UNDP Global Project:
Capacity Development for Policy Makers to Address Climate Change

Assessment of Investment and Financial Flows to Adapt to Climate Change in the LULUCF/Agriculture Sector in Namibia

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Capacity development for policy makers: addressing climate change in key sectors

In May 2008, the United Nations Development Program (UNDP) launched the global project, "Capacity Development for Policy Makers to Address Climate Change". The overall goals of the project are twofold:

- Increased national capacity to raise awareness and co-ordinate Ministerial and stakeholder views on climate change, leading to enhanced participation in the UNFCCC process;

- Support for long-term climate change planning and priority setting, using assessments of investment and financial flows to address climate change in key sectors, which can provide a better understanding of the magnitude and intensity of national efforts needed to tackle climate change, as well as provide more accurate estimates of the funds needed to implement mitigation and adaptation actions.

Namibia is one of the 15 countries participating in the project that undertook the assessment of investment and financial flows, using a UNDP methodology. National experts in Namibia identified two key sectors for the assessment: energy (for mitigation actions), and agriculture/land-use (for adaptation options).

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Acronyms

AWG	Adaptation Working Group
BAU	Business As Usual
CCP	Climate Change Policy
DRFN	Desert Research Foundation of Namibia
EU	European Union
FDI	Foreign Direct Investments
FF	Financial flow
IECN	Integrated Environmental Consultants Namibia
IF	Investment flow
IFF	Investment and Financial Flows
LULUCF	Land Use Land Use Change and Forestry
MAWF	Ministry of Agriculture Water and Forestry
MET	Ministry of Environment and Tourism
MTEF	Medium Term Expenditure Framework
MTI	Ministry of trade and Industry
NCCC	National Committee on Climate Change
NCRs	North Central Regions
NDP	National Development Plans
NPC	National Planning Commission
NPV	Net Present Value
ODA	Overseas Development Assistance
OM	Operational and Maintenance
PASS	Pan-African Start Secretariat
SPA	Strategic Priority on Adaptation Fund
UN	United Nations
UNDP	United Nation Development Program
UNFCCC	United Nations Framework Convention on Climate Change
VA	Vulnerable Assessment
WG	Working Group

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Executive Summary

This Investment and Financial Flows Assessment has been conducted in Namibia with the aims of determining the country's current and future financial requirements to address the impact of climate change and to support long-term capacity enhancement in climate change planning and decision-making in the public sector. The sectors chosen for this analysis have been the Energy sector and LULUCF sector, with mitigation strategies considered for the former and adaptation strategies for the later. On the LULUCF adaption assessment, the livestock and crop subsectors have been assessed.

Whilst the impact of climate change on the Namibian agriculture sector is difficult to predict with any definitive accuracy, the availability of water in terms of the flow of perennial rivers is an area of particular uncertainty, it is likely that the livestock and cropping activities assessed will be adversely affected by the predicted increases in temperatures and variability of rainfall. Although the climate of Namibia makes agriculture a somewhat marginal activity, subsistence agriculture is vital for a large number of rural Namibians.

The LULUCF assessment compared two broad scenarios: a Business as Usual (BAU) scenario and an adaptation to climate change scenario. Under the BAU scenario, the expected impact of climate change on the sector from 2005 to 2030 was modelled, taking into account climate change projections and the current policy and business climate. The adaptation scenario likewise modelled the impacts of climate change over the period 2005 to 2030, but with the inclusion of several additional adaptation measures not part of the current policy framework. By modelling the estimated changes in productive output for both sub-sectors under both scenarios, the costs and impacts of the additional adaptation measures have been calculated.

The additional adaptation measures assessed for the livestock sector include:

- Increasing the level of support provided to subsistence farmers, to share best practices and increase market availability
- Reducing cattle numbers in communal areas to sustainable levels to increase the off-take of cattle
- Encouraging commercial farmers to switch to game production from cattle and small stock production, given the resilience of ingenious wildlife to climactic variability in comparison to domesticated livestock.
- Encouraging farmers in both communal and commercial areas to switch to indigenous breeds of livestock, given the potential for these breeds, as with game, to withstand natural climactic variability.
- A programme of debushing, to increase the effective area of rangeland available for farming purposes.

Altogether, the incremental costs of these livestock activities over the time period considered are estimated to be around US$2.45 billion, broadly half of which relate to investments half in the form of increased O&M costs. Although the benefits associated with these measures have

not been estimated, the expected impact of these activities would be to increase the tonnage of meat produced per annum by 40,000 tonnes by 2030. This difference in tonnes produced between the adaptation and baseline scenarios is equivalent to 35 percent of 2005 produced tonnes of meat.

For crops, the additional adaptation measures considered are:

- Increasing the area of land for irrigation
- Partial mechanisation of communal farms
- Training of commercial farmers to improve irrigation possibilities

The incremental costs of these measures are expected to be around US$590 million, US$430 million of which is in the form of investments over the 2005-2030 time period considered and US$160 million of which is in the form of increase O&M costs. The impact of these measures would be to increase crop yield in 2030 by 118,000 tonnes (the difference between BAU and adaptation scenarios), which is equivalent to 82% of 2005 production yields. It should be noted that the availability of water from perennial rivers for irrigation purposes was assumed to be sufficient: in the absence of this water availability, increases in yields would be greatly reduced.

Currently the Namibian government is in the final stages of developing a national Climate Change Policy (CCP). The main purpose of this policy is to provide the legal framework and overarching national strategy for the development, implementation, monitoring and evaluation of climate change mitigation and adaptation activities. The policy will promote the enhancement of synergies amongst sectors, policies and stakeholders for effective and efficient action on climate change mitigation and adaptation.

Climate change is a relatively new item on the national development agenda in Namibia. Many of the legal and policy instruments developed in the past do not necessarily take climate change issues into account. Although it should be noted that the range of adaptation measures considered was not comprehensive, this assessment evaluates the costs of some of the adaptation measures available for the agriculture sector, and as such can be a useful tool for policy makers in the future. Further work is recommended, both in terms of assessing other adaptation measures and in terms of localised climate change modelling.

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Definitions

The key terminology used in the assessment:

I. **Investment flow (IF)** is the capital cost of a new physical asset with a life of more than one year, such as the capital cost of a new power plant.

II. **Financial flow (FF)** is an ongoing expenditure on programmatic measures; financial flows encompass expenditures other than those for expansion or installation of new physical assets, e.g. expenditures for an agricultural extension program for farmers. These expenditures are operation and maintenance costs, e.g. salaries and raw materials.

III. **Investment entity** is an entity making an investment. These are the entities that decide to invest, e.g. in a wind farm. Investment entities include households, corporation and government.

IV. **Sources of I&FF funds** are the origins of the funds invested by the investment entities e.g. domestic equity, foreign debt, domestic subsidies, and foreign aid.

V. **Operation and Maintenance (O&M):** the physical assets purchased with investment flows will have operation and maintenance (O&M) costs associated with them i.e., ongoing fixed and variable costs such as salaries and raw materials.

VI. **Baseline scenario** is a reflection of the business-as-usual conditions, i.e. it is a description of what is likely to occur in the absence of new policies to address climate change.

VII. **Mitigation scenario** incorporates measures to mitigate GHG emissions, i.e. the mitigation scenario describes the expected socio-economic trends, technological changes, new measures to mitigate GHG emissions, and expected investments in the energy sector given the implementation of the various mitigation measures.

VIII. **Government** is used to indicate the Government of the Republic of Namibia

1. Introduction

The agriculture sector in Namibia is categorized into two main subsectors: livestock and crop farming. Livestock farming constitutes a significant portion of Namibia's agricultural output, contributing around 70 percent of the total GDP contribution of the agriculture sector in 1995 before declining to account for 59 percent in 2004. Crop farming, which accounted for only 8 percent of the total GDP contribution of the sector in 1995, more than doubled, reaching 17 percent in 2004. Despite the growth of crop farming, livestock farming continues to dominate the total agricultural output.

Namibia's population of some 2 million people is spread over a land area exceeding 800,000 km², making Namibia one of the least densely populated countries in the world. According to the Namibian Labour Force Survey (MoL, 2004), the agricultural sector employed 102,636 employees during 2004, which constitutes 27% of the country's active workforce. Of these, 95,240 (93%) operate in rural areas, and 37,645 (37%) are women actively employed within the agricultural sector. The 2003/4 Household Income and Expenditure Survey (CBS, 2005) indicated that 48% of rural households (106,145) obtain their main source of income from subsistence farming.

Livestock farming in Namibia comprises of large stock, mainly cattle, and small stock such as sheep and goats. In terms of output, beef production is the major livestock farming activity in Namibia followed by mutton/lamb and goat production. Beef is produced in both the communal and communal areas; in communal areas efficient production is constrained by over-stocking (MET, 2010) and low capital intensity, whereas the commercial sector is highly capital intensive.

The total number of cattle marketed declined from 414,489 in 1995 to 377,072 in 2005, a 9 percent reduction. In part this reflects the fact that some commercial farmers have begun to make more use of indigenous wildlife for both farming and tourism purposes, due to the greater resilience of wildlife species to the highly variable climate and more consistent returns available (MET, 2010).

Namibia's beef is exported primarily into the European Union (EU) as carcass, de- boned beef and on-hoof to South Africa. The main marketing channels for beef include auctions, ad hoc purchases by Meatco[1] and local abattoirs. Marketing within the communal areas varies, with those farmers south of the Red Line[2] having better market access due to better infrastructure and the disease free status of the area.

[1] Meatco is Namibia's biggest exporter of prime beef, taking up to 80 percent of the local export market (http://www.meatco.com.na).

[2] The Red Line is a cordon fence established in the 1960s with the aim of controlling livestock disease, particularly Foot and Mouth Disease. Strict controls remain in terms of transportation of live animals and meat from North of the Line to the South.

Small stock production is the key agricultural activity in the arid southern parts of Namibia. According to the Agricultural census of 2004 (MAWF, 2005), sheep accounted for about 57 percent of the total production of small stock in Namibia, while goats accounted for the remaining 43 percent. When disaggregated according to breed types, the Dorper sheep is the principal breed, which accounted for about 36 percent of the total production of the small stock, followed by the Boer goat at 21 percent for the total. Karakul sheep, accounted for only 4.4 percent, while the remaining 38.6 percent was accounted for by other sheep and goats.

Namibia enjoys a global comparative advantage in terms of supplying short haired and lighter Karakul pelts. Available statistics show that a significant number of goats are produced in rural Namibia, which in 2004 accounted for about 73 percent of the total production of goats (MAWF, 2005). One of the issues affecting the marketing of goats is the limited market for goat meat cuts. Subsequently, about 90 percent of goats are often sold on-hoof to South Africa.

Year on year, climactic conditions (most especially rainfall) can have significant impacts on the total number of animals marketed. Aside from the climate however, there are other factors that impact the productivity of the sub-sectors. These include:

- bush encroachment, which limits the grazing capacity of the land
- poor selection of breeds, which can be unsuited to Namibian conditions
- the low bull to cow ratio
- disease, in particular Foot and Mouth Disease, which limits the access to markets for farmers in the North of the country
- uncertainties emanating from the land reform process and the inactive involvement of the Ministry of Agriculture, Water and Forestry in extension work
- exchange rate volatility
- meat quality and marketing channels.

Pearl millet, commonly known as “mahangu”, is the major crop cultivated in Namibia, followed by white maize, sorghum and wheat: 96,370 tonnes of mahangu were produced in 2004 compared to 55,597 tonnes of maize in the same year. Mahangu is cultivated primarily in the North Central Regions (NCRs), Kavango and Caprivi and over the past 20 years or so has been produced in increasing quantities, with volumes increasing by 64 from 1996 to 2004. In contrast to wheat and maize, mahangu is mostly utilised for domestic consumption. Available information indicates that the government envisages setting up a mahangu storage facility in the northern communal areas in future, although the details of this plan are not fully defined. Unlike wheat and maize, mahangu grains are not significantly imported from other countries on an annual basis.

White maize is the major commercial crop produced in Namibia and is planted under both rain-fed and irrigation-based methods. As such, the annual maize yield depends upon both the quantity and timing of rainfall. Although the volume of marketed maize increased substantially by 937 percent from 5,361 tonnes in 1995/96 to 55,597 tonnes in 2004/5, Namibia depends on imports of maize, particularly from South Africa. For example, in 2004, maize imports

accounted for 61 percent of the total consumption of white maize in Namibia. Wheat is planted under irrigation in winter (June/July) for harvesting during November/early December. Wheat volume marketed in Namibia increased significantly by 89 percent from 6,000 tonnes in 1994/95 to 11,340 tonnes in 2004/05 (MAWF, 2005). As with maize however, Namibia also depends upon imports to meet its consumption requirements for wheat. It should be noted that the observed increases in marketed volume relate to farm practice changes, rather than improvements in the suitability for maize and wheat production. Indeed, for maize, rainfed production is already seen as a somewhat marginal activity under the current climactic conditions (MET, 2010).

The Namibian Agricultural Policy suggests that there is considerable potential for expansion of irrigated agriculture through the sustainable utilisation of the country's perennial and ephemeral river sources. Envisaged development of irrigated agriculture under the Green Scheme Initiative will pose additional demands on both perennial river systems and groundwater as sources of irrigation water. Recent efforts to initiate rice growing in the Cuvelai basin in northern Namibia show great potential for the utilisation of Oshana water source, the water from which would otherwise be 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). Any additional abstraction from water systems therefore needs to take such ecosystem service into account.

1.1 Objectives

Namibia is one of 19 countries worldwide[3] participating in a UNDP supported project on assessing Investment and Financial Flows to address Climate Change in key sectors of the economy. The assessment aims to provide actual financial information on the expected costs of mitigation and adaptation to selected key sectors, over an approximately 20 years planning framework. Such information would be used to show-case the investment needs for effective adaptation and mitigation sector efforts, both to national and international policy and decision-makers, and to provide a strong planning foundation for future investments.

In terms of **mitigation**, Namibia selected to assess aspects of the energy sector. The energy sector is key to the developmental opportunities for Namibia in the future. Southern Africa as a whole is challenged by energy crises and so it is therefore of great importance for Namibia to position herself in a proactive manner to address future energy needs in the context of climate change.

In terms of **adaptation**, Namibia initially intended to assess I&FF relating to adaptation needs in the Land Use, Land Use Change and Forestry (LULUCF) sector. In Namibia, the scope of the

[3] Algeria, Bangladesh, Bolivia, Colombia, Costa Rica, Dominican Republic, Ecuador, Gambia, Honduras, Liberia, Namibia, Nepal, Nicaragua, Niger, Paraguay, Peru, St Lucia, Togo, Turkmenistan, and Uruguay.

LULUCF sector is interpreted to include key production systems, i.e. (1) Agriculture, including both crops and livestock, (2) Forestry, (3) Fisheries (inland), (4) Tourism, (5) Wildlife and (6) underlying Ecosystem Services[4]. LULUCF overall plays a significant role in the developmental prospects of Namibia, especially in terms of the integrative and complex way that the sector interacts with other aspects of the Namibian economy. However, due to time constraints and data issues, it was decided to focus the assessment on the agriculture sector, with particular attention on the two subsectors; crop and livestock production.

The key objective of this assessment is to quantify the investments and financial flows required for the two sub-sectors of Namibia's agricultural sector to adapt to the effects of climate change.

In addition, a further objective of the assessment is to empower the participant experts, to enable them to participate in future assessment works. This assessment of the two subsectors of the agricultural sector has paved the way for future works for overall IFF assessment of all the agricultural subsectors. The future assessment works will provide an integrated and coordinated evaluation of Namibia's financial needs to combat the effects of climate change in general and hence strengthen its current and future negotiating position at national and international platforms.

1.2 Background

In Namibia, several relevant climate change papers have been produced that have been of use for the I&FF assessment. However, our findings and experience with the IF and FF assessment show that the previous Vulnerability Assessment (DRFN and CSAG, 2008), whilst useful from a qualitative point of view, did not provide substantive quantitative figures that could be used in the assessment. Therefore there is a need for more focused and specialised research studies to generate relevant data from the various agricultural subsectors, which will be used for elaborated future IF and FF assessments.

Other sources with valuable data for this I&FF assessment were therefore also used. In the cases where specific information has not been available, the assessment has extrapolated information from other non-Namibian sources.

In terms of **adaptation**, work that is of particular relevance includes:

- LULUCF Adaptation concept paper (Zeidler, 2009)
- Namibia's V&A Assessment (DFRN, 2008)

[4] According to the UNFCCC guidance, the Land Use, Land Use Change and Forestry (LULUCF) sector includes six broad land use categories: (1) Forestland, (2) Cropland, (3) Grassland, (4) Wetlands, (5) Settlements, and (6) Other land. In Namibia, the National Climate Change Committee (NCCC) decided that in the country context it is important to tackle Climate Change (CC) and Climate Change Adaptation (CCA) in all these land use categories, also taking into consideration that land use change, including the conversion from one land use type to another but also in terms of degradation is a pressing environmental issue that needs to be addressed. Consequently it is understood that the LULUCF sector encompasses key production systems, which in Namibia's terrestrial context would primarily be: (1) Agriculture, including both crops and livestock, (2) Forestry, (3) Fisheries (inland), (4) Tourism, (5) Wildlife and (6) the underlying Ecosystem Services, and which are practiced in the various land use categories in and integrated manner.

- Technology needs assessment (Beakat, 2005)
- Research on farming systems change to enable adaptation to Climate Change
- Africa Adaptation Programme
- Climate Change Adaptation - SPA pilot; various reports (coping mechanisms, baseline assessment, forecasting etc.).

