of extension staff in the collection activity.

8.3.2 Climate Change Monitoring

The clearest objective at present is to prepare for changing climatic hazards by reducing vulnerability, through developing monitoring capabilities and enhancing the responsiveness of the agricultural sector to forecasts production variations and food crises. Resilience of the agricultural production sector also depends on improved use of systems for monitoring weather, soil, moisture, nutrient requirements, and pest infestations. Finally, strong communication links among the agricultural research, production, and policy sectors are essential.

8.3.3 DSSAT Crop Model Simulation and Validation

Following the capacity-building initiative, there is a need for technical support in validation of the crop models with experimental data from the fields. Simulation experiments with the crop models utilizing baseline data and climate change scenarios, with and without the direct effects of CO_2 on crop growth, with irrigated production, sensitivity tests, and adaptation responses are required. The adaptations response simulation should include shifts in planting date, fertilizer rates and crop varieties. This will allow for results on modeled yield changes, such as changes in growing season length arising from climate change, and the identification and evaluation of alterations in agricultural practices that would lessen any adverse consequences of climate change.

8.3.4 Ricardian Approach-Based Study

Current initiatives to model climate change impacts are limited to crops. There is a need to model the impact of climate change on other farming systems, other than crops. The Ricardian model offers a rigorous alternative model for studying climate change impacts on the agricultural economy. As was done in many African countries, the implementation of the Ricardian model in Namibia can be supported technically through the established relations between these institutions, and such a collaboration need to be initiated. The Ricardian Model requires a fully fledged fieldwork-based study, to collect data on the various parameters to be included in the model. The intention of the study is to provide policy makers with an assessment of the scope for government intervention to hasten, and in some cases, to unlock the process of farming adaptation to climate change.

CHAPTER 9: CONCLUSSION

Namibia's agricultural production potential is limited by its ecologically fragile ecosystems. As a direct consequence, extreme climate change occurrences have a direct impact on the agricultural economy of Namibia. Climate change and variability are among the most important challenges facing Namibia because of its strong economic reliance on natural resources and rain-fed agriculture. Unfortunately, it is predicted that if global warming is not reduced the country will become hotter and drier. The fact is that the majority of Namibians live in rural areas and their socio-economic circumstances makes them especially vulnerable to negative climate change occurrences such as droughts and floods. There is already sufficient evidence that farming systems have changed, land degradation, bush encroachment and other environmental threats continue to threaten household dependence on agriculture as a livelihood. There is therefore a need to fastrack policies and strategies that enhance Namibia's resilience to climate change impacts.

This study succeeded in establishing the baseline situation in the Namibian agriculture sector: its significance to the national economy, high level of sensitivity to key climatic variables, climate variability-induced losses in agricultural outputs in recent past, other socio-economic drivers for vulnerability of the sector, traditional knowledge and practices existing within the farming community for coping with climate variability, knowledge and information gaps for better decision making and farming system management.

Long-term climate change and variability could increase the frequency and severity of climatic extremes such as droughts and floods. Continuing changes may expose farming systems to conditions not experienced before. For example, there is a risk that changing climate conditions predicted by various studies will shift the areas where agricultural production can occur. Hypothetically, this could mean the margins of the northern crop producing areas, or the entire mahangu profile change, because of changing rainfall profiles or flood and drought frequency. Such geographical shifts in agricultural land use could threaten the viability of key agricultural sub-sectors, and also disrupt rural communities and the infrastructures that support rural development and livelihoods. There is a need to recognize that droughts and floods are a normal part of the Namibian agricultural environment, and that in the future such events may become more common. Moreover, climate change may increase climate variability beyond the range considered normal under past experiences. Notably, while such scenarios may pose threats in some regions, they may create opportunities in other regions.

Potential impacts of long-term climate change on farming systems could include increased invasion of unwanted plant species, pest and diseases, changes in pasture growth and carrying capacity, and a more limited capacity for diversification e.g. reduction in the potential for expansion in irrigated agriculture. Changing rainfall patterns, combined with higher temperatures, could reduce water availability and add pressure on water allocation systems. Effective adaptation measures, such as efficient use of resources, low water use crop cultivars, drought-tolerant livestock, and diverse income opportunities for rural communities could reduce the extent of these impacts.

