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DEVELOPMENT AND CLIMATE CHANGE IN TANZANIA: FOCUS ON MOUNT KILIMANJARO

by

Shardul Agrawala, Annett Moehner, Andreas Hemp, Maarten van Aalst, Sam Hitz, Joel Smith, Hubert Meena, Stephen M. Mwakifwamba, Tharsis Hyera and Obeth U. Mwaipopo

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FOREWORD

This document is an output from the OECD Development and Climate Change project, an activity being jointly overseen by the Working Party on Global and Structural Policies (WPGSP) of the Environment Directorate, and the Network on Environment and Development Co-operation of the Development Co-operation Directorate (DAC-Environet). The overall objective of the project is to provide guidance on how to mainstream responses to climate change within economic development planning and assistance policies, with natural resource management as an overarching theme. Insights from the work are therefore expected to have implications for the development assistance community in OECD countries, and national and regional planners in developing countries.

This document has been authored by Shardul Agrawala and Annett Moehner. It draws upon four primary consultant inputs that were commissioned for this country study: “Climate Impacts and Responses in Mount Kilimanjaro” by Andreas Hemp (University of Bayreuth, Germany); “Review of Development Plans, Strategies, Assistance Portfolios, and Select Projects Potentially Relevant to Climate Change in Tanzania” by Maarten van Aalst of Utrecht University, The Netherlands; “Analysis of GCM Scenarios and Ranking of Principal Climate Impacts and Vulnerabilities in Tanzania” by Stratus Consulting, Boulder, USA (Sam Hitz and Joel Smith); and “Development and Climate Change in Tanzania” by the Center for Energy, Environment, Science and Technology (CEEST), Dar es Salaam, Tanzania (Hubert Meena, Stephen M. Mwakifwamba, Tharsis Hyera, and Obeth U. Mwaipopo).

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Further inquiries about either this document or ongoing work on sustainable development and climate change should be directed to Shardul Agrawala of the OECD Environment Directorate: shardul.agrawala@oecd.org, or Georg Caspary of the OECD Development Co-operation Directorate: georg.caspary@oecd.org.

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EXECUTIVE SUMMARY

This report presents the integrated case study for Tanzania carried out under an OECD project on Development and Climate Change. The report is structured around a three-tiered framework. First, recent climate trends and climate change scenarios for Tanzania are assessed, and key sectoral impacts are identified and ranked along multiple indicators to establish priorities for adaptation. Second, donor portfolios in Tanzania are analyzed to examine the proportion of donor activities affected by climate risks. A desk analysis of donor strategies and project documents as well as national plans is conducted to assess the degree of attention to climate change concerns in development planning and assistance. Third, an in-depth analysis is conducted for climate change impacts and response strategies for Mount Kilimanjaro – a critical ecosystem, biodiversity hotspot, and source of freshwater. This part of the analysis draws upon extended field research by a case study consultant in collaboration with national and international partners.

Analysis of recent climate trends reveals that climate change poses significant risks for Tanzania. While projected changes in precipitation are uncertain, there is a high likelihood of temperature increases as well as sea level rise. Climate change scenarios across multiple general circulation models show increases in country averaged mean temperatures of 1.3°C and 2.2°C projected by 2050 and 2100, which are broadly consistent, though lower than, projections used in Tanzania's Initial National Communication. The sectors potentially impacted by climate change include agriculture, forests, water resources, coastal resources, human health, as well as energy, industry and transport.

While uncertainties in climate change and impact projections pose a challenge for anticipatory adaptation in any country, Tanzania's case has several specific characteristics that might suggest the need for a differentiated adaptation strategy. First, the climate change projections which form the basis of national assessments rely on an older generation of climate models which project higher temperature increases than more recent models analyzed in the present study. Updating of climate scenarios and impact projections through the use of multiple and more recent models might therefore be advisable prior to the formulation of aggressive (and potentially expensive) adaptation responses. A second characteristic feature of Tanzania is that certain sectors such as agriculture and water resources are projected to experience both negative and positive impacts under climate change – for example, while production of maize is projected to decline, the production of two cash crops (coffee and cotton) is projected to increase. The implication for adaptation therefore may be to not only cushion adverse impacts, but also to harness positive opportunities. A third key characteristic is that unlike most other countries where the need for adaptation relies on projections of *future* impacts, some discernible trends in climate and attendant impacts are already underway in Tanzania. Such impacts – as is the case of the Kilimanjaro ecosystem - argue for more immediate adaptation responses as opposed to a "wait and see" strategy.

Tanzania receives close to a billion US dollars of Official Development Assistance (ODA) annually. Analysis of donor portfolios in Tanzania using the OECD-World Bank Creditor Reporting System (CRS) database reveals that between 12-25% of development assistance (by aid amount) or 20-30% of donor projects (by number) are in sectors potentially affected by climate risks. However, these numbers are only indicative at best, given that any classification based on sectors suffers from over-simplification – the reader is referred to the main report for a more nuanced interpretation. Donor and government documents generally do not mention climate change explicitly, although frequent references are made to the impacts of climate variability and their linkages to economic performance. There is however considerable synergy between priorities of at least some national plans and measures that might be required for climate change adaptation, such as water conservation, improving agricultural resilience, and forest conservation. However, some of these goals (such as water conservation) had been articulated, though not successfully implemented in previous plans. Therefore, a key obstacle facing “mainstreaming” is not synergies at the level of planning documents, but rather the successful implementation of such plans.

The in-depth sector analysis focuses on the climate change impacts and policy responses on the Mount Kilimanjaro ecosystem. Glaciers on Mount Kilimanjaro have been in a general state of retreat on account of natural causes for over a hundred and fifty years. Due to a decline in precipitation coupled with a local warming trend that has been recorded in the second half of the twentieth century Kilimanjaro’s ice cap is now projected to vanish entirely by as early as 2020. The symbolism of this loss is indeed significant, and furthermore the loss of the ice cap would also imply that valuable records of past climates contained in its ice cores would also be irreplaceably destroyed. From a physical and socio economic perspective however, this analysis concludes that the impact of the loss of the ice cap is likely to be very limited. Much more significant is the enhancement in the intensity and risk of forest fires on Mount Kilimanjaro as a consequence of the increase in temperatures and a concomitant decline in precipitation over the past several decades. Forest fires have resulted in the replacement of the fog intercepting subalpine forest belt by low lying shrub which has already seriously impacted the hydrological balance of the mountain as fog intercepting cloud forests play a key role in the water budgets of high altitude drainage basins. A continuation of current trends in climatic changes, fire frequency, and human influence could result in the loss of most of the remaining subalpine Erica forests in a matter of years. With this, Mount Kilimanjaro will have lost its most effective water catchment. Among the more immediate adaptation responses identified by this report are institutional measures such as the inclusion of the forest belt into the Kilimanjaro National Park and the creation of a paramilitary ranger group to deter logging, as well as better investments in early warning systems, particularly the purchase of one or two aircraft for aerial surveillance. There is also a need to limit cross-border migration of big game from neighbouring Amboseli, which is adding to the stress on the Kilimanjaro ecosystem. In addition to short term solutions there is a critical need to develop a comprehensive and holistic development plan focusing on fire-risk and forest destruction, livelihood needs of the local population as well as on conservation strategies to ensure the long term sustainability of the valuable resources of the Kilimanjaro ecosystem.

LIST OF ACRONYMS

AfDB	African Development Bank
AMA	African Mountain Association
asl	Above Sea Level
AVVA	Aerial Videotape-assisted Vulnerability Analysis
CBO	Community Based Organization
CCCM	Canadian Climate Centre Model
CEEST	Centre for Energy, Environment, Science and Technology
CERES-Maize	Crop Environment Resource Synthesis model
COMPACT	Community Management of Protected Areas Conservation Project
CRS	Creditor Reporting System of the OECD/World Bank
DAC	Development Assistance Committee
DFID	Department for International Development
EACC	East African Coastal Current
FAO	Food and Agriculture Organization of the United Nations
FFYP	First Five Year Plan
GCA	Game Controlled Areas
GCM	General Circulation Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gases
GMBA	Global Mountain Biodiversity Assessment
GNP	Gross National Product
GNI	Gross National Income
IDA	International Development Assistance
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
KINAPA	Kilimanjaro National Park
MW	Mega Watt
NEAP	National Environmental Action Plan
NEP	National Environmental Policy
NCAA	Ngorongoro Conservation Authority Area
NGO	Non Governmental Organization
ODA	Official Development Assistance
PRSP	Poverty Reduction Strategy Papers
SIDA	Swedish International Development Agency
TAF	Tanzanian Association of Foresters
TANAPA	Tanzanian National Parks
TFYP	Third Five Year Plan
UN	United Nations
UNCB	United Nations Convention on Biodiversity
UNCCD	United Nations Convention to Combat Desertification
UNCED	United Nations Conference on Environment and Development
UNDAF	United Nations Development Assistance Framework
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNF	United Nations Foundation
UNFCCC	United Nations Framework Convention on Climate Change
USAID	The United States Agency for International Development
USCSP	United States Country Studies Program
WHO	World Health Organization
WNHS	World Natural Heritage Sites

1. Introduction

This report presents the integrated case study for Tanzania for the OECD Development and Climate Change Project, an activity jointly overseen by the Working Party on Global and Structural Policies (WPGSP), and the Working Party on Development Co-operation and Environment (WPENV). The overall objective of the project is to provide guidance on how to mainstream responses to climate change within economic development planning and assistance policies, with natural resource management as an overarching theme. The Tanzania case study was conducted in parallel with five other country case studies[1] in Africa, Latin America, and Asia and the Pacific.

Each case study is based upon a three-tiered framework for analysis (Agrawala and Berg 2002).

1. Review of climate trends and scenarios at the country level based upon an examination of results from seventeen recent general circulation models, as well as empirical observations and results published as part of national communications, country studies, and scientific literature. These projections are then used in conjunction with knowledge of socio-economic and sectoral variables to rank key sectoral and regional impacts on the basis of a number of parameters. The goal of this tier is to present a framework to establish priorities for adaptation.

2. Review of economic, environmental, and social plans and projects of both the government and international donors that bear upon the sectors and regions identified as being particularly vulnerable to climate change. The purpose of this analysis is to assess the degree of exposure of current development activities and projects to climate risks, as well as the degree of current attention by the government and donors to incorporating such risks in their planning. This section will review donor portfolios and projects, as well as development priorities of the Government of Tanzania to determine the degree of attention to potential risks posed by climate change on relevant sectors.

3. In-depth analyses at a thematic, sectoral, regional or project level on how to incorporate climate responses within economic development plans and projects, again with a particular focus on natural resource management. In the case of Tanzania this case study provides an overview of critical impacts and mainstreaming challenges for a number of sectors. This is followed by an in-depth analysis on Mount Kilimanjaro – a UNESCO World Heritage Site and also a critical ecosystem and source of freshwater resources for Tanzania. The analysis on climate change impacts and response strategies for the Mount Kilimanjaro ecosystem draws upon field research over an extended period by a case study consultant in collaboration with national and international partners.

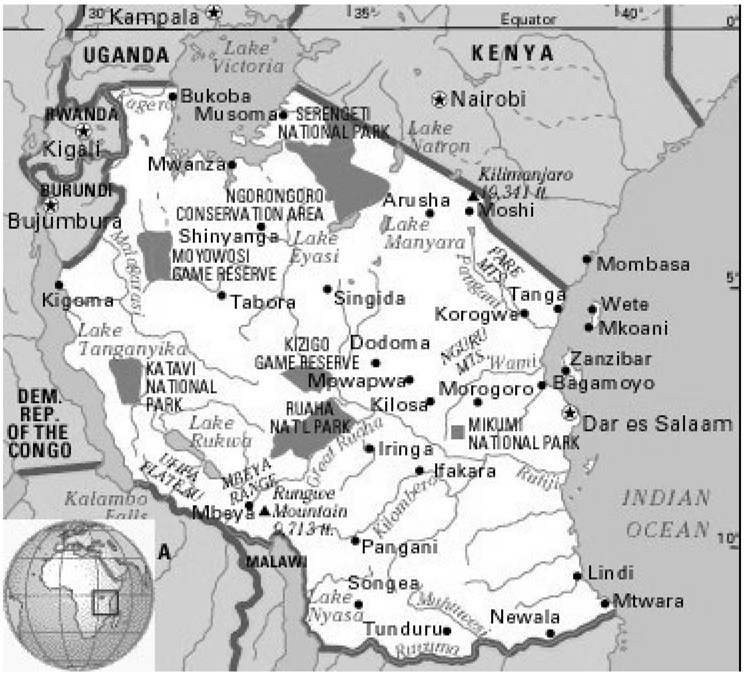
2. Country background

Tanzania is located in East Africa, on the Indian Ocean bordered by Kenya to the north and Mozambique to the south (Figure 1). It has an area of 945,000 km^2 which includes the three major coastal islands of Mafia, Pemba, and Zanzibar, and a coastline that is about 800 km long. The geography is characterized by plains along the coast, a central plateau, and highlands in the north and south. The northwest of the country encompasses approximately one-half of Lake Victoria, the second largest body of freshwater in the world, and the western and southwestern borders abut the comparably massive Lake Tanganyika and Lake Nyasa. Elevations range from sea level to the highest point in Africa, the glaciated peak of Kilimanjaro at 5,895 m, the expansive slopes of which constitute one of the unique ecosystems of

[1] Bangladesh, Egypt, Uruguay, Fiji, and Nepal.

Africa. Tanzania also includes the Serengeti, the site of one of the last major terrestrial mammalian migrations in the world and a prominent tourist destination.

Figure 1. Map of Tanzania



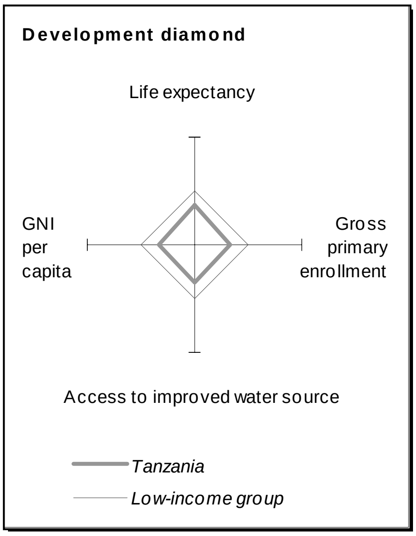
Tanzania is one of the poorest countries in the world with a GNI per capita of only US $ 280 (World Bank 2002). Gross national income per capita over the period 1994-2000 stood at about US$270 compared to US$470 for sub-Saharan Africa in general. Some 42% of the total population and 50% of the rural population live below the poverty line, according to a 1993 survey, with 20% of the entire population surviving on less than US$1 per day (World Bank, 2002). Based on the same 1993 survey, the Gini Coefficient[2] for Tanzania is 0.38, with the poorest 10% accounting for 2.8% of the national income and the richest 10% accounting for 30.1%. According to World Bank estimates, Tanzania's population in 2000 was 33.7 million, and growing at 1.8% a year. Average Life-expectancy is only 43.1 years (World Bank 2002). While an overwhelming proportion of the population still lives in rural areas, by the late 1990s, 27.8% of the country's population lived in an urban setting, up from only 10.1% in 1975. Tanzania's economy is heavily dependent on agriculture, which accounts for nearly one-half of GDP, employs 80% of the work force, and provides 85% of exports (World Bank, 2002). Topography and climatic conditions, however, limit cultivated crops to only 4% of the land area. Industry has traditionally been limited to the processing of agricultural products and light consumer goods. However, with a significant infusion of funds from the World Bank, International Monetary Fund, and bilateral donors, growth over the last decade has featured

2 The Gini coefficient is a number between zero and one that measures the degree of inequality in the distribution of income in a given society. The coefficient would register zero inequality for a society in which each member received exactly the same income and it would register a coefficient of one (maximum inequality) if one member got all the income and the rest got nothing.

an increase in industrial production and a substantial increase in output of minerals (CIA, 2002). Private sector growth and investment have also increased and, coupled with donor aid and liberal macroeconomic policies, should support continued growth of about 5% (World Bank, 2002).

Economic growth could play an important role in increasing the capacity of a country like Tanzania to adapt to climate change. However, the current state of its infrastructure and educational system is likely an impediment to Tanzania's ability to cope effectively with climatic risks. In 2000, only 4.2% of Tanzania's road network was paved, compared to 16.5% for low income countries in general. Further, while 37% of tertiary level students were enrolled in science and engineering programs between 1987 and 1997, gross tertiary enrolment stood at only 0.66% by 1997 (World Bank, 2002). Similarly, gross secondary enrolment was 6.5%. Adult literacy was 24.9% in 2000. Figure 2 provides an indication of how Tanzania compares to other low income countries in terms of four key indices of development. On all four measures of development, Tanzania ranks considerably below the average for low income countries.

Figure 2. Development diamond for Tanzania



Source: World Bank 2002

3. Climate: baseline climatology and climate change scenarios

This section briefly reviews projections of temperature and precipitation change for Tanzania from climate models, and then provides a synthesis of key climate change impacts and vulnerabilities.

3.1 Current climate

Tanzania's climate ranges from tropical to temperate in the highlands. Average annual precipitation over the entire nation is 1,042 mm. Average temperatures range between 17°C and 27°C, depending on location. Natural hazards include both flooding and drought. Within the country, altitude plays a large role in determining rainfall pattern, with higher elevations receiving more precipitation. Generally speaking, the total amount of rainfall is not very great. Only about half the country receives more than 762 mm annually (Mwandosya et al., 1998). Tanzania's precipitation is governed by two rainfall regimes. Bimodal rainfall, comprised of the long rains of *Masika* between March-May and short rains of *Vuli* between October-December, is the pattern for much of the northeastern, northwestern (Lake Victoria basin) and the northern parts of the coastal belt. A unimodal rainfall pattern, with most of the rainfall during December-April, is more typical of most of the southern, central, western, and southeastern parts of the country.

3.2 Climate change and sea level rise projections

Changes in area averaged temperature and precipitation over Tanzania were assessed using outputs from over a dozen recent (post 1995) GCMs which are processed using a new version of MAGICC/SCENGEN. MAGICC/SCENGEN is briefly described in Box 1. First, results for Tanzania for 17 GCMs developed since 1995 were examined. Next, 11 of 17 models which best simulate current climate over Tanzania were selected. The models were run with the IPCC B2 SRES scenario (Nakicenovic and Swart 2000)[3].

Box 1. A brief description of MAGICC/SCENGEN

MAGICC/SCENGEN is a coupled gas-cycle/climate model (MAGICC) that drives a spatial climate-change scenario generator (SCENGEN). MAGICC is a Simple Climate Model that computes the mean global surface air temperature and sea-level rise for particular emissions scenarios for greenhouse gases and sulphur dioxide (Raoer et al., 1996). MAGICC has been the primary model used by IPCC to produce projections of future global-mean temperature and sea level rise (see Houghton et al., 2001). SCENGEN is a database that contains the results of a large number of GCM experiments. SCENGEN constructs a range of geographically-explicit climate change scenarios for the world by exploiting the results from MAGICC and a set of GCM experiments, and combining these with observed global and regional climate data sets. SCENGEN uses the scaling method of Santer et al. (1990) to produce spatial pattern of change from an extensive data base of atmosphere ocean GCM – AOGCM (atmosphere ocean general circulation models) data. Spatial patterns are "normalized" and expressed as changes per 1°C change in global-mean temperature. The greenhouse-gas and aerosol components are appropriately weighted, added, and scaled up to the actual global-mean temperature. The user can select from a number of different AOGCMs for the greenhouse-gas component. For the aerosol component there is currently only a single set of model results. This approach assumes that regional patterns of climate change will be consistent at varying levels of atmospheric greenhouse gas concentrations. The MAGICC component employs IPCC Third Assessment Report (TAR) science (Houghton et al., 2001). The SCENGEN component allows users to investigate only changes in the mean climate state in response to external forcing. It relies mainly on climate models run in the latter half of the 1990s.

Source: National Communications Support Program Workbook

The spread in temperature and precipitation projections of these 11 GCMs for various years in the future provides an estimate of the degree of agreement across various models for particular projections. More consistent projections across various models will tend to have lower scores for the standard deviation, relative to the value of the mean. The results of the MAGICC/SCENGEN analysis for Tanzania are shown in Table 1.

3 The IPCC SRES B2 scenario assumes a world of moderate population growth and intermediate level of economic development and technological change. SCENGEN estimates a global mean temperature increase of 0.8 °C by 2030, 1.2 °C by 2050, and 2 °C by 2100 for the B2 scenario.

Table 1. GCM estimates of temperature and precipitation changes[4]

Year	Temperature change (°C) mean (standard deviation)					Precipitation change (%) mean (standard deviation)				
Tanzania	Annual	JJA[5]	SON[6]	DJF[7]	MAM[8]	Annual	JJA	SON	DJF	MAM
2030	0.9 (0.20)	1.0 (0.21)	.8 (0.17)	.8 (0.30)	0.9 (0.30)	4.1 (5.05)	-2.4 (7.98)	3.9 (10.04)	6.6 (8.06)	2.2 (5.34)
2050	1.3 (0.28)	1.5 (0.31)	1.2 (0.25)	1.1 (0.43)	1.3 (0.44)	5.9 (7.30)	-3.5 (11.53)	5.6 (14.51)	9.6 (11.64)	3.1 (7.72)
2100	2.2 (0.49)	2.6 (0.54)	2.1 (0.43)	1.9 (0.75)	2.3 (0.77)	10.2 (12.70)	-6.0 (20.07)	9.7 (25.27)	16.7 (20.27)	5.4 (13.44)

The results indicate that mean annual temperatures are projected to rise by 2.2 C by 2100, with somewhat higher increases (2.6 °C) over June, July and August, and lower values (1.9 °C) for December, January, February. Low standard deviations relative to the mean indicate good agreement across the 11 models. The Initial National Communication of Tanzania (2003) projects a temperature increase between 3-5 °C under doubling of carbon dioxide, which is benchmarked to the year 2075. The lower estimates of MAGICC/SCENGEN are likely from the use of more recent scenarios (SRES) and multiple (17), more recent (post 1995) GCMs with a better treatment of aerosols in the MAGICC/SCENGEN analysis. The Tanzania National Communication meanwhile relied on four earlier generation models (primarily the UK1989), as well as older (unspecified) emissions scenarios. Both sets of analyses however show temperature increases, and furthermore the patterns of seasonal temperature increase are consistent. Specifically, greater warming is projected for the cooler months (June-August) compared to the warmer months (December-February).