Institutional arrangements and collaborators

The institutional arrangements for carrying out the assessment were designed to create strong government ownership and engagement in the assessment process. This was both to draw on specific knowledge contained within individual ministries and to build capacity within each the ministries with regards to this issue. Individual experts from different line ministries and private sector institutions were involved in the initial project definition and training workshops, and were later invited to become active assessment team members. Two Working Groups (WGs) were finally formed in February 2010, when the assessment commenced implementation.

The Adaptation Working Group (AWG) initially contained members from a wide range of sectors, to cater for expertise and input from all sectors relevant to the LULUCF context. However, after it was decided to focus the assessment more specifically on the agriculture sector (with LULUCF linkages), particularly crop and livestock production, membership was narrowed down. The Ministry of Agriculture, Water and Forestry (MAWF), the Ministry of Environment and Tourism (MET), the Ministry of Trade and Industry (MTI), the United Nations Development Programme (UNDP) remained key members, and a private sector expert office, Integrated Environmental Consultants Namibia (IECN) were heavily involved in the early stages of the project. IECN was commissioned to support the assessment process through providing a capacity support expert, Dr. Juliane Zeidler.

1.3 Methodology and Terminology

The AWG convened regular weekly meetings. Technical sub-teams were formed to work on specific "sections" of the assessment (e.g. scenario & model team, data team) and progress of each sub-team was discussed with the WG throughout the process. Data collection and approach questions were mainly addressed through individual consultations with selected key experts and institutions, and through the AWG meetings. Furthermore a workshop was held in Swakopmund, Namibia, together with experts from the Pan-African Start Secretariat (PASS) to deliberate on the issues surrounding the technicalities of the assessment.

As prescribed in the methodology guidebook provided by the United Nations Development Programme (UNDP), the following steps were undertaken during the assessment:

a) Establish key parameters of the assessment

- Define in detail the scope of the sector
- Specify the assessment period and the reference year,
- Identify preliminary adaptation measures

- Choose the analytical approach.

b) Compile historical data I&FF and operation and maintenance costs (O&M), subsidies and other input data for scenarios

- Compile historical annual I&FF, broken down by entity and source of investment,
- Compile historical annual O&M costs, broken down by entity and source of investment,
- Compile historical annual subsidy costs if subsidies are explicitly included in the assessment
- Compile other input data for the scenarios.

c) Defining the baseline

- Describe the socio-economic and technological change, national and sectoral plans, and expected investments, given the current national and sectoral plans.

d) Estimate IF, and FF annual and annual O&M costs and subsidies if included explicitly, for the baseline

- Estimate the annual I&FF for each type of investment broken down by investment entity and source of funding,
- The annual O&M costs, broken down by investment entity and source of funding,
- The annual cost of subsidies for each type of investment and for I&FF and O&M costs if subsidies are explicitly included in the assessment.

e) Define the adaptation scenario

- Describe socio-economic trends, technology change, adaptation measures, and investment given implementation of adaptation measures

f) Describe the socio-economic and technological change, adaptation measures and investments, given the implementation of adaptation measures and estimate annual I&FF, O&M costs and subsidies, if included explicitly for the adaptation scenario

- Estimate the annual I&FF for each type of investment broken down by investment entity and source of funding and the annual O&M costs for each IF, broken down by entity and source of investment financing
- Estimate the annual cost of subsidies for each type of investment and relevant for I&FF and O&M costs if subsidies are explicitly included in the assessment.

g) Calculate changes in I&FF and O&M costs and subsidy if included explicitly required to implement adaptation measures (currently on-going)

- Calculate the changes in I&FF and cumulative O&M costs, by source of funding for each type of investment and for all types of investment (the total investment)
- Calculate the changes in annual &FF and O&M costs for each type of investment and for each source of funding, and all types of investment and sources of funding, consider calculating the subsidy changes, if subsidies are explicitly included.

h) Assess policy implications (currently on-going)

- Reassess the initial prioritization of adaptation measures undertaken in step 5;
- Identify policy measures to encourage induce changes in I&FF.

In this report, a number of key terms are used:

- **Investment flows (IF)**, the capital cost of an active material with a lifespan of more than a year.
- **Financial flows (FF)**, the ongoing expense for programmatic measures, the FF cover expenses other than those for the expansion or installation of new physical assets. Material goods purchased with investment flows (IF) have **operation and maintenance (O&M) costs** shareholders (that is to say, permanent fixed costs and variable costs such as wages and raw materials).
- **Households**, individuals or groups of individuals (i.e. families) who act as a financial unit.
- The **companies** include financial institutions (banks and micofinance institutions), non-financial enterprises, as well as profit and non-profit organizations.
- A **scenario** is a characterization of consistent and plausible future conditions over a specified period. We distinguish two cases, the **baseline scenario** describes the conditions of the status-quo, i.e. a description of what will probably happen if no new policy measure to cope with climate change is set place during the assessment period (2005-2030). The **adaptation scenario** includes new measures to address the potential impacts of climate change.
- The **assessment period**, the time horizon for assessment, i.e. the number of years covered by the baseline and the climate change scenario and associated annual I&FF and O&M costs. The assessment period to assess I&FF should cover at least 20 years and not more than 30 years.
- The **reference year**, the first year of the assessment period, that is to say the first year of the baseline. The base year should be a recent year for which information on I&FF and O&M costs are available.

2. Scope, Data Inputs and Scenarios

2.1 Sectoral scope

During the I&FF assessment preparatory phase, the NCCC selected the LULUCF sector for the adaptation assessment. A technical background study was commissioned to fully describe the Namibian interpretation and application of the LULUCF sector (Zeidler, 2009). The following subsectors or elements thereof are interpreted to be part of the LULUCF sector:

- Agriculture, incl. crops & livestock
- Forestry
- Fisheries (inland)
- Tourism
- Wildlife
- Ecosystem services.

It is clear that various production systems are considered part of a broader picture in Namibia. In fact the important inter-linkages of the traditional sectors are recognized in all development planning that has taken place in Namibia (e.g. in Vision 2030 and Namibia's 3rd National Development Plan (NDP 3). However, due to time constraints, only the crop and livestock subsectors were selected for assessment following the consultation with PASS during a workshop held in Swakopmund, Namibia. This decision was mainly taken to narrow down the scope of the work, and to use the first two subsectors assessment as a learning opportunity. Additional sector assessments could and should be conducted at a later stage. The livestock sub-sector focused and concentrated on cattle, small stock and game, while the crop sub-sector concentrated on four crops: wheat, maize, mahangu and sorghum.

In addition, two experts were co-opted from the Energy Working Group to assist the LULUCF/agriculture Working Group, on the approach and with the mechanics and technicalities of modelling. This allowed the WG to arrive at the point of establishing the investment requirements for the two subsectors and costing to populate the IF, FF and O&M cost tables as per the UN Methodology Guidebook.

2.2 Methodology and data inputs

2.2.1 Assessment period and cost accounting parameters

The overall I&FF adaptation assessment period is from 2005 to 2030. It was agreed to use the end of the Second National Development Plan (NDP2), which has 2005 as the baseline cut-off. Therefore, 2005 is used as the starting point for adaptation scenario, which coincides with the start of NDP3. The overall planning horizon of the scenario is in line with Namibia's long term Vision 2030, running up to 2030. Historical data has been mapped out prior to 2005, as far as possible.

In line with the recommendations from the UN, costs are displayed in 2005 US$. The discount rate used for the Net Present Value (NPV) calculations was 8 percent based on cost of government bonds/borrowing in Namibia.

The discount rate was used to reflect government's long term borrowing costs, which we proxy as the secondary market trading cost of the bond with the longest maturity (the GC24 at the time of selecting the discount rate).

The currency conversion to 2005 US$ was done by deflating current (or otherwise) prices in Namibian dollars and then converting these 2005 prices to US$. For deflation we used CPI data from Bank of Namibia[5]; for the exchange rate we used information from the 2009 Preliminary National Accounts with N$1 = US$6.41 in 2005.

2.2.2 Analytical approach

The conceptual framework for the assessment was developed through working group discussions and discussions with capacity support experts from PASS.

It was decided to closely follow the Namibian development-planning framework with its overarching Vision 2030 as a planning context, and specific NDPs as a guide for the baseline and scenario elements of the assessment. Namibia has a strong development-planning framework, which translates into public sector planning and financing. The Medium-Term Expenditure Framework (MTEF) and annual budgets are based on the systematic planning in the overall context[6].

Models on the livestock and crop sub-sectors were developed in Microsoft Excel, covering both the business as usual and the adaptation scenarios. In both models a distinction is made between commercial and subsistence farming, although it should be noted that in practice such a clear distinction might not necessarily be found. Annexes A and B list the various assumptions used in each model.

Livestock sub-sector

The main focus for the analysis of I&FF for the livestock sub-sector is meat production, specifically in relation to beef, game and mutton. Although meat consumption and production changes have been modelled, consumption figures have been modelled for indicative purposes only. Given the constraints affecting the industry, it is unlikely that a growing demand will be satisfied without a significant increase in imports of meat.

Under the BAU scenario, a programme of extension services is the key government policy in place that is partially designed to reduce the impact of climate change. This programme is

[5] See www.bon.com.na/
[6] See www.mof.gov.na/budget.htm

designed to provide knowledge to farmers more generally on all aspects of farming practice, with a regional staff of Extension Officers employed by the government. Under the adaptation scenario, several additional measures are proposed, including: increasing funding available for extension services, a programme of de-bushing and rangeland restoration, switching to game production from livestock production, adjusting livestock breeds and livestock number reductions in communal areas. All of these measures are designed to address the expected impacts of climate change, and hence on the suitability of the land to support livestock farming.

Model specifications

Meat demand:
Namibian meat demand is based on local consumption levels, export levels and import levels.

Local consumption is dependent on population numbers and income growth, with an increase in population assumed to lead to a commensurate change in total meat consumption and income increases assumed to lead to a greater per capita consumption of meat. Based on figures obtained from the National Planning Commission, population is expected to grow by 1.7% per annum from 2005 on average and GDP is forecasted to grow by 4% per annum over the same period (World Bank, 2010). The income elasticity of demand for meat consumption, following Elam's (2009) analysis of meat production and consumer expenditure data from the FAO and World Bank respectively, is assumed to be 0.91[7]. For simplicity, the model assumes a constant rate of growth for both population and GDP per annum. Meat consumption in 2005 is derived from statistics on slaughter, imports and exports provided by the Meat Board of Namibia[8]. In 2005 beef consumption was approximately 19kg per person and mutton consumption was 3kg per person. Although game consumption figures are not readily available, figures for exports and slaughter numbers allow us to estimate game consumption per person as only 60g per annum. Based on projected population and income growth rates, total meat consumption is expected to increase 2.5 times over the period of analysis. Note that it is assumed that the share of meat consumption attributable to beef, game and mutton remains constant for the country as a whole (i.e. preferences for meat types do not change over time).

Exports are not expected to increase in size over the period of analysis, whereas imports, as the residual of production minus local consumption and exports, are expected to increase significantly. Note that the impact of prices have not been modelled for simplicity, thus prices are assumed to remain constant in real terms over the time period of analysis. This is despite the fact that the expected increase in meat demand, given the constraints on local supply, implies an increase in prices into the future.

Meat supply:

[7] This means that a 1% increase in per capita income (consumer expenditure assumed to be a suitable proxy for income) leads to a 0.91% increase in production (production assumed to follow consumption).
[8] See http://www.nammic.com.na/ for further information

As discussed above, the demand for meat is expected to be sufficient to encourage maximum livestock productivity. However, productivity is constrained by the available land area and the productivity of that land (the grazing capacity). Land area for livestock farming is assumed to remain almost constant, with land for commercial cattle farming declining slightly to reflect changes due to the expansion of area designated for cropping under both scenarios[9]. The grazing capacity of the land is expected to decline in the face of climate change, partly due to the declining availability of water. Of course, the actual impact of climate change is very hard to gauge, depending upon numerous factors, but in the interest of clarity midpoint estimates based on estimates from Reid et al. (2007) have been used. Overall, beef production is estimated to decline by 23 percent from 2005 to 2030, mutton production is expected to decline over the same period by 33 percent and game meat production is expected to decline by 13 percent.

Under both the BAU and Adaptation Scenarios, the Government programme of extension services is expected to partially address the impact of climate change by providing information to farmers about best practices. Given production of meat is dependent on carrying capacity and land area, a change in grazing capacity as a result of extension officer work will lead to an increase in meat production and (equivalently) animal numbers. By the same token, the additional adaptation measures of further funding to extension services, cattle number reductions in communal areas, breed choices and de-bushing are also expected to alter the grazing capacity of the land. Game switching for commercial farmers is beneficial in the sense that climate change is not expected to impact game production as much as for beef or mutton production.

It should be noted that cattle number reductions would partially reduce meat production in communal areas and differing breed choices would lead to a reduction in average weight of animal slaughtered. These two factors serve to temper the magnitude of impact of grazing capacity increases of the two measures.

As with the growth of GDP and population, these changes are expected to occur at a constant rate over time. For all of the additional adaptation measures, this implies that the effect of the measure increases at a constant rate over time, from 2010 to 2030. For de-bushing, the impact is lagged by five years, as the land will need time to recover; as such the impact of de-bushing is not expected to be felt on grazing capacity until 2015.

Costs:
The costs associated with each measure under the two scenarios for each meat type are calculated based on the scenarios as developed (see scenario descriptions below for further information). Costs are broken down into Investment costs, Financial Flows and Operations and Maintenance costs.

[9] See description on I&FF crop model for further information

The costs for extension services are based on historical data, where the costs "ramp-up" to a current level of spending and then remain static over time. These programmatic costs are assumed to be independent of productivity levels and hence are equal under both scenarios. The additional spend on extension services under the adaptation scenario follows the same principle, with costs increasing from 2010 to 2014 up to the levels currently experienced for extension services, after which they remain stable programmatic costs. It is assumed that under the adaptation scenario, extension service costs are effectively double. Extension services costs and the additional adaptation extension service costs are government funded Investments, Financial Flows and Operation and Maintenance costs.

There are no associated direct costs assumed for the destocking measure in subsistence cattle farming. Indirectly, there are savings from this measure on Operation and Maintenance costs for subsistence farmers, by the virtue that there are less cattle to manage (costs are modelled on a per head basis and based on data from MAWF).

The costs relating to the choice of breeds under the adaptation scenario cover Investment and Operations and Maintenance costs. Under this scenario, indigenous breeds replace exotic cattle and small stock breeds over time at a constant rate. This requires investment in purchasing different breeds of cattle and small stock that are more resilient: for commercial farmer's, purchases are privately funded, for subsistence farmer's purchases are partially subsidised by the government. Animal purchase costs have been provided by MAWF. It should be noted that such replacement per annum is likely to be less than the overall off-take rate and as such the investment cost of replacement is assumed to be built in to the standard costs facing farmers. However, the measure itself increases the effective carrying capacity of the land, increasing the number of animals overall, meaning there are investment costs related to this change in animal numbers. The impact on Operation and Maintenance costs refers to the fact that the grazing capacity for indigenous breeds is expected to increase in the face of climate change relative to the grazing capacity for exotic breeds. Additional animals suggest increased management costs.

In a similar fashion the costs relating to switching from cattle and small stock to game farming relate to the investment cost of purchase of game. Likewise the Operations and Maintenance costs associated with this measure relate to the additional management cost of additional game, minus the savings from a reduction in cattle and small stock numbers.

The costs associated with de-bushing are based on a proposal by De Klerk (2004) to reduce invader bush coverage in both commercial and communal areas (see description below in the description of the adaptation scenario). In commercial areas, these investment costs are mostly born by farmers themselves, with a small contribution from the government; in communal areas these costs are born by the government alone. As above, the impact of this measure leads to changes in animal numbers as a result of grazing capacity improvements, leading to increases in Operations and Maintenance costs.

Crop sub-sector

The crop model focuses on four crops; wheat, maize and mahangu and sorghum, with the later two crops amalgamated due to data availability issues. In common with the Livestock model, the Crop model is primarily concerned with maximising production to meet domestic demand. Domestic demand and domestic supply are modelled under two scenarios for each crop. Under the Business as Usual (BAU) scenario, production of these crops is projected until 2030, given the potential impact of climate change. This is based on the assumption that current policies (or intentions) of the government remain unchanged. In the model we consider that the only substantial and relevant current policy relates to an increase in the amount of land cultivated under irrigation. Under the adaptation scenario we follow the same approach, but in 2010 we introduce additional measures aimed at increasing total production in order to minimise (or adapt to) the impact of climate change on cereal production. These additional measures include increasing the area of land available under irrigation, adjusting irrigation techniques, mechanising communal area crop production and training to farmers. Table 1 below illustrates current arable land use for the various crops and the up-scaling of irrigation.

Table 1: Arable Land Use, 2005 and 2030 for BAU and Adaptation Scenarios, ha.