Climate change impacts are likely to vary across geographical regions and this could impact on the comparative advantage of existing farming systems with possible influences on sectoral commodity trade. Climate change adaptation measures have the ability to enhance opportunities and minimize risks to exposed sectors.

Adaptation practices require extensive high quality data and information on climate, and on agricultural, environmental and social systems affected by climate, with a view to carrying out realistic vulnerability assessments and looking towards the near future. Climate change assessment must observe impacts of variability and changes in mean climate (inter-annual and intra-seasonal variability) on agricultural systems. However, agricultural production systems have their own dynamics and adaptation has a particular emphasis on future agriculture. The study concludes that the capacity of a farming system to adapt to changing weather and climate conditions is chiefly based on its natural resource endowment and associated economic, social, cultural and political conditions.

In responding to climate change, government and development partners have a significant and ongoing role in supporting the efficient allocation of resources, managing distribution of costs and benefits proportionally amongst those potentially affected, and facilitating efficient decision-making by providing information, institutional support and policy frameworks. Developing and implementing adaptation strategies to climate change oblige the involvement and concerted efforts of many stakeholders in ensuring an efficient delivery system. Implementing adaptation measures at farm level requires that research and development, coupled with extension, is well coordinated.

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ANNEXURE A: TERMS OF REFERENCE

REPUBLIC OF NAMIBIA

MINISTRY OF ENVIRONMENT AND TOURISM

TERMS OF REFERENCE FOR RESEARCH ON FARMING SYSTEMS CHANGE TO ENABLE ADAPTATION TO CLIMATE CHANGE FOR THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

BACKGROUND

Namibia ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1995 and became legally obligated to adopt and implement policies and measures designed to mitigate the effects of climate change and to adapt to such changes. The Global Environment Facility (GEF) through the United Nations Development Program (UNDP) approved funding for Namibia's proposal on its Second National Communication (SNC) to be presented to the United Nations Framework Convention on Climate Change (UNFCCC). The Ministry of Environment and Tourism (MET) through its Directorate of Environmental Affairs (DEA) is responsible for overseeing the coordination of Climate Change issues in Namibia thus the implementation of the SNC project in order to fulfill the country's obligations under the Convention. The SNC project activities will build on and continue the work done under the Initial National Communication (INC) and the top-up Enabling Activities Projects in which different components of the project were identified

The Initial National Communication (INC) of Namibia presented to the UNFCCC in 2002 reported that the Namibian agricultural output is extremely sensitive to climatic conditions. Periodic droughts currently cause considerable stock losses and reduced grain production. The uncertainty in future rainfall trends makes projection of agricultural impacts very difficult. Various studies and assessments have identified agriculture as one of the most vulnerable sectors that will be affected by climate change and more Systems must be developed to match crop species and cultivars to environmental conditions, including climate, soils and farming systems.

THE TASK

The NCCC, chaired by the MET, and with the support of the United Nations Development Program requires the services of a consultant or an institution or consortium to asses and conduct research needs on farming systems change in Namibia's to enable adaptation to climate change. The consultant or institution will be required to make recommendations on the suitability of the existing data as well as others suitable for inclusion in the compilation of Namibia's second and subsequent national communications.

Consultants, institutions or consortia with proven capabilities in the conduct of such reviews are encouraged to apply. The selected entity must demonstrate a thorough understanding of and familiarity with the subject matter, practical experience in the field and knowledge and familiarity with decision 17/CP.8 of the UNFCCC National Communications from Parties not included in Annex I to the Convention and IPCC requirements and methodologies to conduct the reviews. The consultancy requires the consultant to compile the farming systems change through various consultations by collecting national data over a wide range of institutions and sources particularly the Ministry of Agriculture, Water and Forestry (MAWF) and the SADC National Plant Genetic Resources Centre. In order to encourage capacity building and reduce costs, preference will be given to proposals that include the training and use of students and other young Namibians in the implementation this task.

Specific Tasks

The selected consultant, institution or consortium must demonstrate capabilities and experience the review and update of GHG and preparation for the 2000 Inventory and the evaluation of factors that make up such inventories.