In terms of precipitation meanwhile, according to the MAGICC/SCENGEN analysis annual precipitation over the whole country is projected to increase by 10% by 2100, although seasonal declines of 6% are projected for June, July and August, and increasers of 16.7% for December, January, February. However, high standard deviations are indicative of low confidence in these projections across the various models. Furthermore, the precipitation regimes across Tanzania vary considerably, as discussed in the preceding section. Therefore country averaged values for precipitation, as is done in the MAGICC/SCENGEN analysis, are of limited utility[9]. The Tanzania Initial National Communication does offer greater regional specificity – although the results should be interpreted with caution as they do not include an uncertainty analysis and rely on one or two older climate models. Under a doubling carbon dioxide scenario some parts of Tanzania are projected to experience increases in annual rainfall, while

4 This analysis uses a combination of the 11 best SCENGEN models (BMRCTR98, CCSRTR96, CERFTR98, CSI2TR96, CSM_TR98, ECH3TR95, ECH4TR98, GFDLTR90, HAD2TR95, HAD3TR00, PCM_TR00) based on their predictive error for annual precipitation levels. Errors were calculated for each of the models, and for an average of the 17 models. Each model was ranked by its error score, which was computed using the formula 100*[(MODEL-MEAN BASELINE / OBSERVED) - 1.0]. Error scores closest to zero are optimal. The error score for an average of the 17 models was 30%, and the error score for an average of the 11 models was 21%. See the appendix for details.

5 June July August

6 September October November

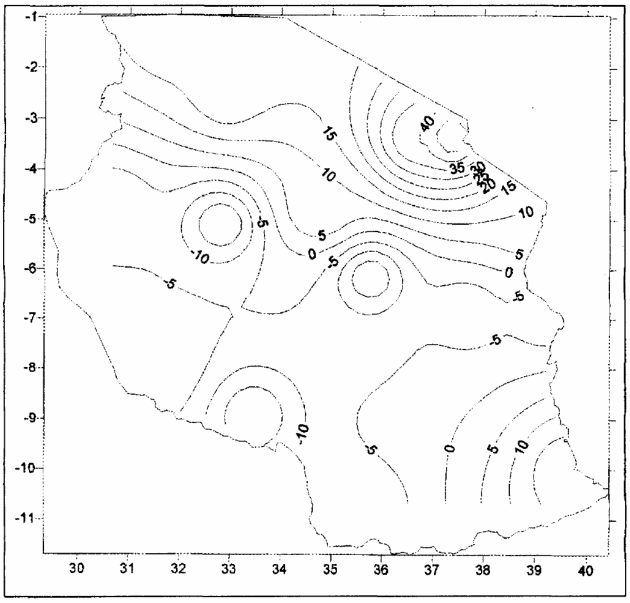
7 December January February

8 March-April-May

9 A higher resolution analysis across multiple GCMs was beyond the scope of this study.

precipitation is projected to decline in other areas (see Figure 3). However, the timing of these changes might vary from location to location as well. The National Vulnerability and Adaptation Assessment of Tanzania (Mwandosaya et al. 1998, which is the bases for the Initial National Communication of 2003) estimates that northern and southeastern sectors of the country would experience an increase in rainfall ranging from between 5% and 45% under doubling of carbon dioxide. The central, western, southwestern, southern, and eastern parts of the country might experience a decrease in rainfall of 10% to 15%. The southern highlands might similarly experience a decrease of 10%, which could alter the suitability of this area for maize cultivation. Seasonal patterns in possible changes in rainfall could be complex. For instance, the northeastern sector might experience an increase of 25%-60% in the short rains and an increase of 20-45% in the long rains. Or, the north coastal region might get an increase of 0-20% in the short rains and a decrease of 0-10% in the long rains. In the unimodal region, rainfall might decrease between 0% and 25% in central regions during October, November, and December, but increase by 15% in March, April, and May. Finally, the southeastern sector could get between 5 and 45% increase in rainfall during the first three months of the season and in increase of 10-15% during the last three months.

Figure 3. Change in mean annual rainfall (in %) under 2XCO2



Source: Mwandosaya et al. 1998

The Tanzania National Vulnerability and Adaptation Assessment (1998) as well as the Initial national Communication (2003) do not include sea-level rise scenarios for Tanzania's 800 km coastline. Tide gauge records in Tanzania cover only a very short period of time with some missing data. Instead, a coastal vulnerability assessment is conducted under two arbitrary sea level rise scenarios 50cm and 1m, coupled with aerial videotape assisted mapping of coastal topography, resources, and land use. Given the most recent IPCC assessment (the Third Assessment Report), the 50cm scenarios roughly falls in the middle, and the 1m scenarios a little beyond the upper estimate of the range of global sea level rise (9cm-88cm) projected to occur by 2100.

4. Overview of impacts, vulnerabilities and adaptation responses

Given the large size and widely different climatology and climate change projections and impacts across Tanzania, a national priority ranking might conflate intra-sectoral or sub-national positive and negative effects of climate change, and thereby produce misleading results. Therefore, this synthesis highlights the spectrum of possible sectoral and or regional impacts, and identifies critical impacts and vulnerabilities, but without an aggregate sectoral or regional ranking. The section concludes with a discussion of adaptation strategies and priorities for adaptation.

4.1 Agriculture

Agriculture is clearly the most important sector of the Tanzanian economy. It comprised 45.1% of GDP in 2000 (World Bank, 2002). Upwards of 80% of the population of the country relies directly on agriculture of one sort or another for their livelihood. Only 3.3% of the cropland was irrigated as of 1999 (World Bank, 2002). The three most important crops are: maize, coffee and cotton – with maize being a major food staple, coffee a major cash crop grown in large plantations (and contributing significantly to the GNI), while cotton is another cash crop grown largely by smallholder farmers.

Estimates of the affect of climate change on maize yields are available from model runs of the Crop Environment Resource Synthesis model (CERES-Maize) (Jones and Kiniry, 1986). In general, simulation results show that maize yields were lower, a result of higher temperatures and, where applicable, decreased rainfall. The average yield decrease over the entire country was 33%, but simulations produced decreases as high as 84% in the central regions of Dodoma and Tabora. Yields in the northeastern highlands decreased by 22% and in the Lake Victoria region by 17%. The southern highland areas of Mbeya and Songea were estimated to have decreases of 10-15%. These results suggest that climate change may significantly influence future maize yields in Tanzania, reducing them in all zones that were studied, relative to baseline levels. These reductions are due mainly to increases in temperature that shorten the length of the growing season and to decreases in rainfall. Consequently, the continued reliance on maize as a staple crop over wide areas of the country could be at risk. The two cash crops on the other hand are projected to experience increases in yield (Tanzania Initial National Communication 2003). For Lyamunugu, located within an area of bimodal rainfall, coffee yields are expected to increase by 18%, and for Mbozi, where rainfall is unimodal, the coffee yield is expected to increase by 16%. These yield estimates depend critically on estimates of change in precipitation. The potential impacts of climate change on cotton production in Tanzania parallel that for coffee. The agriculture sector thus may have both negative and positive impacts that could partially offset each other. However, maize production in particular might require particular attention for adaptation and mainstreaming responses, given that it is a critical food crop.

4.2 Forests

Tanzania has about 338,000 km^2 under forest cover, which represents about 44% of the total land area. These forests are an important source of fuel wood and other products for large numbers of Tanzanians. Furthermore, many of Tanzania's 43 threatened mammal species, 33 threatened bird species, and prodigious biodiversity depend on its forests (World Bank 2002). Under climate change most of the forests across Tanzania are projected to shift towards drier regimes: from subtropical dry forest, subtropical wet forest, and subtropical thorn woodland to tropical very dry forest, tropical dry forest, and small areas of tropical moist forest respectively (Tanzania Initial National Communication 2003). Much of this projected change in distribution is attributed to an increase in ambient temperatures and a decline in precipitation in forested regions of the country.

Current assessments of climate change impacts on forests in Tanzania however do not explicitly account for the potential effects of climate change on disturbances such as fire. The Kilimanjaro region deserves particular attention. In addition to the well-known glacier retreat and eventual disappearance of the ice cap, there might be major changes in the extent, distribution, and species composition of the forests on the Kilimanjaro as a consequence of changes in fire regimes. There is indication that intensification of fire risk as a result of warmer and drier conditions might already be underway. Continued loss of the montane forest belt (which collects a significant amount of water from fog entrapment) from fire intensification would lead to a significant reduction of water yields with serious regional implications, affecting sectors such as agriculture and livestock as well. These issues as well as possible responses on the Kilimanjaro are the focus of in-depth analysis later in this report.

4.3 Water resources

Like the agriculture sector, climate change is projected to have both positive and negative consequences for Tanzania's water-resources, specifically for the three major river basins: Ruvu, Pangani, and Rufiji. The Ruvu basin, of particular importance because it is upstream of Tanzania's major population center, Dar es Salaam, could experience a 10% decrease in runoff according to the Initial National Communication (2003). The Pangani basin supplies water to the Tanga, Kilimanjaro, and Arusha regions, supporting a number of economically important activities. These include the Arusha Chini sugar plantations in the Kilimanjaro region, the lower Moshi irrigation scheme, the Handeni District water supply, and a number of important power stations. For the Pagani River, there is some seasonal variation with runoff projected to increase in some months runoff and decrease in others, with annual basin runoff decreasing by an estimated 6%. However, the Kikuletwa River, also within the Pagani Basin, is projected to decrease in all months, with annual reductions of 9%. The Rufiji basin meanwhile is a large catchment in the south of the country, focused on the Great Ruaha River, which is economically important to the nation in part because of the hydropower it generates at Mtera Dam and Kidatu Dam. The national assessment of vulnerability and adaptation (Mwandosaya et al. 1998) projects increases in annual runoff of 5% and 11% at Mtera and Kidatu, respectively, most coming in the period from November to March. All these estimates however are based on scenarios from a single GCM, and should be interpreted with some caution. Real uncertainties exist concerning present and future withdrawals for irrigation, changed land use, and urbanization. Nevertheless, decreases in runoff could potentially have serious affects on socioeconomic activities in the regions of Dar es Salaam, Morogoro, Tanga, Coast, and Kilimanjaro. Dar es Salaam might be particularly vulnerable because it is the largest industrial, commercial, and administrative city in Tanzania.

4.4 Coastal resources

The coastline of Tanzania is about 800 km long and the coastal zone varies in width from 20 km to 70 km gradually rising to a plateau. Tanzania has relatively limited coastal lowlands, but there are extensive coastal wetlands, some important cities (Dar es Salaam), a number of important islands (such as Zanzibar), and a delta — the Rufigi River (Mwaipopo 2001). The main coastal features include mangrove forests and swamps, coral reefs, sand and mudflats, tidal marshes, woodland, and sisal and cashew nut estates. Mangrove forests in particular represent an important economic resource for coastal people, supplying firewood and timber for the construction of fishing boats, and providing feeding, breeding, and nursery grounds for a number of fish species and a variety of insects, birds, and small animals. The highest densities of population that might be threatened are found near Dar es Salaam and the islands of Zanzibar and Pemba.

The Initial National Communication of Tanzania (2003) considers scenarios of both 0.5 m and 1 m sea level rise over the next century. Maps with a 2 m and 20 m contour were used and it was assumed that land rises linearly from sea level to these contours. The 0.5 m and 1 m contours and the land area they represent were approximated. Estimates of land lost to erosion were also produced with the aid of aerial videotape-assisted vulnerability analysis. Total land-loss is estimated to be 247 km^2 and 494 km^2 for 0.5 and 1 meters of sea level rise respectively. According to this analysis the Dar es Salaam region would be vulnerable with values of structures at risk estimated to total US$ 48 million for a 0.5 m sea level rise and US$82 million for a 1 m rise (Tanzania Initial National Communication 2003).

4.5 Human health

Climate plays an important role in the geographical distribution and seasonal abundance of vector species that are responsible for the transmission of a number of human diseases. Changes in temperature, precipitation, humidity, and wind patterns will directly affect vector species' reproduction, development, and longevity. The distribution of vector borne diseases in the human population is also limited by temperature in many regions where the climate is too cold for parasite survival (Martens et al. 1999). Of the various vector borne diseases malaria in particular is a major public health concern in Tanzania. It accounts for 16.7% of all reported deaths in Tanzania and is one of the leading causes of morbidity in all regions, ranging from 24.4% in Rukwa regions to 48.9% in Dar es Salaam (Tanzania Initial National Communication 2003). Also, the problem of malaria is getting worse because of growing parasite resistance to first line anti-malarial drugs and mosquito resistance to insecticides. Malaria is endemic in most of Tanzania even under the current climate. However, many population centers are located in areas where malaria transmission is currently only epidemic or nonexistent. Most of these centers are located in the central highlands region (e.g., Mbeya, Njombe, Iringa, and Arusha), where cooler temperatures prevent or interrupt the transmission of malaria. These areas are of particular concern in considering a warmer climate. Increased temperatures might open new areas to seasonal or year-around transmission. The vulnerability of highland populations to an increase in the endemicity of transmission of malaria, or of any of Tanzania's population to climate change induced health risks, will depend strongly on the evolution of control methods and the ability of Tanzania to afford such measures (Tol and Dowlatabadi, 2002).

4.6 Energy, industry and transport

Climate change may also have direct and/or indirect effects on Tanzania's energy, industry, and transportation sectors. Among the direct effects, an increase in temperatures would likely increase energy demands for cooling. Areas projected to have declines in precipitation and or stream flow are also likely to face increased demands for purposes such as irrigation. However, as highlighted by the discussion on climate change scenarios, the projections for changes in precipitation remain highly uncertain. The Tanzania country study also projects decline in stream flow in two key river basins (as discussed in Section 4.3), which will not only increase energy demands for irrigation, but more significantly adversely impact energy supply, given that these two basins are significant contributors to Tanzania's hydroelectric generation. Transportation infrastructure such as railways, roads, pipelines and ports may also be at risk from impacts of climate change (particularly sea level rise), but specific vulnerability analyses are lacking. Other potential impacts of climate change on energy supply include the vulnerability of the Songo Songo and Mnazi Bay natural gas reserves to sea level rise.

4.7 Overview of adaptation responses

While uncertainties in climate change and impacts projections are a characteristic feature that poses a challenge for anticipatory adaptation for any country, Tanzania's case has several characteristics that might argue for a differentiated adaptation strategy. *First*, the climate change projections on which all national impact and vulnerability assessments are based (all the way to the Initial National Communication of 2003) rely on a limited number of older generation of climate models and scenarios, circa early 1990s which has several implications for assessment of impact and adaptation options. For example, an analysis based on more recent climate models conducted as part of this study concludes that the magnitudes of temperature increases projected for Tanzania might be somewhat lower (though the trends are broadly consistent) with the projections used in the National Assessment of Vulnerability and Adaptation. Thus, information on impacts might need updating in Tanzania prior to the formulation of aggressive adaptation responses, more so than in other countries where projections might be based on more recent models. *Second*, some key sectors are projected to experience both positive and negative impacts under climate change – for example, while production of maize is projected to decline, the production of two key cash crops (coffee and cotton) is projected to increase. Similarly, while stream-flows are projected to decline in two of three key river basins (Ruvu and Pangani), they are projected to increase in the third (Rufiji). The implication for adaptation therefore might be to not only cushion adverse impacts, but also to harness positive opportunities. *Finally,* a third key characteristic is that unlike most other countries where the need for adaptation relies largely on projections of future impacts, there might be some discernible trends in climate and attendant impacts already underway in Tanzania. This might argue for more immediate adaptation measures in the case of such impacts as opposed to a “wait and see” strategy.

For all the above reasons, there might be a need for a *differentiated* adaptation strategy across various sectors and regions depending upon the certainty of projections, the mix of beneficial and adverse impacts, and the urgency and timing of such impacts. For the case of agriculture a key portfolio of adaptation responses would involve measures that boost maize production: increased irrigation, increased use of manure and fertilizer, and better use of management tools including climate information. These measures are discussed in Tanzania’s Initial National Communication. However, given that the production of the country’s two cash crops (coffee and cotton) is projected to increase under the same climate scenarios, another adaptation response – which is not discussed in Tanzania’s Initial National Communication - might involve a strategic shift over the medium to the long term from maize towards these cash crops.

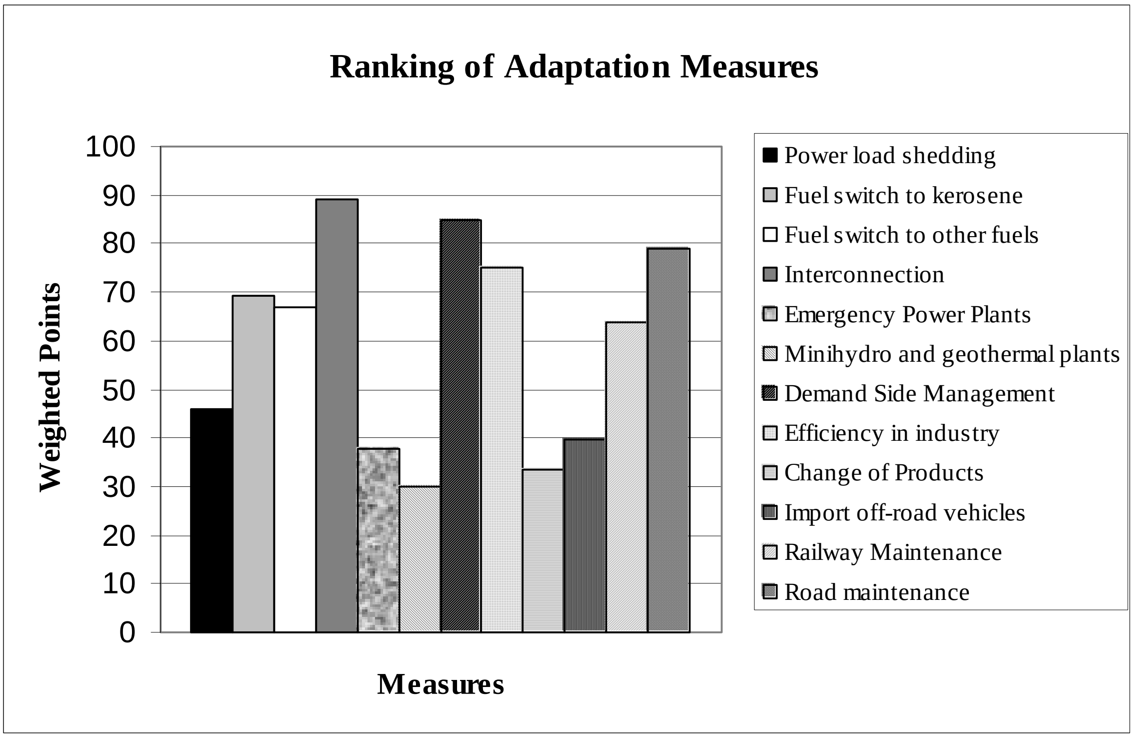
With regard to human health, the spread of malaria to the population centers in the highlands as a result of rising temperatures is a key concern. Much of Tanzania however is already malaria endemic, so policy responses might need to be driven by the additionality of the disease burden, and not necessarily the existence of the risk itself. Most roll back malaria programs function in the reactive mode (antimalarial drugs, spraying of insecticides, and elimination of breeding sites), while in the cases of highland areas precautionary adaptation to prevent or limit the spread of malaria to these regions might be ideal.

For coastal resources meanwhile a key priority is to construct regional sea level rise scenarios, that not only incorporate local topography (as has been done) but also subsidence rates. Lacking such specific information, and given the long time-scales at which sea level rise will manifest itself, an initial set of adaptation priorities should ideally focus on no regrets measures in particularly low lying or otherwise vulnerable areas including urban areas as well as coastal wetlands and mangroves, such as the Mafia Island Marine Park, the Menai Bay Conservation Area, and the Misali Island Conservation Area. Coastal zones adaptation priorities may also be synergistic with several ongoing government-donor initiatives including the Conservation of Lowland Coastal Forests Project, the Sustainable Dar es Salaam Project and the Tanzania Coastal Management Partnership.

No regrets adaptation - specifically water and energy conservation – could be a viable initial priority for adaptation in water resources, where stream-flow is projected to decline in two critical river basins (Ruvu and Pangani), affecting water use and hydroelectricity generation. The Tanzania Initial National Communication identifies privatization (as is already the case for Dar es Salaam) as a key adaptation response to promote efficient water use. This measure however may have equity effects as it may result in an increase in price of water making it unaffordable to the poor. Further, given that roughly half of the water in Dar es Salaam is lost to leakage, a second key no regrets response would be leakage prevention – although it would require significant new capital investment and regular maintenance of water infrastructure. Third, given that streamflow in a third river basin – the Rufiji – is projected to increase, another adaptation strategy may revolve around water transfer from Rufiji to Dar es Salaam which relies on the Pangani. However, given that streamflow projections are based upon the results from one water balance model (and dated climate scenarios), and the fact that the costs and environmental impacts of inter-basin transfers are yet to be analyzed, such a response may not be advisable at this time.

With regard to the energy, industry and transportation sectors, the Tanzania National Action Plan (1997) has conducted a hierarchical screening of potential adaptation responses. Given that climate change is projected to impact energy demands (through rise in temperature), as well as particular sources of energy supply (hydro and to some extent natural gas fields located in coastal areas), these adaptation options focus on either demand side management or on the promotion of energy supply sources that are not impacted by climate change. Figure 4 shows the results of various adaptation responses from this hierarchical screening. A majority of these measures are no-regrets. However some measures – particularly a fuel switch to kerosene – may run into conflict with greenhouse gas mitigation, as they may imply a switch away from an energy source of lower carbon intensity (natural gas and hydro). Therefore, synergy between mitigation and adaptation responses, as well as with other development priorities must also be considered in screening adaptation measures.

Figure 4. Screening of adaptation measures in the energy, industry and transportation sectors



Source: National Action Plan on Climate Change 1997

One area where the need for adaptation may be immediate is the Kilimanjaro ecosystem where climatic changes are likely already contributing to significant impacts on the natural and human system, including the intensification of fire risk, in part a consequence of observed changes in temperature and precipitation patterns, and to a lesser extent the retreat of the ice cap. The causes and implications of these impacts, as well as potential responses to them and the potential synergies and conflicts with environmental and development priorities are investigated in-depth later in Section 8.

5. Attention to climate concerns in donor activities

Tanzania receives large amounts of donor aid, in the order of one billion US$ per year, which is equivalent to about 11% of its GNI. The largest donors, in terms of overall investments, are the World

Bank (IDA), Japan, and the United Kingdom. Figure 5 displays the distribution of this aid by development sector and by donor.

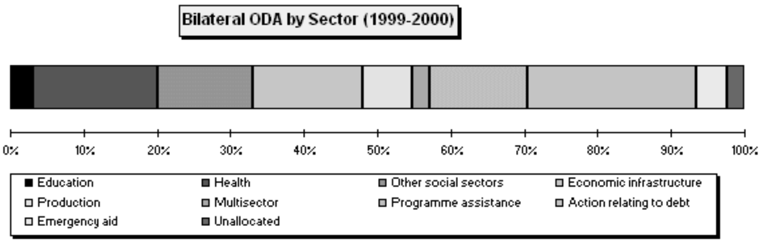
Figure 5. Development aid to Tanzania (1998-2000

Tanzania

Receipts	1998	1999	2000
Net ODA (USD million)	1 000	990	1 045
Bilateral share (gross ODA)	72%	58%	70%
Net ODA / GNI	11.7%	11.3%	11.2%
Net Private flows (USD million)	- 1	- 74	122

For reference	1998	1999	2000
Population (million)	32.1	32.9	33.7
GNI per capita (Atlas USD)	240	260	280

Top Ten Donors of gross ODA (1999-2000 average)		(USD m)
1	IDA	170
2	JAPAN	155
3	UNITED KINGDOM	121
4	NETHERLANDS	76
5	DENMARK	75
6	IMF	67
7	EC	56
8	SWEDEN	55
9	GERMANY	51
10	NORWAY	42



Sources: OECD, World Bank.