	Total arable land in 2005, BAU and Adaptation, ha	wheat	maize	mahangu + sorghum		TOTAL
all	rainfed subsistence	-	17,748	256,094		**273,842**
all	rainfed mechanisation	-	-	-		**-**
all	rainfed commercial	-	8,446	-		**8,446**
all	commercial irrigation	1,577	2,926	-		**4,502**
	Total arable land by 2030, BAU, ha	wheat	maize	mahangu + sorghum		TOTAL
BAU	rainfed subsistence	-	17,748	256,094		**273,842**
BAU	rainfed mechanisation	-	-	-		**-**
BAU	rainfed commercial	-	8,446	-		**8,446**
BAU	commercial irrigation	8,333	9,631	-		**17,964**
	Total arable land by 2030, Adaptation, ha	wheat	maize	mahangu + sorghum		
adapt	rainfed subsistence	-	-	180,143		**180,143**
adapt	rainfed mechanisation	-	17,748	75,951		**93,698**
adapt	rainfed commercial	-	4,223	-		**4,223**
adapt	commercial irrigation	8,333	13,854	-		**22,187**

Source: Price Waterhouse Coopers & MAWF

Domestic demand:

Domestic demand is based on consumption per head of each crop, imports and exports. In common with meat consumption, the consumption of the grains considered is assumed to increase in line with population growth. Whereas meat consumption per head also increases with income, evidence for such a link for grain consumption is minimal. Consumption of all grain types therefore increases by 1.7% per annum from historically observed levels, in line with estimated population growth per annum. It should also be noted that a 10 percent stock of grains are held from that year's production and carried over for consumption into the next year. This has been factored into the model for overall grain demand.

Export levels for grain production are extremely low for Namibia, so it is assumed throughout that exports are negligible. Given the predicted growth in demand and the estimated impacts of climate change, the main focus of the adaptation measures proposed are to boost

production and hence limit imports. Imports are therefore determined by the ability of domestic production to match consumption figures: in 2005 imports represented 807 percent of all wheat consumption, 80 percent of maize consumption and less than 1 percent of sorghum and mahangu consumption.

Consumption levels are assumed to be unaltered by the adaptation measures proposed and hence are equal for each crop type under the BAU and adaptation scenarios.

Domestic supply:
In common with meat production, the major constraints on grain production relate to the availability of land and the productivity of the land.

Under both scenarios, the area of land available for cropping increases by 13,261 hectares, of which 6,556 hectares is for wheat production and 6,705 hectares for maize production. This increase is assumed to occur at a constant rate from 2010 to 2030.

The productivity of the land is dependent on the impact of climate change on crop production for irrigated and rainfed land, together with the measures proposed under the adaptation scenario. Based on Reid et al. (2007), the impact of climate change is estimated to be a 15 percentage reduction in productivity for irrigated crops and a 30 percent reduction in productivity for rainfed crops over the time period analysed. Increased mechanisation, irrigation measures and training are estimated to have a counteracting impact on production, with the changes in productivity likewise occurring at a constant rate over time. Although the impacts of the measures and climate change on productivity are assumed to be felt equally across the different crop types, the proportion of land used for irrigation and rainfed for each crop type varies. Hence the measures themselves have varying impacts by crop (see discussion in adaptation section below).

Costs:
As in the Livestock model, the costs associated with each scenario have been broken down into Investment costs, Financial Flows and Operation and Maintenance costs. In all instances the costs are modelled on a per hectare basis and are based on cost estimated provided by the MAWF. The amount of hectares under each production system for each crop – irrigated, rainfed mechanised and rainfed non-mechanised – provided the associated costs under each scenario. The cost of training of commercial farmers that are using irrigated land to improve their productivity under the adaptation scenario also reflects the hectares under this system of production in the model.

2.3 Historical IF, FF, and O&M data, and subsidies

The historical assessment period for which the Investment Flow (IF), Financial Flow (FF) and the Operation and Maintenance cost date were collected for the year 2005 to 2030.

Livestock sub-sector

Under the historical costs there is no Investment, Financial Flow or O&M costs recorded or estimated by both investing entities by investing activities associated with the adaptation measures described. O&M costs based on farming practices total N$1.433 billion for cattle farming, N$1.01 billion for game farming and N$1.6 billion for small stock farming. The costs associated with game farming are likely to be an overestimate, as the majority of game on commercial land is not managed for meat purposes in the same way as cattle and small stock.

Crop Sub-sector

For the crop sub-sector, the only significant cost for rain-fed subsistence farming was made by households in the form of O&M costs. The total amount invested by households through equity and debt was US$40.63 million. Corporations and government recurrent expenditure is assumed to be zero on investment and financial flows. In 2005, none of the investment entities made an investment of any form into the mechanization of rain-fed agriculture. In terms of rain-fed commercial crop farming only commercial farmers (who fall under corporations) made an investment of US$6 Million on O&M costs. In terms of irrigated commercial crop farming, commercial farmers spent a total of US$7.55 Million on O&M of irrigation schemes. The only investment made, in 2005, into crop production was only for the operation and maintenance costs. Table 3A below illustrates the base year FF & IF date, by investment type, investment entity, and funding source (million 2005 US$).

Table 2. Base Year IF & FF Data, By Investment Type, Investment Entity, and Funding Source (million 2005 US$)												
	Rain fed Subsistence			mechanization: Subsistence			Rain fed Commercial			Irrigation Commercial		
Investment Entity Category/Source of Funds	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs
Households												
Domestic												
Equity & debt			40.63									
Total Household Funds	**0.00**	**0.00**	**40.63**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Corporations												
Domestic												
Domestic equity									6.00			7.55
Domestic borrowing									0.00			0.00
Total Domestic Sources	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**6.00**	**0.00**	**0.00**	**7.55**
Foreign												
FDI									0.00			0.00
Foreign borrowing									0.00			0.00
ODA									0.00			0.00
Total Foreign Sources	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Corporation Funds	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**6.00**	**0.00**	**0.00**	**7.55**
Government												
Domestic												
Domestic funds												
Foreign												
Foreign borrowing												
Bilateral ODA												
Multilateral ODA												
Total Foreign Sources	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Government Funds	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Funds	**0.00**	**0.00**	**40.63**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**6.00**	**0.00**	**0.00**	**7.55**
Data Sources: Ministry of Agriculture, Water and Forestry; own calculations												

2.4 Baseline scenario description

Livestock sub-sector

As discussed above, for the purpose of this assessment 2005 was used as the base year. The Namibian population is expected to grow up to about 3 million by the year 2030. Although Namibian agriculture contributed less than 5% of Namibia's GDP in 2003, about 70% of the Namibian population depended on agricultural activities for livelihood, mostly in the subsistence sector. In 2003, food and live animal exports constituted roughly 15% of total Namibian exports. Livestock production is the driver of the agricultural economy, and meat is one of the major export goods of Namibia. In the period 2000-2004 the livestock sector has, on average, contributed 89.3% to the sectors contribution to GDP (Republic of Namibia, 2004). The predominant sub-sectors are cattle and sheep/goat production.

In the commercial sector, agriculture consists primarily of livestock ranching. Cattle raising is predominant in the central and northern regions, while karakul sheep and goats are concentrated in the more arid southern regions. Subsistence farming is confined to the "communal lands" of the country's populous north, where roaming cattle herds are prevalent and there are limited marketing infrastructures. In the small scale sector, livestock farming is dominated by goats and cattle, some poultry and then smaller numbers of pigs, donkeys and a very few sheep. It is popularly believed that every farmer has livestock, but a significant number of households have none. For example, more than half of all households have no cattle, pigs, sheep or donkeys, while about two –fifths do not have goats. About one-third of households have neither cattle nor goats.

Amongst those who are livestock owners, most have fewer than 30 cattle and goats. In total, approximately 600,000 cattle and 950,000 goats are owned in this farming system. Farmers with the biggest herds of cattle are in Caprivi and Kavango. Sheep, donkeys and pigs are not kept in Caprivi or Kavango in significant numbers but are kept in Ohangwena, Oshikoto, Oshana and Omusati. The great majority of households have less than 10 of these animals, while few people own more than 20 chickens. Again, far fewer farmers in Caprivi and Kavango have small stock and poultry than those to the west.

Livestock generally graze and browse on their own, although young men or boys herd them if there is a chance of the animals damaging crops, or if the pastures are far from their homes. The animals return to kraals each evening, usually after being watered at a river or drinking at a borehole or piped watering point. Breeding is not controlled and calving rates are usually below 50%. Compared to those elsewhere in Namibia, livestock in this farming system generally suffer from high morbidity and mortality, as a result of food shortages and disease. Only cattle are vaccinated on a regular basis by veterinary officials, primarily to curb the spread of foot and mouth disease and lung sickness.

Overall off-take rates of goats and cattle are estimated to be about 7%. Most animals that are slaughtered are consumed at home, and comparatively few animals are therefore sold to the

Meatco abattoirs or to local bush markets. Indeed, the majority of cattle and goats sold in the north-central regions come from Kunene. A variety of factors limit marketing such as, the small herds and flocks, the importance of retaining livestock as capital assets, the moderate prices offered by formal markets and the difficulties in selling a few animals at a time.

In the large scale sector, the main purpose of this farming system is the commercial production of beef. The system covers all of Otjozondjupa, much of Kunene, Omaheke and Khomas, the southern parts of Omusati, Oshana, Oshikoto and Kavango, and eastern areas of Erongo. About 315,000 square kilometres, or 38% of Namibia, is used for cattle ranching.

In the far north-west the annual average rainfall varies from about 550 millimetres in the north-east to 300 millimetres in the south and 150 mill metres in the far north-west. The most arid north-western areas are grazed by cattle only intermittently, herds being moved in a roving fashion into areas where occasional rainfall has produced pastures. Since rainfall is the main determinant of grass biomass and both rainfall and pasture production are moderate in most years, cattle production requires large areas of grazing. Cattle ranchers therefore either have big, fenced farms or graze their animals over large expanses of open, communal land.

Cattle are farmed for beef on a substantial scale in three distinct areas of land tenure. The first and most widely recognized is the extensive, freehold, titled cattle ranches that cover much of central Namibia. There are about 2,400 of these farm units. Those in areas formerly allocated to white owners have an average size of about 7,300 hectares, while farm units average less than 1,000 hectares in the former Rehoboth district. Approximately 11,000 households and 47,000 people live on, and are largely supported by these farms.

A second category comprises the farms that have been fenced off into exclusive ranches in communal areas, each of which ranges between approximately 1,000 and 8,000 hectares. Some were demarcated by the previous government and allocated to farmers between the 1960s and 1980s to encourage commercial agriculture in communal areas. There are about 300 such farms in the Mangetti Block of Oshikoto and Kavango, and the Okamatapati and Rietfontein areas. At least 700 new farms have been established since independence in Caprivi, Kavango, Oshikoto, Omusati, Otjozondjupa and Omaheke. There are an estimated 5,500 households and 35,000 people associated with these farms.

The third group is made up of farmers using open access grazing on communal land, most of which is in northern Kunene, eastern and northern Otjozondjupa, northern Omaheke and the Aminuis Block. Here an estimated 3,600 households, with about 24,000 people are probably directly involved in commercial beef production. Approximately 1.4 million or 58% of the roughly 2.4 million Namibian cattle are within the cattle farming areas.

Cattle marketing:
The national livestock census (MAWF, 2009) reported a total of 2,309,390 cattle in Namibia of which 887,667 were classified as commercial cattle and 1,462,033 as communal cattle. A total of 302,327 cattle were reported as having been formally marketed for beef production in the

same year (Meat Board of Namibia, 2010). Of these marketed animals, 292,926 cattle originated south of the cordon fence; dividing 292,926 by the total number of cattle reported commercially gives an annual off-take for commercial beef production of 33 percent. Equivalent calculations for previous years yield similar figures. Various studies indicate that the total off-take is about 10% across this broad swathe of the country, which includes an average of 16,000 cattle slaughtered each year at the Meatco abattoirs in Oshakati and Katima Mulilo. The remaining animals are used for domestic consumption or sold at informal meat markets in northern Namibia.

A variety of reasons are offered for the low off-take rates in the northern areas, such as irregular calving and high mortality losses, the lack of markets, a shortage of labour to improve management, and the value in keeping cattle as capital assets and for draught power, milk, manure, and other products. Most farmers also have very small herds from which it is difficult to produce beef commercially. The sale of one or two animals represents a substantial reduction of the herd, especially if irregular and infrequent calving and high mortality rates imply that the farmer cannot be certain that the animals sold will be replaced easily. Finding a buyer willing to pay a reasonable selling price for such a small purchase may also not be simple. Finally, there may be little incentive to earn a few thousand Namibian dollars from one or two cattle if the perceived profit is small compared to cash earnings from wages and other incomes.

Notwithstanding these factors, greater beef production will only be achieved if cattle numbers increase or, alternatively, if higher rates of off-take are achieved by increasing calving and lowering mortality rates. The great majority (92%) is exported, mainly to South Africa or Europe, while the remaining 8% is for the local Namibian market. Of all exports, 54% of cattle were exported live to South Africa, generally for fattening and subsequent slaughter, 27% were exported as carcasses or processed meat to South Africa, and 19% were sold to European markets. Very small volumes have also been exported to Botswana and Angola. The European market is dominated by sales to the United Kingdom (73% of European exports) and Norway (13%). As is the case of sheep, the export of live cattle to South Africa is a concern to the government. Greater value could be added if the carcasses were processed locally, jobs could be generated, and Namibia would obtain value from the hides and other by-products. While intended levies on live exports may boost these local benefits, they would also limit the growth of beef production by farmers in communal areas. Namibian beef is widely held as being of high quality. Much is done to protect that reputation, not least in ensuring that all exports are certified as free of diseases. The Meat board has recently introduced the Farm Assured Namibian Meat Scheme (or FAN Meat) as an additional method of guaranteeing quality. In essence, the scheme allows all meat producers to be traced from the final market destination back to the original farm.

One aspect to pursue in developing beef production in communal areas is the quality of meat. Many of the cattle sold to abattoirs are old and the meat of poor grades. For example, about 30% of carcasses are categorised as A or B grades in the northern communal areas, the other 70% being C grades. By contrast, 76% of carcasses sold by freehold farmers are A and B grades, the remaining 24% being C grade.

Small stock

Small stocks are dominant in the southern and western part of Namibia. This is a semi-arid area lying between true desert to the west and savanna woodlands to the east and north with the annual rainfall ranging between 100 and 250 mm per annum but with high degree of variation. This farming comprises of farmers farming with sheep and goats on large, exclusive freehold farms and in open access communal land of which most of the production is sold, both locally and to SA markets. The small stock system focuses very largely on sheep (including Karakul) and goats. About 85% of sheep, 90% of Karakul and 26% of goats are within the farming system. Sheep dominates livestock holding on freehold farms, whereas communal farmers have higher number of goats and cattle, and few sheep.

During the 1940s and 1950's , Karakul sheep comprised of about 70% of an estimated 4.5 million small stock south of the veterinary cordon fence, the rest were goats and mutton sheep. In contrast by 2004, only 8% of all the sheep and 4% of all small stock in Namibia were Karakul.

Currently Dorper, Damara, Van Rooy and Blackhead Persian are the main sheep breeds among the several mutton sheep and cross-breeds or hybrids produced in Namibia. Each breed has its particular characteristics that shape its meat production potential. The Dorper is one of the breed that forms the backbone of the country's mutton industry. The breed was developed for farming in arid areas, and is now widely regarded as a source of high quality mutton. The rates of reproduction are higher, with about 80 to 85% of the lambs born in the year reaching the weaning and marketable weights of 32 to 36 kg at the ages of four to five months. Dorpers produces valuable meat, but they require more water and high quality food, and are more vulnerable to parasites than other breeds.

Damara sheep are hardy, being well adapted to conditions of limited water and food supply. Other features include tasty meat, good resistance to parasites and a varied diet with up to 64% of its food consisting of browse.. It requires little care and this makes it more suitable to communal areas. Van Rooy has favourable characteristics that include hardiness, high ram fertility rate unlimited mating seasons and good maternal care.

There are approximately 2.5 million goats in Namibia of which, about 40% are Boer goats and 60% belongs to indigenous breeds. In addition, there are a handful of Angora and Dairy goats in Namibia. Boar goats are indigenous to Africa and their value lies in hardiness, high reproductive rate, high resistance against external parasites and their lean, tender meat, which has a low cholesterol content. They prefer browsing on woody plants, making them less competitive to cattle that depend more on grasses.

Indigenous goats, as a broad category, cover animals locally called by such names as North Central, Kavango, North West and Caprivi goats. Most are kept by small-scale farmers in northern communal areas, where they form an important component of the small-scale cereals and livestock farming system. Genetically, these indigenous breeds have considerable value due

to their fertility, high survival rates and resistant to diseases, because they are well adapted to local environment.

Small Stock Marketing
Sheep and goats are sold in several ways: at auctions, directly to local buyers, abattoirs and butchers, and on an ad hoc informal basis. Auction sales have evidently declined in recent years, and many farmers now prefer selling directly from their farms. This saves transport cost to auctioning points and commissions charged by middlemen. Local buyers are often called speculators who buy up animals and keep them until prices are sufficiently attractive to sell to local abattoirs or to export to SA.

Most sheep sold for mutton production are exported either live or as whole carcasses after slaughtering at export abattoirs. In order to add local value through slaughtering and processing of meat cuts, the government has been discouraging the export of live animals. As a result, the number of sheep carcasses exported rose from an average of about 85,000 per year during the 1990's to 390,941 in 2004, which then made up 44% of all sheep exports. New regulations require that the figure be raised to 85%, so that live exports of sheep are limited to the remaining 15% of production. The average auction price per live sheep was N$ 304 during the 2004, and so the formal market production of 922,860 head was worth some N$ 285 million.

While the export of mutton carcasses and cuts can be promoted, the same is not true for goats. Most of the 262,972 goats exported went to Kwazulu-Natal and the Eastern Cape in SA mainly for sale to Muslims, Zulus and Xhosas who buy live animals. The goats are bled for religious and ritual purposes, goats of various colours being required for different occasions. This market has proved lucrative to communal farmers in southern Namibia, and prices for goats have been higher than those of sheep over the past several years. Exports of goats in 2004 were worth some N$ 40 million to Namibia economy.

