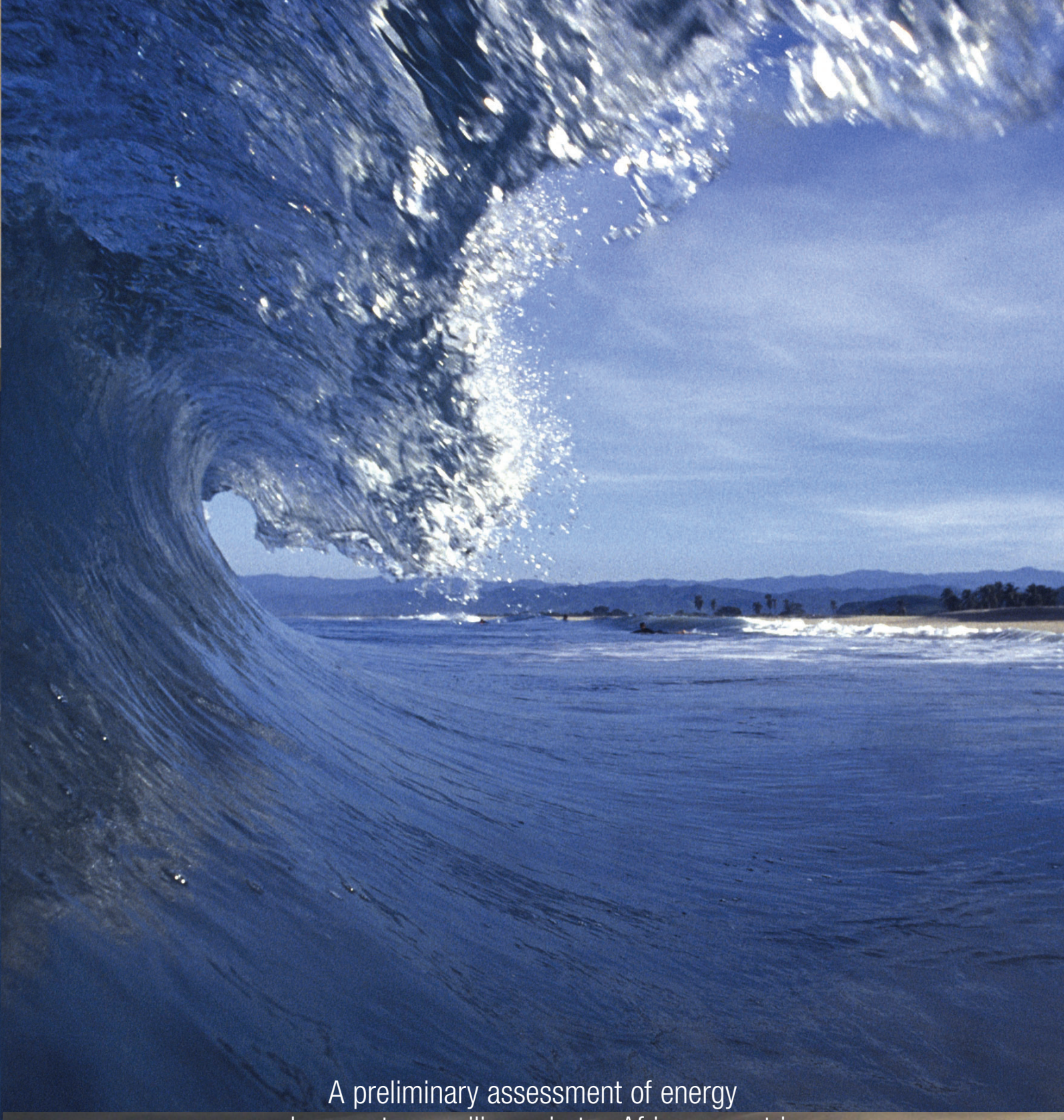

A preliminary assessment of energy
and ecosystem resilience in ten African countries

HELIO
International

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ABOUT HELIO INTERNATIONAL

Who We Are

Founded in 1997, HELIO International is an independent, international network of leading energy analysts whose objective is to identify, assess, measure and publicise the contribution of energy systems and policies to sustainable and equitable development. These experts carry out independent evaluations of national energy policies and inform decision- and policy-makers about their value and effectiveness. They constitute the Sustainable Energy Watch (SEW). They also analyse and advise on ecodevelopment and climate stabilisation and cooperate with major energy organisations and networks.

HELIO International is a non-profit organisation based in Paris, France. It is an accredited observer to the United Nations Economic and Social Council (ECOSOC), the United Nations Framework Climate Convention (UNFCCC) and the United Nations Environment Programme (UNEP).