The activities to be undertaken will support the following:

- The research section of the MAWF faces financial and other constraints that limit crop and climate change modeling. The consultant will assist with the development and usage of agricultural models. There is a current need to acquire models and for capacity building in the application of models. Support will be provided to the research section of MAWF in further developing and strengthening its capacity in the development and application of climate change and crop models. Courses in modeling by ICASA will also be utilized to fulfill this need.
- The consultant is required to support in the further development of indigenous livestock breeds that have tolerance to hot and arid conditions, and require low agricultural inputs. The consultant will give recommendations and support the selection and testing of genetic material suited for the temperature and rainfall conditions that are projected to occur in the future. Technical expertise, indigenous germplasm collections and collaboration with Regional and international plant genetic resources centres such as the National Plant Genetic Resources Centre, and possibly the SADC Plant Genetic Resources Centre, will be required. Collaboration will also be established with MAWF which participates in an indigenous livestock breeds project funded by FAO, promoting the superior tolerance of local livestock breeds in hot and dry conditions with low agricultural inputs.
- The consultant will therefore support further quantification of the economic and social impacts that would occur as a direct result of the predicted changes. This information will help in preparing adequate coping strategies and implementation plans. The consultant will carry out this exercise with the cooperation of the MAWF, MLR, NPC, FAO, and other local and international development partners.

The consultancy should provide recommendation about the procedures and institutional arrangements required to sustain the process of data collection and archiving.

During implementation the contractor will liaise with the Program Coordinator on day-to-day issues and will meet with a sub-committee of the NCCC once per month to report on implementation progress and problems.

DURATION
It is expected that the implementation of this activity will be completed over a six-month period commencing on 25 June 2007 ending on 18 February 2007 and will not exceed fifty (50) actual working days.

BUDGET
The selected consultant, institution or consortium must submit a budget detailing estimated cost of the expected implementation of these activities. This budget must be in the form of a complete breakdown detailing costs of key personnel and the amount of time allocated to each key person, transportation, materials and other items. A payment schedule should also be included that links payments with performance milestones. The budget should be submitted in the form of a financial proposal separately from the technical proposal in different envelopes. A fixed price contract will be entered into with the selected contractor.

APPLICATIONS
Interested consultants, institutions or consortia should submit technical and financial proposals in separate envelopes and in duplicate indicating their interest in and capability to implement the above work in a sealed envelopes marked **CLIMATE CHANGE RESEARCH ON FARMING SYSTEMS CHANGE TECHNICAL PROPOSAL** and **CLIMATE CHANGE RESEARCH ON FARMING SYSTEMS CHANGE FINANCIAL PROPOSAL** respectively to the either of the following addresses by **MARCH 2, 2007:**

Ms. Uazamo Kaura
Environmental Conventions and Related Programs Unit
Directorate of Environmental Affairs
Ministry of Environment and Tourism
6th Floor Capital Center Building
Private Bag 13306 Windhoek
Email: uazamo@dea.met.gov.na
Tel: 061-2842701
Or
Ms. Catherine Odada
Program Assistant
UNDP Namibia
13th Floor Sanlam Building
Private Bag 13329 Windhoek
Email: catherine.odada@undp.org
Tel: 061-204-6232

Proposals must indicate the period of validity of the bid. No facsimile tender documents will be considered.