An average of about 75,000 Karakul pelts was produced each year during the mid-1990s when the market was at its lowest. Annual production has risen to an average of 140,000 pelts over the last few years. The value of pelt sales to Namibia in 2005 amounted to some N$ 18 million. Fresh pelts are dried by farmers before being sent for sorting and grading to Agra in Windhoek, which then dispatches the pelts for auctioning at the Copenhagen Fur Centre in Denmark. Agra also exports Karakul wool, about 95% of total production of 400,000 kg in 2004 being sold in SA.

Scenario development
Under the baseline scenario, climate change is expected to reduce the carrying capacity of land for livestock farming, reducing livestock numbers and marketable livestock numbers. The policy of extension services is expected to partially offset this impact for subsistence farmers, by increasing knowledge of best practices. The following table illustrates the expected impact of climate change on the grazing capacity of the land for each species type, and the predicted impact of extension services on the effective grazing capacity.

Table 3. Impact on Grazing Capacity, BAU

	Cattle		Harvested game		Small stock	
	Subsistence	Commercial	Subsistence	Commercial	Subsistence	Commercial
CC impact	-22.5%	-22.5%	-7.7%	-7.7%	-32.5%	-32.5%
Extension services impact	5%	0%	5%	0%	5%	0%

Source: Reid et al. (2007) and internal discussions with colleagues from MAWF

With the exception of the subsistence activities for harvested game, the impact of climate change over the period of analysis is overwhelmingly negative. It is important to note that these impacts are average impacts across the country for farming activities: regionally these impacts may be much greater, potentially limiting the possibility of such farming in future.

Crop sub-sector

A key feature of Namibian agriculture is its dualistic nature, being comprised of commercial sector and communal sector. Communal farmers (also known as subsistence farmers) are characterized mostly as low-input low-output farmers while commercial farming on large ranches provides good source of income to a small number of commercial farmers.

Crop production plays an important role for household food security, particularly in the northern parts of the country. Main crops produced in Namibia are maize, pearl millet (mahangu), sorghum and wheat. In Namibia, white maize is produced under irrigation and dry-land conditions.

Dry-land 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 has limited yield production, except in areas receiving 400 mm and above annually. Dry-land production is associated with a high risk of crop failure due to erratic nature of rainfall. Maize is largely produced by commercial farmers while Mahangu, and to an extent sorghum, is almost exclusively grown by estimated 150,000 communal farmers, especially in the Northern Communal Areas (NCAs) as well as in Caprivi and Kavango regions mainly for own consumption.

Table 4. Area Planted for Maize Production (ha)

Year	2004	2005	2006	2007	2008	2009
Total Area Planted	**25,308**	**26,315**	**25,553**	**27,356**	**27,694**	**27,127**
Commercial (total)	*12,843*	*13,424*	*11,373*	*12,737*	*12,868*	*11,955*
Rainfed	9,084	9,606	7,903	8,223	8,664	8,750
Irrigation	3,759	3,818	3,470	4,514	4,204	3,205
Communal	*12,465*	*12,891*	*14,180*	*14,619*	*14,826*	*15,172*

Source: MAWF, 2010 and MET, 2010

Dry-land producers are found in areas such as Maize Triangle (Otavi-Grootfontein-Tsumeb), Otjozondjupa region (Hochfeld, Otjiwarongo), Omaheke region (Gobabis and Summerdown), Caprivi region and Kavango region. Dry-land producing season normally commence towards the end of November each year after the first showers. All the said areas contain mostly commercial farmers. Communal farmers in Kavango also plant maize under dry-land, mainly for domestic consumption.

Mahangu is a staple food crop produced for a large number of people. Mahangu is highly adapted to low rainfall and under poor soil conditions of Oshikoto, Ohangwena, Omusati, Oshana and Kavango regions (V&A Assessment, 2008). Generally, the yield obtained from mahangu fields has been low for the past years with an average of 280kg per ha during the period of 2000 to 2004 (MAWF, 2005). Furthermore, a majority of these communal farmers are still making use of traditional methods to cultivate their fields, a process that delays the crop production and thus affect the yield.

Table 5. Mahangu and Sorghum Production, Consumption and Imports (tonnes)

Year	2004	2005	2006	2007	2008	2009
Total Production	91,057	78,521	115,901	48,497	39,898	41,970
Consumption	96200	83900	77600	72100	86000	87500
Imports	204	0	59	0	2185	3795

Source: MAWF, 2010

Table 6. Area Planted for Mahangu and Sorghum Production - Communal Dry-land (ha)

Year	2004	2005	2006	2007	2008	2009
Total	**275,715**	**258,754**	**265,785**	**211,655**	**197,114**	**277,337**

Source: MAWF, 2010

Irrigation crop production

There is a significant potential in communal land tenure farming for increased agricultural productivity, which can be achieved through well planned interventions, including adaptations and adoptions of improved farming techniques (PWC, 2005). Based on the latter, Namibia commenced the promotion of irrigation production through the implementation of Green Scheme policy of 2003 (amended 2008). The total land under irrigation is estimated at 10000 ha (2010) of which approximately 5000 ha are under staple food crops (maize and wheat). Considering the existing national water and land resources, the arable development potential through irrigation in Namibia is estimated at 22,000ha (PWC, 2005). The model uses 22,187ha as maximum area that will be put under irrigation for wheat and maize (no irrigation for mahangu). However, irrigation is still well within the maximum 43,000ha area. This will ensure import substitution as well as enhance the export of high value horticulture products.

Maize production under irrigated farming is conducted in areas such as Maize Triangle, Mariental (Hardap Irrigation Projects), Stampriet, Gobabis, Kavango region (Mashare, Musese, Sarasungu, Shadi Kongoro, Shitemo, and Vungu-Vungu) and North-Central regions (Etunda Irrigation project).

Table 7. Maize Production, Consumption and Imports (tonnes)

Year	2004	2005	2006	2007	2008	2009
Total Production	64,795	52,939	63,633	55,523	58,101	57,320
Commercial (irrigation and dry-land)	54,940	43,969	52,930	48,515	50,488	49,566
Communal (Dry-land)	9,855	8,970	10,703	7,008	7,613	7,754
Consumption	160,000	150,500	155,700	153,000	155,200	158,900
Imports	87,434	76,534	48,247	60,141	111,714	95,203

Source: Namibia Agronomic Board, 2010

Wheat is produced only under irrigation conditions as it is a winter crop and Namibia has no rains during winter. Wheat is grown in Hardap, Naute, Kavango region (Musese, Shadikongoro, Vungu-vungu, Shitemo), North-Central regions (Etunda Irrigation project). An average yield of 5.90 tonnes per ha has been recorded for wheat for the past 10 years, whereas a hectare has a potential of 7.0 tonnes under correct management.

Table 8. Wheat Production, Consumption and Imports (tonnes)

Year	2004	2005	2006	2007	2008	2009
Total Production	**11,340**	**12,987**	**12,312**	**12,163**	**14,581**	**12,448**
Consumption	61,500	73,000	72,400	71,700	72,600	74,000
Imports	79,888	73,411	58,227	61,665	51,014	66,824

Source: Namibia Agronomic Board, 2010

Table 9. Area Planted for Wheat Production (ha)

Year	2004	2005	2006	2007	2008	2009
Area Planted	2,123	2,434	2,136	2,369	2,734	1,852

Source: MWAF, 2010

Food consumption in Namibia

In the case of maize and wheat grains, Namibia imposes import restrictions to ensure that grain is imported only after commercial production has been purchased by millers. Mahangu has also become a controlled crop and could be marketed commercially. As such, grain imports vary in line with domestic production (V&A Assessment 2008). The balance for staple grains is partly determined by rainfall because bulk of production is dry-land. Years of good rainfall have notable grain self-sufficiency.

Scenario development

Under the baseline scenario, yields are expected to drop, by 15 percent on average, from 2005 to 2030 for irrigated cropping and 30 percent for subsistence farming over the same period for all crop types. The change in land use expected from livestock production to commercial irrigated cropping will serve to partially offset this impact on overall yields, but not significantly.

2.5 Adaptation scenario description

Livestock sub-sector

As mentioned above, the additional measures proposed under the adaptation scenario are expected to offset the impacts of climate change. These additional activities commence in 2010 and occur at an equal rate until 2030 (with the exception of de-bushing, where the impact starts to be felt in 2015):

- *Additional funding for Extension Services*: additional funding will be required in order to increase the number of extension officers so that they can effectively render extension services to local communities. More local support will increase the effective carrying capacity of the land. It is assumed that the impact will be similar to that achieved by extension services currently (i.e. a 5 percent increase in grazing capacity for subsistence farmers).

- *De-bushing*: bush encroachment is estimated to cost the Namibian economy around N$700 million per annum, due to the reduced carrying capacity (de Klerk, 2004). It is estimated that 26 million hectares are encroached with invader bush, with 10-12 million ha, subjected to severe production losses (de Klerk, 2004). Following de Klerk (2004) a programme of de-bushing is proposed on 5 million ha. of rangeland, half of which is on communal land and half on commercial land. The impact of de-bushing is estimated to be a trebling of the carrying capacity of these lands. For simplicity, 75% of targeted land is assumed to be on cattle farming rangeland and 25% will be for sheep and goat farming. The majority of encroached land is in the northern parts of the country and presently used mostly for cattle

farming. Although the programme would begin in 2010 and end in 2030, the impact of bush clearing would not be felt until 5 years after the clearing (to allow for re-growth).

- *Switching to game production*: the impact of climate change on game production is expected to be significantly less than for more traditional livestock types, due to game natural resilience/adaptation to the climate extremes found in Namibia. As such, an adaptation strategy introduced into the livestock model is the potential for commercial farmers to switch some cattle ranching towards game ranching. At present a 10% switch of land towards game farming by 2030 is assumed within the model, increasing game numbers substantially. Game viewing, trophy hunting and scenery driven tourism production are other aspects available to farmers from this switch.

- *Choice of breeds:* a further adaptation measure that is built into this model is switching to more resilient breeds of cattle and small stock. This would increase the effective carrying capacity of the land in the face of climate change. A small reduction in meat per animal as a result of the switch to smaller breeds is factored into the model.

- *Livestock number reductions:* overstocking in communal areas impacts the productivity of farming in these areas (represented by the off-take). Although stocking densities are far higher than in commercial areas, seemingly leading to a higher carrying capacity in these areas, the off-take is significantly lower. De-stocking is one of the adaptation measures which farmers can employ to ensure that the carrying capacity of a given area is not exceeded.

Scenario development

As with the BAU scenario, under the adaptation scenario, climate change is expected to reduce the grazing capacity of the land for all livestock types. However, the various measures investigated aim at improving the productivity of grazing land for livestock.

Table 10. Impact on Grazing Capacity, Adaptation Scenario

	Cattle		Harvested game		Small stock	
	Subsistence	Commercial	Subsistence	Commercial	Subsistence	Commercial
CC impact	-22.5%	-22.5%	-7.7%	-7.7%	-32.5%	-32.5%
Extension services impact	5%	0%	5%	0%	5%	0%
Additional Extension services impact	5%	0%	5%	0%	5%	0%
Animal number reductions*	25%	0%	0%	0%	0%	0%
Choice of breeds**	50%	50%	0%	0%	50%	50%
Land restoration	6.0%	6.6%	0.0%	0.9%	4.5%	4.0%

Source: various (see Annex B)

* Although animal number reductions increase the effective off-take per animal, the number reductions are assumed to exactly offset this increase, such that meat production remains the same (but as there are less animals, for less cost). This is the minimum impact that would need to take place for this measure to maintain off-take numbers.

** The choice of breeds has a potential impact on grazing capacity. However, this impact is offset by the reduced meat yield from indigenous animals compared to exotic animals. Based on MAWF data, the meat yield is expected to decline by a maximum of 20 percent for cattle and 10 percent for small stock.

Crop sub-sector

To allow crop production to adapt and thrive in adverse effects of climate change to produce sufficient food for Namibians, a number of measures have been investigated. Some of these measures include:

- **Increase land under irrigation -** Namibia is a dry country and crop production under rain fed may prove futile in the next 30 years. Speeding up the process of developing irrigation systems and scaling up efforts of the government through Green Scheme is a potential way of keeping up with food demand. The current area under irrigation stands at ≈10,000 ha in total. The food demand in Namibia can be met if about 27,000 ha are put under irrigation with about 18,000 ha of it used for grain production.

- **Mechanization of agricultural practices in communal areas to replace traditional practices** - This measure aims to speed up the production of food and divert from the laborious, inefficient and time consuming traditional way of crop production. As it is projected, rain seasons are expected to get shorter with poor rainfall distribution. It is important to employ mechanisms that would ensure utilisation of water in the shortest time. Mechanization coupled with the use of water conservation practices; use of drought resilient crop varieties and fertilizers will enable farmers to adapt to climate change effects.

- **Training of farmers -** For the farmers to reach maximum yield per ha, it is recommended that farmers are given training on all production aspects especially wheat farmers. This will enable wheat farmers to increase their productivity from the current 5.90 tonnes/ha (which under climate change can be 4.5 tonnes/ha) to 7.0 tonnes/ha with training as an adaptation measure.

2.5.1 Production under the BAU and Adaptation Scenarios

Livestock

The tables below show the impacts of climate change and the measures discussed in aggregate across the three livestock types. As is evident, imports as a share of consumption are much less under the adaptation scenario for all three species, although for cattle and small stock this share is significantly greater than 2005 due to population and economic growth. It is worth noting that game production is expected to increase dramatically under the adaptation scenario, to the extent that exports are expected to increase substantially. As mentioned previously, these changes reflect current consumption preferences, which almost certainly will change towards game consumption in future, in light of the potential price impacts of climate change.

Table 11. Cattle Consumption, Production and Imports

	2005	BAU 2030	ADAPT 2030	% Difference
Consumption (including exports), tonnes	84,701	124,293	124,293	0.00%
Total domestic production				
Animal numbers	2,373,207	1,989,584	3,858,525	93.94%
Slaughter numbers	409,594	338,022	602,775	78.32%
Tonnes of meat	83,942	69,274	98,205	41.76%
Imports	759	55,020	26,088	-52.58%
Imports % share of consumption	0.9%	44.3%	21.0%	

Table 12. Game Consumption, Production and Imports

	2005	BAU 2030	ADAPT 2030	% Difference
Consumption (including exports), tonnes	420	586	586	0.00%
Total domestic production				
animal numbers	1,530,678	1,424,519	3,289,111	130.89%
slaughter numbers	6,930	6,449	14,891	130.89%
Tonnes of meat	420	391	904	130.89%
Imports	-	195	(318)	-263.24%
Imports % share of consumption	0.0%	33.2%	-54.2%	

Table 13. Small Stock Consumption, Production and Imports

	2005	BAU 2030	ADAPT 2030	% Difference
Consumption (including exports), tonnes	31,141	43,832	43,832	0.00%
Total domestic production				
animal numbers	4,612,507	3,534,327	5,869,705	66.08%
slaughter numbers	1,715,600	1,305,430	2,083,390	59.59%
Tonnes of meat	30,881	23,498	34,639	47.42%
Imports	260	20,334	9,192	-54.79%
Imports % share of consumption	0.8%	46.4%	21.0%	

Crop production

In common with Livestock production, the modelled impact of climate change and the measures presented are very different under the two scenarios (see below). Whilst consumption remains static, domestic production is significantly higher. The largest difference in production is for maize, followed closely by mahangu and sorgum and wheat. In the case of mahangu and sorgum, under the adaptation scenario, imports are expected to decline to zero. For wheat and maize, despite reductions, imports are expected to continue to play an important role on consumption in Namibia.

Table 14. Wheat Consumption, Production and Imports

	2005	BAU 2030	Adaptation 2030	% change
Consumption	**71,816.67**	**109,525.78**	**109,525.78**	0%
Total dom Production	**9,307.12**	**41,815.90**	**49,581.35**	19%
Irrigation communal	-	-		
Mechanisation				
Drycrop commercial				
Irrigation commercial	9,307.12	41,815.90	49,581.35	19%
Imports	**62,631.82**	**67,893.22**	**60,127.77**	-11%
Imports % of consumption	87.2%	62.0%	54.9%	
Stock	**7,059.40**	**10,769.23**	**10,769.23**	0%

Table 15. Maize Consumption, Production and Imports

	2005	BAU 2030	Adaptation 2030	% change
Consumption	**140,866.67**	**214,832.18**	**214,832.18**	0%
Total dom Production	**42,299.50**	**72,110.32**	**124,635.30**	73%
Drycrop	7,585.33	6,826.80	-	
Mechanisation	0	0	22,878.27	
Drycrop commercial	16,778.67	15,100.80	7,550.40	-50%
Irrigation commercial	17,935.50	50,182.72	94,206.63	88%
Imports	**98,806.99**	**143,081.49**	**90,556.51**	-37%
Imports % of consumption	70.1%	66.6%	42.2%	
Stock	**13,846.84**	**21,123.59**	**21,123.59**	0%

Table 16. Mahangu and Sorghum Consumption, Production and Imports

	2005	BAU 2030	Adaptation 2030	% change
Consumption	**92,900.00**	**141,679.43**	**141,679.43**	0%
Total dom Production	**92,900.00**	**83,610.00**	**141,912.63**	70%
Drycrop	92,900.00	83,610.00	58,813.48	-30%
Mechanisation	0	0	83,099.15	
Drycrop commercial	-	-	-	
Irrigation commercial	-	-	-	
Imports	**158.16**	**58,306.60**		-100%
Imports % of consumption	0.2%	41.2%	0.0%	
Stock	**9,131.84**	**13,930.77**	**13,930.77**	0%

3. Results

The results of the assessment are discussed below, commencing with a discussion of the baseline costs, followed by the costs relating to the adaptation scenario and finally an assessment of the incremental costs. In all cases, the bases for the values are models developed by the AWG, using various assumption and data sources (as discussed above).