Our Activities

SEW is the core activity of HELIO International. SEW's objective is to measure progress toward sustainable energy and development practices nationally, regionally and globally. National reporters and regional coordinators collect and analyse energy data against a series of indicators selected for their relevance, clarity, balance and timeliness. Using these indicators as benchmarks, the in-country reporters provide an independent view of the national energy scene. Their reports can then be used by governments, industry, NGOs and other stakeholders to promote ecodevelopment through policy development, projects and local activities.

This work has recently expanded to address the interface of the vulnerability and resilience of energy systems within the context of climate change.

HELIO's other activities include:

- providing independent input to the design and implementation of ecodevelopment, energy and climate projects;
- designing analytical tools and organising training workshops on energy policy assessment and monitoring;
- promoting the creation and integration of citizen users' councils in the energy decision-making process;
- supporting the work of other international energy and development networks by providing strategic expertise and disseminating information via the HELIO network; and,
- maintaining a website that includes SEW reports on national and regional energy developments, information on HELIO projects and relevant energy developments occurring elsewhere.

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PREFACE

We run carelessly to the precipice, after we have put something in front of it to prevent us from seeing it. – Pascal (*Pensées*)

Though the fact remains less widely known than might be expected, the vulnerability of our traditional energy systems is no longer a question for debate. The public is becoming more aware that there are problems, when conditions result in accidents, embargoes and other inconveniences. However, few official analyses pinpoint the heart of these growing problems: the configuration of our relationship to energy.

First and foremost, the architecture of our energy systems is intrinsically vulnerable. Consider their complexity: vast electrical grids, at times impossible to control; management and synchronisation requirements; dependency on communication and transport systems which are themselves complex and fragile; material hazards such as natural gas, gasoline and radioactive substances; the interdependence of many energy systems; the need for specialised equipment and technicians; the difficulty of repairing such systems; and, the dependence on distant and sometimes hostile nations for fuel. What were we thinking when we created such fragile constructs?

Paired with this physical vulnerability are significant economic and social costs. Such costs are influenced not only by the price of the resource and its transportation costs, but by the exchange rate and political climate. The price of oil can be a major contributor to the national debt, directly affecting entire populations. Despite all this, the idea persists that the more we consume, the happier we are.

Our love of speed and growth at any cost remains ridiculously myopic. We still do not have a good grasp as to how our so-called techno-economic imperatives, such as economies of scale, bypass the limits of logic and entropy. This limited vision has resulted in a global economy with far-reaching economic, ecological and social side-effects. Low-quality consumer goods criss-cross the globe before arriving in our hands, leaving behind them an ecological footprint out of proportion to the well-being they provide.

But what has brought about a growing awareness—accompanied by a well-justified fear of these issues—is the impact of energy systems on the environment. Toxic by-products are now found globally; the accumulation of greenhouse gases is changing weather patterns, threatening the health of the planet.

Almost three centuries after the first speculations on the acceleration of the greenhouse effect (Charles Fourier, 1772-1837) and twenty years after the first sounding of the alarm (NASA, 1987), humanity is finally prepared to move out of the age of fossil fuels. However, the solution is not to remain in the age of nuclear energy. Despite its low carbon emissions, moving to nuclear as a power source would be like jumping from the frying pan into the fire. The French experienced this firsthand in 2003 when a devastating heat wave caused the Fessenheim nuclear power reactor to overheat; it had to be hosed down like an overheated jalopy.

How are we to address this situation? We are careening towards the edge of the precipice, as Pascal said, "What safety net can we deploy right now?" Ironically, we have been discussing this predicament since the first oil embargo in 1973. Efforts were made, but due to the low price of gasoline and a lack of awareness of our energy systems' environmental impact, they were largely ignored.

In the short term, the safety net can be constructed in multiple ways, but primarily by limiting the production of electricity from fossil fuels to an absolute minimum, greatly developing local renewable energy, and putting an end to road freight transport and to personal travel that use polluting fuels. In the long term, it will include putting Factor 10 into general use. It is urgent to prepare this roadmap for if we don't, it will be our last.

Every nation has assets that can be put to use in developing its own mode of resilience. The most important is undoubtedly an educated population imbued with civic responsibility; a population that enjoys the social capital required to participate authentically in public life. Good social and cultural practices are the mortar of resilience.

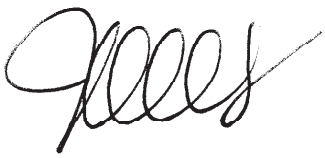
Resilience will be built on the pre-existing characteristics inherent to each nation. It will employ adapted modular structures and a transparent, uncomplicated and stable system of training and management that prevents errors while permitting redundancies, substitutions, diversity, dispersion and a degree of standardisation. Resilience requires a good knowledge of the loading capacity of environmental as well as energy systems to ensure harmonious services and sustainable livelihoods.