The following sections highlight the possible extent of climate risks to development investments in Tanzania and examine to what extent current and future climate risks are factored in to development strategies and plans, as well as individual development projects [10]. Given the large quantity of strategies and projects, our analysis is limited to a selection. This selection was made in three ways (i) a direct request to all OECD DAC members to submit documentation of relevant national and sectoral strategies, as well as individual projects (ii) a direct search for some of the most important documents (including for instance national development plan/PRSP, submissions to the various UN conventions, country and sector strategies from multilateral donors like the World Bank and UNDP, and some of the larger projects in climate-sensitive sectors), and (iii) a pragmatic search (by availability) for further documentation that would be of interest to our analysis (mainly in development databases and on donors' external websites). Hence, the analysis is not comprehensive, and its conclusions are not necessarily valid for a wider array of development strategies and activities. Nevertheless, the authors feel confident that this limited set allows an identification of some common patterns and questions that might be relevant for development planning.

5.1 Donor activities affected by climate risks

This section explores the extent to which development activities in Tanzania are affected by climate risks, which gives an indication of the importance of climate considerations in development planning. The extent to which climate risks affect development activities in Tanzania can be gauged by examining the sectoral composition of the total aid portfolio, which is analyzed here using the World

10 The phrase "climate risk" or "climate-related risk" is used here for all risks that are related to climatic circumstances, including weather phenomena and climate variability on various timescales. In the case of Tanzania, these risks include the effects of seasonal climate anomalies, including droughts, as well as trends therein due to climate change, and risks due to sea level rise. "Current climate risks" refer to climate risks under current climatic conditions, and "future climate risks" to climate risks under future climatic conditions, including climate change and sea level rise.

Bank/OECD Creditor Reporting System (CRS) database (Box 2). Development activities in sectors such as agriculture, infectious diseases, or water resources could clearly be affected by current climate variability and weather extremes, and consequently also by changing climatic conditions. At the other end of the spectrum, development activities relating to education, gender equality, and governance reform are much less directly affected by climatic circumstances.

Box 2. Creditor Reporting System (CRS) Database

The Creditor Reporting System (CRS) comprises of data on individual aid activities on Official Development Assistance (ODA) and official aid (OA). The system has been in existence since 1967 and is sponsored and operated jointly by the OECD and the World Bank. A subset of the CRS consists of individual grant and loan commitments (from 6000 to 35000 transactions a year) submitted by DAC donors (23 members) on a regular basis. Reporters are asked to supply (in their national currency), detailed financial information on the commitment to the developing country such as: terms of repayment (for loans), tying status and sector allocation. The secretariat converts the amounts of the projects into US dollars using the annual average exchange rates.

In principle, the sectoral selection should include all development activities that may be designed differently depending on whether or not climate risks are taken into account. In that sense, the label "affected by climate risks" has two dimensions. It includes projects that are at risk themselves, such as an investment that could be destroyed by flooding. But it also includes projects that affect the vulnerability of other natural or human systems. For instance, new roads might be fully weatherproof from an engineering standpoint (even for climatic conditions in the far future), but they may also trigger new settlements in high-risk areas, or it may have a negative effect on the resilience of the natural environment, thus exposing the area to increased climate risks. These considerations should be taken into account in project design and implementation. Hence, these projects are also affected by climate risks. A comprehensive evaluation of the extent to which development activities are affected by climate change would require detailed assessments of all relevant development projects as well as analysis of site specific climate change impacts, which was beyond the scope of this analysis. This study instead assesses activities affected by climate risks on the basis of CRS purpose codes (see Appendix B, which identifies "the specific area of the recipient's economic or social structure which the transfer is intended to foster")[11, 12].

Clearly, any classification that is based solely on sectors suffers from oversimplification. In reality, there is a wide spectrum of exposure to climate risks even within particular sectors. For instance, rain-fed agriculture projects may be much more vulnerable than projects in areas with reliable irrigation. At the same time, the irrigation systems themselves may also be at risk, further complicating the picture. Similarly, most education projects would hardly be affected by climatic circumstances, but school buildings in flood-prone areas may well be at risk. Without an in-depth examination of risks to individual projects, it is impossible to capture such differences. Hence, the sectoral classification only provides a rough first sense about the share of development activities that may be affected by climate risks.

To capture some of the uncertainty inherent in the sectoral classification, the share of development activities affected by climate change was calculated in two ways, a rather broad selection, and a more restrictive one. The first selection includes projects dealing with infectious diseases, water supply

11 Each activity can be assigned only one such code; projects spanning several sectors are listed under a multi-sector code, or in the sector corresponding to the largest component.

12 The OECD study "Aid Activities Targeting the Objectives of the Rio Conventions, 1998-2000" provides a similar, but much more extensive database analysis. It aimed to identify the commitments of ODA that targeted to objectives of the Rio Conventions. For this purpose, a selection was made of those projects in the CRS database that targeted the Conventions as either their "principal objective", or "significant objective".

and sanitation, transport infrastructure, agriculture, forestry and fisheries, renewable energy and hydropower[13], tourism, urban and rural development, environmental protection, food security, and emergency assistance. The second classification is more restricted. First of all, it excludes projects related to transport and storage. In many countries, these projects make up a relatively large share of the development portfolio, simply due to the large size of individual investments (contrary to investments in softer sectors such as environment, education and health). At the same time, infrastructure projects are usually designed on the basis of detailed engineering studies, which should include attention at least to current climate risks to the project.[14] Moreover, the second selection excludes food aid and emergency assistance projects. Except for disaster mitigation components (generally a very minor portion of emergency aid), these activities are generally responsive and planned at short notice. The treatment of risks is thus very different from well-planned projects intended to have long-term development benefits. Together, the first and the second selection give an indication of the range of the share of climate-affected development activities.

In addition, the share of emergency-related activities was calculated. This category includes emergency response and disaster mitigation projects, as well as flood control. The size of this selection gives an indication of the development efforts that are spent on dealing with natural hazards, including, often prominently, climate and weather related disasters.

The implications of this classification should not be overstated. If an activity falls in the "*climate-affected*" basket, which does not mean that it would always need to be redesigned in the light of climate change or even that one would be able to quantify the extent of current and future climate risks. Instead, the only implication is that climate risks could well be a factor to consider among many other factors to be taken into account in the design of development activities. In some cases, this factor could be marginal. In others, it may well be substantial. In any case, these activities would benefit from a consideration of these risks in their design phase. Hence, one would expect to see some attention being paid to them in project documents, and related sector strategies or parts of national development plans. Figures 6 and 7 show the results of these selections, for the three years 1998, 1999, and 2000[15].

13 Traditional power plants are not included. Despite their long lifetime, these facilities are so localized (contrary to, e.g., roads and other transport infrastructure) that climate risks will generally be more limited. Due to the generally large investments involved in such plants, they could have a relatively large influence on the sample, not in proportion with the level of risk involved.

14 Note however, that they often lack attention to trends in climate records, and do not take into account indirect risks of infrastructure projects on the vulnerability of natural and human systems.

15 The three-year sample is intended to even out year-to-year variability in donor commitments. At the time of writing, 2000 was the most recent year for which final CRS data were available. Note that coverage of the CRS is not yet complete. Overall coverage ratios were 83% in 1998, 90% in 1999, and 95% in 2000. Coverage ratios of less than 100% mean that not all ODA/OA activities have been reported in the CRS. For example, data on technical co-operation are missing for Germany and Portugal (except since 1999), and partly missing for France and Japan. Some aid extending agencies of the United States prior to 1999 do not report their activities to the CRS. Greece, Luxembourg and New Zealand do not report to the CRS. Ireland has started to report in 2000. Data are complete on loans by the World Bank, the regional banks (the Inter-American Development Bank, the Asian Development Bank, the African Development Bank) and the International Fund for Agricultural Development. For the Commission of the European Communities, the data cover grant commitments by the European Development Fund, but are missing for grants financed from the Commission budget and loans by the European Investment Bank (EIB). For the United Nations, the data cover the United Nations Children's Fund (UNICEF) since 2000, and a significant proportion of aid activities of the United Nations Development Programme (UNDP) for 1999. No data are yet available on aid extended through other United Nations agencies. Note also that total aid commitments in the CRS are not directly comparable to the total ODA figures in Figure 5, which exclude most loans.

Figure 6. Share of aid amounts committed to activities affected by climate risk and to emergency in Tanzania (1998-2000

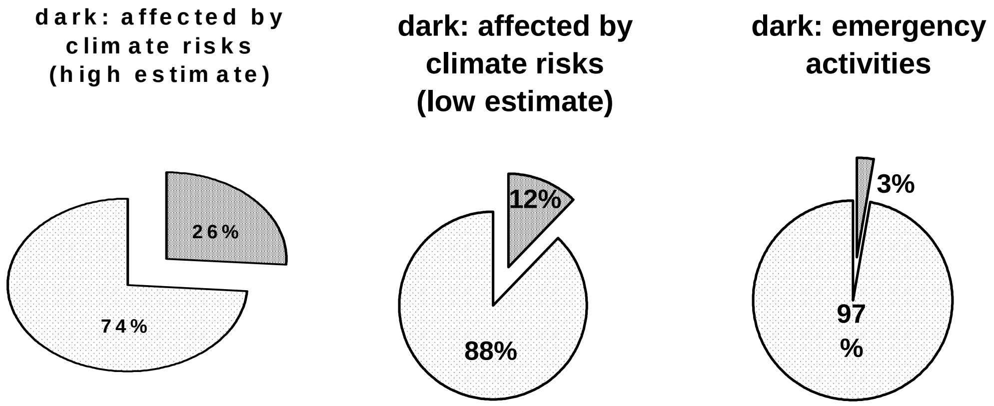
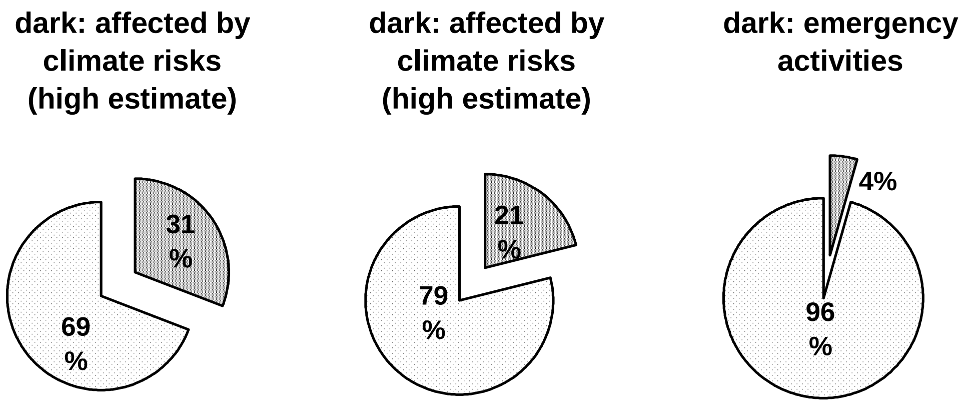


Figure 7. Share (by number) committed to activities affected by climate risk and to emergency activities in Tanzania (1998-2000



Emergency projects make up 3 to 4% of all activities. In monetary terms, between one-eighth and a quarter of all development activities in Tanzania could be affected by climate change. By number, the shares are higher, between about 20 and 30 percent[16]. In addition to providing insight in the sensitivity of

16 Note that the number of activities gives a less straightforward indication than the dollar amounts. First of all, activities are listed in the CRS in each year when a transfer of aid has occurred. Hence, when a donor disburses a particular project in three tranches, that project counts three times in our three-year sample. If the financing for a similar three-year project is transferred entirely in the first year, it only counts once. Secondly, the CRS contains a lot of non-activities, including items like "administrative costs of donors". Moreover, some bilateral donors list individual consultant assignments as separate development activities. In most cases, such transactions will fall outside of the "climate-affected" category. Hence, the share of climate-affected activities relative to the total number of activities (which is diluted by these non-items) is

development activities in Tanzania as a whole, the classification also gives a sense of the relative exposure of various donors. These results are listed in Table 2 and 3 (again in the years 1998, 1999, and 2000).

Table 2. Relative shares of CRS activities, by total disbursed amounts, for the top-five donors in Tanzania (1998-2000)

Amounts of activities (millions US$)			Activities affected by climate risks (high estimate)			Activities affected by climate risks (low estimate)			Emergency activities		
Donor	Amount	%	Donor	Amount	%	Donor	Amount	%	Donor	Amount	%
Total	2916	100 %	Total	761	100%	Total	356	100%	Total	81	100 %
UK	524	18%	CEC/EDF	134	18%	Germany	50	14%	USA	31	39%
IDA	453	16%	Denmark	81	11%	UK	41	12%	AfDF	13	16%
Japan	326	11%	Germany	72	9%	Japan	38	11%	UK	11	13%
CEC/EDF	264	9%	Japan	71	9%	IFAD	33	9%	CEC/EC	8	10%
Denmark	215	7%	UK	58	8%	Norway	32	9%	Sweden	7	8%

Table 3. Relative shares (by number) of CRS activities for the top-five donors in Tanzania (1998-2000)

Numbers of activities			Activities affected by climate risks (high estimate)			Activities affected by climate risks (low estimate)			Emergency activities		
Donor	Number	%	Donor	Number	%	Donor	Number	%	Donor	Number	%
Total	1745	100%	Total	536	100%	Total	369	100%	Total	76	100%
Sweden	232	13%	Ireland	72	13%	Ireland	64	17%	Switzerl.	16	21%
UK	222	13%	UK	67	13%	UK	42	11%	Sweden	15	20%
Norway	210	12%	Norway	53	10%	Norway	37	10%	UK	14	18%
Ireland	191	11%	Sweden	46	9%	Sweden	31	8%	Norway	6	8%
Germany	124	7%	Germany	36	7%	Germany	30	8%	Finland	5	7%

Given the extensive share of development activities in Tanzania that could be affected by climate risks, one would assume that these risks are reflected in development plans and a large share of development projects. The following sections examine to which extent this is the case.

5.2 Attention to climate risks in donor strategies

Tanzania regularly suffers from various climate-related hazards, including droughts that have substantial effects on economic performance and poverty. Many development plans and projects recognize this influence, and Tanzania's climate even turns up in the context of economic analyses. However, few of the development plans and projects that were reviewed take these risks into account. Given that current climate risks are already being neglected, it comes as no surprise that climate change is often ignored

lower. On the other hand, the shares by total amount tend to be dominated by structural investments (which tend to be more costly than projects in sectors such as health, education, or environmental management).

altogether. In the few cases where climate change does receive attention, the focus is on mitigation, rather than adaptation.

Several donor strategies recognize Tanzania's dependence on favourable weather, and the linkages between poverty, drought, and food security. For instance, the AfDB Country Strategy Paper highlights the impact of weather on economic performance: "growth rates have been fluctuating from year to year reflecting the vulnerability of the economy to external shocks. Although strong growth was registered in FY 1996/97 (4.2 percent), it declined to 3.3 percent in FY 1997/98 due to the adverse impact of the drought on agricultural output. The drought was followed by the El-Nino floods late 1997 and early 1998, which destroyed some of the crops and damaged roads, thereby, disrupting internal movement of agricultural commodities as well as export shipments." IFAD's Country Strategic Opportunities Paper estimates that the country has a structural food deficit of about 700 tons, with imports rising to up to 1.5 million tons in times of flood or drought. This vulnerability cannot be attributed to weather conditions alone. For instance, the AfDB paper notes that less than 20% of the irrigation potential is utilized, unnecessarily exposing agricultural production to droughts. "While droughts have contributed to water supply problems, the underlying factors include weak institutional capacity in the sector, poor water resource management, and the dilapidated condition of the water schemes and distribution networks in the rural and urban areas resulting from the under-funding of maintenance and rehabilitation." The UN Development Assistance Framework (UNDAF) also highlights Tanzania's vulnerability to climate-related disasters, due to natural and human factors: "Natural and man-made disasters erode the coping capacity of the vulnerable population especially in drought-prone areas. There have been poor rains in Central Tanzania for the last three years, and traditional coping strategies are breaking down as land pressure increases. These types of shocks have become a frequent phenomenon in Tanzania in recent years. Floods and droughts, epidemics and crop pests, environmental damage and economic instabilities, have all had their effects on people's capacity to meet their basic needs and subsequently their ability to survive and pursue their development ambitions and potential".

Despite these strong linkages between climate and economic performance, as well as the relationships between droughts, environmental degradation and poverty, none of the donor strategies even mentions climate change. Attention to current hazards, particularly droughts, varies from donor to donor. Some of them, including SIDA, Ireland Aid and the EU, do not explicitly recognize the impact of current climate-related risks on the success of development investments. Others, such as DFID and IFAD, have components that aim to address Tanzania's vulnerability to such risks.

In 2001, a joint "Emergency Consolidated Appeal for the Drought in Tanzania" was launched by a number of UN agencies. Instead of just addressing short-term relief, the appeal intended to address the underlying causes of the chronic droughts, including early warning systems, and drought mitigation measures in Rural and Agricultural Development Strategies. Despite the longer-term focus of the appeal, climate change was not considered.

5.3 Climate risks in selected development programs and projects

None of the (relatively few) development projects that were reviewed paid attention to the risks associated with climate change. For instance, a World Bank forest conservation and management project, which explicitly addresses climate change through carbon uptake, does not address current or future climate-related risks. A regional GEF-funded World Bank project to improve the long-term environmental management of Lake Victoria, does not consider the potential impacts of climate change on the water resources and ecosystems at stake, and a USAID-sponsored coastal management partnership neglects sea level rise in its analysis of integrated coastal zone management options.

6. Attention to climate concerns in national planning

Since attaining its independence in 1961, Tanzania has been addressing its development process through long, medium and short-term development plans and programs, which are developed by the Planning Commission in the Ministry of Planning and Privatization. See Table 4 for an overview on Tanzania's planning history. The latest medium-term program is the so-called Three Year Rolling Plan and Forward Budget, which rolls on an annual basis and has been in place since 1993/94 up to the present. The major macroeconomic and sectoral policy objectives and cross-sectoral issues included in Tanzania's plan are poverty alleviation, population, science and technology as well as environmental protection.

Besides, Tanzania also embarks on long term planning, the latest being the National Development Vision 2025, which aims for economic prosperity, equity, self-reliance, the transformation from a rural based agricultural economy to a more diversified and industrialized one, as well as sustainability by the year 2025. Despite the Vision's long time horizon, climate change is not mentioned. It neither discusses climate-related risks, nor strategies to mitigate or to adapt to them (such as irrigation, reforestation, and crop diversification). Similarly, the shorter-term (5-year) Tanzania Assistance Strategy ("a medium-term framework for promoting local ownership and development partnerships") does not discuss climate change either. However, climate-related risks, mainly floods and droughts, feature prominently. Besides specific attention to disaster preparedness activities, the plan also advocates the integration of disaster mitigation in Tanzania's development plans.

Table 4. Tanzania's main planning documents

National Plans	Period
National Development Plans	
Three Year Plan	1961-1963/64
First Five Year Plan	1964/65-1968/69
Second Five Year Plan	1969/70-1973/74
Third Five Year Plan	1976/77-1980/81
First Union Five Year Plan	1981/82-1985/86
Second Union Five Year Plan	1988/89-1992/93
Three Year Rolling Plan and Forward Budget (rolls annually)	1993/94 to date
Emergency Plans	
National Economic Survival Programme	1982
Structural Adjustment Programme	1983-85
Economic Recovery Programme (ERP-I)	1986/87-1988/89
Economic Recovery Programme (ERP-II)	1989/90-1991/92
Long Term Perspective Plans	
15 Year Development Plan	1964-1980
20 Year Development Plan	1981-2000
National Development Vision 2025	1998-2025

In 1997 Tanzania developed a first National Action Plan on Climate Change, which contained an inventory of emissions by source and removal by sinks of greenhouse gases based on 1990 data. Besides the Action Plan, various studies focusing on technological and other options for mitigating greenhouse gases in Tanzania as well as on the assessment of vulnerabilities and possible adaptation measures have been completed. Tanzania has also signed or ratified a number of multilateral environmental agreements, and has a number of national level environmental and sectoral plans that intersect with responses that may be required to manage climate variability and long term climate change.

6.1 National Action Plan on Climate Change

The National Action Plan on Climate Change was developed in 1997 and has different objectives for various timeframes:

6.1.1 Short term program (Year 1 - 2)

In the beginning efforts should be undertaken to raise awareness of possible impacts stemming from climate change on various social and economic activities. The overall aim of these meetings would be to explore possibilities of how current activities or sectoral plans could complement climate change mitigation options. Besides, there is a need to analyze the effects of governmental macroeconomic policies in relation to climate change.

6.1.2 Medium term program (Year 2 - 5)

In the medium term, projects already internalizing climate change aspects, especially those reducing GHG emissions, should be supported. Support will either be sought from internal such as the Government budget or from external sources. In addition, climate change aspects should be included into the educational curriculum, preferably starting at secondary school level. Also, the Government should start introducing environmental economic instruments such as fiscal measures (pollution taxes, input taxes, product taxes, import tariffs, royalties , land user taxes, tax differentiation etc), property rights (ownership right, user right, and development rights], and performance bonds (land reclamation bond, waste delivery bond, environmental performance bond, etc.) as incentives to increase environmental conservation.

6.1.3 Long term program (Year 10 - 20)

In the long-term, large projects in the energy and transport sector should be undertaken. In addition, adaptation measures to cope with a rising sea level and its adverse effects on coastal infrastructures should be implemented.

6.2 National communications to international environmental agreements

Tanzania is a party to various international environmental agreements, including the UNFCCC, UNCCD, and UNCBD. Tanzania recently submitted its Initial National Communication to the UN FCCC (in July 2003), and is currently preparing a National Adaptation Programme of Action (NAPA).

While Tanzania's *National Report to the UN Convention on Biodiversity* does not mention climate change at all, its *First National Report to the UN Convention to Combat Desertification* refers only to climate change mitigation mainly through the diversification of Tanzania's energy resources. The Second National Report to the UNCCD, however, does highlight the linkages between climate change and desertification. It also notes that desertification programs have been quite successful, not only in terms of awareness raising, but also by mainstreaming desertification concerns in national and sectoral plans and policies.

Tanzania's *National Report to World Summit on Sustainable Development* (2002) refers to the national vulnerability and adaptation assessment, and explicitly lists agriculture, water resources, forestry, grasslands, livestock, coastal resources and wildlife and biodiversity as vulnerable to climate change. Nevertheless, adaptation receives very little attention (except in agriculture, where further work is planned), in sharp contrast to mitigation, which is discussed extensively. Several components of potential climate change adaptation strategies are included in efforts to address current-day vulnerability to climate-related risks, including better water management, for instance in the context of irrigation development, and research on drought-resistant, high-yield crops.