3.1 Baseline IF, FF, O&M costs, and subsidy costs

Livestock Sub-sector

Table 17 below illustrates the Baseline Scenario Cumulative discounted IF, FF and O&M estimates by type, investing entities and funding sources, by various investing entities by adaption measures. Under the BAU scenario, only the extension services measure is included as an adaption measure.

Extension services
The extension services measure is fully funded by government, to assist subsistence farmers. Therefore households spend nothing on investments and financial flows on extension services. However they (HH) spend an estimate of US$7.51 million on operational and maintenance costs, based on the fact that extension services work improves the effective carrying capacity of the land and hence the number of animals that can be kept.

As extension services has little direct impact on Commercial farmers (the so-called Corporations in our analysis) Corporations also do not invest or spend on extension services neither incur O&M costs related to extension service.

Government spends US$22.54 million on investments in livestock extension services, US$13.9 million on financial flows and US$100.5 million on the O&M coasts related to extension services. These costs reflect current programmatic spending levels. Bilateral ODA is expected to provide US$ 6.76 million for investment costs.

Table 17. Livestock Baseline Scenario: Cumulative Discounted IF, FF and O&M Estimates by Investment Type, Investment Entity and Funding Source

	Extension services		
Investment Entity Category/Source of Funds	IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)
Households			
Domestic			
Equity & debt	0.00	0.00	7.51
Total Household Funds	**0.00**	**0.00**	**7.51**
Corporations			
Domestic			

Domestic equity	0.00	0.00	0.00
Domestic borrowing	0.00	0.00	0.00
Total Domestic Sources	**0.00**	**0.00**	**0.00**
Foreign			
FDI	0.00	0.00	0.00
Foreign borrowing	0.00	0.00	0.00
ODA	0.00	0.00	0.00
Total Foreign Sources	**0.00**	**0.00**	**0.00**
Total Corporation Funds	**0.00**	**0.00**	**0.00**
Government			
Domestic			
Domestic funds	15.78	13.90	100.48
Foreign			
Foreign borrowing	0.00	0.00	0.00
Bilateral ODA	6.76	0.00	0.00
Multilateral ODA	0.00	0.00	0.00
Total Foreign Sources	**6.76**	**0.00**	**0.00**
Total Government Funds	**22.54**	**13.90**	**100.48**
Total Funds	**22.54**	**13.90**	**107.99**
Data Sources: MAWF			

As shown in Table 18, investment flows for extension services are estimated at US$0.23 million in 2006, increasing to US$1.92 million in 2010, before declining to US$0.41 million. For the first years the increase relates to increasing the size of the programme; the decline from 2010 is based on present value calculation of costs (in fact in nominal terms investment costs are fixed from 2010 onwards). This pattern of increasing costs until 2010 and then declining costs due to the discounting of future costs is reflected in the FF and O&M costs also. At a maximum, FF costs are estimated at US$1.22 million in 2010 (after discounting). O&M costs however peak in 2009, based on the historical information available on extension services costs.

Table 18. Livestock Baseline Scenario: Annual IF, FF and O&M Estimates by Investment Type

	Extension services		
Year	IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)
2005	0.00	0.00	0.00
2006	0.23	0.00	6.89
2007	0.08	0.01	7.86
2008	0.31	0.40	6.60
2009	1.20	0.25	7.33
2010	1.92	1.22	6.90
2011	1.77	1.13	6.45
2012	1.64	1.05	6.03
2013	1.52	0.97	5.64
2014	1.41	0.90	5.27
2015	1.30	0.83	4.92
2016	1.21	0.77	4.59
2017	1.12	0.71	4.29

2018	1.03	0.66	4.00
2019	0.96	0.61	3.73
2020	0.89	0.57	3.48
2021	0.82	0.52	3.24
2022	0.76	0.49	3.02
2023	0.70	0.45	2.81
2024	0.65	0.42	2.62
2025	0.60	0.39	2.44
2026	0.56	0.36	2.27
2027	0.52	0.33	2.11
2028	0.48	0.31	1.97
2029	0.44	0.28	1.83
2030	0.41	0.26	1.70

Data Sources: MAWF expenditure data

Crop Sub-Sector

Table 19 below illustrates the baseline scenario: cumulative discounted IF, FF and O&M estimates by investment type, investment entity and funding source (million 2005 US$) for the crop sub-sector. Households are expected to have no IF and FF, but are estimated to spend US$474.33 million of equity and debts on O&M costs under rain fed subsistence' farming. As commercial farmers do not carry out rainfed subsistence farming, costs under the baseline scenario for this cropping type are assumed to be zero. Likewise, government expenditure on this production system is expected to be zero in the absence of any support in terms of the measures considered.

For rain-fed commercial crop production; households, corporations, government and foreign sources do not invest in this production system. However it is estimated that corporations will spend US$70.1 million of their domestic equities on O&M costs.

Under irrigation commercial crop production, households are not spending or involved, but it is estimated that corporations will have investment flow into irrigation schemes to the tune of US$95.34 million, US$66.74 of which is funded by domestic sources, with the remainder funded by foreign borrowing. O&M costs are estimated to be US$152.15 million for corporations under this production system.

All investments for all types of productions systems amounted to US$95 million, while O&M costs are estimated at US$596 million.

Table 19. Crop Baseline Scenario: Cumulative Discounted IF, FF and O&M Estimates by Investment Type, Investment Entity and Funding Source (million 2005 US$)

Investment Entity Category/Source of Funds	Rain fed Subsistence			Rain fed Commercial			Irrigation Commercial			All investments		
	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs
Households												
Domestic												
Equity & debt			474.33									474
Total Household Funds	**0.00**	**0.00**	**474.33**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0**	**0**	**474**
Corporations												
Domestic												
Domestic equity						70.01	38.13		152.15	38	0	222
Domestic borrowing						0.00	28.60		0.00	29	0	0
Total Domestic Sources	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**70.01**	**66.74**	**0.00**	**152.15**	**67**	**0**	**222**
Foreign												
FDI						0.00	0.00		0.00	0	0	0
Foreign borrowing						0.00	28.60		0.00	29	0	0
ODA						0.00	0.00		0.00	0	0	0
Total Foreign Sources	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**28.60**	**0.00**	**0.00**	**29**	**0**	**0**
Total Corporation Funds	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**70.01**	**95.34**	**0.00**	**152.15**	**95**	**0**	**222**
Government												
Domestic												
Domestic funds			0.00			0.00	0.00		0.00	0	0	0
Foreign												
Foreign borrowing			0.00			0.00	0.00		0.00	0	0	0
Bilateral ODA			0.00			0.00	0.00		0.00	0	0	0
Multilateral ODA			0.00			0.00	0.00		0.00	0	0	0
Total Foreign Sources	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0**	**0**	**0**
Total Government Funds	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0**	**0**	**0**
Total Funds	**0.00**	**0.00**	**474.33**	**0.00**	**0.00**	**70.01**	**95.34**	**0.00**	**152.15**	**95**	**0**	**696**

Data sources: Ministry of Agriculture, Water and Forestry; own calculations

Table 20 below illustrates the expected baseline costs under the BAU scenario for each year of the analysis. Rain-fed subsistence crop production under the baseline scenario investments in rain-fed subsistence is assumed to be zero, O&M expenditures are projected to be constant throughout the period from 2005 to 2030, at US$40.63million due to stable land use and production methods (the reductions displayed in the table reflect the impact of discounting to bring cost to 2005 present values).

Under rain-fed commercial production systems, both investments and financial flows are kept at or assumed to be zero. O&M expenditure is assumed to be constant at US$6.00million, based on the area of land farmed an cost per hectare, throughout the period of analysis from 2005 to 2030 (as before discounting to present value accounts for the apparent reduction over the time period). Although the increase in population levels implies an increase in labour supply and hence a reduction in wages, labour is currently not a constraint for agricultural production: unemployment in Namibia has been estimated at greater than 50 percent of the population (MoL, 2010).

Commercial irrigation IF, is estimated at US$8.81million in 2010, while FF is assumed to be zero. The O&M costs are projected to decrease from US$7.55 million to US$4.32 million by 2030, although in nominal terms these costs are actually increasing year on year with the increase in area planned for this farming system.

Table 20. Crop Baseline Scenario: Annual IF, FF and O&M Estimates by Investment Type (million 2005 US$)

	Rain fed Subsistence			Rain fed Commercial			Irrigation Commercial			All investments		
Year	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs
2005	0		40.63	0		6.00	-		7.55	-		54.18
2006	0		37.62	0		5.55	-		6.99	-		50.16
2007	0		34.83	0		5.14	-		6.47	-		46.45
2008	0		32.25	0		4.76	-		5.99	-		43.01
2009	0		29.86	0		4.41	-		5.55	-		39.82
2010	0		27.65	0		4.08	8.81		5.85	8.81		37.58
2011	0		25.60	0		3.78	8.16		6.08	8.16		35.46
2012	0		23.71	0		3.50	7.56		6.24	7.56		33.45
2013	0		21.95	0		3.24	7.00		6.34	7.00		31.53
2014	0		20.32	0		3.00	6.48		6.40	6.48		29.72
2015	0		18.82	0		2.78	6.00		6.41	6.00		28.01
2016	0		17.42	0		2.57	5.55		6.38	5.55		26.38
2017	0		16.13	0		2.38	5.14		6.33	5.14		24.84
2018	0		14.94	0		2.21	4.76		6.24	4.76		23.39
2019	0		13.83	0		2.04	4.41		6.14	4.41		22.01
2020	0		12.81	0		1.89	4.08		6.01	4.08		20.71
2021	0		11.86	0		1.75	3.78		5.87	3.78		19.48
2022	0		10.98	0		1.62	3.50		5.72	3.50		18.32
2023	0		10.17	0		1.50	3.24		5.56	3.24		17.23
2024	0		9.41	0		1.39	3.00		5.39	3.00		16.20
2025	0		8.72	0		1.29	2.78		5.22	2.78		15.22
2026	0		8.07	0		1.19	2.57		5.04	2.57		14.30
2027	0		7.47	0		1.10	2.38		4.86	2.38		13.43
2028	0		6.92	0		1.02	2.21		4.68	2.21		12.62
2029	0		6.41	0		0.95	2.04		4.50	2.04		11.85
2030	0		5.93	0		0.88	1.89		4.32	1.89		11.12

Data Sources: Ministry of Agriculture, Water and Forestry; own calculations

3.2 Adaptation scenario IF, FF, O&M costs and subsidy costs

Under the adaptation scenario, a range of measures have been considered as potential climate change adaptation solutions for both the livestock and crop subsectors.

Livestock sub-sector

Table 22 below presents the expected costs associated with the measures discussed under the adaptation scenario for livestock farming.

Extension Services- As before with the BAU scenario, households and corporations are not expected to invest in this measure. However, as the programme increases the grazing capacity and therefore potential to increase livestock numbers, households are expected to spend US$8.8 million on O&M costs on extension services. Government is expected to invest about US$15.8 million from domestic sources in extension services, US$13.9 million on financial flows and US$100.9 million on O&M costs associated with extension services.

Additional Extension Services- For additional extension services, government will be required to invest a total of US$15.2 million, US$9.4 million will be spent on financial flows and US$70.2 million for O&M costs from budgetary allocations. It is worth noting that the difference in costs between extension services and this additional adaptation funding on extension services relates to the start date of the programme. As before, the expected costs to households relate to the impact that the measure has on livestock numbers.

Destocking- The impact of destocking will be to reduce O&M costs for households, by US$7.9 million. As government need not subsidise the cost of bulls for the animals no longer purchased, government is also expected to make a saving from this measure.

Choice of Breed- Households are projected to invest US$13.9 million in choice of breed by purchasing different breeds and spend US$83.6 million on O&M costs related to the choice of breed as an adaptive measure. Note that these costs relate to the fact that the choice of breed impacts the grazing capacity of the land, which in turn adjusts the number of animals possible on a given ha. of land. Corporations are projected to invest US$85.3 million and spend US$450.6 million O&M for the choice of breeds. Based on subsidisation of animal prices, government will also face significant costs relating to this measure: US$174 million in terms of investment costs and US$27.9 million in terms of O&M costs.

Game Switching- As this measure related to commercial farmers, households are not expected to face any costs relating to this measure. Corporations (commercial farmers) on the other hand will face significant costs in terms of investment US$89.9 million and US$511.5 million for O&M costs.

De-bushing- Households are expected to spend US$8 million on O&M costs for de-bushing, based on the change in animal numbers as a result of the measure. Corporations are expected to spend US$425.9 million in terms of investment on de-bushing, and US$55.43 on O&M costs. Government will spend about US$301 million on de-bushing programs (IF), and around 2US$2.68 million on O&M costs, again, due to the subsidisation of animal purchases and change in animal numbers as a result of the measure.

Table 21. Livestock Adaptation Scenario: Cumulative Discounted IF, FF and O&M Estimates by Investment Type, Investment Entity and Funding Source

Investment Entity Category/Source of Funds	Extension services			Additional Extension services			Destocking		
	IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)	IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)	IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)
Households									
Domestic									
Equity & debt	0.00	0.00	8.80	0.00	0.00	8.36	0.00	0.00	-7.90
Total Household Funds	**0.00**	**0.00**	**8.80**	**0.00**	**0.00**	**8.36**	**0.00**	**0.00**	**-7.90**
Corporations									
Domestic									
Domestic equity	0.00	0.00	0.00	0.00	0	0.00	0.00	0	0.00
Domestic borrowing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Domestic Sources	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Foreign									
FDI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Foreign borrowing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ODA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Foreign Sources	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Corporation Funds	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Government									
Domestic									
Domestic funds	15.78	13.90	100.91	10.65	9.35	70.19	0.00	0.00	-2.63
Foreign									
Foreign borrowing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bilateral ODA	6.76	0.00	0.00	4.56	0.00	0.00	0.00	0.00	0.00
Multilateral ODA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Foreign Sources	**6.76**	**0.00**	**0.00**	**4.56**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Government Funds	**22.54**	**13.90**	**100.91**	**15.21**	**9.35**	**70.19**	**0.00**	**0.00**	**-2.63**
Total Funds	**22.54**	**13.90**	**109.71**	**15.21**	**9.35**	**78.55**	**0.00**	**0.00**	**-10.53**

Data Sources: See Annex A

Table 21. Livestock Adaptation Scenario: Cumulative Discounted IF, FF and O&M Estimates by Investment Type, Investment Entity and Funding Source (cont.)

Choice of breeds			Game switching			Debushing			All investments		
IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)	IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)	IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)	IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)
13.96	0.00	83.58	0.00	0.00	0.00	0.00	0.00	8.03	13.96	0.00	100.87
13.96	**0.00**	**83.58**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**8.03**	**13.96**	**0.00**	**100.87**
									0.00	0.00	0.00
									0.00	0.00	0.00
34.12	0	450.57	35.98	0	511.49	168.89	0	55.42	238.99	0	1017.48
25.59	0.00	0.00	26.98	0.00	0.00	126.67	0.00	0.00	179.24	0.00	0.00
59.71	**0.00**	**450.57**	**62.96**	**0.00**	**511.49**	**295.56**	**0.00**	**55.42**	**418.23**	**0.00**	**1,017.48**
									0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.59	0.00	0.00	26.98	0.00	0.00	126.67	0.00	0.00	179.24	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.59	**0.00**	**0.00**	**26.98**	**0.00**	**0.00**	**126.67**	**0.00**	**0.00**	**179.24**	**0.00**	**0.00**
85.29	**0.00**	**450.57**	**89.95**	**0.00**	**511.49**	**422.23**	**0.00**	**55.42**	**597.47**	**0.00**	**1,017.48**
									0.00	0.00	0.00
									0.00	0.00	0.00
121.81	0.00	27.86	0.00	0.00	0.00	298.16	0.00	2.68	446.40	23.25	199.00
									0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52.20	0.00	0.00	0.00	0.00	0.00	127.78	0.00	0.00	191.32	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52.20	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**127.78**	**0.00**	**0.00**	**191.32**	**0.00**	**0.00**
174.02	**0.00**	**27.86**	**0.00**	**0.00**	**0.00**	**425.95**	**0.00**	**2.68**	**637.72**	**23.25**	**199.00**
273.27	**0.00**	**562.01**	**89.95**	**0.00**	**511.49**	**848.18**	**0.00**	**66.12**	**1,249.16**	**23.25**	**1,317.35**

Data Sources: See Annex A

Table 22. Livestock Adaptation Scenario: Annual IF, FF and O&M Estimates by Investment Type

	Extension services			Additional Extension services			Destocking			Choice of breeds		
Year	IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)	IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)	IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)	IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)
2005	0.00	0.00	0.00	0.00	-	0.00	-	-	0.00	0.00	-	0.00
2006	0.23	0.00	6.85	0.00	-	0.00	-	-	0.00	0.00	-	0.00
2007	0.08	0.01	7.78	0.00	-	0.00	-	-	0.00	0.00	-	0.00
2008	0.31	0.40	6.49	0.00	-	0.00	-	-	0.00	0.00	-	0.00
2009	1.20	0.25	7.20	0.00	-	0.00	-	-	0.00	0.00	-	0.00
2010	1.92	1.22	6.62	0.17	0.00	5.11	-	-	-0.01	2.88	-	6.16
2011	1.77	1.13	6.22	0.06	0.01	5.83	-	-	-0.03	5.06	-	11.32
2012	1.64	1.05	5.85	0.23	0.29	4.92	-	-	-0.05	6.96	-	15.71
2013	1.52	0.97	5.51	0.88	0.18	5.48	-	-	-0.09	8.61	-	19.40
2014	1.41	0.90	5.18	1.41	0.90	5.18	-	-	-0.12	10.03	-	22.48
2015	1.30	0.83	4.84	1.30	0.83	4.84	-	-	-0.16	10.59	-	24.65
2016	1.21	0.77	4.56	1.21	0.77	4.56	-	-	-0.21	11.79	-	27.19
2017	1.12	0.71	4.29	1.12	0.71	4.29	-	-	-0.26	12.32	-	26.87
2018	1.03	0.66	4.05	1.03	0.66	4.05	-	-	-0.30	13.17	-	28.43
2019	0.96	0.61	3.82	0.96	0.61	3.82	-	-	-0.35	13.91	-	29.66
2020	0.89	0.57	3.60	0.89	0.57	3.60	-	-	-0.40	14.53	-	30.63
2021	0.82	0.52	3.40	0.82	0.52	3.40	-	-	-0.45	15.06	-	31.35
2022	0.76	0.49	3.21	0.76	0.49	3.21	-	-	-0.50	15.50	-	31.86
2023	0.70	0.45	3.04	0.70	0.45	3.04	-	-	-0.55	15.87	-	32.19
2024	0.65	0.42	2.87	0.65	0.42	2.87	-	-	-0.59	16.17	-	32.37
2025	0.60	0.39	2.72	0.60	0.39	2.72	-	-	-0.64	16.42	-	32.41
2026	0.56	0.36	2.57	0.56	0.36	2.57	-	-	-0.68	16.62	-	32.34
2027	0.52	0.33	2.44	0.52	0.33	2.44	-	-	-0.73	16.78	-	32.17
2028	0.48	0.31	2.32	0.48	0.31	2.32	-	-	-0.77	16.91	-	31.93
2029	0.44	0.28	2.20	0.44	0.28	2.20	-	-	-0.81	17.01	-	31.63
2030	0.41	0.26	2.09	0.41	0.26	2.09	-	-	-0.85	17.10	-	31.27

Table 22. Livestock Adaptation Scenario: Annual IF, FF and O&M Estimates by Investment Type (million 2005 US$) (cont.)