ANNEXURE B: LIST OF PERSONS CONSULTED

Surname	Initial	Position	Institution / Agency / Station
Amadhila	E	Chief Forester	DoF, Eenhana
Amakali	J	Agricultural Extension Officer	DEES, Eenhana
Amufufu	A	Agricultural Extension Officer	DEES, Ongwediva
Amwaama	P	Farm Manager	Farm Ombandje, Otavi
Appolus	G	Senior Agricultural Extension Technician	DEES, Karasburg
Aushona	A	Forester	DoF, Eenhana
Benade	V	Senior Agricultural Extension Technician	DEES, Rehoboth
Boois	D	Farmer	Karasburg
Burger	B	Senior Agricultural Extension Technician	DEES, Mariental
Calitz	A	Senior Agricultural Research Officer	DART – AEZ, Windhoek
Chitate	F	State Veterinarian	DVS, Katima Mulilo
Cloete	D	Senior Agricultural Extension Technician	DEES, Rehoboth
Coetzee	M	Chief Agricultural Research Officer	DART – AEZ, Windhoek
Collman	W	Senior Agricultural Extension Technician	DEES, Keetmanshoop
Dakwa	T	State Veterinarian	DVS, Keetmanshoop
Diergaardt	P	Senior Agricultural Extension Technician	DEES, Rehoboth
Els	J	Chief Agricultural Research Officer	DART, Windhoek
Embundile	M	Chief Agricultural Extension Officer	DEES, Eenhana
Fleissner	K	Project Coordinator	DRFN, Gobabis
Goliath	J	Projects Administrator	Agronomic Board, Windhoek
Gonoseb	R	Land Use Planner	Kunene Regional Council, Opuwo
Hager	C	Land Desk Coordinator	DRFN, Windhoek
Hangero	T	Farmer	Otjinene
Horn	L	Agricultural Research Officer	DART, Windhoek
Imbili	S	General Manager	NNFSG Cooperative, Mahenene
Ingo	E	Program Coordinator: Crops	NNFU, Oshakati
Ipinge	S	Acting Director	DART, Windhoek
Iyambo	M	Commercial Farmer	Tsumeb
Jona	C	Agricultural Extension Officer	DEES, Rundu
Kakujaha	Z	Senior Agricultural Extension Technician	DEES, Epukiro
Kakondo	H	Forester	DoF, Opuwo
Kamseb	A	Acting Chief Regional Officer	Kunene Regional Council, Opuwo
Kandjii	E	Representative	Otjozondjupa Regional Farmers' Union
Kanguatjivi	EI	Agricultural Extension Officer	NSU – MAWF, Windhoek
Kanguatjivi	W	Agricultural Training Officer	DART, Windhoek
Kangueehi	K	Technical Assistant	NNFU, Windhoek

Kanyomeka	L	Head	Crop Science, Unam, Ogongo
Kapi	AM	Secretary General	Ngatuuane Farmers Union, Opuwo
Kapi	UB	Vice President	Ngatuuane Farmers Union, Opuwo
Kapimbi	Y	Acting Chief Agricultural Extension Officer	DEES, Opuwo
Karumendu	H	Commercial Farmer	Eramba
Kasheeta	S	Acting Director: DEES	MAWF, Windhoek
Kashikola	D	Director, Planning and Development Services	Ohangwena Regional Council
Katire	F	Agricultural Extension Officer	MAWF, Katima Mulilo
Katjimune	T	Senior Agricultural Extension Technician	DEES, Opuwo
Katjiteo	Z	Agricultural Research Officer	DART, Ongwendiva
Kaura	U	Conservation Scientist	DEA, Windhoek
Kaunotje	D	Livestock Procurement Officer	MeatCo, Otjiwarongo
Kavandara	L	President	Omaheke Regional Farmers Union
Kavetu	RV	Representative	Otjikaambuti Farmers Ass., Opuwo
Kazetu	S	Agricultural Research Officer	DART, Ongwendiva
Kruger	B	National Coordinator	Joint Presidency Committee, Windhoek
Loots	S	Curator	NBRI, Windhoek
Losper	L	Agricultural Economist	DoP, Windhoek
Mate	I	Deputy Director: Livestock Research	DART, Windhoek
Matundu	B	Farmer	Kunene North
Mazenge	B	Farmer	Outjo
Mbai	M	Farmer	Grootfontein
Mbaumba	L	Farmer	Kunene North
Mieze	B	Animal Health Technician	DVS, Keetmanshoop
Mukuahima	G	Agricultural Extension Officer	DEES, Tsumeb
Mumbuu	H	Farmer	Opuwo
Munjanu	O	Programme Coordinator	NNFU, Windhoek
Mupya	L	Livestock Procurement Officer	MeatCo, Opuwo
Murangi	N	Commercial Farmer	Epukiro
Muwonge	M	Librarian	NPC Information Centre, Windhoek
Mvula	E	Acting Director	SANUMARC – Unam, Hentiesbay
Mwangala	S	Chief Meteorological Technician: Climate	NMS, Windhoek
Nakande	M	Agricultural Extension Officer	DEES, Ongwendiva
Namalambo	E	Chief Agricultural Extension Officer	MAWF, Windhoek
Namwandi	R	Agricultural Research Officer	DART, Gellap-Ost, Keetmanshoop
Nantanga	L	Chief Agricultural Extension Officer	DEES, Outapi
Nashindengo	N N	Senior Agricultural Extension Officer	DEES, Eenhana
Ndjarakana	F	Regional Head	Rural Water Supply, Opuwo
Nyembo	J	Farm Manager	Okomumbonde Research Station
Opperman	I	Farmer	Grootfontein