6.3 Poverty Reduction Strategy Paper (PRSP)

Although Tanzania's PRSP recognizes the grave impact of weather and climate hazards on development, and particularly on the poor, it neglects climate change. The important impact of climate-related risks, however, is clearly recognized. For instance, stakeholder groups that were interviewed in preparation for the poverty strategy voiced their worries: "A major concern of the poor is their vulnerability to unpredictable events. In Tanzania, famine often results from either floods or drought. Since the mid-1990s, Tanzania has in fact experienced a series of adverse weather conditions, which undermined food security. […] There is, therefore, a growing need for safety-nets." In response, the PRSP lists a number of activities to reduce this vulnerability, including early warning systems, irrigation, better food supply systems, development of drought resistant crops, facilitation of the provision of adequate, safe and clean water to the rural areas from 48.5% population coverage in 2000 to 85% by 2010, promotion of the use of rainwater harvesting and sustained efforts in reforestation as well as sustained efforts in adaptation.

The PRSP progress report, which was published a year later, notes that agricultural growth has been lagging behind expectation "owing to adverse weather and the collapse of export prices". Despite this observation, the report's response to this lagging growth includes no direct measures to reduce vulnerability to climate risks, not even the ones mentioned in the original PRSP a year earlier. Similarly, these options are also neglected in the World Bank/IMF Joint Staff Assessments of the PRSP and the PRSP progress report, suggesting that climate-related risks do not get much attention in the PRSP oversight process.

6.4 Other national policies of relevance to climate change

Tanzania has put in place a number of environmental and sectoral policies and plans especially during the 1990s, which are intended to increase its ability to cope with current environmental problems as well as with additional risks posed by climate change. The following paragraphs discuss some of the most relevant policies.

The *National Environmental Action Plan* (NEAP) of 1994 was a first step towards incorporating environmental concerns into national planning and development. NEAP identified six priority environmental concerns, namely land degradation; lack of accessible, good quality water for both urban and rural inhabitants; pollution; loss of wildlife habitats; deterioration of marine and freshwater systems; and deforestation. In order to address these issues the *National Environmental Policy* (NEP) was promulgated in December 1997 to provide a framework for mainstreaming environmental considerations into the decision-making processes in Tanzania. Though NEP does not pay explicit attention to climate change, the primary environmental issues brought forward include many of the concerns that would be addressed by no-regrets climate change adaptation measures. In particular, the NEP highlights the importance of integrating environmental management in several sectoral programs and policies.

A particularly strong example of such integration is found in the agriculture sector, which is crucial for food security and the eradication of rural poverty. The NEP, for example, proposes "the improvement of land husbandry through soil erosion control and soil fertility improvement; the minimization of encroachment in public lands including forests, woodlands, wetlands, and pastures; the strengthening of environmentally sound use, monitoring, registration and management of agrochemicals; as well as the improvement in water use efficiency in irrigation, including control of water logging and salinization." In addition, the forestry section of NEP is most explicit in giving attention to cross-sectoral environmental issues: "the main objective is the development of sustainable regimes for soil conservation and forest protection, taking into account the close linkages between desertification, deforestation, freshwater availability, climate change, and biological diversity." The only other paragraph in the NEP that relates to climate change reads as follows "The need to undertake climate studies in order to come up with mitigation options is stressed. In view of Tanzania's vulnerability to climate variations, an assessment of impacts of climate change and climate variations will be undertaken. In this regard strategies will be evolved to ensure that options which are pursued do not unduly sacrifice national development endeavors."

Similarly, the 1998 *National Forestry Policy* (NFP), which is a review of the 1953 one, gives no direct references to climate change despite the vulnerability of Tanzanian forests to changed climatic conditions. One of the main objectives of the NFP is to ensure ecosystem stability through conservation of forest biodiversity, water catchments, and soil fertility. The policy states that new forest reserves for conservation will be established in areas of high biodiversity value and that biodiversity conservation and management will be included in the management plans for all protected forests. This policy is a great departure from the traditional forestry approach of command-and-control by involving communities and other stakeholders through joint management agreements.

Likewise, despite the criticality of climate change impacts on water resources the new *National Water Policy* (NAWAPO), which has been approved by the Tanzanian cabinet in July 2002, does not explicitly mention the issue. Nonetheless, the NAWAPO is participatory, multi-sectoral, river-basin based and tries to integrate land use with water use and water quality as well as quantity. The four key issues in the revised policy are 1) the demand respond approach, which leads to community ownership and management of water and sanitation facilities; 2) private sector participation; 3) integration of water supply and sanitation and finally 4) decentralization of service delivery from central government to district councils.

7. Climate change and Mount Kilimanjaro

Mount Kilimanjaro derives its name from the Swahili words *Kilima Njaro* meaning "shining mountain", a reference to its legendary ice cap. It is the retreat of this ice cap, arguably linked to rising temperatures, that has made the Kilimanjaro a prominent symbol of the impacts of global climate change. Beyond the symbolism of the ice cap Kilimanjaro is also a hot spot of biodiversity with nearly 3000 plant species and providing a range of critical ecosystem services to over one million local inhabitants who depend on it for their livelihoods, as well as to the broader region that depends on water resources that originate at the Kilimanjaro. The Kilimanjaro ecosystem is also subject to wide ranging impacts that may be more directly attributable to changes in temperature and precipitation patterns, and which may have far greater significance than the melting of the ice cap itself. This in-depth analysis has two objectives: (i) to provide an overview on the impact of climatic changes on Mt. Kilimanjaro and on the resulting impacts on the environment, ecosystems and on the human population; and (ii) to describe adaptation responses to reduce or manage some of the most critical impacts and their synergy or conflict with other environmental and development priorities.

Mt. Kilimanjaro is located 300 km south of the equator in Tanzania, on the border with Kenya. It is the highest mountain in Africa, a huge strato-volcano (ca. 90 by 60 km), composed of three single peaks, Kibo, Mawenzi and Shira that reach respectively an altitude of 5,895, 5,149 and 3,962 meters (Figure 8). Kilimanjaro is also the world's highest free standing mountain, looming 5,000 meters above an open undulating plain that averages around 1,000 meters above sea level. The morphology of the upper areas of Mt. Kilimanjaro is formed by glaciers which reached down to an altitude of 3000 m above sea level (asl) during the ice age (Downie & Wilkinson 1972, Hastenrath 1984).

Figure 8. Mount Kilimanjaro

7.1 Climate, glaciers, and hydrology

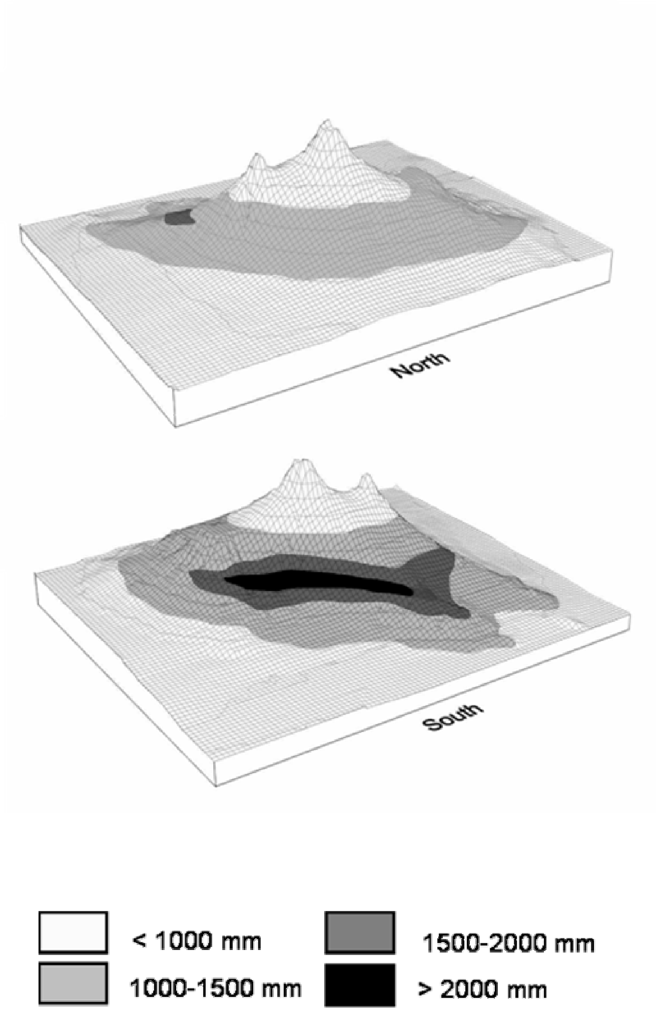
Mt. Kilimanjaro is characterized by a typical equatorial day-time climate. Due to its near-equator location, it experiences two distinct rainy seasons: the long rains from March to May forming the main rainy season; and the short, but heavy rains centered on the month of November of the small rainy season. The driest period falls into the months from July to October, while April and May are the wettest months. However, rainfall and temperature vary with altitude and exposure due to the dominant wind blowing from the Indian Ocean. Annual rainfall reaches a maximum of around 3,000 mm at 2,100 meters on the central southern slope in the lower part of the forest belt, clearly exceeding precipitation on other East African high mountains (HEMP 2001a). Higher up at 2,400, 2,700 and 3,000 meters, approximately 90, 70 and 50% respectively of this maximum precipitation has been observed. The northern slopes, on the leeward side of the mountain, receive much less annual rainfall (Figure 9).

The mean annual temperature in Moshi township (813 m) is 23.4°C (Walter et al. 1975). It decreases to 9.2°C at an altitude of 3100 m, 5.0°C at 4000 m (HEMP, unpub. data) and –7.1°C on top of the Kibo peak at about 5800 m (Thompson et al. 2002), with a lapse rate of about 0.6°C per 100 m increase in altitude. The climate in the alpine belt above 3500-4000 m is characterized by extremes, with nightly frosts and intense sunshine during daytime all year round (HEDBERG 1964).

Kilimanjaro represents a rare instance of the occurrence of glaciers in equatorial regions and like the glaciers of Rwenzori and Mt. Kenya these are a relic of the colder and wetter climatic conditions of the region during the Pleistocene (Downie & Wilkinson 1972). At present permanent ice exists only on Kibo - covering an area of 2.6 km2 (Thompson et al. 2002). Yet, the distribution of moraines reaching down to an altitude of 3000 m indicates that a much greater area of the mountain was formerly covered by ice (Downie & Wilkinson 1972, Hastenrath 1984).

Mt. Kilimanjaro is a critical water catchment for both Tanzania and Kenya. High rainfall and extensive forests give Mt. Kilimanjaro its high catchment value. The southern and the south-eastern forest slopes form the main upper catchments of the Pangani River, one of Tanzania's largest rivers, which drains into the Indian Ocean near Tanga. Although the greater aridity of the northern slopes is reflected in a sparser network of valleys on this side, in their shallower cross-section and in the general absence of running water above 3000 m (Downie & Wilkinson 1972), the north-western slopes form the catchment of the Tsavo River, a tributary of the Galana River, one of Kenya's major rivers. The Amboseli National Park in Kenya also depends on the hydrology of Mt. Kilimanjaro[17].

Figure 9. Annual precipitation on Mt. Kilimanjaro



Source: Hemp 2001a

Mt. Kilimanjaro's ice cap is relatively small in comparison to its height and surface area and its contribution in developing water sources must be assumed to be equally slight (Ramsay 1965)[18]. Very few streams originate in this zone and most of these have small flows. In contrast, the montane forest belt between 1600 and 3100 m provides most of the water (96%) coming from the mountain (Ramsay 1965). In

17 Further afield in Kenya, it is likely that the mountain has an effect on Ol Turesh swamp and possibly Mzima Springs, whose primary catchment is the Chyulu Hills.

18 Only Weru-Weru and Kikafu River, important branches in the headwaters of the Pangani River, are linked by permanent streams to glaciers on the south-west edge of Kibo. The relatively few springs between the ice cap and the forest belt indicate that the percolation of melt water downwards through the permeable surface volcanic ash is small as well. Therefore - except below the glaciers of south-west Kibo - the valleys above 3600 m are dry for a large part of the year (Downie & Wilkinson 1972).

this zone the rainfall is very high while evaporation losses are low due to an almost permanent cloud cover. A great amount of water from this zone flows underground, directly to the savanna plains.

7.2 Ecosystems, biodiversity and land tenure on Mount Kilimanjaro

The Kilimanjaro Region consists of six administrative districts: Moshi Rural (1,713 km^2), Moshi Urban (58 km^2), Hai (2,111 km^2), Rombo (1,442 km^2), Same (5,186 km^2) and Mwanga (2,698 km^2) of which only the four former are immediately adjacent to Mt. Kilimanjaro. Regional headquarter is Moshi. Most of the forest is part of the Mt. Kilimanjaro Forest Reserve (107,828 ha). The upper areas of Mt. Kilimanjaro that lie above the 2,700 meters contour fall within Kilimanjaro National Park with 75,575 ha. Mt. Kilimanjaro has a rich diversity of ecosystems, particularly of vegetation types that result mainly from a large range in altitude and rainfall (summarized in Table 5). Due to the high diversity of its ecosystems, Mt. Kilimanjaro is also very rich in fauna and flora, including about 2200 vascular plant species and 140 mammals. Details on the fauna and flora on Mt. Kilimanjaro are summarized in Box 3 and 4 respectively.

Kilimanjaro is one of the main agricultural regions of Tanzania contributing approximately 30% of the country's high quality *Arabica* coffee in 1985/1986 (O'KTING´ATI & KESSY 1991). In addition to coffee the other cash crops are sugar cane, sisal, pyrethrum and cotton. Mt. Kilimanjaro is also important in terms of food crops such as bananas, beans, rice and millet. Most of this activity on the southern and (north) eastern slope of Mt. Kilimanjaro is performed by smallholders of the Chagga tribe, who use the vegetation zones in various ways (see Table 6), depending on the climatic conditions (cp. HEMP et al. 1999). On the southern slopes of the mountain, the area below the montane forest was traditionally divided into two zones. The upper part, the highland area of the irrigated banana belt in the submontane zone ("kihamba" land), was permanently cultivated and inhabited by the Chagga for reasons of suitable climate and defense against the Masai. The lower part, the "shamba" land of the colline savanna zone was cultivated seasonally and provided annual crops like maize, beans and finger millet as well as fodder for cattle.

Box 3. Flora of Mount Kilimanjaro

About 2,200 vascular plant species occur on Mt. Kilimanjaro (HEMP, unpub. data). These are 22% of the approximately 10,000 vascular plant species of Tanzania (BRENAN 1978). Dissecting diversity into different types of habitats or formations, the forest belt is the most important habitat in terms of species diversity on Mt. Kilimanjaro. Nearly 900 species occur in the forests of Kilimanjaro, representing roughly 45% of the whole vascular flora (HEMP, unpub. data). Besides the richness in *epiphytes* another prominent feature of the forests of Mt. Kilimanjaro is the wealth of ferns, especially on the southern slope, due to the high humidity. 145 taxa of *pteridophytes*, constituting roughly 35% of the pteridophyte flora of Tanzania, occur on the mountain, most of them (over 90%) in the forests (HEMP 2001 a, b, 2002). The number of *vascular plants* capable of enduring the harsh climate conditions in the alpine zone is rather small – together with the ericaceous subalpine zone Kilimanjaro harbours in its alpine belt only 350 species of vascular plants (HEMP, unpub. data), 13 of which are endemic to Kilimanjaro (HEDBERG 1961). About 600 species of *bryophytes* (of which 415 are mosses and 185 are liverworts) and approximately 120 *lichens* occur on Mt. Kilimanjaro. 12 bryophytes are strict endemics. The richest belt for bryophytes is between 2100-4100 m (PÓCS 1991).

Table 5. Altitudinal zones and main vegetation units at Mount Kilimanjaro

Altitude (meters)	Main vegetation type	Altitudinal zone according to Hemp (2001 a)		
4400	Cushion vegetation (*Helichrysum*)	11	lower	Alpine
3800	*Erica* shrubland, *Helichrysum* cushion vegetation	10	upper	Subalpine
	Erica shrubland, *Erica excel*sa forest, *Hagenia-Rapanea* forest	9	middle	
2800	*Erica excelsa* forest, *Podocarpus* forest, moorland	8	lower	
2700	*Podocarpus-Ocotea* forest, *Erica excelsa* forest	7	upper	Montane
	Ocotea-Podocarpus forest	6	middle	
	Agauria-Ocotea forest, *Cassipourea* forest	5	lower	
1600	*Agauria-Ocotea* forest, coffee-banana plantations, *Bulbostylis* meadows	4		
1500	Coffee-banana plantations, *Croton-Olea* forest, *Hyparrhenia* meadows	3	upper	Submontane
900	Coffee-banana plantations, savanna bushland and grassland, agriculture, pasture	2	lower	
800 700	Savanna bushland and grassland, agriculture, pasture	1	Colline	

Box 4. Fauna of Mount Kilimanjaro

GRIMSHAW et al. (1995) recorded about 140 species of mammals for Mt. Kilimanjaro, a number far exceeding the diversity known for Mt. Kenya (GATHAARA 1999). Among them, 87 species are regarded as being pure forest species. Black Rhinoceros is now extinct in the area, as possibly are reedbuck and klipspringer. Twenty four antelope species are recorded in the area, as well as 25 species of carnivores and 7 species of primates. The forest is home to the largest known population of Abbot's duiker, which is globally threatened. There are also 25 species of bats (Chiroptera).

SJÖSTEDT (1909) listed 405 bird species in his expedition report for Mt. Meru and Mt. Kilimanjaro, while GRIMSHAW (1996) gives a number of 179 highland bird species inhabiting Mt. Kilimanjaro. In an ethno-zoological study, 82 bird species were recorded on the southern slopes in the area of the Chagga home gardens, mostly from an altitude of 1400 m (Hemp et al. 1999) reflecting the high diversity of bird habitats. 4 bird species which are globally threatened occur on Kilimanjaro. These are Lesser Kestrel, the Taita Falcon, the Corncrake and Abbot´s Starling. The Madagascar Pond-Heron and the Pallid Harrier are near threatened species

418 reptile species are recorded for East Africa of which 302 are listed for Tanzania. The habitat range of 88 reptile species lies within Mt. Kilimanjaro (SPAWL et al. 2002). Thus Kilimanjaro harbours about 21% of the reptile fauna of East Africa and 29% of Tanzania. The side-spotted dwarf gecko (*Lygodactylus laterimaculatus*) known only from Mt. Kilimanjaro and the Taita Hills, and the Mt. Kilimanjaro two-horned Chameleon (*Chameleo tavetanus*) occurring on Mt. Kilimanjaro and Mt. Meru, the adjacent North and South Pare Mts., and the Chyulu and Taita Hills in Kenya are locally restricted species.

SJÖSTEDT recorded 1,310 species of beetles (Coleoptera), 594 Hymenoptera, 447 bugs and allies (Hemiptera), and 537 butterflies and moths (Lepidoptera) species for the area including Mt. Meru, but with a main focus on Mt. Kilimanjaro. The insect materials collected highlight the diversity of Mt. Kilimanjaro and the large number of endemic species: 47 of the 107 known Homoptera species were endemic to the mountain, as well as 27 of the 57 recorded Darkling beetles (Tenebrionidae). A high rate of endemism was also recorded for the Rove beetles (Staphylinidae, 39% endemism), the Scarab beetles (Scarabaeidae, 25% endemism) and the long-horned beetles (Cerambycidae, 36% endemism in the mountain among all species known in East Africa) (FORCHHAMMER & BREUNING 1986; HEMP & WINTER 1999; HEMP, C., 2001). Grasshoppers and locusts (Saltatoria) have been well studied on Mt. Kilimanjaro; 140 species of Acridoidea have been collected around the mountain in the past 10 years (HEMP & HEMP, in press), which represent 33% of the species found in entire Tanzania according to a list published by JOHNSEN & FORCHHAMMER (1975). Together with the Ensifera, about 190 species of Saltatoria are recorded on the mountain, of which 12 species are only known from Mt. Kilimanjaro localities (HEMP, C., in press), and three species are still un-described, representing 8% endemism in this insect group.

439 species of Odonata are reported for East Africa of which 171 occur in Tanzania (CLAUSNITZER 2001). Nevertheless, the number of dragonflies recorded for Tanzania is constantly growing with every field survey due to the very poor original data base. There are 16 species restricted to Tanzania which means a share of 9% endemism of dragonflies for Tanzania. Mt. Kilimanjaro alone harbours 85 species (20%), among them are 14 species typical for montane areas (17%) (CLAUSNITZER, pers. comm.). In comparison to other montane habitats of volcanic origin in East Africa, Kilimanjaro, though being the youngest, shows an unusual high diversity due to Eastern Arc species, which reached Kilimanjaro via the adjacent North Pare Mountains. Thus, this particular insect group exemplary reflects the high diversity of habitats on Kilimanjaro.

Table 6. Land-use in the different vegetation zones of Mount Kilimanjaro

Altitude (meters)	Land-use	Altitudinal zone
3200 2700	• South eastern slopes: forest border with tussock grasses and giant lobelias are fringed by so-called moorland zones into Erica bushland at steeper slopes • Tussock grassland, although already situated in the Kilimanjaro National Park (KINAPA), is in some areas cut by fodder collectors • Bee hives were seen up to over 3000 m with bees sucking on *Erica*. Except for the tourist climbing routes the afro-alpine zone of the National Park is mostly undisturbed by direct human impact	Subalpine zone
1700	• Southern and eastern slope: half-mile forest strip ranges between the plantation belt and the forest reserve; provides timber and firewood (mostly pines, cypress and eucalyptus) • Meadows reach far into the montane forest, especially along the rivers • Forest strip grades into natural montane forest, which should be excluded as "forest reserve" from any usage. Nevertheless, since the 1950s about 12% of the forest was changed into cypress and pine plantations • Northern, north eastern and western slope: large forest plantations • Honey collectors also frequent the montane forest zone • Special type of land use: Shamba (Taungay) system practices (allowing local farmers to inter-crop annual agricultural crops – mainly potatoes, carrots and cabbage – with tree seedlings in forest plantation areas until the third year of tree growth. By the third year, the young tree canopy casts too much shade for the normal growth of agricultural crops. At this point farmers move out and are allocated another plot, if available)	Montane forest
1000	• Most intensively cultivated by the Chagga (population density 500 person per km^2) • Tree layer provides firewood, fodder and shadow, banana trees (in about 25 varieties) • Network of irrigation canals • The Chagga live among their home gardens in single dwellings, villages as such do not exist • Livestock like cattle, goats, sheep and pigs, sometimes even chicken, are kept in stalls • Bee-keeping plays an important role (Two bee species are kept: the bigger, stinging honey-bee *Apis mellifera* ssp. *monticola* resembling the European honey-bee, and a small stingless bee of the genus *Meliponula*)	Submontane coffee-banana zone
700	• Southern foothills: most areas planted with maize and beans • North-eastern foothills: maize, finger millet (important ingredient of local beer), pigeon peas, groundnuts and sunflowers • Western and north western foothill: large farms owned by big companies or the government growing mainly wheat • East of Moshi: rice • South of Moshi: sugar plantations	Colline savanna zone

7.3 Climatic trends on Mount Kilimanjaro

Over the past millennium, equatorial East Africa has witnessed a series of contrasting climate conditions[19]. A drastic climatic dislocation took place during the last two decades of the 19th century,

19 A significantly drier climate than today occurred during the "Medieval Warm Period" (~AD 1000-1270) and a relatively wet climate during the so-called "Little Ice Age" (~AD 1270-1850), which was interrupted

manifested in a drop of lake levels and in the onset of glacier recession (Hastenrath 1984, 2001, Verschuren et al. 2000, Nicholson 2000, Nicholson & Yin 2001)[20]. A decrease in the annual precipitation of the order of 150 mm with attendant albedo and change of cloudiness during the last quarter of the 19th century constitutes also the most likely cause of the retreat of the Lewis Glacier on Mt. Kenya. In contrast, the continuation of ice retreat beyond the early decades of the 20th century – as is the case for Kilimanjaro – has been favored by a warming trend (Kruss 1983). Further, weather patterns on the Kilimanjaro are intricately linked to landscape characteristics (e. g. Altmann et al. 2002)[21]. During the past few decades vast savanna woodlands have increasingly been turned to agricultural use and thousands of hectares of forest cover on the mountain have been destroyed by logging and burning. Whether such reciprocal effects caused by (mostly man-made) landscape changes or whether climatic changes are of higher influence on the Kilimanjaro remains an open question.