Game switching			Debushing			All investments		
IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)	IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)	IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)
0.00	-	0.00	0.00	-	0.00	0.00	-	0.00
0.00	-	0.00	0.00	-	0.00	0.23	0.00	6.85
0.00	-	0.00	0.00	-	0.00	0.08	0.01	7.78
0.00	-	0.00	0.00	-	0.00	0.31	0.40	6.49
0.00	-	0.00	0.00	-	0.00	1.20	0.25	7.20
5.88	-	13.13	71.64	-	0.00	82.48	1.23	23.70
5.76	-	24.26	66.97	-	0.00	79.63	1.14	34.12
5.63	-	33.61	62.63	-	0.00	77.08	1.34	41.35
5.48	-	41.40	58.57	-	0.00	75.06	1.15	48.69
5.32	-	47.79	54.79	-	0.00	72.96	1.80	53.96
5.16	-	52.97	51.26	-	2.99	69.62	1.67	60.72
4.99	-	57.08	48.07	-	3.32	67.26	1.54	64.82
4.81	-	60.25	45.10	-	3.59	64.46	1.43	65.62
4.63	-	62.60	42.32	-	3.82	62.19	1.32	67.93
4.45	-	64.24	39.72	-	4.00	60.00	1.22	69.59
4.28	-	65.27	37.29	-	4.15	57.87	1.13	70.69
4.10	-	65.76	35.03	-	4.27	55.83	1.05	71.32
3.92	-	65.80	32.91	-	4.36	53.85	0.97	71.53
3.75	-	65.45	30.93	-	4.42	51.96	0.90	71.38
3.58	-	64.77	29.08	-	4.46	50.14	0.83	70.93
3.42	-	63.81	27.35	-	4.49	48.40	0.77	70.23
3.26	-	62.61	25.74	-	4.49	46.73	0.71	69.32
3.10	-	61.23	24.23	-	4.48	45.14	0.66	68.23
2.95	-	59.70	22.81	-	4.46	43.63	0.61	67.00
2.80	-	58.04	21.49	-	4.43	42.20	0.57	65.66
2.66	-	56.29	20.26	-	4.39	40.84	0.53	64.23

Data Sources: See Annex A

Table 22 provides information of the costs of the adaption scenario measures over the time period of analysis. The choice of breed and debushing measures are the most costly in terms of the investment costs required, whereas game switching is the most costly in terms of the O&M costs required.

Crop sub-sector

As illustrated in Table 23 below, there are no investment costs assumed for rain-fed subsistence farming based on the measures considered in this analysis. However, O&M costs are estimated at US$436.8 million for the households practicing this farming method.

Investment flows into the rain-fed mechanization production system is expected to be paid for by government, in terms of converting otherwise rainfed subsistence farming into this farming method. These costs are estimated at US$7.3 million. Households are expected to provide US$184.7 million in the form of equities and debts for O&M costs for mechanization.

In terms of rain-fed commercial crop production systems, investment flow is assumed to be zero by all sources and types of funding. However, corporations will spend US$61.3 million on O&M costs.

Under irrigation commercial systems, corporations are estimated to invest US$281.4 million, based on expanding the area used for irrigation. Corporations are also expected to use own funds in the form of domestic equity for O&M costs which will amounts to US$173.9 million. In addition, Government faces a small cost in terms of the cost of training commercial farmers of US$60,000.

Table 24 displays these costs on an annual basis. As expected due to discounting, overall costs decline in the table from 2010 to 2030.

Table 23. Crop Adaptation Scenario: Cumulative Discounted IF, FF and O&M Estimates by Investment Type, Investment Entity and Funding Source (million 2005 US$)

	Rain fed Subsistence			Rain fed mechanisation			Rain fed Commercial			Irrigation Commercial			All investments		
Investment Entity Category/Source of Funds	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs
Households															
Domestic															
Equity & debt			436.78	0.00		184.68									621
Total Household Funds	**0**	**0**	**436.78**	**0.00**	**0**	**184.68**	**0**	**0**	**0.00**	**0.00**	**0.00**	**0.00**	**0**	**0**	**621**
Corporations															
Domestic															
Domestic equity									61.29	77.54		173.95	78	0	235
Domestic borrowing									0.00	72.75		0.00	73	0	0
Total Domestic Sources	**0**	**0**	**0.00**	**0.00**	**0**	**0.00**	**0**	**0**	**61.29**	**150.29**	**0.00**	**173.95**	**150**	**0**	**235**
Foreign															
FDI									0.00	58.40		0.00	58	0	0
Foreign borrowing									0.00	72.75		0.00	73	0	0
ODA									0.00	0.00		0.00	0	0	0
Total Foreign Sources	**0**	**0**	**0.00**	**0.00**	**0**	**0.00**	**0**	**0**	**0.00**	**131.15**	**0.00**	**0.00**	**131**	**0**	**0**
Total Corporation Funds	**0**	**0**	**0.00**	**0.00**	**0**	**0.00**	**0**	**0**	**61.29**	**281.44**	**0.00**	**173.95**	**281**	**0**	**235**
Government															
Domestic															
Domestic funds			0.00	7.28		0.00			0.00	58.40	0.06	0.00	66	0	0
Foreign															
Foreign borrowing			0.00	0.00		0.00			0.00	58.40	0.00	0.00	58	0	0
Bilateral ODA			0.00	3.12		0.00			0.00	58.40	0.00	0.00	62	0	0
Multilateral ODA			0.00	0.00		0.00			0.00	58.40	0.00	0.00	58	0	0
Total Foreign Sources	**0**	**0**	**0.00**	**3.12**	**0**	**0.00**	**0**	**0**	**0.00**	**175.19**	**0.00**	**0.00**	**178**	**0**	**0**
Total Government Funds	**0**	**0**	**0.00**	**10.40**	**0**	**0.00**	**0**	**0**	**0.00**	**233.58**	**0.06**	**0.00**	**244**	**0**	**0**
Total Funds	**0**	**0**	**436.78**	**10.40**	**0**	**184.68**	**0**	**0**	**61.29**	**515.02**	**0.06**	**173.95**	**525.42**	**0**	**856.71**

Data Sources: Ministry of Agriculture, Water and Forestry; own calculations

Table 24. Crop Adaptation Scenario: Annual IF, FF and O&M Estimates by Investment Type (million 2005 US$)

	Rain fed Subsistence			Rain fed mechanisation			Rain fed Commercial			Irrigation Commercial			All investments		
Year	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs
2005	0		40.63	-		-	0		6.00	-	0.0000	7.55	0		54.18
2006	0		37.62	-		-	0		5.55	-	0.0000	6.99	0		50.16
2007	0		34.83	-		-	0		5.14	-	0.0000	6.47	0		46.45
2008	0		32.25	-		-	0		4.76	-	0.0000	5.99	0		43.01
2009	0		29.86	-		-	0		4.41	-	0.0000	5.55	0		39.82
2010	0		27.27	0.13		1.88	0		3.98	9.82	0.0059	6.10	9.95	0.1	39.23
2011	0		24.89	0.57		3.50	0		3.60	9.09	0.0054	6.53	9.66	0.1	38.52
2012	0		22.71	0.53		4.91	0		3.25	8.42	0.0050	6.87	8.95	0.1	37.73
2013	0		20.71	0.50		6.10	0		2.93	7.80	0.0046	7.12	8.30		36.86
2014	0		18.88	0.47		7.12	0		2.64	7.22	0.0043	7.29	7.69		35.93
2015	0		17.20	0.45		7.98	0		2.38	6.68	0.0040	7.40	7.13		34.96
2016	0		15.66	0.42		8.69	0		2.14	6.19	0.0037	7.46	6.61		33.94
2017	0		14.25	0.75		9.27	0		1.93	5.73	0.0034	7.46	6.48		32.91
2018	0		12.96	0.71		9.73	0		1.73	5.31	0.0032	7.43	6.01		31.85
2019	0		11.78	0.67		10.09	0		1.56	4.91	0.0029	7.35	5.58		30.78
2020	0		10.70	0.63		10.36	0		1.40	4.55	0.0027	7.25	5.18		29.71
2021	0		9.71	0.59		10.56	0		1.25	4.21	0.0025	7.12	4.80		28.65
2022	0		8.81	0.56		10.68	0		1.12	3.90	0.0023	6.98	4.46		27.58
2023	0		7.98	0.52		10.74	0		1.00	3.61	0.0022	6.81	4.13		26.53
2024	0		7.23	0.49		10.74	0		0.89	3.34	0.0020	6.63	3.84		25.50
2025	0		6.54	0.46		10.70	0		0.80	3.10	0.0018	6.44	3.56		24.48
2026	0		5.91	0.44		10.62	0		0.71	2.87	0.0017	6.24	3.30		23.49
2027	0		5.34	0.41		10.50	0		0.63	2.65	0.0016	6.04	3.07		22.51
2028	0		4.81	0.39		10.35	0		0.56	2.46	0.0015	5.83	2.85		21.56
2029	0		4.34	0.37		10.18	0		0.50	2.28	0.0014	5.62	2.64		20.64
2030	0		3.90	0.34		9.99	0		0.44	2.11	0.0013	5.41	2.45		19.74

Data Sources: Ministry of Agriculture, Water and Forestry; own calculations

3.2 Incremental changes in IF, FF, O&M costs and subsidy costs

Livestock sub-sector

Extension Services - As shown below in Table 25, incremental expenditures on investments on extension services is estimated to be zero over the time period shown, as the programmatic costs are the same under the two scenarios. O&M costs are expected to be slightly higher under the adaption scenario US$1.72 million, based on the slightly different impact of the measure on animal numbers in conjunction with the other adaptation measures.

The costs associated with the other measures considered are the same as those for the adaptation scenario, as under the BAU scenario, none of the measures are being undertaken.

Overall the costs of the measures described are estimated to be US$1.2 billion in terms of investment, US$9.4 million in terms of financial flows and US$1.2 billion for O&M costs. The share of those costs applicable to households is relatively small compared to the costs expected for corporations and government, which have similar costs for investments and O&M. It is worth noting that the high O&M cost reflects the impact of the measures on livestock numbers: as O&M costs are based on a cost per head, any change in numbers will increase O&M costs.

As a costing exercise, the impact of the measures on the benefits for the three actors is not considered, but assuming a profit margin on each cow sold, the measures are likely to increase benefits by at least as much as the increase in O&M costs.

Table 25.Livestock Incremental Cumulative Discounted IF, FF and O&M Estimates by Investment Type, Investment Entity and Funding Source (million 2005 US$)

	Extension services			Additional Extension services			Destocking			Choice of breeds		
Investment Entity Category/Source of Funds	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs
Households												
Domestic												
Equity & debt	0.00	0.00	1.29	0.00	0.00	8.36	0.00	0.00	-7.90	13.96	0.00	83.58
Total Household Funds	**0.00**	**0.00**	**1.29**	**0.00**	**0.00**	**8.36**	**0.00**	**0.00**	**-7.90**	**13.96**	**0.00**	**83.58**
Corporations												
Domestic												
Domestic equity	0.00	0.00	0.00	0.00	0	0.00	0.00	0	0.00	34.12	0	450.57
Domestic borrowing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.59	0.00	0.00
Total Domestic Sources	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**59.71**	**0.00**	**450.57**
Foreign												
FDI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Foreign borrowing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.59	0.00	0.00
ODA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Foreign Sources	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**25.59**	**0.00**	**0.00**
Total Corporation Funds	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**85.29**	**0.00**	**450.57**
Government												
Domestic												
Domestic funds	0.00	0.00	0.43	10.65	9.35	70.19	0.00	0.00	-2.63	121.81	0.00	27.86
Foreign												
Foreign borrowing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bilateral ODA	0.00	0.00	0.00	4.56	0.00	0.00	0.00	0.00	0.00	52.20	0.00	0.00
Multilateral ODA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Foreign Sources	**0.00**	**0.00**	**0.00**	**4.56**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**52.20**	**0.00**	**0.00**
Total Government Funds	**0.00**	**0.00**	**0.43**	**15.21**	**9.35**	**70.19**	**0.00**	**0.00**	**-2.63**	**174.02**	**0.00**	**27.86**
Total Funds	**0.00**	**0.00**	**1.72**	**15.21**	**9.35**	**78.55**	**0.00**	**0.00**	**-10.53**	**273.27**	**0.00**	**562.01**

Data Sources: Own calculations

Table 25.Livestock Incremental Cumulative Discounted IF, FF and O&M Estimates by Investment Type, Investment Entity and Funding Source (cont.) (million 2005 US$)

Game switching			Debushing			All investments		
IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs
0.00	0.00	0.00	0.00	0.00	8.03	13.96	0.00	93.36
0.00	**0.00**	**0.00**	**0.00**	**0.00**	**8.03**	**13.96**	**0.00**	**93.36**
						0.00	0.00	0.00
						0.00	0.00	0.00
35.98	0	511.49	168.89	0	55.42	238.99	0	1017.48
26.98	0.00	0.00	126.67	0.00	0.00	179.24	0.00	0.00
62.96	**0.00**	**511.49**	**295.56**	**0.00**	**55.42**	**418.23**	**0.00**	**1,017.48**
						0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26.98	0.00	0.00	126.67	0.00	0.00	179.24	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26.98	**0.00**	**0.00**	**126.67**	**0.00**	**0.00**	**179.24**	**0.00**	**0.00**
89.95	**0.00**	**511.49**	**422.23**	**0.00**	**55.42**	**597.47**	**0.00**	**1,017.48**
						0.00	0.00	0.00
						0.00	0.00	0.00
0.00	0.00	0.00	298.16	0.00	2.68	430.62	9.35	98.52
						0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	127.78	0.00	0.00	184.55	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	**0.00**	**0.00**	**127.78**	**0.00**	**0.00**	**184.55**	**0.00**	**0.00**
0.00	**0.00**	**0.00**	**425.95**	**0.00**	**2.68**	**615.17**	**9.35**	**98.52**
89.95	**0.00**	**511.49**	**848.18**	**0.00**	**66.12**	**1,226.61**	**9.35**	**1,209.36**

Data Sources: Own calculations

Table 26. Livestock Incremental Annual IF, FF and O&M Estimates by Investment Type (million 2005 US$)