The move towards energy practices that are efficient without being destructive begins with the innovative spirit of thousands of researchers, scientists and amateur enthusiasts throughout the world. The increasing scarcity and expense of fossil fuels push us toward energies that are both renewable and increasingly competitive. Given governments' constant hesitation to take measures that promote renewable energies, this transition will be a delicate one.

Such measures will require courage unequalled in human history as they must be applied globally, without reservation or exception. We will have to limit personal vehicular transportation to emergencies, taxis, ambulances and non-polluting cars. It will be the end of discount vacations to the other side of the world, the end of unlimited air conditioning and electric heating.

But it is in such tests that the spirit reveals itself: the people of the twenty-first century will rise to the challenge. Citizens are calling for such policies. They have already lived with the disturbing consequences of climate change. HELIO's latest report series on Africa demonstrates the growing vulnerability of this continent, but also highlights the vision of peoples who have the assets to reinforce their resilience and the will to construct a viable future for generations to come.

If the economies of the north were built with financial capital at the expense of natural capital, it is clear now that the only liveable future is one that the leverages social capital and natural capital. Mobilising northern and southern social forces to redirect development priorities and put them at everyone's service is the last frontier that we shall conquer together. Africa is the best place to start.



Hélène CONNOR, PhD
President – HELIO International

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Section I.

Setting the Context: An introduction

Adaptation to climate change, energy development and poverty alleviation are high on the political agenda. Geographically, Africa is a climate priority as it is prone to both recurrent drought and flood episodes that are associated with the El Niño-Southern Oscillation (ENSO) phenomena. Deterioration in trade, the lack of significant investment, high population growth rates coupled with a highly variable climate make it difficult for the region's countries to generate development plans that reduce pressure on natural resources while supporting livelihoods. Africa is vulnerable on two fronts: one, because of existing vulnerabilities; two, due to capacity limitations for disaster mitigation and inability to adapt to climate change. There is an urgent need to ensure that activities centring on adaptation to climate change and sustainable energy development are increased and maintained so as to generate sustainable livelihoods.

Energy poverty condemns the vast majority of people in sub-Saharan Africa to a life of abject poverty; it hinders economic development and stifles the potential of people to generate decent livelihoods. Eighty-nine percent of the region's population relies on biomass—wood, animal dung or crop waste—and other natural resources for their main energy requirements, i.e., cooking and heating. This dependency increases the vulnerability of much of Africa's rural population as traditional biomass scarcity is tied to the extremes of climate variability. In addition, ecosystem desertification, high intensity of floods and droughts and an overall inability of various ecosystems to withstand climatic changes, i.e., lack of ecosystem resilience,[1] contribute to the vulnerability[2] of these rural households. The combination of climate-related threats to existing energy systems, coupled with the low efficiency of existing energy technologies and reliance on expensive, decentralised energy supply systems, further compounds the problem of ensuring local energy access and meeting demand.

For Africa to meet its poverty reduction goals and primary energy needs in a sustainable manner the following areas must be addressed: affordability of, and access to basic energy sources for cooking, heating and lighting; sustainable natural resources management combined with sustainable energy generation and adaptation to climate change.

In the past, the focus of climate change impact and vulnerability analysis—including energy system vulnerability—has focused on "top-down" climate model scenarios or forecasting approaches. Recently, a number of "bottom-up" approaches have been developed that focus on promoting local resilience strategies and localised energy planning. Results from these new methods are guiding the latest policy and strategy developments across Africa through various platforms such as the Africa Partnership Forum, under the auspices of New Partnership for Africa's Development (NEPAD). Greater attention should be given to how these "bottom-up" approaches can benefit Africa.

This project is a preliminary attempt to identify points of vulnerability as they relate to climate change-related events and sketch out what changes are needed—both politically and programmatically—to increase resilience. Subsequent chapters explore the current state of vulnerability and potential for adaptation. Results from in-country assessments[3] are then presented. The final chapter offers recommendations on how best to ensure that issues of sustainable energy development, adaptation and resiliency are central components of any poverty reduction strategy.

1 Ecosystem resilience to various climatic conditions refers to the capacity of an ecosystem to cope with disturbances, such as storms, droughts, floods, fire and pollution, without shifting into a qualitatively different state (IPCC, 2001).

2 Vulnerability of an ecosystem is described as "a degree to which a system is susceptible to or unable to cope with, adverse effects of climate change, including variability and extremes" (IPCC, 2001).

3 The countries are: Burkina Faso; Cameroon; Democratic Republic of Congo; Kenya; Mali; Nigeria; South Africa; Senegal; Tanzania; and, Uganda. Preliminary assessments and recommendations from eight of these countries are presented in Section IV of this report. The full reports are available on the HELIO website at: www.helio-international.org

Section II.