The most striking and most easily recognizable evidence for a steady change in regional climatic conditions on Mt. Kilimanjaro, directly influencing landscape characteristics, are the vanishing glaciers. As there are no signs of an increasing volcanic activity on a major scale this phenomenon has to be linked to climatic conditions. Also, the fact that such glacier retreat is coincident with similar patterns elsewhere around the globe leads to the assumption that their causes are also of a global character (Kaser 1999). In contrast to this direct climatic impact, there are other even larger landscape changes, which are linked indirectly to changing weather conditions. During the last century not only were the glaciers melting rapidly, but there was also a significant increase in number and intensity of wild fires on Mt. Kilimanjaro, which are most likely caused by the same climatic changes and which are simultaneously enhanced by human influence. Changing weather patterns influence not only landscape characteristics but also animal distributions (cp. Altmann et al. 2002). A changing migration behavior and population dynamic of big game has been observed in the forests of Mt. Kilimanjaro.

Analysis of proxy data reveals that annual precipitation decreased by 150 mm, this means a lapse rate of 7.5 mm/year between about 1880 and 1900. Since 1935 there are actual daily rainfall records from the Lyamungu Coffee Research Institute which is located at an altitude of 1200 meters in the submontane cultivated zone on the southern slope of Mt. Kilimanjaro. The annualized values are shown in Figure 10.

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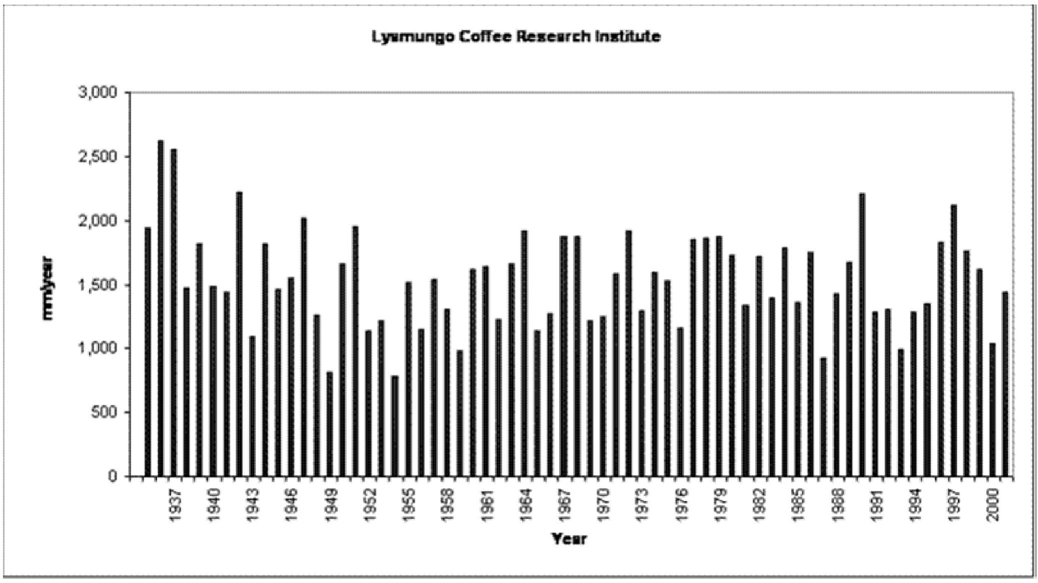
by three episodes of several decades of persistent aridity more severe than any recorded drought of the twentieth century (Verschuren et al. 2000).

20 This glacier recession was caused by enhanced solar radiation due to diminished cloud cover which accompanied the reduced precipitation. The drastic drop of the water level of Lake Victoria from around 1880 to the turn of the century was caused by a reduction in annual precipitation of about 150-200 mm (Hastenrath 1984). These data are apparently indicative of an important precipitation reduction throughout an area exceeding East Africa (cp. the variations of the water level of Lake Chad (Street-Perrott & Perrott 1990), where severe droughts started from the year 1900), followed by little secular precipitation variation.

21 The role of temperature and rainfall in shaping the landscape has long been recognized. More recently both empirical evidence and mathematical models have highlighted the reciprocal impact of landscape changes on weather patterns.

Figure 10. Annual precipitation at the Lyamungu Coffee Research Institute



Source: Lyamungu Coffee Research Institute

It appears that there is a decrease in precipitation since 1935 of about 11% or 177 mm (equivalent to 2.6 mm/year) at Lyamungo or a lapse rate of 2.6 mm per year. If this rate is extrapolated back to the year 1900 this would mean an annual loss of over 400 mm compared with the situation before 1880.

This records from Lyamungu are consistent with a general reduction in rainfall throughout most of Africa since 1950 (Nicholson 2000) and in the area of Kilimanjaro according to the maps presented by Hay et al. (2002) for the time interval 1941-1995 between 1941-1960 and 1971-1995. In addition to the decline in annual precipitation, the Lyamungo data also reveal that the number of dry months with less than 30 mm increased, whereas wet months with more than 125 mm were stable. With regard to temperature, the maps presented by Hay et al. (2002) indicate that spatially averaged temperatures in the area of Kilimanjaro rose between 1951-1960, were stable or decreased slightly between 1960-1981, and increased again between 1981-1995. While no time-series exists for a particular location on the mountain, there is however a 25-year temperature record (from 1976) from the Amboseli region just to the north (Altmann et al. 2002). This record shows daily temperatures increased dramatically throughout the same 25-year period. Mean daily maximum temperatures increased with a rate of 0.275 °C per annum, with increases being greatest during the hottest months of February and March.

To summarize, available climate records reveal a declining trend in precipitation on the Kilimanjaro at least since 1880. Although available data is not sufficient to infer temperature trends at different altitudes on the mountain, a distinct overall warming trend has been observed for most of the period since 1950 to present. Observations from neighboring Amboseli in fact indicate a local warming rate of 0.275 °C per decade between 1976-2000, significantly higher than globally averaged warming.

Either of these trends – declining precipitation or increasing temperature – contribute to enhanced glacier melting, as well as to enhanced fire risk[22]. Consistent with the pronounced decrease of precipitation

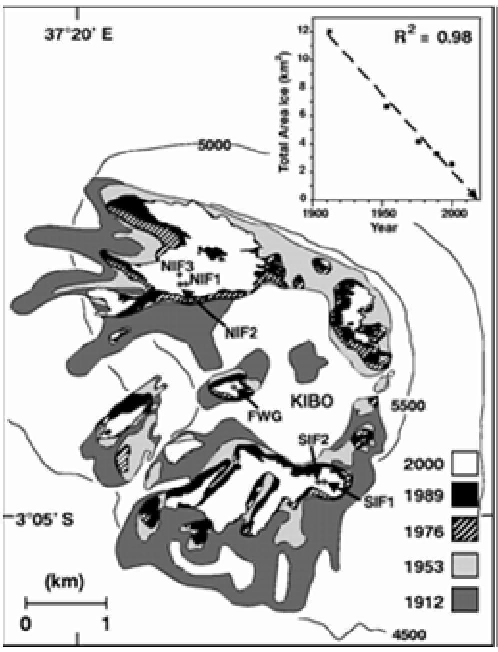
22 Decreased precipitation reduces cloud cover and therefore enhances the sunlight reaching the glacier, causing it to melt faster. The effect of increased temperatures on glacier melting is self evident. With

at the end of the 19th century fires in the areas of the subalpine forests were documented by the first Europeans on the mountain (Meyer 1890, Volkens 1897, Jaeger 1909). At the same time the glaciers started to recede (Kaser et al. under review) – driven by such changes in precipitation[23]. In the following decades the climatic situation was more stable while the glaciers changed more slowly (Kaser 1999). Enhanced glacier melt and fire risk have both been empirically observed in recent decades. These effects are consistent with the simultaneity of precipitation decline and temperature increase[24] which has been observed during the same time period.

7.4 Potential impacts of climatic changes: glacier retreat

The ice cap on the Kilimanjaro has been in a general state of retreat since the end of the Little Ice Age around 1850. This retreat was driven by natural climatic shifts (particularly a decline in regional precipitation), but appears to have accelerated due to the warming observed in the second half of the 20th century. Later in 1976 the glaciers covered 4.2 km^2 (Hastenrath & Greischar 1997) compared with only 2.6 km^2 in 2000 (Thompson et al. 2002). Measurements taken in 2000-2001 on Kilimanjaro show that its glaciers are not only retreating but also rapidly thinning (Thompson et al. 2002). Figure 11 shows the diminishing extent of the glaciers on Kibo between 1962 and 2000. Over these 38 years, Kilimanjaro has lost approximately 55 % of its glaciers. There is general consensus that the ice cap of Kilimanjaro will have disappeared by the year 2020 for the first time in the surveyed period of over 11,000 years.

Figure 11. Development of the Kilimanjaro (Kibo) ice fields from 1912 to 2000



Source: Thompson et al. 2002

The symbolism of this loss notwithstanding, it is important to note that the impact of the disappearance of the ice cap on the natural and human systems would be very limited. The present glaciers of Kibo cover an area equivalent to 0.2% of the area covered by the forest belt on Mount Kilimanjaro.

regard to forests, drier and hotter conditions both contribute to enhanced inflammability of the forest, thereby enhancing fire risk.

23 The causes of such changes in precipitation are likely natural and not linked to climate change.

24 The warming in recent decades is consistent with climate change.

Only two rivers are directly linked by very small streams to the glaciers, while 90% of the precipitation is tapped by the forest belt. Even if the glaciers have melted till 2020 there will still be precipitation on Kibo feeding springs and rivers, although not so continuously and to a much lesser degree.

Therefore, contrary to the opinion expressed by Thompson et al. (2002) it is very unlikely that the loss of the glaciers will have a major impact on the hydrology of the mountain. Kaser et al. (under review) come to the same conclusion. Further, observations of dry river beds are not necessarily an indicator of long term climatic changes or the impact of shrinking glaciers. Dried out rivers in some areas are much more likely the result of forest destruction or of increasing water demands of the rapidly growing population. Water diversion has in fact quadrupled in certain areas during the last 40 years (Sarmett & Faraji 1991).

Today Kilimanjaro National Park (KINAPA) is a major tourist attraction in Tanzania and gains the most foreign exchange of any National Park in Tanzania (Newmark & Nguye 1991). Most visitors are mainly interested in reaching the summit of Kibo, known as Uhuru Peak, the highest point in Africa. Since the establishment of the Park in 1972, the number of visitors of KINAPA has multiplied by five. Without any doubt Mt. Kilimanjaro will lose part of its beauty with the inevitable loss of its glaciers. However, it will still remain the highest mountain in Africa – and incentive enough to climb. Therefore, a decline in tourist numbers is unlikely.

7.5 Potential impacts of climatic changes: enhancement of fire risk

A less publicized and possibly far more significant impact of climate change on Mount Kilimanjaro is the intensification of fire risk and its attendant impacts on biodiversity as well as ecosystem services. In theory rising temperatures should result in the upward migration of vegetation zones, as observed in the Alps by GRABHERR & PAULI (1994). This effect however has been offset by the intensification of fire risk as a result of warmer temperatures and declining precipitation. This risk is particularly acute in the vast ericaceous belt in the upper reaches of the vegetation. Consequently, climatic changes have actually pushed the upper forest line *downward* on the Kilimanjaro.

On Mt. Kilimanjaro fires are common in the colline savanna zone, in the (sub-) alpine zone and – to a lesser degree – in the submontane and lower montane forest zone, whereas in the middle montane forest zone – at least on the southern slope – fires are rare. Most of these fires are lit by man (often as a maintenance tool), especially in the cultivated areas on the lower reaches of the mountain. The situation however is different in the upper regions of the mountain where no grazing or agriculture exists above the forest belt and logging in the upper forest zone is also rare[25]. Since climate change is the objective of this analysis, man lit fires are of minor interest. Therefore the destructive role of fires in the forests and in the alpine zone where climatic conditions play a more critical role are the focus of this discussion.

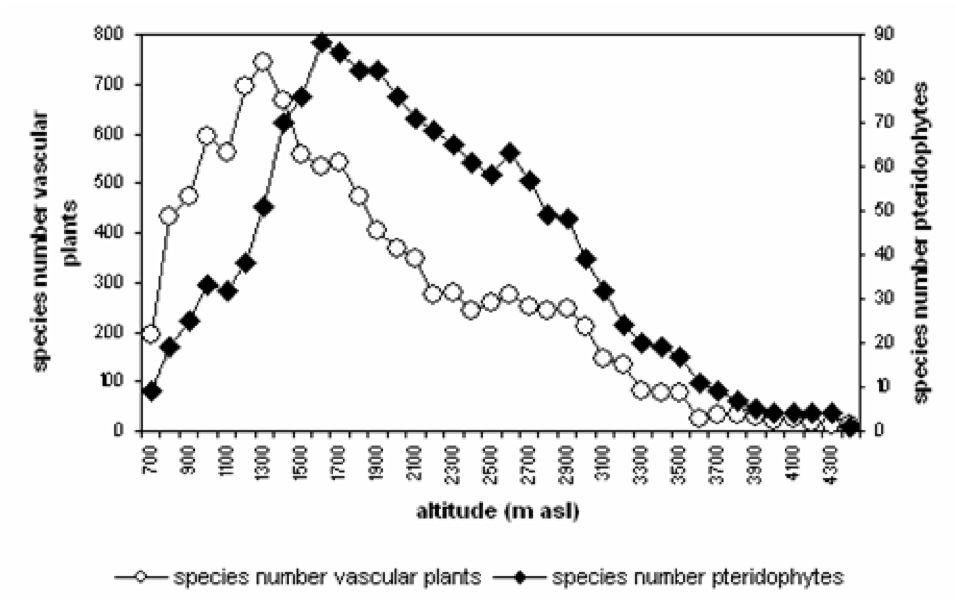
7.5.1 Elevation distribution of species richness and its relationship to fire

Fire variously influences species diversity, composition and vegetation structure in the different altitudinal zones on Kilimanjaro (Hemp, in press). Figure 12 shows the species numbers of vascular plants

[25] Although even these remote areas are not free from human influence, as population on the foothills has increased enormously. Since 1895 population has multiplied by 20. As a result an increasing human activity can be seen in all altitudinal zones and areas, promoted in particular by tourism. Since the establishment of the park in 1972, the number of visitors of KINAPA has multiplied by five. Together with porters, guides and tourists about 100.000 people visit the upper regions of Kilimanjaro per year. Such increasing numbers of visitors have certainly effects on the environment. Thus, the (natural) impacts of the changing climatic conditions are additionally enhanced by human influence.

at 100 m elevation intervals between 700 and 4500 m. Vascular plants have their maximum (745 species) in the 1300 - 1400 m interval in the area of the banana-coffee plantations of the submontane zone.

Figure 12. Absolute species numbers of ferns and of all occurring vascular plants on the southern slope of Mount Kilimanjaro



Source: HEMP 2001a

As shown in Figure 12 species numbers are highest in moderately cultivated or disturbed areas and not in natural, completely untouched areas. In this context the second peak at 2600 m at the lower border of the subalpine zone is of interest. In this altitude fire starts to be an important ecological factor on Mt. Kilimanjaro, creating a mosaic of different fire induced stages of forest, shrub and tussock grassland communities. This high diversity in habitats - compared with the closed forest at lower altitudes and the monotonous heath lands at higher altitudes – leads to a high diversity in species numbers. This trend is enhanced by the occurrence of fire-tolerating species, which show the same bimodal altitudinal distribution with a gap in the wettest central forest parts where fires are uncommon. They can therefore be regarded as fire indicators.

7.5.2 Influence of fire on regeneration, composition and structure of forests

Forest fires are frequent in the subalpine zone and also, less frequent in the submontane and lower montane zone between 1300 and 2000 m above sea level (asl). Fires in the *submontane and lower montane* forests are mostly set by people. In these forests, fire changes species composition and structure of the tree as well as the herb layer (HEMP, A. in press). This is of major importance for forest regeneration, as the dense cover of bracken impedes the sprouting of trees. In the *subalpine forests* between 2800-3000m asl fire causes sharp discontinuities in the floristic composition and structure[26]. Once *Erica excelsa* has established, regeneration of a broad-leaved forest becomes more and more improbable (HEMP & BECK 2001). If the frequency of fire becomes too high it degrades *Erica excelsa* forests into bush lands in which *E. excelsa* is substituted by *E. trimera* and *E. arborea*. This *Erica* bush extends between

26 Giant heather (*Erica excelsa*) becomes dominant at this altitude forming dense mono-specific stands, which border the *Podocarpus* and *Juniperus* forests without any transition (HEMP & BECK 2001).

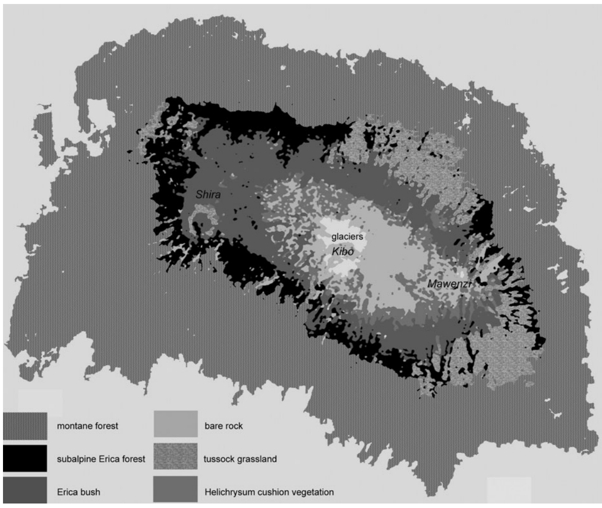
3200 and 3900 m asl. Continuously high frequency of fires destroys this bush vegetation, ultimately resulting in *Helichrysum* cushion vegetation.

7.5.3 Major impacts of fire on Mount Kilimanjaro's ecosystem

On Mt. Kilimanjaro structure and composition of the subalpine vegetation is strongly influenced by recurrent fires. Above 3200 m asl *Erica excelsa* forest is replaced today by *Erica trimera* and *E. arborea* bush in most areas. But from field observations and historical descriptions (JAEGER 1909, KLUTE 1920) it can be assumed that the forest extended up to 3600 m in some areas of Kilimanjaro at the beginning of the twentieth century while an open *Erica* forest was reported at altitudes of over 3900 m; this is 800 m higher than today (HEMP & BECK 2001). On the south-eastern slopes at an altitude of 2800 m *Erica excelsa* stands and the "moorland" tussock vegetation produce very abrupt boundaries. Tree-islands consisting of a core of *Podocarpus* forest are surrounded by a fringe of *Erica* trees and various shrubs. In this area, a mosaic of *Podocarpus* forest, *Erica* forest and subalpine grassland occur at the same altitude. Substantial microclimatic differences can thus be ruled out as an explanation for this pattern. Rather, recurrent fires may be the crucial factor pushing the forest back from the subalpine to lower and moister regions.

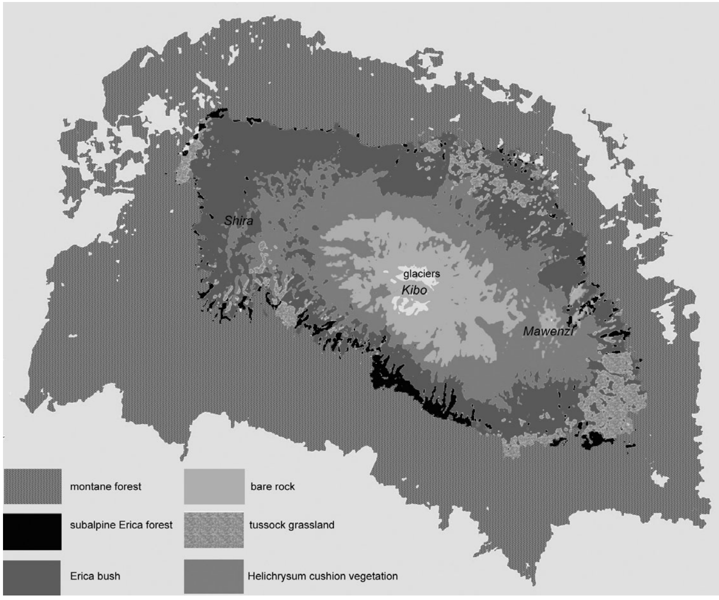
The comparison of two classified Landsat images from 1976 and 2000 reveals enormous changes in the upper vegetation zones of Mt. Kilimanjaro during the last 24 years (Figures 13 and 14)[27].

Figure 13. Vegetation cover in the montane and alpine zone on Mount Kilimanjaro (1976)



[27] It should also be mentioned that on Fig. 13 and 14 differences in glacier size are apparent. While in 1976 the glaciers covered 4.2 km^2 (HASTENRATH & GREISCHAR 1997) in 2000 they have been shrunk to 2.6 km^2 (THOMPSON et al. 2002).

Figure 14. Vegetation cover in the montane and alpine zone on Mount Kilimanjaro (2000)



In 1976, the *Erica trimera* bush, which today is depressed in the western and northern parts of the mountain below 3400 m, reached up as a continuous belt to over 4100 m into an area which today is covered by *Helichrysum* cushion vegetation. *Erica* forests covered nearly 5 times the current area (166 and 36 km^2 respectively), extending in many places up to 3700 m. This equals a loss of 130 km^2 or over 10% of Kilimanjaro's forest cover due to fire since 1976.