	Extension services			Additional Extension services			Destocking			Choice of breeds		
Year	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs
2005	0.00	0.00	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-	0.00
2006	0.00	0.00	-0.05	0.00	-	0.00	0.00	-	0.00	0.00	-	0.00
2007	0.00	0.00	-0.08	0.00	-	0.00	0.00	-	0.00	0.00	-	0.00
2008	0.00	0.00	-0.11	0.00	-	0.00	0.00	-	0.00	0.00	-	0.00
2009	0.00	0.00	-0.14	0.00	-	0.00	0.00	-	0.00	0.00	-	0.00
2010	0.00	0.00	-0.28	0.17	0.00	5.11	0.00	-	-0.01	2.88	-	6.16
2011	0.00	0.00	-0.23	0.06	0.01	5.83	0.00	-	-0.03	5.06	-	11.32
2012	0.00	0.00	-0.18	0.23	0.29	4.92	0.00	-	-0.05	6.96	-	15.71
2013	0.00	0.00	-0.13	0.88	0.18	5.48	0.00	-	-0.09	8.61	-	19.40
2014	0.00	0.00	-0.09	1.41	0.90	5.18	0.00	-	-0.12	10.03	-	22.48
2015	0.00	0.00	-0.08	1.30	0.83	4.84	0.00	-	-0.16	10.59	-	24.65
2016	0.00	0.00	-0.04	1.21	0.77	4.56	0.00	-	-0.21	11.79	-	27.19
2017	0.00	0.00	0.01	1.12	0.71	4.29	0.00	-	-0.26	12.32	-	26.87
2018	0.00	0.00	0.05	1.03	0.66	4.05	0.00	-	-0.30	13.17	-	28.43
2019	0.00	0.00	0.09	0.96	0.61	3.82	0.00	-	-0.35	13.91	-	29.66
2020	0.00	0.00	0.12	0.89	0.57	3.60	0.00	-	-0.40	14.53	-	30.63
2021	0.00	0.00	0.16	0.82	0.52	3.40	0.00	-	-0.45	15.06	-	31.35
2022	0.00	0.00	0.19	0.76	0.49	3.21	0.00	-	-0.50	15.50	-	31.86
2023	0.00	0.00	0.22	0.70	0.45	3.04	0.00	-	-0.55	15.87	-	32.19
2024	0.00	0.00	0.25	0.65	0.42	2.87	0.00	-	-0.59	16.17	-	32.37
2025	0.00	0.00	0.28	0.60	0.39	2.72	0.00	-	-0.64	16.42	-	32.41
2026	0.00	0.00	0.30	0.56	0.36	2.57	0.00	-	-0.68	16.62	-	32.34
2027	0.00	0.00	0.33	0.52	0.33	2.44	0.00	-	-0.73	16.78	-	32.17
2028	0.00	0.00	0.35	0.48	0.31	2.32	0.00	-	-0.77	16.91	-	31.93
2029	0.00	0.00	0.37	0.44	0.28	2.20	0.00	-	-0.81	17.01	-	31.63
2030	0.00	0.00	0.39	0.41	0.26	2.09	0.00	-	-0.85	17.10	-	31.27

Data Sources: Own calculations

Table 26. Livestock Incremental Annual IF, FF and O&M Estimates by Investment Type (cont.) (million 2005 US$)

Game switching			Debushing			All investments		
IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs
0.00	-	0.00	0.00	-	0.00	0.00	-	0.00
0.00	-	0.00	0.00	-	0.00	0.00	-	-0.05
0.00	-	0.00	0.00	-	0.00	0.00	-	-0.08
0.00	-	0.00	0.00	-	0.00	0.00	-	-0.11
0.00	-	0.00	0.00	-	0.00	0.00	-	-0.14
5.88	-	13.13	71.64	-	0.00	80.57	0.00	16.81
5.76	-	24.26	66.97	-	0.00	77.85	0.01	27.67
5.63	-	33.61	62.63		0.00	75.44	0.29	35.32
5.48	-	41.40	58.57	-	0.00	73.54	0.18	43.05
5.32	-	47.79	54.79	-	0.00	71.55	0.90	48.70
5.16	-	52.97	51.26	-	2.99	68.31	0.83	55.80
4.99	-	57.08	48.07	-	3.32	66.05	0.77	60.22
4.81	-	60.25	45.10	-	3.59	63.34	0.71	61.33
4.63	-	62.60	42.32	-	3.82	61.16	0.66	63.93
4.45	-	64.24	39.72	-	4.00	59.04	0.61	65.86
4.28	-	65.27	37.29	-	4.15	56.99	0.57	67.22
4.10	-	65.76	35.03	-	4.27	55.00	0.52	68.08
3.92	-	65.80	32.91	-	4.36	53.09	0.49	68.51
3.75	-	65.45	30.93	-	4.42	51.25	0.45	68.57
3.58	-	64.77	29.08	-	4.46	49.49	0.42	68.31
3.42	-	63.81	27.35	-	4.49	47.79	0.39	67.79
3.26	-	62.61	25.74	-	4.49	46.17	0.36	67.05
3.10	-	61.23	24.23	-	4.48	44.63	0.33	66.12
2.95	-	59.70	22.81	-	4.46	43.16	0.31	65.04
2.80	-	58.04	21.49	-	4.43	41.76	0.28	63.83
2.66	-	56.29	20.26	-	4.39	40.43	0.26	62.53

Data Sources: Own calculations

Crop sub-sector

Table 27 (below) shows the estimated incremental costs associated with the BAU and adaption scenarios for crop production. The projection scope covers the following production systems:

Rain-Fed subsistence – for rain-fed subsistence IF, FF incremental costs are assumed to be zero, while O&M costs are estimated to be US$-37.5 million (i.e. a saving). This reflects the movement for some subsistence farmers away from this production system towards rainfed mechanised farming.

Rain-fed Mechanization- for rain-fed mechanization, the incremental costs are equal to the costs under the adaption scenario. Investment flows into the rain-fed mechanization production system is expected to be done by government, in terms of converting otherwise rainfed subsistence farming into this farming method. These costs are estimated at US$7.3 million. Households are expected to provide US$184.7 million in the form of equities and debts for O&M costs for mechanization.

Rain Fed Commercial- in common with the costs for rainfed subsistence farming, there are no expected difference in costs between BAU and adaptation scenarios for this production system. As with rainfed subsistence, there is a saving with the adaptation scenario in comparison with the BAU scenario for O&M, although this time the saving is for corporations (US$8.7 million). This saving reflects the movement away from this system towards irrigation under the adaptation scenario.

Irrigation commercial- For irrigation commercial production system the incremental costs fall on both the government and corporations. Incremental investment costs are estimated at US$186.1 million for Corporations and US$233.6 for Government. O&M costs are estimate to be US$21.8 million higher under the adaptation scenario for Corporations.

Table 27. Crop Incremental Cumulative Discounted IF, FF and O&M Estimates by Investment Type, Investment Entity and Funding Source (million 2005 US$)

	Rain fed Subsistence			Rain fed mechanisation			Rain fed Commercial			Irrigation Commercial			All investments		
Investment Entity Category/Source of Funds	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs
Households															
Domestic															
Equity & debt	-	-	-37.5	-	-	184.7	-	-	-	-	-	-	-	-	147.1
Total Household Funds	**-**		**-37.5**	**-**		**184.7**	**-**		**-**	**-**		**-**	**-**		**147.1**
Corporations															
Domestic															
Domestic equity	-	-	-	-	-	-	-	-	-8.7	39.4	-	21.8	39.4	-	13.1
Domestic borrowing	-	-	-	-	-	-	-	-	-	44.2	-	-	44.2	-	-
Total Domestic Sources	**-**		**-**	**-**		**-**	**-**		**-8.7**	**83.6**		**21.8**	**83.6**		**13.1**
Foreign															
FDI	-	-	-	-	-	-	-	-	-	58.4	-	-	58.4	-	-
Foreign borrowing	-	-	-	-	-	-	-	-	-	44.2	-	-	44.2	-	-
ODA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Foreign Sources	**-**		**-**	**-**		**-**	**-**		**-**	**102.5**		**-**	**102.5**		**-**
Total Corporation Funds	**-**		**-**	**-**		**-**	**-**		**-8.7**	**186.1**		**21.8**	**186.1**		**13.1**
Government															
Domestic															
Domestic funds	-		-	7.3	-	-	-	-	-	58.4	0.1	-	65.7	0.1	-
Foreign			-	-	-	-	-	-	-	-	-	-	-	-	-
Foreign borrowing	-		-	-	-	-	-	-	-	58.4	-	-	58.4	-	-
Bilateral ODA	-		-	3.1	-	-	-	-	-	58.4	-	-	61.5	-	-
Multilateral ODA	-		-	-	-	-	-	-	-	58.4	-	-	58.4	-	-
Total Foreign Sources	-		**-**	**3.1**		**-**	**-**		**-**	**175.2**		**-**	**178.3**		**-**
Total Government Funds	**-**		**-**	**10.4**		**-**	**-**		**-**	**233.6**	**0.1**	**-**	**244.0**	**0.1**	**-**
Total Funds	**-**		**-37.5**	**10.4**		**184.7**	**-**		**-8.7**	**419.7**	**0.1**	**21.8**	**430.1**	**0.1**	**160.2**

Data Sources: own calculations

Table 28. Crop Incremental Annual IF, FF and O&M Estimates by Investment Type (million 2005 US$)

	Rain fed Subsistence			Rain fed mechanisation			Rain fed Commercial			Irrigation Commercial			All investments		
Year	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs
2005	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2008	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2009	-	-	-	-	-	-	-	-	-	-	-		-	-	-
2010	-	-	-0.38	0.13	-	1.88	-	-	-0.10	1.01	0.01	0.24	1.13	0.1	1.64
2011	-	-	-0.71	0.57	-	3.50	-	-	-0.18	0.93	0.01	0.45	1.50	0.1	3.06
2012	-	-	-1.00	0.53	-	4.91	-	-	-0.25	0.86	0.01	0.62	1.40	-0.1	4.28
2013	-	-	-1.24	0.50	-	6.10	-	-	-0.31	0.80	0.00	0.77	1.30	-	5.33
2014	-	-	-1.45	0.47	-	7.12	-	-	-0.36	0.74	0.00	0.89	1.21	-	6.21
2015	-	-	-1.62	0.45	-	7.98	-	-	-0.40	0.69	0.00	0.99	1.13	-	6.95
2016	-	-	-1.77	0.42	-	8.69	-	-	-0.43	0.64	0.00	1.07	1.05	-	7.56
2017	-	-	-1.88	0.75	-	9.27	-	-	-0.45	0.59	0.00	1.13	1.34	-	8.06
2018	-	-	-1.98	0.71	-	9.73	-	-	-0.47	0.54	0.00	1.18	1.25	-	8.46
2019	-	-	-2.05	0.67	-	10.09	-	-	-0.49	0.50	0.00	1.22	1.17	-	8.77
2020	-	-	-2.11	0.63	-	10.36	-	-	-0.50	0.47	0.00	1.24	1.09	-	9.00
2021	-	-	-2.15	0.59	-	10.56	-	-	-0.50	0.43	0.00	1.25	1.02	-	9.16
2022	-	-	-2.17	0.56	-	10.68	-	-	-0.50	0.40	0.00	1.25	0.96	-	9.26
2023	-	-	-2.18	0.52	-	10.74	-	-	-0.50	0.37	0.00	1.25	0.89	-	9.31
2024	-	-	-2.18	0.49	-	10.74	-	-	-0.50	0.34	0.00	1.24	0.84	-	9.30
2025	-	-	-2.18	0.46	-	10.70	-	-	-0.49	0.32	0.00	1.23	0.78	-	9.26
2026	-	-	-2.16	0.44	-	10.62	-	-	-0.48	0.29	0.00	1.21	0.73	-	9.18
2027	-	-	-2.13	0.41	-	10.50	-	-	-0.47	0.27	0.00	1.18	0.68	-	9.08
2028	-	-	-2.10	0.39	-	10.35	-	-	-0.46	0.25	0.00	1.16	0.64	-	8.94
2029	-	-	-2.07	0.37	-	10.18	-	-	-0.45	0.23	0.00	1.13	0.60	-	8.79
2030	-	-	-2.03	0.34	-	9.99	-	-	-0.44	0.22	0.00	1.09	0.56	-	8.61

Data Sources: own calculations

3.4 Policy implications

The impact of climate change on the Namibian farming system is difficult to ascertain given the uncertain impacts of climate change over the next 20 years. Predicted increases in temperatures leading to high rates of evaporation as well as increased variability of rainfall however suggest that in general terms farming will become even more of a marginal activity than is currently the case in Namibia. Based on predicted population and economic growth rates, climate change therefore poses a significant challenge to establishing food security.

Although a self sustaining food economy is perhaps the surest way to guarantee such food security, as a modern, economically diverse and open economy, food security can be found in numerous other ways, the most obvious being robust trade agreements that make use of global comparative advantage. However, there are measures that Namibia can take to counteract the impact of climate change, some of which have been considered here, which aim to increase the productivity of farming, reducing the need for imports to a certain extent.

Other measures, such as improving land tenure in communal areas could also be investigated, opening up markets at enabling communal farmer's surety on loan agreements.

In order to achieve sustainable livestock and crop production the following policy implications and options need to be considered and implemented on a medium and long-term.

Medium -Term Policy Implications and Options

- Expansion of land under irrigation/Scaling up of irrigation schemes. Based on the current analysis and suggested growth under the adaptation scenario, this would cost an additional US$420 million to implement, with an increase of US$22 million in O&M costs. The expected approximate increased yield from this measure would be approximately 44,000 tonnes of additional grain, or 30 percent of 2005 production tonnage. Note that this increased tonnage assumes that water availability, in terms of abstraction from perennial rivers, is sufficient.
- Mechanisation of subsistence farming could be another measure to be considered in future. Based on our analysis, a programme of mechanisation (principally improving the availability of machinery) would likewise lead to an approximate increase in tonnes of grain produced over the period of analysis, by around 74,000 tonnes, or 51% of 2005 total tonnes produced. This measure would cost around US$10.4 million in investment costs, with an increase of US$147 million O&M costs over the time period of analysis.
- Invest in the expansion of agricultural extension services to communal areas. Extension services provide communication, advisory and training services to communal farmers. This contributes to the implementation of effective drought preparedness and responsive drought management system. Expansion of extension services will be pertinent to farmers i.e. to be on standby to provide need advisory services in the wake of climate change related risks. Our analysis suggests that a doubling of funding to extension services could lead to an approximate increase of 12,000 additional cattle and 20,000 small stock being slaughtered per annum in communal areas by 2030.

- Choice of breeding livestock- climate resilient breeds. For this option to materialize, effective awareness raising campaigns should be undertaken to sensitize farmers. However research has shown that whilst providing less meat per animal, smaller framed animals provide as great a yield of meat as larger framed animals as they require less grazing land per animal.
- Sensitisation of need for livestock number reduction in communal area to match carrying capacity of communal rangeland. This is a sensitive issue that crosses cultural boundaries and ties in with the issue of land tenure. However, even if overall offtake could remain constant given the effective increase in land area available per animal, costs would be reduced allowing for household investment in other livelihood aspects.

Long-Term Policy Implications and Options

- The Government's National Agriculture Policy should be revised to embed/streamline climate change issues into its projects and programmes.
- The realization of the proposed adaptation options and the successful implementation thereof depends on the commitment of the Government and development partners to mobilize and set aside sufficient financial resources for climate change adaptation.
- Empowerment of communities and farmers through capacity strengthening is pertinent to strong buy-in and communities and farmers openness to implement the proposed adaptation options.
- Identification, development and implementation of appropriate technologies to promote adaptation to changed conditions. This assessment is proposing particularly mechanization of subsistence crop production in communal areas to replace traditional practices.
- Supporting the implementation of monitoring networks (including community observation and traditional knowledge) to identify emerging climate trends and impacts on food production/security etc. Improved early warning systems, preparedness and access to high quality information is crucial for effective response to impacts of climate related risks, therefore development of monitoring networks are viable options.
- Switching to game production. Studies have shown that game adapts better (in comparison to livestock) to dry conditions. The sensitization of farmers to switch to game productions as a complementary to livestock production is proposed, together with increased utilisation of game as a meat resource is a sound strategy that could be pursued.
- De-bushing to improve rangeland productivity is a proposition that could be carried out over the longer term. Although our analysis shows this measure to be costly, it would provide employment and a wood resource, the benefits of which have not been assessed.

Other adaptation options that government and other stakeholders can consider

- Improved conservation agriculture and water conservation practices including timing of activities, tillage practices, inter-cropping etc. As Namibia is already water constrained, water conservation practices will offer opportunities for adapting to increased variability

of rainfall, decreased precipitation and increased temperatures. Conservation agriculture will offer opportunities for improved soil conditions therefore contributing to increased yields in rain-fed environment.

- Improved storage facilities to ensure food security in lean periods(e.g. drought years).
- Government should promote the marketing and slaughtering of communal farmers livestock and assist in the training of communal farmers on animal health.
- On crop production government is advised to scale up the research and development as well as extension services aimed at improving crop varieties. Government should also encourage the use of bio and mineral fertilizers and provide subsidy to communal farmers.
- Government is also advised to improve its early warning systems and to provide reliable /accurate weather forecasting rainfall patterns.

3.5 Key uncertainties and methodological limitations

Livestock Model

Data and time constrains have meant that the model developed for assessing the I&FF relating to the livestock sector has a relatively narrow scope of analysis. The focus of this analysis has been the meat market, specifically for beef, game and mutton meat. Other areas that will also be heavily impacted by climate change, such as dairy production or leather and skin production have not been included in this analysis and are areas that could be investigated with further work. Likewise, the various adaptation measures that have been assessed are not exhaustive and as such further work could expand on the current analysis to evaluate the costs and efficacy of further measures.

In common with all models relying on future projections, there is an inherent uncertainty about the model outputs. In this case this is compounded by the relative lack of data on climate change in Namibia, itself a highly uncertain prospect. Whilst there have been several reports detailing the broad changes that may emerge for the agricultural sector as a result of climate change, there has been little specific research on agriculture. It is recommended that such research be carried out in the future, for example assessing the likely change in carrying capacity as a result of climate change.