Ortner	H	Farmer	Outjo
Ozuuko	A	Assistant Farm Manager	Namibia Grape Company
Prinsloo	D	Agronomist	GSA, Windhoek
Serogwe	I	Animal Health Technician	DVS, Okakarara
Sheuyange	TP	Farm Manager	Okapya Livestock Development Centre
Shihungileni	TN	Chief Control Officer	EMU, Windhoek
Shilongo	P	Deputy Director, Planning	Kunene Regional Council, Opuwo
Shilulu	I	Agricultural Research Officer	DART, Mahenene
Shiningavamwe	K	Agricultural Research Officer	DART, Windhoek
Shipandeni	M	Agricultural Extension Officer	DEES, Otjiwarongo
Shivute	A	Agricultural Extension Officer	DEES, Outapi
Shoopala	J	State Veterinarian	DVS, Opuwo
Sihova	B	Manager	MADI – DART, Rundu
Tjeundo	KZ	Secretary General	KUNOCOFU, Opuwo
Tjijahura	Z	Manager	NAMWATER, Cuvelai Region
Tjijombo	U	Animal Health Technician	DVS, Keetmanshoop
Tjikurame	BR	Senior Agricultural Extension Technician	DEES, Opuwo
Tjitaura	B	Animal Health Technician	DVS, Rundu
Tjivikua	K	Farmer	Kunene North
Tsanixab	S	Senior Agricultural Extension Officer	DEES, Grootfontein
Tuyendapi	G	Chief: Livestock Marketing	Meat Board, Windhoek
Uandia	J	Farmer	Otjinene
Uheua	J	Agricultural Extension Officer	DEES, Gobabis
Uusiku	S	Agricultural Extension Officer	DEES, Eenhana
Van Lille	C	Senior Agricultural Extension Technician	DEES, Mariental
Vleermuis	E	Farmer	Karasburg
Zeck	S	Farmer	Kunene North

ANNEXURE C: LIST OF DSSAT TRAINING PARTICIPANTS

Surname	Name	Current Position	Organization & Station
Alweendo	Twewaadha E.	Senior Agric Research Officer	MAWF, Windhoek
Amunyanyo	Maria	Senior Agric Research Technician	MAWF, Okashana
Ashipala	Sarafia	Senior Agric Research Tech	MAWF, Windhoek
Calitz	Albert	Senior Agric Research Officer	MAWF, Windhoek
Endjala	Loide	Chief Agric Extension Tech	MAWF, Ongwediva
Horn	Lydia N.	Agric Research Officer	MAWF, Windhoek
Jona	Cecilia	Agric Extension Officer	MAWF, Rundu
Kamburona	Charlene	Agric Training officer	MoE, Ogongo
Kandjimi	Olavi S.	Agric Economist	MAWF, Windhoek
Kuvare	Uparura	Lecturer	Unam, Ogongo
Ndjodhi	Mathew N.	Agric Economist	MAWF, Windhoek
Prinsloo	Dirk	Agronomist	GSA, Windhoek
Lutombi	Richard S.	Agric Research Technician	MAWF, Bagani
Shilulu	Irene	Agric Research Officer	MAWF, Mahenene
Shiningayamwe	Ella	Agric Research Officer	MAWF, Tsumeb
Shipepe	Basilia	Agric Research Officer	MAWF, Mashare
Shivolo	Ottilie T.	Senior Agric Training Officer	MoE, Ogongo
Shivute	Anna N.	Agric Extension Officer	MAWF, Outapi
Tuinenberg	Obbe	Researcher	DRFN, Windhoek