As discussed earlier, *Erica* vegetation is largely influenced and controlled by fire. The growing influence of fire pushed down the forest line replacing *Erica* forests with *Erica* bush. Fire has also shifted the upper border of *Erica trimera* bush by replacing it with *Helichrysum* cushion vegetation. The *Helichrysum* cushion vegetation is not threatened by fire because its little biomass provides little fuel. In addition, distances between vegetation patches and cushions are too high to allow fire to spread. When fire reaches this vegetation zone it stops. Therefore, the upper line of this vegetation formation has been stable for the examined 24 years. On the lower edge, however, fire was able to spread into the *Erica* bush zone. It can be assumed that most of the *Erica* bush of the year 1976 as shown in Figure 13 has still been *Erica* forest at the end of the 19^{th} century while most of the *Erica* forest of 1976 was still broadleaved forest at that respective time. This constitutes a loss of over 300 km^2 of upper montane forest (or a third of the present forest size) during the last 120 years. As a consequence, the ericaceous belt on Kilimanjaro with the easily inflammable heathlands became larger, giving rise to more and bigger fires.

7.5.4 Socioeconomic impact of increasing fire intensity

The increase in fire intensity on the slopes of Mt. Kilimanjaro has very significant impacts on both the natural and human systems that it sustains. The most direct impact is a significant decline in water resources; other impacts include effects on farming and other activity, as well as a loss of biodiversity.

7.5.4.1 Water resources

The devastation of 13,000 ha of forests, mostly of *Erica* forest, in the upper reaches of the Kilimanjaro since 1976 by fire has caused a serious disturbance in the water balance of the entire mountain, given that the forest belt functions as the main water catchment area. Montane and subalpine mossy or cloud forests are of great importance for watersheds in East Africa. They play an active and important role in the protection of slopes against erosion by controlling the damaging effects of torrential rainfall and regulating the outflow patterns of watercourses. In cloud forests about one third of the total rainfall is absorbed by the dense epiphytic layer (PÓCS 1976). Destruction of these forests reduces the function of the forest belt as a water filter and reservoir. Instead of remaining in the thick epiphytic biomass, humus and upper soil of the forest, percolating slowly to the groundwater, rainwater flows off quickly on the surface to the rivers eroding the soil and increasing the danger of floods on the foothills. Another consequence of the quicker rate of rain flow is water shortage during periods without rain.

In addition to the function of filtering and storing water the upper montane and subalpine cloud forests have a high potential of collecting cloud water (fog interception). Fog interception or fog deposition refers in this case to the small cloud droplets that do not settle on horizontal surfaces and, thus, are not collected in a rain gauge. Cloud water droplets are blown by the wind against the vegetation where they coalesce to form large drops that run off and fall to the ground. Fog droplets have to be intercepted by the vegetation and do not precipitate spontaneously (cp. CAVELIER et al. 1996, GLASOW & BOTT 1999).

Above 2000 m asl fog and mist occur nearly every day, above 2600 m asl every day. Thus, fog interception increases with altitude, especially its relative share of water input. The amount depends on the height and leaf area index of the vegetation providing wetting capacity for interception, the frequency of fog, and exposure to the prevailing wind (CAVELIER & GOLDSTEIN 1989, CAVELIER et al. 1996, GLASOW & BOTT 1999, ZIMMERMANN et al. 1999). Several studies suggest that fog can supply different amounts of liquid water to tropical montane cloud forests. In some areas fog interception represents 99% of the water input while in others only 3.5%. In general, fog interception is an important additional water source at sites with regular and frequent occurrence of fog, contributing far more than one third of the bulk precipitation in tropical montane forests (cp. e. g. CAVELIER & GOLDSTEIN 1989, JUVIK & NULLET 1993, CAVELIER et al. 1996). In lower montane tropical rain forests an average of about 16% was measured (CAVELIER et al. 1996).

The following calculations are based on a comprehensive ecological and meteorological database collected by a consultant to this report. A vegetation map was produced by analyzing over 1200 vegetation plots. In addition, 16 meteorological stations along 4 transects inside the forest belt were established, producing the first reliable weather data (rainfall, temperature, air humidity, radiation, wind speed etc.) from this vegetation zone of Mt. Kilimanjaro. Using these data a map of mean annual rainfall and mean annual temperature was created. According to the distribution of the different forest types, the annual rainfall, the estimated amounts of cloud water collection and evapotranspiration (based on measured vegetation density, altitude, climatic parameters and numbers given in literature e.g. LARCHER 1984, CAVELLIER et al. 1997) the forest belt was divided in 11 eco-climatic zones. For the first time this approach allows to estimate the water output of the 939 km^2 of indigenous forest (excluding forest plantations) of Mt. Kilimanjaro (Table 7).

Table 7. Hydrometrical data of the forest belt on Mount Kilimanjaro

Water Input		Water Output	
Rain (million m^3)	fog (million m^3)	Evapotranspiration (million m^3)	groundwater and streams (million m^3)
1,533.5	560.0	797.4	1296.1
73.3%	26.7%	38.1%	61.9%

The indigenous forests of Mt. Kilimanjaro receive 2093.5 million m^3 water annually of which 73% is by rainfall and 27% by fog interception. The intercepted moisture has to be considered to be a net gain, since the energy used in its evaporation from the leaf surfaces during fog-free periods would have been used in transpiration of an equal amount of water from the soil (KERFOOT 1968). In contrast, half of the amount of rainwater re-evaporates back to the air by evapo-transpiration. The circa 1,300 million m^3 of remaining water percolate into the groundwater or run off as surface flow into streams. The approximately 800 million m^3 of water evapo-transpired are not lost for the ecosystem. The forest dampens the air, leading to permanent high air humidity over the forest belt. This results in cloudiness and rain showers even during the dry seasons. Therefore the forest stores water not only in its biomass and the forest soil, but even in its surrounding air. This mechanism enhances the forest's function as a water reservoir regulating the outflow patterns of watercourses. Without such a permanent cloud cover over the forest evapo-transpiration would be much higher (due to higher temperatures) and rain showers during the dry season would be absent.

In his analysis of the value of East African forests in influencing climate and water supply NICHOLSON (1936) estimates the condensing capacity of montane forests add up to at least 25% of the total annual rainfall. This amount (in the case of the forests on Kilimanjaro equivalent to 383.4 million m^3) has to be added to the 560 million m^3 water of fog interception, to get a more reliable impression about the influence of the forest on the water balance. This gives 943.4 million m^3 or a surplus of 146 million m^3 water (nearly 10% of the rain water input) which forests on Kilimanjaro contribute more to the water balance every year than comparable open areas. Table 7 further shows that fog interception is an important factor in the hydrological balance of the mountain. About one quarter of the atmospheric water input in the forests derives from this source. Without the cloud water collecting forests this water would be lost for the mountain. If the surface and groundwater run-off is compared with only the "ordinary" precipitation, i. e. rainfall, the role of forest for the water production becomes evident.[28]

Consequently, the loss of 13,000 ha of *Erica* forest since 1976 results in a water yield reduction of about 58 million m^3 of fog water annually. This number represents over 10% of the annual fog water input of the entire forest belt or the equivalent of the annual drinking water demand of nearly three million inhabitants on the mountain (this calculation is based on numbers given by UNITED REPUBLIC OF TANZANIA & CES 2002). In this calculation, however, are neither the several 10,000 ha of destroyed ericaceous bush land nor the montane forests, which have been lost due to logging activities included.

Since the Chagga with their irrigation system are highly dependent on a steady river discharge changes to the water balance present a serious threat to their existence. During the dry seasons water shortages especially on the lower foothills become increasingly common. Women and children have to spend a big part of the day fetching water. Yet, the water demand grows rapidly. The hydrometric report of the Hai district water supply Phase IV (UNITED REPUBLIC OF TANZANIA & CES 2002) referring to an selected area on the south western, western and northern parts of the mountain presents the following numbers: Currently, population in this area totals 132,258 inhabitants with a daily demand of 7,200 m^3 water and it is expected to rise until 2015 to 162,570 inhabitants demanding daily about 8,900 m^3 water.

Besides, the situation on Mt. Kilimanjaro affects the entire region. The Pangani River, one of Tanzania's largest rivers, provides water to the hydropower plants of Nyumba ya Mungu (8 MW), Hale (17 MW) and Pangani Falls (66 MW), which generate some 20% of Tanzania's total electricity output. A water shortage during the dry periods would increase the number of power cuts which have already inhibit economic prosperity. Fishing in Nyumba ya Mungu dam yields a maximum catch of approximately 4,000 tonnes annually. The river also supplies the large scale South-East Moshi rice scheme. Furthermore, the

28 Although in general water output by run off is lower than the input caused by rains, this relation varies within the 11 distinguished eco-climatic zones. In the relatively dry submontane *Croton-Calodendrum* forests the run-off counts only to 40% of the rainwater input. In higher altitudes with lower evapo-transpiration but higher fog interception this ratio turns: In the *Juniperus* forests above 2600 m the total water run-off is 110% of the rainfall input. This is due to the additional water available from fog deposition. In the *Podocarpus, Hagenia* and *Erica* forests this ratio lies even higher at 120%.

southern slopes provide water to Arusha Chini sugarcane plantation. In Kenya, the Amboseli ecosystem including the wetlands of Ol Tukai and Kimana, which support Masai pastoralists and an abundance of wildlife, depend on the Kilimanjaro water supplies.

7.5.4.2 Other ecosystem services diminished by fire

Forest fires do not only reduce the water budget of the mountain, but they also directly and indirectly destroy other goods and benefits. Forest fires burn huge amounts of precious wood including fire wood, which people are allowed to collect, and timber, which people cut illegally. Besides, fires reduce the beauty of the heathlands that attract tourists and destroy the flower trees for bees. Bee-keeping is important on Mt. Kilimanjaro. An ethnobotanical study (HEMP 1999) showed that the Chagga make use of their plant environment in a variety of ways. The plants serve as forage for households and agricultural purposes, and many are used in medicinal applications either as drugs or for “magic” purposes. The montane forest is home to many of such plants. In addition, repeated burning also modifies the nutrient balance of soils (CRUTZEN & ANDREAE 1990).

7.6 Other threats to the Mount Kilimanjaro ecosystem

The climate related threats to the Kilimanjaro ecosystem need to be viewed in conjunction with other stresses stemming from human activities as well as changed migration behavior and population dynamics of big game. The results of a 2001 aerial survey (LAMBRECHTS et al. 2002) and the examination ground data revealed that the forests of Mt. Kilimanjaro are heavily impacted by illegal logging of indigenous trees in most areas below 2,500 metres on the western, southern and eastern slopes, and by the establishment of forest villages in the western and northern slopes. Logging activities affect the entire broadleaved mixed forests below an altitude of 2,500 metres on the southern slopes of Mt. Kilimanjaro. The moist *Ocotea* forests which cover most of the southern slopes are subject to serious destruction due to intensive illegal logging of camphor trees.[29]

In addition, large tracts of indigenous forests on the north-western and northern slopes have been converted into forest plantation, using fast growing exotic tree species, such as pine and cypress. On the north western slopes, the expansion of the forest plantations has reduced the indigenous forest belt to a width of less than one kilometer. The majority of the clear felled compartments within the forest plantations have not been replanted as required by the normal rotation management. To summarize, the aerial survey revealed that the forest belt is threatened on its upper and lower border, thus shrinking on both sides. This further exacerbates the adverse impacts on the water balance of the mountain.

Changing climate patterns not only influence landscape characteristics but also animal distributions. The Kenyan Amboseli National Park is situated on the northern foothills of Mt. Kilimanjaro. This area has experienced extensive habitat changes since the early 1960`s (ALTMANN 2002). These include dramatic loss of tree and shrub cover which was partly caused by an increasing elephant population and temperature changes. The “natural” landscape alterations are further enhanced by a steadily growing Masai population on the whole northern foothill of Mt. Kilimanjaro. According to rangers of Kilimanjaro

29 During the survey, over 2,100 recently-logged camphor trees were counted. On the lower slopes bordering the half-mile forest strip, there was no recent logging of camphor trees since these areas have already been depleted. However, other indigenous tree species were targeted; some 4,300 recently-logged indigenous trees were recorded. As a result, evidence of 57 landslides in the heavily impacted *Ocotea* forests was recorded. To the east, above Marangu, 19 cleared fields have been opened up in the forest, and a large number of livestock was seen up to 8 kilometers deep into the forest. There were fewer observations recorded in the half-mile forest strip because this zone is virtually denuded of indigenous trees. Some areas have been completely cleared. Logging activities also impact heavily the east and west sides of the northern slopes; 574 recently-logged cedar trees were counted, as well as over 800 other indigenous trees.

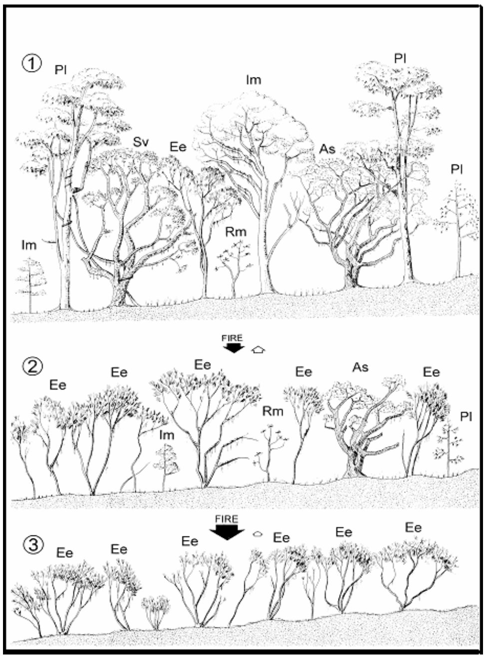
National Park elephant migration from the Amboseli National Park through the so-called "Kitendeni corridor" into the forests of Kilimanjaro has increased. In addition, more elephant herds stay permanently inside Kilimanjaro's forests given the better conditions compared with the Amboseli basin.

A ground survey of the forests on the western and northern slopes of Kilimanjaro reveals that in most places elephants and buffaloes are abundant. Besides former logging activities (the last sawmills inside the indigenous forest were closed in the 1970´s) grazing patterns of big game cause a change in the dense forest cover towards a mosaic of openings and patches of closed canopies. If the openings become larger, forest regeneration is impeded. In the long term, this development will destroy the forest and change it into a bush land with scattered trees with all the known disadvantages.

7.7 Scenarios for 2020 with respect to fire impact

Assuming that the observed trends in fire frequency continue in a linear mode the following scenarios are probable. Regarding the upper forest line, most of the remaining subalpine *Erica* forests will have disappeared within five years. As a result, Mt. Kilimanjaro will have lost its most effective water catchment area. Compared with the situation of 2000, this means an annual loss of 16.2 million m^3 fog water. Subsequently, the upper forest line will retreat more slowly because on the one side mostly broad-leaved forests remain, which are to a much lesser degree inflammable and because on the other the lower areas receive an increasing amount of precipitation. Nevertheless, an average retreat of the upper forest line of about 100 m in altitude seems to be probable by 2020, when the glaciers will have melted. Forest regeneration will completely be inhibited and regressive succession will prevail, as illustrated in Figure 15, substituting increasing areas of *Erica* heathland with low layered *Helichrysum* cushion vegetation.

Figure 15. Forest succession after continued fires



Linear increasing temperature and decreasing precipitation in combination with increasing logging activity will also result in more forest fires, which will heavily destroy the lower forest zone up to an average altitude of 2000 m (for example closed forests will be replaced with an open bush that cannot carry out the necessary ecological functions). These trends will cause a further shrinking and fragmentation of the forest belt. Especially on the western and eastern but also on the south eastern slopes the forest zone will be interrupted by large gaps with all the known disadvantages for wildlife and the ecological balance.

7.8 Climate risks in perspective: shrinking glaciers versus enhanced fire risk

With an average thickness of 30 m as indicated by ice core drilling (THOMPSON 2000, THOMPSON et al. 2002) and likewise observations from KASER et al. (under review) the existing 2.6 km^2 of glaciers constitute a water volume of about 72 million m^3. However, most of this water is not available for the lowlands since most glacier ablation occurs as sublimation and the remaining melting water evaporates immediately into the atmosphere (KASER et al. under review). If one quarter (or 18 million m^3) of glacier water would percolate into the rivers, an average annual water output of about 0.9 million m^3 would result until 2020, when the glaciers are predicted to have being melted. But even then, one can still expect precipitation on Kibo to feed springs and rivers although not so continuously and to a lesser degree.

In contrast, Mt. Kilimanjaro receives 58.5 million m^3 less water each year due to forest depletion and vegetation changes incurred as a result of forest fires since 1976. The number is likely an underestimate since the calculation assumes the timberline to remain stable for the next 20 years, which is very unlikely. Moreover, the calculation did not include the several 10,000 ha of ericaceous bush land which has been substituted by low *Helichrysum* cushion vegetation.

Summarizing, compared with roughly 1.3 billion m^3 of water, contributed every year by the 1000 km^2 of indigenous forest, the consequences of losing 2.6 km^2 of glaciers providing an annual water output of about 0.9 million m^3, the loss of Mt. Kilimanjaro's ice cap is negligible. Still, the melting glaciers are certainly an alarming indicator of severe environmental changes on Mt. Kilimanjaro.

8. Policy responses for Mount Kilimanjaro

The preceding section has laid out the complex interaction between climatic and other stresses that are causing significant changes in the Kilimanjaro ecosystem and adversely impacting the ecosystem services it provides. While the most visible impact – glacier retreat – may only have limited consequences, enhancement of fire risk that has resulted from climatic trends and human interference poses significant threats not only to the viability of the ecosystem, but also neighboring regions through its critical influence on regional water resources. Some of these changes (such as glacier retreat) may be inevitable, but others can be managed to make the ecosystem more sustainable. However, this requires a comprehensive set of policy responses that take into account the underlying demographic, environmental and climatic stresses. This section starts with a brief discussion of policy responses to the shrinking ice cap, to the general environmental threats facing the Kilimanjaro ecosystem, as well as to the enhancement of fire risk. Finally, given that human livelihood choices might provide the trigger for forest fires, the section reviews alternate livelihood strategies that might alleviate some of these stresses.

8.1 Policy responses to the shrinking ice cap

The melting of Kilimanjaro's ice cap receives much attention. Articles in local, regional and international newspapers described the results of ice core drilling by American scientists during the years 2000-2001. A study on climatic changes in the context of the receding ice level on Mt. Kilimanjaro was chosen to be a topic among the proposed research priorities for the next years of TANAPA (Tanzanian National Parks). However, there is obviously nothing that could be done by way of policy responses to avoid or even delay its eventual loss.

8.2 Policy responses to general environmental threats

The vulnerability of the Kilimanjaro to climate change can be alleviated at least partially by reducing other environmental stresses on it. Since Mt. Kilimanjaro is a UNESCO World Natural Heritage Site, the environmental problems of this unique volcano have attracted international attention and a number of conservation projects are already under way. The United Nations Development Programme (UNDP) and the United Nations Foundation (UNF) have jointly disbursed 264,000 US$ to the Tanzanian government for running different environmental conservation projects and promoting eco-tourism on Mt. Kilimanjaro. A first comprehensive inventory of threats - including wild fires – to Mt. Kilimanjaro was taken during an aerial survey in September 2001.[30] As a result of this survey it was decided by the Ministry of Natural Resources and Tourism that the forest belt of Mt. Kilimanjaro and Mt. Meru will be taken away from the Forest Department and included into Kilimanjaro National Park and Meru National park respectively. A similar shift in management from Forest Department to Kenya Wildlife Service in 2000 on Mt. Kenya resulting from an aerial survey had dramatic consequences. The illegal cutting dropped drastically. Comparing the situation in 2002 with 1999 logging of camphor was reduced by 96%, logging of cedar by 73% and logging of other indigenous trees by 92% (LAMBRECHTS, pers. com.). It is therefore expected that such a shift in management in the Kilimanjaro will have similar effects.

While these efforts are underway, several important challenges remain. One major threat is the cross-border migration of big game from the Amboseli National Park. There is a need for the formulation of a cross-border response between Tanzania and Kenya. An initial step would be to survey and count the numbers of elephants and buffalos. Based on these figures further steps, including control or reduction measures have to be taken into account. Also, the animals should be provided with adequate areas in the Amboseli basin by restricting permanent settlements of the Masai.

8.3 Policy responses to enhanced fire risk

There are two general ways to cope with wild fires: first, reduction of fire risk and second, fighting of fires. The main area of interest in this respect is the upper montane and subalpine zone on Mt. Kilimanjaro, where fires are most common. The first aim is to protect the still existing upper montane and subalpine forests from further destruction by fire. Second, since the potential climatic and historic tree line is much higher than the actual fire-induced one it should be tried to increase the forest area and to push up the actual forest line to areas that were formerly covered by forests.

8.3.1 Responses to forest destruction

While the natural montane forest on the Kilimanjaro has had protected status since the early twentieth century, the cutting of indigenous trees continued to increase until 1984 when the severe forest destruction led to the banning of all harvesting from the catchment forests on Kilimanjaro by a Presidential Order. Prior to the ban local people were used to entering the reserve without restriction to utilize its resources. Therefore, the new restrictions were not effective and encroachment activities have continued illegally. Nevertheless, general awareness for the protection of Mt. Kilimanjaro's natural resources especially of its forests is high among local people, governmental and non-governmental institutions. Everywhere Panda miti! (Plant trees!) stickers can be seen in offices, governmental cars and schools. The government awards prizes to those villages that have planted the most trees. Unfortunately, no indigenous

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[30] The request for the aerial survey of the forests of Mt. Kilimanjaro was originally presented by UNDP/GEF Small Grants Programme, New York. The objective was to identify the type, extent and location of the threats to the forests and provide a baseline assessment for the newly developed Community Management of Protected Areas Conservation Project (COMPACT). The aerial survey on Mt. Kilimanjaro was supported by the Ministry of Natural Resources and Tourism and the Tanzania National Parks.

trees are used for such competitions. The churches, which have great influence on people, also support afforestation measures.

Many NGO's like the Tanzania Association of Foresters (TAF) run reforestation projects on the mountain. Some villages like Mbokomu and private institutions like the Maua Seminary do the same, mostly without any support from the forest department in Moshi and sometimes even against the authorities[31]. Another significant development was the initiation of the catchment forestry project in 1988. The first phase of the project (1988-1992) focused on improving catchment forest management by establishing an inventory of the forest by resurveying, replanting boundaries, mapping and through reviving the management and protection activity. The second phase (1992-1996) tried to improve management of the forest through boundary marking, mapping, policing and people's participation. Efforts are currently being made to involve the local communities in the management of the forest reserve. Villages adjacent to the forest have now the responsibility to watch that there is no encroachment into the forest. Village conservation committees are responsible for establishing tree nurseries, to organize patrols into the forest, to mobilize the people for fire fighting and to control the entrance into the forest by issuing permits. Timber that has been confiscated during the patrols becomes (partly) property of the village (MISANA 1999). However, these activities of the forest department were not very successful, which became apparent during the aerial survey of LAMBRECHTS et al. (2002).