A key limitation of the model (and perhaps a weakness) concerns the important impact of water availability on the agricultural sector. Although not made explicit, implicitly it is assumed that water availability is captured by the expected climate change impact on the sector. In reality, water availability is a key constraint on agricultural production in Namibia and so a greater consideration of how this would affect production could be assessed, along with the various measures, such as rainwater harvesting. Again data constraints limit the potential of this analysis: for example, the impact of high use of groundwater supplies by Livestock farmers has received less attention than perhaps the significance of this issue demands.

Another major stumbling block regarding data is the lack of availability of information on the funding sources of the projects. There is no historical data available on the sources of funding of any of the economic agents (i.e. households, corporations or government) but even if there was, raising funds depends on a number of factors such as available capital in the country, willingness of domestic investors to lend, domestic interest rates vis-à-vis foreign interest or foreign exchange rates. In this case, it is almost impossible to know with certainty the origin of financing beyond a one year span. A final important limitation within the model concerns the use of averages across the whole model, from the average costs of production to the average impact that climate change will have on the sector. Clearly the costs and impacts facing farmers across Namibia will vary, but for the macro-level analysis as required, such a general approach is sufficient. However, an assessment at a more local level is recommended, given the potential variation that occurs across the country.

Crop Model

Due to time and data constraints, the model is not exhaustive. It only considers three crops (wheat; maize; and mahangu and sorghum) and three adaptation measures (training for irrigation farmers, increase of land under irrigation and mechanisation of rainfed subsistence land), leaving room for more exhaustive research on the impact of climate change on the overall agricultural sector.

Besides, as with all models dealing with projections into the future there is an inevitable level of uncertainty regarding future trends. This uncertainty is somehow exacerbated by the fact that the unavailability of sufficient historical data points on all the variables precludes the use of econometric projections. Instead, we had to resort to simple extrapolation by using the average of the figures of the previous five years (the maximum available) or, where enough data was not available, we had to resort to expert opinion. This problem is compounded in this report by the lack of official studies focusing on the potential impact of climate change on crop production in Namibia which forced us to rely on a study focusing on Botswana.

Another major stumbling block regarding data is the unavailability of information on the funding sources of the projects. There is no historical data available on the sources of funding of any of the economic agents (i.e. households, corporations or government) but even if there was, raising funds depends on a number of factors such as available capital in the country, willingness of domestic investors to lend, domestic interest rates vis-à-vis foreign interest or foreign exchange rates. In this case, it is almost impossible to know with certainty the origin of financing beyond a one year span.

Problems with the data aside, the major limitations of the model relate to productivity and the availability of water. With regards to productivity, due to data unavailability we are assuming that all land has the same yield potential regardless of its geographical location (albeit each crop has a different yield). This could be a significant drawback if productivity varied significantly among the different regions of the country.

With regards to the availability of water, the absence of a study focusing on the impact of climate change also means that there are not precise figures linking the potential land that can be cultivated and the water that might be available in the coming years. We tried to limit this problem by curbing the amount of land that is transferred from rainfed to irrigation, but we had to rely on expert guesswork rather than figures derived from scientific sources.

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Annexes

Annex A – Assumptions used in the livestock model

Assumption		Reference/Basis	Further details
Population growth rate per annum	1.7% average	National Planning Commission personal communication	
Estimated GDP growth per annum	4% average	World Development Indicators Database – World Bank	Average of growth rates 2000-2005
Discount rate	8%		Based on the return on Long Term Government bonds
N$/US$, 2005	6.41	www.oanda.com	Average annual rate
Income Elasticity of Demand for meat	0.91	Elam, 2009	Based on analysis of FAO data on meat production and World Bank data on consumer expenditures. Consumer expenditures assumed a proxy for income; production as a proxy for demand
Climate change reduction on grazing capacity of a ha. for differing animal types (both subsistence and commercial farming)	• Cattle: 23% • Game: 13% • Small stock: 33%	Reid et al., 2007 – Cattle and Small stock - Game	Based on broad estimates for Namibia
Land area decrease 2005 to 2030	Subsistence cattle – 13,462 ha. Other land use constant		Based on the land use change as a result of increased area for arable cropping (see above)

Average animal off-take per annum (n.b. assumed constant over the time period of analysis)	• Cattle
	  • Subsistence – 7%
	  • Commercial – 36%
	• Game
	  • Subsistence – 0.5%
	  • Commercial – 0.5%
	• Small stock
	  • Subsistence – 20%
	  • Commercial – 48%
		Slaughter statistics from MAWF
		Cattle and small stock numbers from MAWF
		Export statistics from MAWF
		Game numbers from Brown, 2007
			Cattle and Small stock off-take are based on slaughter statistics and statistics on animal numbers.
			Game off-take figures are based on export figures, the estimated share of exports to local consumption (using cattle figures) and game numbers

Land utilised by livestock type million ha. 2005	• Cattle • Subsistence – 17.86	Mendolsohn 2006 Conservancy statistics	Cattle and small stock area derived from Mendolsohn (2006).

	• Commercial – 14.5
	• Game
	  • Subsistence – 13.3
	  • Commercial – 2.63
	• Small stock
	  • Subsistence – 7.99
	  • Commercial – 21.4
			Subsistence game area used the area under conservancy support as a proxy
			Commercial game area is extrapolated from the International Development Consultancy (2005, from Mendolsohn 2006) figures on game meat output per ha., average animal weights for Kudu, Oryx and Springbok and estimate consumption figures (as above)

Land utilised by livestock type million ha, 2030 adaptation scenario	• Cattle
	  • Subsistence – 17.85
	  • Commercial – 13.05
	• Game
	  • Subsistence – 13.3
	  • Commercial – 6.22
	• Small stock
	  • Subsistence – 7.99
	  • Commercial – 19.23
			Reductions from 2005 figures based on change in land utilisation by arable farming and due to adaptation measure regarding switching land use to game production

Average deboned meat weight per animal (kg), 2005	• Cattle – 204.94 • Game – 60.68 • Small stock - 18	Market statistics from the Meat Board of Namibia	Cattle and small stock weights are an average from 2000-2009 from the Meat Board of Namibia Game weight is an average of small stock and cattle weight
Average deboned meat weight per animal (kg), 2030, under adaptation scenario	• Cattle – 162.92 (Sanga/Nguni) • Game – 60.68 (as above) • Small stock – 16.63 (Tswana)	Omatjenne Research Station data, MAWF MAWF data Meat Board of Namibia	Conversion of liveweight to deboned weight based on Meat Board data

BAU and Adaptation scenario: Impact of Extension services (current Government policy) on grazing capacity 2005-2030	• Cattle
	  • Subsistence – 5%
	  • Commercial – 0%
	• Game
	  • Subsistence – 5%
	  • Commercial – 0%
	• Small stock
	  • Subsistence – 5%
	  • Commercial – 0%
			Estimate, based on discussions with experts at MAWF

Adaptation scenario: Impact of additional Extension services on grazing capacity 2005-2030	• Cattle
	  • Subsistence – 5%
	  • Commercial – 0%
	• Game
	  • Subsistence – 5%
	  • Commercial – 0%
	• Small stock
	  • Subsistence – 5%
	  • Commercial – 0%
			A doubling of funding assumed to have a doubling of impact

Adaptation scenario: Impact of animal no. reductions by 20% in subsistence cattle farming on grazing capacity 2005-2030	• Cattle
	  • Subsistence – 25%
	  • Commercial – 0%
	• Game
	  • Subsistence – 0%
	  • Commercial – 0%
	• Small stock
	  • Subsistence – 0%
	  • Commercial – 0%
			Calculated based on the minimum increase in grazing capacity to keep off-take constant with 2005 figures

Adaptation scenario: Impact of changed breed choices cattle and small stock 2005-2030	• Cattle
	  • Subsistence – 50%
	  • Commercial – 50%
	• Small stock
	  • Subsistence – 50%
	  • Commercial – 50%
		Spotlight on Agriculture, MAWF, 1998	Based on observed differences in herd sizes for small and large frames cattle (small stock change assumed to be the same). Note that the deboned weight per animal reduces as a result of this change (see above)

Adaptation scenario: Impact of animal no. reductions by 20% in subsistence cattle farming on grazing capacity 2005-2030	• Cattle
	  • Subsistence – 25%
	  • Commercial – 0%
	• Game
	  • Subsistence – 0%
	  • Commercial – 0%
	• Small stock
	  • Subsistence – 0%
	  • Commercial – 0%		

Adaptation scenario: Impact of debushing on grazing capacity 2005-2030	• Cattle
	  • Subsistence – 5.98%
	  • Commercial – 6.63%
	• Game
		De Klerk, 2004	Impacts based on proposal for debushing from de Klerk and calculated impacts on grazing capacity

	• Subsistence – 0% • Commercial – 0.9% • Small stock • Subsistence – 4.46% • Commercial – 4.01%		
Investment costs N$ per animal (unless otherwise stated) – cattle	• Extension services • Subsistence – 6,014,119 (programmatic costs) • Commercial - 0 • Additional extension services • Subsistence - 6,014,119 (programmatic costs) • Commercial - 0 • Choice of breed • Subsistence bull – 25,000 • Subsistence heifer – 7,500 • Commercial bull – 25,000 • Commercial heifer – 7,500 • Game switching • Subsistence - 0 • Commercial - 0 • Debushing • Subsistence – 150 (per ha.) • Commercial – 150 (per ha.	MAWF data MET Wildlife Accounts, 2007 De Klerk, 2004	Investment costs for extension services are based on current costs for extension services provided by MAWF. Costs relating to choice of breed are based on information provided by MAWF Costs for debushing are from de Klerk
Investment costs N$ per animal (unless otherwise stated) – game	• Extension services • Subsistence – 6,014,119 (programmatic costs) • Commercial - 0 • Additional extension services • Subsistence - 6,014,119 (programmatic costs) • Commercial - 0 • Game switching • Subsistence - 767 • Commercial - 767	MAWF data	Investment costs for extension services are based on current costs for extension services provided by MAWF. Game switching costs relate to the average purchase cost of Kudu, Oryx and Springbok from MET Wildlife Accounts
Investment costs N$ per animal (unless otherwise stated) – small stock	• Extension services • Subsistence – 6,014,119 (programmatic costs)	MAWF data MET Wildlife Accounts, 2007	Investment costs for extension services are based on current costs for extension services provided by

	• Commercial - 0
	• Additional extension services
	  • Subsistence - 6,014,119 (programmatic costs)
	  • Commercial - 0
	• Choice of breed
	  • Subsistence ram – 1,800
	  • Subsistence ewe – 550
	  • Commercial ram – 1,800
	  • Commercial ewe – 550
	• Game switching
	  • Subsistence - 0
	  • Commercial - 0
	• Debushing
	  • Subsistence – 150 (per ha.)
	  • Commercial – 150 (per ha.
		De Klerk, 2004	MAWF.
			
			Costs relating to choice of breed are based on information provided by MAWF
			
			Costs for debushing are from de Klerk

Financial flows N$ per animal (unless stated)- cattle	• Extension services
	  • Subsistence – 3,841,177 (programmatic costs)
	  • Commercial - 0
	• Additional extension services
	  • Subsistence - 3,841,177 (programmatic costs)
		MAWF data	Investment costs for extension services are based on current costs for extension services provided by MAWF.

Financial flows N$ per animal (unless stated)- game	• Extension services
	  • Subsistence – 3,841,177 (programmatic costs)
	  • Commercial - 0
	• Additional extension services
	  • Subsistence - 3,841,177 (programmatic costs)
	  • Commercial - 0
		MAWF data	Investment costs for extension services are based on current costs for extension services provided by MAWF.

Financial flows N$ per animal (unless stated)- small stock	• Extension services
	  • Subsistence – 3,841,177 (programmatic costs)
	  • Commercial - 0
	• Additional extension services
	  • Subsistence - 3,841,177 (programmatic costs)
		MAWF data	Investment costs for extension services are based on current costs for extension services provided by MAWF.

	• Commercial - 0		

Operations and maintenance costs N$ per animal (unless stated) - cattle	• Extension services
	  • Subsistence – 20,390,015 (programmatic costs)
	  • Commercial - 0
	• Additional extension services
	  • Subsistence - 20,390,015 (programmatic costs)
	  • Commercial – 0
	• General Subsistence (all) – 163
	• General Commercial (Meat animals) – 2,218; (Breeding animals) – 1,034
		MAWF data	N.b. 1 bull to 25 heifers assumed

Operations and maintenance costs N$ per animal (unless stated) – game	• Extension services
	  • Subsistence – 20,390,015 (programmatic costs)
	  • Commercial – 0
	• Additional extension services
	  • Subsistence – 20,390,015 (programmatic costs)
	  • Commercial – 0
	• General Subsistence (all) – 0
	• General Commercial (all) – 1,439
		MAWF data	

Operations and maintenance costs N$ per animal (unless stated) – small stock	• Extension services
	  • Subsistence – 20,390,015 (programmatic costs)
	  • Commercial - 0
	• Additional extension services
	  • Subsistence - 20,390,015 (programmatic costs)
	  • Commercial – 0
	• General Subsistence (all) – 92
	• General Commercial (Meat animals) – 510; (Breeding animals) – 253
		MAWF data	N.b. 1 ram to 50 ewes assumed

Percentage of costs paid by each agent – general O&M costs farming	• Subsistence
	  • Household: 75%,
	  • Business: 0%,
	  • Government: 25%
	• Commercial
		MAWF data	

	• Household: 0%, • Business: 100%, • Government: 0%		

Percentage of costs paid by each agent – extension services and additional extension services	• Subsistence
	  • Household: 0%,
	  • Business: 0%,
	  • Government: 100%
	• Commercial
	  • Household: 0%,
	  • Business: 0%,
	  • Government: 100%
		MAWF data	

Percentage of costs paid by each agent – destocking	• Household: 20%, • Business: 0%, • Government: 80%	MAWF data	

Percentage of O&M costs paid by each agent – choice of breeds	• Subsistence
	  • Household: 7%,
	  • Business: 0%,
	  • Government: 93%
	• Commercial
	  • Household: 0%,
	  • Business: 100%,
	  • Government: 0%
		MAWF data	Current subsidy provided to communal farmers for bulls is 93% of auction value

Percentage of O&M costs paid by each agent – game switching	• Commercial
	  • Household: 0%,
	  • Business: 100%,
	  • Government: 0%		

Percentage of O&M costs paid by each agent – debushing	• Subsistence
	  • Household: 0%,
	  • Business: 0%,
	  • Government: 100%
	• Commercial
	  • Household: 0%,
	  • Business: 15%,
	  • Government: 85%
		MAWF data	

Annex B – Assumptions used in the crop model

Assumption		Reference/Basis	Further details
Population growth rate per annum	1.7% average	National Planning Commission personal communication	
Estimated GDP growth per annum	4% average	World Development Indicators Database – World Bank	Average of growth rates 2000-2005
Discount rate	8%		Based on the return on Long Term Government bonds
N$/US$, 2005	6.41	www.oanda.com	Average annual rate
Income Elasticity of Demand for grain	0 (i.e. no response to changes in income)		No clear evidence found of relationship between income growth and demand for cereals
Climate change reduction on productivity of a ha. to produce crops: rainfed	• Wheat – N/A (all wheat irrigated) • Maize – 30% • Mahangu and Sorghum – 30%	Reid et al., 2007	Based on broad estimates for Namibia
Climate change reduction on productivity of a ha. to produce crops: irrigated	• Wheat – 15% • Maize – 15% • Mahangu and Sorghum – N/A (all M&S rainfed)	Reid et al., 2007	Based on broad estimates for Namibia
Land area increase 2005 to 2030	6,757 ha. for wheat, 6,705 for maize	PWC, 2005	Based on the green scheme horticultural initiative
Grain stock as a share of previous year's production	10%	MAWF data	
Costs based on a per ha. basis on average	Assumed fixed over time		Simplifying assumption
Investment costs per ha. - wheat	• Commercial irrigation (previously non-agricultural land) – N$174,271	MAWF data	
Investment costs per ha.- maize	• Rainfed mechanised – N$1,877; • Commercial irrigation (previously non-agricultural land) – N$174,271 • Commercial irrigation (previously farmed land) – N$63,571	MAWF data	
Investment costs per ha. – magangu and sorghum	• Rainfed mechanised – N$2,111;	MAWF data	
O&M costs per ha. - wheat	• Commercial irrigation – N$12,899	MAWF data	

O&M costs per ha. – maize	• Rainfed subsistence – N$1,280; • Rainfed mechanised – N$6,294 • Rainfed commercial – N$6,126 • Commercial irrigation – N$15,316	MAWF data	
O&M costs per ha. – mahangu and sorghum	• Rainfed subsistence – N$1,280 • Rainfed mechanised – N$6,297	MAWF data	
Training costs per ha.	• N$76	MAWF data	
Percentage of IF costs paid by each agent – subsistence farming	• Household: 0%, • Business: 0%, • Government 100%:		
Percentage of IF costs paid by each agent – commercial farming	• Household: 0%, • Business: 100%, • Government: 0%		
Percentage of O&M costs paid by each agent – subsistence farming	• Household: 100%, • Business: 0%, • Government: 0%		
Percentage of O&M costs paid by each agent – commercial farming	• Household: 0%, • Business: 100%, • Government: 0%		
Breakdown of funding by source: IF	• Business – domestic equity 40%, domestic borrowing 30% and foreign borrowing 30% • Government – domestic funds 70%, bilateral ODA 30%		
Breakdown of funding by source: O&M	• Business – domestic equity 100% • Government – domestic funds 100%		
Breakdown of funding by source: FF	• Government – domestic funds 100%		