In 2000, the GEF Small Grants Program implemented by UNDP, in collaboration with the United Nations Foundation (UNF), launched the Community Management of Protected Areas Conservation Project (COMPACT). The main objective of COMPACT is to demonstrate, by complementing and adding value to existing conservation programs, how community-based initiatives can significantly increase the effectiveness of biodiversity conservation in and around World Natural Heritage Sites (WNHS). The project also aims at (i) enhancing the capacities of local organizations and NGOs whose existence and future prospects are closely linked to these protected areas; (ii) increasing local awareness of, and concern for, the protection of WNHS, (iii) promoting and supporting communication and cooperation among park management personnel and other concerned groups, particularly local communities, (iv) increasing general understanding of the synergies between community development and the role of globally significant protected areas in contributing to sustainable development, and (v) drawing lessons from project experience that can be shared widely at local, national and international levels.

Mount Kilimanjaro is one of six World Natural Heritage Sites on three continents participating in COMPACT. A common methodology to prioritize COMPACT interventions at the six sites has been developed. It involves a participatory approach to identify the main threats to the protected area, and to assess the types of activities that may be carried out by local communities to address those threats while improving their quality of life and livelihoods. This planning process involves a wide range of stakeholders of Mt. Kilimanjaro: community-based organizations, local and national NGOs, local and national authorities with management responsibilities of the mountain, and other programs and projects present in the area. It is too early to assess the effect of COMPACT, although the expectation of the funding agencies

[31] The Maua Seminary, a Franziscanian monastery leading a vocational school, is a good example for possibilities and problems of private engagement in environmental projects. The Padres of this monastery are very active replanting the whole valley of the Mue river inside the half-mile forest strip. The trees, although paid and planted by private effort are the property of the government. To cut down expenses and to get local people involved and interested in the project, they tried to use the Shamba (Taungya) system practices as it is done in other forest plantations on the mountain. Many forest plantations in West and North Kilimanjaro have usually been established by allowing local farmers to inter-crop annual agricultural crops with tree seedlings in forest plantation areas until the third year of tree growth. But the Padres have been unsuccessful fighting for eight years to get the permission from the forest office to use the Shamba system. Since they cannot pay a lot, incentives for local people to cooperate are not very high and the afforestation of the valley takes long.

and the host government is that the project empowers local communities to participate effectively in reversing extractive pressures that have adverse impacts on the mountain's resources.

8.3.2 Responses to forest fires

Since most areas heavily affected by fire - *Erica* forests and bush lands, are located inside the Kilimanjaro National Park (KINAPA), effective management of this park is one of the keystones to reduce the fire risk on Mt. Kilimanjaro. During the 1997 fire outbreak, a contingent of 700 fire fighters including the Tanzanian army was needed to extinguish the fire. A special fund of US$5,000 was subsequently set up to fight fires on the mountain. Fundraising to collect the money has targeted various donors including the business community, environmental institutions and other interested parties. However, since large amounts are necessary, the Tanzanian government is seeking new donor funding to conserve forests on Mt. Kilimanjaro (THE EAST AFRICAN, 9.10.2002).

One step towards fire prevention was already taken by the national park authorities by banning camp fires. However as most fires are caused by pit-sawyers, poachers or honey gatherers more effort has to be undertaken to cut down these illegal activities. A paramilitary ranger troop patrol the forests could serve as an effective deterrent, as proven successful on Mt. Kenya.

The construction of open strips as fire breaks seems generally not suitable for the Kilimanjaro due to the very difficult, inaccessible and steep slopes. One suitable area however exists on the south eastern slopes where there is a plateau around 2700-2800 m with moorland vegetation, formed by tussock grasses, occurring at the fringe of the forest. In this area grassland fires affecting the bordering forests are very common and the construction of open strips to prevent fire from spreading into the forest seems to be possible and effective. At the lower forest boundary, fire lines could be reactivated and cleared before the dry seasons.

There is also a need for better forest fire early warning system on Mt. Kilimanjaro. One possibility is the establishment of fire observation points such as fire towers on higher hills or ridges near existing ranger posts or tourist camps and huts. The fire-fighting capabilities could be significantly boosted with the provision of one or two small airplanes, as is the case for Mt. Kenya. A national park of the size, topography and importance like Kilimanjaro cannot be managed properly in many respects (e. g. observation of poachers) without such modern equipment. The fire fighting equipment also needs to be supplemented by a suitably equipped task force.

As mentioned earlier, many NGO's, some villages and private institutions run re- and afforestation projects on the mountain. However, a large scale effort is missing. The forest department in Moshi, which acts as the official initiator of such projects, has failed completely to protect the indigenous forests. Nurseries are used as maize fields and illegal cutting of timber is not prohibited effectively. No government supported tree nursery exists on the southern slopes. A first step might be the recent decision to incorporate the forest belt into the National Park, since this institution should be able to employ well paid rangers to take care for its resources. In addition, bearing in mind the financial resources – the annual park income is US$ 6.5 million (20,000 park visitors stay on average 5 days paying a daily entrance fee of US$ 65) park authorities should ensure that a certain fixed share of the income flows directly back to Kilimanjaro.

The local people should also be involved and get benefits out of the forest to be more interested in its protection. As shown on Mt. Kenya and some Kilimanjaro villages adjacent to the forest, people should be given the responsibility to ensure that there is no encroachment into the forest, to organize patrols and to mobilize people for fire fighting. These efforts should be compensated by rewarding the participating villages with timber which has been confiscated during patrols.

Likewise, the half-mile forest strip should be managed similarly by involving local people. This strip of 8,769 ha on the southern and eastern slope, ranges between the plantation belt and the forest reserve. It is meant to provide timber and firewood, and in some areas even pines, cypress and eucalyptus have been planted. However, people use this strip mainly in an uncontrolled way to collect fodder for their livestock. Sometimes the area even serves as pasture land. Since nobody feels responsible, this area is highly degraded and not managed properly. This is quiet different from the situation in the beginning. The half-mile forest strip was established resulting from a request of the Chagga Council in 1941 brought to the colonial government in response to the need of unrestricted availability of forest products, which could not be gained in the forest reserve. During the 20 years of managing the forest, the local people contributed substantially in planting trees, demarcating the boundary and fighting fires. In return, they were allowed to obtain forest products freely or at minimal costs (MISANA 1999). In 1962, however, management of the strip was transferred to the District Council and later (1972) the central government took control of the strip, which was then managed by the Forest Division, which restricted local people from collecting forest products freely. This situation has not changed up to now, although the management of the strip has been referred to the district councils again in 1987, together with the Forest Division.

Currently, a discussion has started to give the area back to the villages, which has been already done in some areas. This may offer the possibility that the local population will take more care of the land in the future than today. Since many fires originate in the agricultural land surrounding the forest and in the half-mile forest strip, it would reduce the fire risk for the forest as well. However, it cannot be excluded that this land would be abused as agricultural land and for settlement. Therefore, governmental control would be necessary. In any case, this huge area - when properly used and planted with timber trees - has a high potential to reduce the pressure from the indigenous forests.

Regarding replanting it appears to be a necessity to employ well-trained foresters, perhaps from outside the country, to start forestation projects and to educate local foresters. Especially the choice of suitable tree species is of importance. A variety of different species, not only the widely used exotic ones, but also indigenous could be used. Riverine areas could exclusively be replanted with indigenous trees, and existing natural forest patches in the half-mile forest strip situated mostly near rivers should not be replaced with forest plantations.

Right now, the forest plantations in West and North Kilimanjaro are not managed properly. During the aerial survey (LAMBRECHTS et al. 2002) it became evident that over 50% of the Shamba system areas are not under tree growing, either because replanting was not successful or because it was not undertaken at all. Since the production of timber is the primary goal and growing vegetables only a secondary one, the share of tree-planted areas in the forest plantations has to be much higher, even though this implies the removal of illegally erected villages inside the forest reserve.

The Chagga home gardens (vihamba) are an old and very sustainable way of land use that meets several different demands. Besides crop production, the sparse tree layer provides people with fire wood, fodder and timber. However, the high demand for wood and the introduction of coffee varieties that are sun-tolerant endangers this effective system. In some areas of the mountain (e. g. on the eastern slopes) the trees in the banana fields are very scattered or already missing. Therefore it seems to be necessary, in order to reduce the pressure on the forest, to support the tree planting in the Chagga home gardens with their unique agro forestry system. There could also be a program that rewards farmers to have a certain share of their land covered with trees. As the banana belt is nearly as extensive as the forest reserve, this will certainly have major effects in terms of forest protection and water balance. In combination with new marketing and farming strategies for growing organic coffee using traditional methods an advertising campaign should be started. The campaign should point out that the consumer buys high quality ecologically grown coffee supporting not only sustainable land use and an old African cultural heritage but he is also protecting the rain forest. A certain share of the coffee prize should be used to run this environmental Chagga home garden program. Government programs and donor agencies should cover any additional program costs instead of using financial resources for other expensive and in the long-term less effective projects such as dairying, which are not suitable for the Chagga home gardens.

Finally, a comprehensive, holistic environmental development plan focusing on fire risk and forest destruction while defining conservation strategies to ensure the long term sustainability of the mountain should combine all the different requirements, constraints and aims under one leading guideline. The high complexity of Mt. Kilimanjaro's ecosystem requires the expertise of scientists familiar with the biodiversity patterns and ecological conditions of the mountain for the preparation of such a report.

8.4 Promotion of ecosystem friendly livelihood opportunities

A key adaptation response to the threats facing the Kilimanjaro ecosystem is also to reduce human and livelihood pressures that make it vulnerable to other stresses such as climatic change. Humans have continuously occupied the slopes of Mt. Kilimanjaro for the last 2000 years (SCHMIDT 1989). However, the population has multiplied by 20 during the 100 years since 1895. In general, the growth rate is exponential, albeit it is slowly decreasing since 1978. The annual average population growth has been 2.1% between 1978 and 1988 and decreased to 1.6% between 1988 and 2002. In 1991 GAMASSA estimated the doubling of the population within 39 years. The population increase was much higher in urban than in rural areas. While the population has doubled between 1967 and 2002 on Kilimanjaro, the population in Moshi town multiplied 5 times during that same period.

The overall population density for the four districts that comprise Mt Kilimanjaro region was 198 people per km^2 in 2002. If population density would be based upon actual land availability, this number would be approximately 331 people per km^2. Most of the population is concentrated at an altitude between 1100 and 1800 m. Here, densities varying from 500 to 1000 people per km^2 have been recorded in certain places (TIMBERLAKE 1986, FAO 1986). From these data it is evident that every effort in environmental protection, which ignores the demands of a still fast growing population, will fail. Therefore, it is necessary to boost livelihood prospects in sectors that do not pose threat to the Kilimanjaro ecosystem.

Today, the bulk of development processes is departing from the mountain, although most of the population still remains there. Manufacturing in the region has collapsed following the closure of most leading factories. Even in the tourism market neighboring Arusha out-competes Moshi in the Kilimanjaro region.

Agriculture, the livelihood for most residents, accounts for over 85% of the total regional income with coffee being the main cash crop. Lately, however, coffee has become less profitable due to traditional farming techniques and very low coffee prices. Today (March 2003) a farmer gets only 400 TSH (equivalent to 0.4 US Dollar) for one kg of coffee and many farmers think about replacing their coffee trees with other crops such as passion fruits. In the 1970s 35,000 tonnes of coffee were harvested annually in the region whereas today only 12,000 to 15,000 tonnes are produced. Still, coffee accounts for over 60% of the region's income and authorities plan to raise coffee production to over 45,000 tonnes. The Coffee Revival Programme, which was launched in 1998 aimed at producing 100,000 tonnes. The strategy involves the formation of coffee revival committees and replacement of old coffee trees (THE EAST AFRICAN, August 26-September 1, 2002). However, the question whether this could be the solution remains open considering the over supply on the world market. A better way seems to be to raise the quality. According to Tanzania Coffee Board officials (THE EAST AFRICAN, August 26-September 1, 2002) new crop marketing and farming strategies aim at growing organic coffee through traditional methods without any use of pesticides and artificial fertilizers.

Despite its large cattle herds and successive government efforts to promote dairying, Tanzania is a net importer of dairy products (MDOE & WIGGINS 1997). Since independence in 1961 the government of Tanzania has tried to encourage more domestic milk production to achieve self-sufficiency. Since most cattle are stall-fed, and fodder has to be collected and brought from remote areas, large scale dairying in the Chagga home-gardens offers no alternative. Expensive dairy development projects therefore may not be the right way to improve livelihood in the submontane banana zone in the long-term.

In terms of tourism Kilimanjaro National Park (KINAPA) is a major tourist attraction in Tanzania and earns the most foreign exchange of any National Park in Tanzania (NEWMARK & NGUYE 1991). Most visitors are mainly interested in reaching the summit of Kibo, known as Uhuru Peak, the highest point in Africa. In the year 1976 5,000 people tried to reach the summit (CARLÉ 1977). In the year 2002 this number had increased to 20,000 (Chief Park Warden KINAPA, pers. comm.). Since its establishment in 1972, the number of visitors of KINAPA has multiplied by five. Today, about 100,000 people – porters and tourists combined - frequent the alpine areas of Kilimanjaro every year. Such increasing numbers of visitors have certainly effects on the environment. Especially the alpine zone with its highly specialized flora and fauna is a very sensitive ecosystem. Since a national park is meant for nature protection, it appears that tourism has reached a level which should not be exceeded. Therefore, alternatives to the mountain climbing tourism have to be explored.

During the last years a strong development of ecotourism could be observed world wide. Ecotourism can not only help in protecting the environment especially on Mt. Kilimanjaro put also it allows local population to participate in its economic potential. In the long run this type of tourism could be an alternative to the usual climbing tourism on Mt. Kilimanjaro. Another possibility is one or two day guided nature trips to the forest or to the lower alpine zone organized by the Kilimanjaro National Park. Many tourists would prefer to visit only the lower vegetation zones of the park instead of climbing. A special training program for guides should provide them with sufficient, basic knowledge about main vegetation types, flora and fauna to explain the mountain ecosystem to interested tourists. For the promotion of tourism it is of fundamental importance to generally improve tourist facilities and in particular to raise the quality of Tanzanian tourist hotels.

To summarize, due to a rapidly growing population, the decline in coffee production, and the collapse of manufacturing industry, the Kilimanjaro Region, which once has been one of Tanzania's leading economical areas, is now among the most poverty stricken. The region's annual per capita income is less than TSH 96,390 (US$ 96) (THE EAST AFRICAN, August 26-September 1, 2002). The most promising economic alternatives for the region currently appear to be the promotion of high *quality* organic coffee rather than necessarily increasing the *quantity* of production, the production of new cash crops such as passion fruits and flowers, as well as the improvement of eco-tourism and improvement of tourism infrastructure.

9. Concluding remarks

Climate change poses significant risks for Tanzania. While projected trends in precipitation are uncertain (and may differ for various areas of the country), there is a high likelihood of year-round temperature increase, as well as sea level rise. The sectors potentially impacted by climate change include agriculture, forests, water resources, coastal resources, human health, and energy, industry and transport. Given the low level of human development, extreme poverty, and high dependence on agriculture and natural resources, Tanzania may be quite vulnerable to projected climatic changes.

9.1 Differentiated adaptation strategy

While uncertainties in climate change and impacts projections pose a challenge for anticipatory adaptation for any country, Tanzania's case has several specific characteristics that may argue for a differentiated adaptation strategy.

First, the climate change projections on which all national impact and vulnerability assessments (all the way to the Initial National Communication of 2003) rely on an older generation of climate models and scenarios (circa early 1990s). A preliminary analysis based on more recent climate models conducted as part of this study concludes that temperature increases might be somewhat lower than (although broadly consistent with) the estimates used in the National Communication and the National Climate Change Action Plan. Updating of climate scenarios and impact projections through the use of multiple and more recent models might therefore be advisable prior to the formulation of aggressive (and potentially expensive) adaptation responses. This should not however affect "no regrets" adaptation measures such as leakage prevention and water conservation.

A *second* characteristic feature of Tanzania is that certain sectors are projected to experience both negative and positive impacts under climate change – for example, while production of maize is projected to decline, the production of two key cash crops (coffee and cotton) which contribute significantly to the GNI is projected to increase. Similarly, while stream-flow declines are projected to decline in two of three key river basins (Ruvu and Pangani), they are projected to increase in the third (Rufiji). The implication for adaptation therefore may be to not only cushion adverse impacts, but also to harness positive opportunities. This suggests consideration of an enhanced portfolio of linked-adaptation responses – for example a strategic shift from maize to cash crops over the medium term, and inter-basin transfers in the case of water resources. Such strategic shifts however may entail economic and dislocation costs – and therefore require careful screening, particularly with regard to their effects on equity and rural livelihoods. More rigorous testing of particular crop and stream-flow projections may also be advisable prior to undertaking such adaptation responses.

A *third* key characteristic is that unlike most other countries where the need for adaptation relies on projections of *future* impacts, some discernible trends in climate and attendant impacts are already underway in Tanzania. Such impacts – as is the case of the Kilimanjaro ecosystem - argue for more immediate adaptation responses as opposed to a "wait and see" strategy.

9.2 Climate change and donor portfolios

Tanzania receives close to a billion dollars of development assistance annually. An analysis of donor projects using the OECD/World Bank Creditor Reporting System (CRS) database reveals that roughly 12 – 25% (in terms of investment dollars) and 20-30% (in terms of number of projects) of donor portfolios in Tanzania may be potentially affected by climate change. This includes both activities in sectors which may themselves be impacted by climate change, as well as those projects and other activities which may influence the vulnerability of natural or human systems to climate change. These numbers are only indicative at best, given that any classification based on sectors suffers from over-simplification. Nevertheless, such measures can serve as a crude barometer to assess the degree to which particular projects or development strategies may need to take climate change concerns into account. Several donor strategies in fact already do make frequent references to the impacts of climate variability (such as El Nino) and linkages between such events and economic performance. There is however as yet no explicit reference to climate change. The (relatively few) development projects that were reviewed for this report did not pay attention to the risks associated with climate change.

9.3 Attention to climate change concerns in national planning

At the national level meanwhile Tanzania has a draft National Action Plan on Climate Change since 1997 that highlights priorities on three time-scales (Short term 1-2 years; Medium term 2-5 years; and Long term 10-20 years). The short term primarily focuses on capacity building through conferences; the medium term flags "projects internalizing climate change aspects… especially those reducing GHG emissions" and recommends the introduction of economic instruments to accomplish such goals; and the long term identifies major infrastructure projects in energy, transportation, and coastal zones as priority areas. While the sequencing appears reasonable, the plan remains short on specific details on how it may be implemented. Tanzania's recent National Communication to the UN Convention on Biodiversity, and its report to the World Summit on Sustainable Development only make tangential references to climate change. Its Poverty Reduction Strategy paper (PRSP) does explicitly recognize the significance of current climatic impacts on the poor, although the potential links between climatic factors and performance of key sectors (such as agriculture) are generally not discussed.

There is however considerable synergy between priorities of at least some national plans and the measures that may be required for adaptation. Specifically, the National Environmental Policy which emphasizes measures to improve the resilience of the agricultural sector, the National Water Policy that highlights efficient water use and water conservation, and the National Forest Policy which highlights forest conservation and biodiversity preservation. However, some of these goals (such as Water Conservation) have been articulated in previous plans, but have not been successfully implemented. Therefore, despite the obvious synergies between such policies and climate change adaptation, a key obstacle facing successful "mainstreaming" is successful implementation.

9.4 Climate risks in perspective on Mount Kilimanjaro

The second half of this report discusses in-depth climate change impacts and policy responses on the Mount Kilimanjaro ecosystem – Africa's highest mountain and largest glacier, a biodiversity hotspot, and a UNESCO World Heritage Site. Glaciers on Mount Kilimanjaro have been in a general state of retreat on account of natural causes for over a hundred and fifty years. A decline in precipitation coupled with a local warming trend that has been recorded in the second half of the twentieth century accelerated their retreat, and the ice cap is projected to vanish entirely by as early as 2020. While the symbolism of this loss is indeed significant, this analysis concludes that the impact of such a loss on the physical and socio-economic system is likely to be very limited. The present glaciers are already very small, and cover an area which is only 0.2% of the forest belt on Mount Kilimanjaro. Glaciers do not feed any major rivers, and even when they would have melted the mountain will still receive precipitation. Further, even without glaciers Mount Kilimanjaro will remain the world's highest free standing mountain and with Africa's highest peak. Therefore, it is unlikely that the loss of glaciers would have a significant long-term impact on tourism. It must however be emphasised that ice-cores on the Kilimanjaro are a repository of paleo-climatic records, and valuable climatic records would be irreplaceably lost with the loss of the ice cap.

The increase in temperatures and a concomitant decline in precipitation have also significantly enhanced the intensity and risk of forest fires on the Kilimanjaro. Climatic changes have not shifted vegetation zones upwards as in the case of other mountains, but on Mt. Kilimanjaro they have pushed the upper forest line *downward* as a result of increase in forest fire risk and intensity on the upper fringes of the forest. A whole vegetation zone, the ericaceous belt, has moved downwards since 1976 by several hundred meters, substituting 13000 ha of forest. The replacement of the fog intercepting forest belt by low lying shrub has already seriously impacted the hydrological balance of the mountain as fog intercepting cloud forests play a key role in the water budgets of high altitude drainage basins. The decline of 13000 ha of cloud forest since 1976 has already resulted in a reduction of the water yields of about 58 million m^3 of water every year. This constitutes about 10% of the annual fog water input of the whole forest belt. Not included in this calculation are the several thousands of hectares of destroyed ericaceous bush land and the loss of montane forests due to human activities such as logging. These impacts have implications that extend beyond the region as it feeds the Pangani river, one of Tanzania's largest, which is responsible for 20% of Tanzania's electricity output.

Looking into the future, a continuation of current trends in climatic changes, fire frequency and destructive human influence most of the remaining subalpine *Erica* forests could disappear within five years. With this, Mt. Kilimanjaro will have lost its most effective water catchment area as fog interception is of highest importance in the *Erica* forests. A further retreat of the upper forest line by about 100 m altitude seems to be probable until 2020. Increasing logging activity in combination with a higher number of forest fires is also expected to destroy the lower forest zone up to an average altitude of 2000 m. This will result in a further shrinking and fragmentation of the forest belt.

9.5 Policy responses for Mount Kilimanjaro

While glacier retreat is inevitable and cannot even be delayed, forest fire risk can indeed be reduced. Climate change only adds to the urgency of fire prevention and control, as well as forest conservation activities on Mount Kilimanjaro. Among the measures identified by this report are institutional measures such as the inclusion of the forest belt into the Kilimanjaro National Park and creation of a paramilitary ranger group (as in Mount Kenya) to deter logging, as well as better investments in early warning systems, particularly the purchase of one or two aircraft for aerial surveillance. There is also a need to limit cross-border migration of big game from neighboring Amboseli, which is adding to the stress on the Kilimanjaro ecosystem.

In addition to such piecemeal solutions there is an urgent need to better understand the livelihood needs of the local population to engage them more successfully in conservation and fire-prevention efforts. For example, an earlier policy response – the banning of camp-fires – did not have the desired effect because most of the fires were actually being lit not by mountaineers, but by honey collectors. A more sustainable solution therefore needs to identify viable livelihood opportunities that take some of the human pressures away from the forest. Creative solutions to boost local incomes, such as provision of incentives to switch to more lucrative specialty coffee production, may therefore be part of a package of responses that may help reduce the pressures on activities like logging and honey collection. Finally, there is a critical need to develop a comprehensive and holistic development plan focusing on fire-risk and forest destruction as well as to identify conservation strategies to ensure the long term sustainability of the valuable resources of Mount Kilimanjaro.

APPENDIX A: PREDICTIVE ERRORS FOR SCENGEN ANALYSIS FOR TANZANIA

The table below shows the predictive error for annual precipitation levels for each SCENGEN model for each country. Each model is ranked by its error score, which was computed using the formula 100*[(MODEL MEAN BASELINE / OBSERVED) - 1.0]. Error scores closest to zero are optimal. The six models with the highest error scores from the estimation were dropped from the analysis.

Predictive errors for each SCENGEN model for Tanzania

	Average error[32]	Minimum error	Maximum error
Models to be kept for estimation			
ECH3TR95	7%	3%	12%
ECH4TR98	13%	1%	27%
CCSRTR96	14%	5%	26%
HAD3TR00	18%	7%	30%
CERFTR98	22%	18%	25%
BMRCTR98	23%	2%	45%
HAD2TR95	24%	10%	42%
GFDLTR90	25%	1%	37%
CSI2TR96	32%	24%	40%
PCM_TR00	34%	7%	45%
CSM_TR98	35%	19%	57%
Models to be dropped from estimation			
IAP_TR97	40%	7%	93%
GISSTR95	48%	4%	125%
LMD_TR98	63%	29%	100%
CCC1TR99	73%	53%	98%
W&M_TR95	94%	32%	136%
MRI_TR96	132%	94%	154%

32 SCENGEN outputs data for 5×5 degree grids. To estimate for an entire country, a 10×10 degree area was used and the data output from the resulting four 5×5 grids were averaged. The maximum and minimum of these four 5×5 grids are also reported.

APPENDIX B: LIST OF PURPOSE CODES INCLUDED IN THE SELECTION OF CLIMATE-AFFECTED PROJECTS, ORGANIZED BY THE DAC SECTOR CODE

DAC code	General sector name	Purpose codes that are included in the selection
110	Education	-
120	Health	12250 (infectious disease control)
130	Population	-
140	Water supply and Sanitation	14000 14010 14015 14020 (water supply and sanitation – large systems) 14030 (water supply and sanitation – small systems) 14040 (river development) 14050 (waste management/disposal) 14081 (education/training: water supply and sanitation)
150	Government & civil society	15010 (economic & development policy/planning)
160	Other social infrastructure and services	16330 (settlement) and 16340 (reconstruction relief)
210*	Transport and storage	All purpose codes
220	Communications	-
230	Energy	23030 (renewable energy) 23065 (hydro-electric power plants) [23067 (solar energy)] 23068 (wind power) 23069 (ocean power)
240	Banking and financial services	-
250	Business and other services	-
310	Agriculture, forestry, fishing	All purpose codes
320	Industry, mining, construction	-
330	Trade and tourism	33200 (tourism, general) 33210 (tourism policy and admin. management)
410	General environment protection	41000 (general environmental protection) 41010 (environmental policy and management) 41020 (biosphere protection) 41030 (biodiversity) 41040 (site preservation) 41050 (flood prevention/control)# 41081 (environmental education/training) 41082 (environmental research)
420	Women in development	-
430	Other multi-sector	43030 (urban development) 43040 (rural development)
510	Structural adjustment	-
520*	Food aid excluding relief aid	52000 (dev. food aid/food security assist.) 52010 (food security programmes/food aid)
530	Other general programme and commodity assistance	-
600	Action relating to debt	-
700*	Emergency relief	70000 (emergency assistance, general) #
710*	Relief food aid	71000 (emergency food aid, general) # 71010 (emergency food aid) #
720*	Non-food emergency and distress relief	72000 (other emergency and distress relief) # 72010 (emergency/distress relief) #
910	Administrative costs of donors	-
920	Support to NGOs	-
930	Unallocated/unspecified	-

* sector codes that are excluded in the second selection (low estimate).
# purpose codes that are included in the emergency selection

APPENDIX C: REVIEW OF SELECTED DONOR STRATEGIES FOR TANZANIA

C. 1 United National Development Program (UNDP)/United Nations Population Fund (UNPF) Second country cooperation framework for the United Republic of Tanzania 2002-2006 (2001)
This cooperation framework focuses on governance and institutional aspects of poverty reduction, as well as government services. Little attention is being paid to natural resources dimensions. Climate change, current climate-related risks, or even food security in general, are not discussed.

C. 2 United Nations Development Assistance Framework (UNDAF) 2002-2006 (2001)
The UNDAF does not mention climate change. However, it recognizes the linkages between poverty and degradation of natural resources. In particular, it mentions the increasing risk of desertification (with 60% of Tanzania being composed of dry lands), partly caused by extensive deforestation. A fairly comprehensive section on Tanzania's vulnerability to natural hazards also highlights climate-related concerns: *"Natural and man-made disasters erode the coping capacity of the vulnerable population especially in drought-prone areas. There have been poor rains in Central Tanzania for the last three years, and traditional coping strategies are breaking down as land pressure increases. These types of shocks have become a frequent phenomenon in Tanzania in recent years. Floods and droughts, epidemics and crop pests, environmental damage and economic instabilities, have all had their effects on people's capacity to meet their basic needs and subsequently their ability to survive and pursue their development ambitions and potential"* In addition, the UNDAF observes a worrisome trend: "*Some claim that during recent years emergency preparedness has actually decreased and dependency on external support in these kinds of situations has increased. Long term disaster management strategies to deal with predictable, poverty related emergencies are needed to use available resources most effectively*." This general concern is not yet translated into concrete activities in the UNDAF.

C. 3 United Nations Emergency Consolidated Appeal for the Drought in Tanzania 2001
This appeal illustrates Tanzania's high vulnerability to climate variability: "The 1999/2000 rains were very poor in many parts of northern and central Tanzania. This has resulted in abnormally low levels of food production, particularly of the staple crop, maize grain, and has also caused a very poor cash crop harvest, thereby further reducing the cash income of the drought-affected households. This has been highly damaging to the household food security of many farming families in the semi-arid areas, who have suffered a fourth consecutive year of poor harvests and low-income levels. This cumulative effect has greatly undermined their purchasing power, forcing many of the poorest families to sell productive assets in order to survive. The recurrent nature of these food crises exposes the underlying layer of core poverty". The appeal is intended to address Tanzania's consecutive and chronic droughts, which affect the lives of over 9 million people, almost 30% of the total population of Tanzania. About 1.3 million of these live in a situation of total food insecurity. Instead of applying emergency measures year after year, the appeal proposes a more fundamental approach, part of longer-term integrated development strategies, including the Rural Development Strategy and the Agricultural Development Strategy which are currently under development, as well as improved early warning systems. Despite this longer-term focus, shifts in risks, for instance due to climate change, are not discussed. The implementation of the appeal, and particularly the longer-term components, could involve up to eight members of the UN system: FAO, WFP, UNICEF, ILO, UNIDO, IFAD, UNDP and the World Bank.

C. 4 African Development Bank
Country Strategy Paper 1999-2001 (2000)
Country Economic Profile

In its macroeconomic analysis, the strategy notes that overall macroeconomic performance has been satisfactory, but "growth rates have been fluctuating from year to year reflecting the vulnerability of the economy to external shocks. Although strong growth was registered in FY 1996/97 (4.2 percent), it declined to 3.3 percent in FY 1997/98 due to the adverse impact of the drought on agricultural output. The drought was followed by the El-Nino floods late 1997 and early 1998, which destroyed some of the crops and damaged roads, thereby, disrupting internal movement of agricultural commodities as well as export shipments." In response, the strategy underlines the need for "an aggressive export promotion drive and continued diversification of the export base." The direct causes of Tanzania's vulnerability to natural hazards are not analyzed in the macroeconomic analysis or in the sectoral sections.

In a section on poverty, the strategy highlights the links between poverty, drought, and food insecurity: "Since the poor are entirely dependent on agriculture (mainly crops) for their livelihood, their incomes and food consumption are vulnerable to droughts. Food insecurity is therefore a major feature of poverty, especially in drought-prone areas of the country". The strategy also notes that less than 20 percent of the irrigation potential is utilized, unnecessarily exposing agricultural production to droughts. At the same time however, the agriculture section of the strategy attributes poor agricultural performance mainly to limited access to agricultural credits and weak extension services, poor transport infrastructure, limited use of modern inputs (mainly due to high costs), weak agriculture planning and program implementation, and low budgetary allocation to the sector. Dealing with droughts and irrigation are not mentioned here. Donor support has in the past included, among others, small-scale irrigation and soil conservation. However, the results have been mixed, mainly due to lack of counterpart funding, weak institutional capacity in the Ministry of Agriculture, and the lack of a coherent sector framework.

Similarly, the strategy point to the underlying patterns causing water supply problems: "While droughts have contributed to water supply problems, the underlying factors include weak institutional capacity in the sector, poor water resource management, and the dilapidated condition of the water schemes and distribution networks in the rural and urban areas resulting from the under-funding of maintenance and rehabilitation." Hence, the AfDB also focuses mainly on sector reform, operation efficiency, and rehabilitation and expansion of existing facilities. In addition, it has adopted a river basin approach for water management improvements. Finally, the strategy also notes the widespread environmental problems, including land degradation, desertification, loss of biodiversity and wildlife, and the depletion of marine and coastal resources. The environmental degradation is attributed to widespread poverty, high population growth, and poor natural resource management practices. In that context, climatic factors (including wildfires and flood and drought risks related to climate variability) are not discussed. Climate change is not mentioned anywhere in the strategy.

The AfDB Country Economic Profile (from 1995) highlights the interrelationships between natural hazards and natural resources management: "There is widespread consensus that one of the major problems facing the nation is land degradation. This takes many forms: soil erosion, deforestation, bush fires and overgrazing. The root cause often lies in the actions of the agricultural producers themselves. Land degradation results in a loss of productivity in agriculture, land use conflicts, loss of biodiversity and changes in water catchment areas which have led to both drought and floods". These issues are highlighted throughout the study, and illustrated by several examples. Deforestation in particular is highlighted as a pressing problem, for biodiversity, but also floods and droughts. Bush fires are both a cause and consequence. The profile also describes the environmental problems in coastal areas, including pollution, but also clearance of mangrove forests and destruction of corals (particularly by dynamite fishing). Among the consequences is a depletion of fishery resources.

While the document reviews policy options to respond to the challenges, it mainly emphasizes the implementation and further development of government policies that were already in place or under consideration. Climate change is not discussed[33].

C. 5 World Bank

Country Assistance Strategy (2000)

The effect of climate on the country's performance is recognized by the fact that climatic conditions are mentioned as part of the inputs to a (low-case) macro-economic scenario for Tanzania's development. In addition, the strategy states that "Tanzania is vulnerable to external shocks, commodity price changes and droughts", putting climatic conditions on a par with major economic issues that are discussed at length. In addition, it describes that an infrastructure project has been restructured to address "El Nino damages". However, vulnerability to floods and drought is not mentioned, not as a risk to the Bank's own projects, nor as a development opportunity that could have been addressed by concrete activities. Climate change is not mentioned.

C. 6 IFAD

Country Strategic Opportunities Paper (1998)

According to IFAD's strategy paper "*agriculture remains exposed to the vagaries of nature*". For instance, the high growth in maize production (the main staple crop) is highly susceptible to weather conditions. While the country has a structural food deficit of about 700 tons, imports rise to up to 1.5 million tons in times of flood or drought. The main constraints to agricultural production are lack of irrigation, unavailability of credit for the poorest segment of the population, and absence of an appropriate institutional framework to support agricultural development activities. Donor support has been ineffective due to poor counterpart funding from the government, cumbersome and centralized procedures, lack of beneficiary participation and ownership, and lack of appropriate targeting criteria for women. IFAD aims to address these sector-wide issues in order to make the agricultural sector more productive; at the same time, this should contribute to a decrease in vulnerability to adverse weather conditions, particularly for the smallholders who account for about 85% of the cultivable land. Climate-related risks to IFAD projects are not discussed explicitly, although the report mentions the flood damage to irrigation schemes during the 1997/98 El Nino. Climate change is not mentioned.

C. 7 DFID

Country Strategy Paper (1999)

This country paper recognizes that Tanzania's agriculture, accounting for half the GDP and 75% of exports, is "highly vulnerable to climatic shocks". In the past, DFID has provided substantial support in response to natural disasters. The strategy for the coming years contains assistance to help protect poor people's livelihoods and strengthen the government's capacity to prepare for and manage disasters. However, climate risks to development investments and their outcomes are not recognized as a concern, and climate change is not even mentioned.

C. 8 EU

Tanzania Strategy Paper for the Period 2001-2007 (2002)

This country strategy paper defines the priorities for EU assistance to Tanzania in the period 2001-2007. The main sectors to be targeted are transport infrastructure and basic education. Further assistance will go to governance and macro-economic support in line with the PRSP objectives. Ongoing programs in agriculture, water & sewerage, and environment, will be continued. Despite the vulnerability of some of these sectors, even current climate risks are mentioned only once, in the margins of an agriculture section.

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33 It is noted that Tanzania had not yet ratified the UNFCCC, but was in the process of doing so.

C. 9 Ireland Aid

Country Strategy Paper for Bilateral Aid Programme 2000 – 2002 (1999)

Ireland's country strategy focuses on poverty reduction. While increasing food and livelihoods security are among the key goals, weather and climate-related risks are not mentioned at all. In the coastal zone, Ireland Aid is financing the Tanga Coastal Zone Conservation and Development Programme, managed by IUCN, which aims to address issues like the destruction of coral reefs and mangrove swamps. Again, no reference is made to climate change.

C. 10 JICA

Country Study for Japan's Official Development Assistance to the United Republic of Tanzania (1997)

Country Profile on Environment (1999)

The JICA country study recognizes the severe economic implications of climate risks in Tanzania: "Several factors are considered directly responsible for the weakened economy. They include certain political and economic policy choices made following independence, a rapidly growing population, climate anomalies, and a deteriorating conditions for trade in the international market." Recognizing the severe pressures on Tanzania's natural resource base, JICA aims to provide assistance to alleviate those pressures, particularly in the forestry and water resources sectors. However, no attention is paid to interactions of climate-related risks, poverty, and land degradation and water scarcity, or to ways to reduce that vulnerability.

The *JICA Country Profile on Environment* gives a complete overview of environmental problems facing Tanzania. It includes issues like desertification, deforestation and forest fires, but does not mention new risks due to climate change. Even climate variability is largely ignored, for instance when discussing water resources: "*Tanzania is a well-watered country with moderate to good rainfall and with many rivers and lakes. However, rainfall is seasonal and water is not readily available in the dry season*." The most pressing problems, however, occur not in the average dry season, but in a dryer than normal period, due to climate variability.

C. 11 SIDA

Tanzania Country Strategy 2001-2005 (2000)

The country strategy mentions that desertification, deforestation, and problems with coastal and marine environments and urban settlements threaten Tanzania's sustainable development. However, neither climate change, nor even current climate risks that interact with these issues, are discussed.

C. 12 USAID Tanzania

Summary Strategic Plan for Environment and Natural Resources (1999)

Annual Report (2002)

This strategic plan provides an update of previous work of USAID in the area of environmentally sustainable natural resources management. Its new focus will be on improved conservation of coastal resources and wildlife in targeted areas. Climate change and sea level rise are not among the listed causes of coastal degradation. Similarly, several possibly vulnerable biodiversity projects neglect climate risks. Similarly, climate risks do not appear in USAID's Annual Report for Tanzania.

APPENDIX D: REVIEW OF SELECTED DEVELOPMENT PROJECTS/PROGRAMS

D.1 Projects dealing explicitly with climate related risks

D.1.1 US Country Studies Program

The US Country Studies Program supported several studies in Tanzania, on both mitigation and vulnerability & adaptation. Results from these studies, which were performed by the Centre for Energy, Environment, Science and Technology (CEEST) in Dar es Salaam, are reviewed in the Tier-1 component of this project.

D.1.2 Draft National Action Plan on Climate Change in Tanzania (CEEST, 1998)

This Plan, developed with underlying materials from the US Country Study, gives a comprehensive overview of Tanzania's vulnerability to climate change in various sectors, and discusses both mitigation and adaptation options. For adaptation, the focus is on no-regrets measures integrated in sectoral development. Some adaptation options are proposed in Agriculture, Livestock, Forestry, Water Resources, and Coastal Zones. No attention is paid to possible overlaps of adaptation and mitigation options, such as in the forestry sector.

While this 1998 Draft Plan is comprehensive and detailed, it is unclear what its impact has been. It appears that it has not been formally adopted by the Government. Moreover, its recommendations are not well reflected in subsequent sectoral and national development plans.

D.1.3 GTZ (Energy and Transport Division) : Measures to Implement the UN FCCC: Technological and other Options for the Mitigation of Greenhouse Gases in Tanzania (1995)

This somewhat older report discusses GHG mitigation options in Tanzania, including in the forestry sector. This sector might allow for projects that integrate adaptation and mitigation goals, but these are not discussed.

D.2 Other Development Programs and Projects

D.2.1 World Bank Forest Conservation and Management Project
Project Appraisal Document (2001)
Social and Environmental Considerations (2002)

This project focuses on the development of the forestry sector, and on biodiversity conservation in Tanzania's forests. The latter component, which is supported by the GEF and implemented jointly with UNDP, focuses on the Eastern Arc forests, which are recognized as "biodiversity hotspots". Besides their biodiversity value, these forests provide local livelihoods, and are crucial as water catchment areas for Tanzania's water supply and hydroelectric power generation.

The project also aims to contribute to carbon sequestration, partly by limiting forest fires: "The main techniques for increasing carbon uptake in miombo is the reduction in fire frequency. Experiments in many parts of Africa have shown that woody biomass and soil carbon both increase if fires are excluded. Permanent fire exclusion is virtually impossible in the strongly seasonal miombo climate, but a reduction in frequency is probably achievable at reasonable cost. This would simultaneously increase carbon dioxide uptake and decrease the emission of methane and ozone precursors."

While the project thus explicitly addresses climate change, current climate-related risks to the project itself are not discussed, and possible risks due to climate change, including more frequent forest and direct threats to biodiversity, are entirely ignored. It is unclear whether such considerations would have changed the project design, which in its current form already contributes to a reduction in the vulnerability of these valuable forests.

D.2.2 GEF/World Bank Lake Victoria Environmental Management Project (supplemental credit)
Project Information Document (2001)
Integrated Safeguards Sheet (2001)

This project addresses the management of Lake Victoria, and affects the three countries around the lake (Uganda, Kenya, and Tanzania), with Tanzania acting as the regional coordinator. It had many components, varying from community-level management, to watershed improvement, to hydro-meteorological monitoring. Given the far-reaching environmental issues at stake, the project aims to put the region on a long-term path of better management of the Lake and its surrounding natural resources. Despite this long-term focus, climatic changes, which might have strong effects on water resources and ecosystems, are not considered.

D.2.3 GEF/UNDP
Aerial Survey of the Threats to Mt Kilimanjaro Forests (2002) [www.tz.undp.org]

This aerial survey is part of UNDP's Community Management of Protected Areas Conservation Project (COMPACT), which promotes community-based biodiversity conservation in and around World Heritage Sites (such as Kilimanjaro). The main threats identified for the Kilimanjaro region were: logging of indigenous trees, forest fires, and establishment of settlements. No specific attention was paid to issues related to changing climatic circumstances.

D.2.4 USAID
Tanzania Coastal Management Partnership: Options for a national integrated coastal management policy (undated.)

This report (prepared by Tanzania's National Environment Management Council and the University of Rhode Island/Coastal Resources Center and supported by USAID) analyzes options for integrated coastal zone management in Tanzania. Climate change and sea level rise are not discussed. While an ICZM approach would certainly contribute to the sustainable development of Tanzania's coastal areas, opportunities may be missed.

APPENDIX E: SOURCES FOR DOCUMENTATION

Statistics
CRS database, OECD/World Bank http://www.oecd.org/htm/M00005000/M00005347.htm

Government Documents
PRSP related documents www.worldbank.org/prsp
Poverty Reduction Strategy Paper (PRSP) (2000)
PRSP progress report (2001)
PRSP Joint Staff Assessment (by IDA and IMF) (2001)
PRSP Progress Report Joint Staff Assessment (by IDA and IMF) (2001)

Other national strategies www.tzonline.org
Tanzania Assistance Strategy (A Medium Term Framework for Promoting Local Ownership and Development Partnerships) Consultation draft, Ministry of Finance (2001)
Tanzania Development Vision 2025
National Environmental Policy (1997)

UN Conventions

UN Convention on Climate Change (UNFCCC) www.unfccc.int

UN Convention to Combat Desertification (UNCCD) www.unccd.int
Proposed National Action Programme (1999)
Second National Report (2002)

UN Convention on Biodiversity (UNCBD) www.biodiv.org
National Report (2001) www.biodiv.org

World Summit on Sustainable Development www.johannesburgsummit.org
National Report to The Earth Summit on Sustainable Development (2002)
Country Profile (2002)

Donor Agencies
AfDB www.afdb.org
Country Environmental Profile, Environmental and Social Policy Working Paper Series, no. 26 (1995); Country Strategy Paper 1999-2001 (2000)

DFID www.dfid.gov.uk
Country Strategy Paper (1999)

GEF/UNDP
Aerial Survey of the Threats to Mt Kilimanjaro Forests (2002)www.tz.undp.org

EU
Tanzania Strategy Paper for the Period 2001-2007 (2002)

IFAD www.ifad.org
Country Strategic Opportunities Paper (1998)

JICA www.jica.go.jp
Country Study for Japan's Official Development Assistance to the United Republic of Tanzania (1997)
Country Profile on Environment (1999)

SIDA
Tanzania Country Strategy 2001-2005 (2000)

UN
United Nations Emergency Consolidated Appeal for the Drought in Tanzania 2001 Development Assistance Framework (UNDAF) 2002-2006 (2001)

UNDP www.undp.org.np
United National Development Programme (UNDP)/Population Fund (UNPF) Second country cooperation framework for the United Republic of Tanzania (2002-2006) (2001)

UNEP www.unep.org

USAID www.usaid.gov
Summary Strategic Plan for Environment and Natural Resources (1999)
Annual Report (2002)
Tanzania Coastal Management Partnership: Options for a national integrated coastal management policy (n.d.)

World Bank www.worldbank.org
Country Assistance Strategy (2000)
World Bank Forest Conservation and Management Project. Project Appraisal Document (2001), Social and Environmental Considerations (2002)
GEF/World Bank Lake Victoria Environmental Management Project (supplemental credit), Project Information Document (2001), Integrated Safeguards Sheet (2001)

US Country Studies Program

GTZ (Energy and Transport Division)
Measures to Implement the UN FCCC: Technological and other Options for the Mitigation of Greenhouse Gases in Tanzania (1995)

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