The Bad News: Exploring the status quo—the vulnerability of current energy systems to climate variability

Energy security correlates with livelihood security.

Sub-Saharan Africa is home to the world's lowest electricity consumption rates per capita; here poverty and the under-development of modern energy services are clearly linked. Between 1990 and 1999,[4] average per capita consumption fell from 695 kilograms of oil equivalent (kgoe) to 410 kgoe. Although Africa is home to 13% of the world's population and produces 7% of the world's commercial energy, it accounts for only 2% of the world's GDP and 3% of global commercial energy consumption. In 1990 the total primary energy use in sub-Saharan Africa—including South Africa—was: 53% biomass; 26% petroleum; 14% coal; 3% large-scale hydro; 2% natural gas; and, 2% other renewables.

According to the latest African Water Development Report, a total of five countries—South Africa, Egypt, Algeria, Nigeria, and Libya—were responsible for 84% of all energy production in Africa and for 78% of total energy consumed. Because of their centralised, non-renewable energy reserves—and high level of government involvement in energy generation—these countries have managed to develop at a faster rate than most other African countries. Conversely, due to the unavailability of comparable, traditional energy reserves, other African countries have had to import energy or rely primarily on renewable energy sources, e.g., hydro-electric generation, solar thermal and wind technologies.[5] This development disparity illustrates a direct relationship between energy security and economic growth in Africa: energy security is a correlation of livelihood security.

Effects of Energy Vulnerability

As rural and urban low-income households do not have access to alternative energy sources they are the most vulnerable to climate change.[6] This vulnerability is further compounded by national policy development that does not adequately address the needs of the rural population in general or rural energy needs in particular. There is, then, a real need to ensure sustainable energy supplies while also increasing access and affordable energy services for Africa's poor—both rural and urban. In the face of projected climate impacts, the need is even more pressing.

Problems of inefficient energy production and use undermine the income-generating potential of entrepreneurs and small-scale farmers. Studies show that small and medium enterprises (SMEs) in sub-Saharan Africa still depend on biomass for 84% of their energy needs. The increased threat of climate change on natural fuel resources reinforces the need for urgent action to provide alternative and sustainable energy generation and supply for this economic sector.

Energy services for public services such as remote health centres, schools and water supplies are also increasingly under threat. From a public sector perspective—whether it is refrigeration for vaccines, lighting of maternity wards, pumping systems for drinking water or lighting for evening activities—there is no doubt that the presence—or absence—of sustainable electricity has a significant impact on people's quality of life.

4 These statistics were last updated in 1999. At the time of publication, no new statistics have been issued for Africa as a region.

5 Despite the seemingly ready availability of energy via renewable sources, access to modern energy services in sub-Saharan Africa is often limited; energy supply systems are inadequate and unreliable and the energy sources offered are seldom affordable to the majority of the rural population.

6 Biomass fuels make up an estimated 60% to 86% of all primary energy consumption in Africa. North African countries and South Africa, where the wood fuel contribution is less significant, are the exceptions.

In terms of energy generation and supply, the impacts of climate change on the energy sector will be felt primarily through: changes in the growth rates of biomass for fuel use; increased runoff and siltation from land degradation on hydro-generation; and, losses or fluctuations in hydropower production due to increased stresses on water supply systems[7] and changing rainfall patterns.

Hydropower generation is likely to be the most heavily impacted because it is sensitive to the amount, timing and geographical pattern of precipitation as well as temperature—rain or snow, timing and speed of melting, etc. As hydropower is the primary source of electricity in East Africa and Central Africa—and supplying about half of West Africa's needs—the impact on development will be significant.[8] This high dependence on water resources for energy generation further highlights the vulnerability of energy systems across Africa.

In summary, the main areas of vulnerability of energy systems in sub-Saharan Africa include:

- lack of rational territorial distribution of energy resources across this region;
- inaccessibility of reliable and affordable energy for households, local SMEs, public sector and commercial sector;
- lack of a reliable, affordable energy supply;
- increased environmental degradation associated with traditional biomass use; and,
- unexplored and underdeveloped hydropower potential of river basins.

Energy scarcity and increased threats due to climate change also hinder the provision of basic services such as water, health and education.

7 Out of the 19 countries classified with water-stressed supply systems, more are in Africa than in any other region. This number is likely to increase—independent of climate change—due to rising demand from population growth, degradation of watersheds caused by land use changes and siltation of river basins.

8 The Democratic Republic of Congo (DRC), Ghana, Mozambique, Rwanda and Zambia rely on hydroelectric power for more than 80% of their electricity needs. Over 60% of centralised grid-based systems in many African countries—such as Kenya and Zambia—are dependent on hydropower with dependency reaching over 90% in Cameroon and Uganda.

Section III.

The Good News: Adaptation and the potential for change

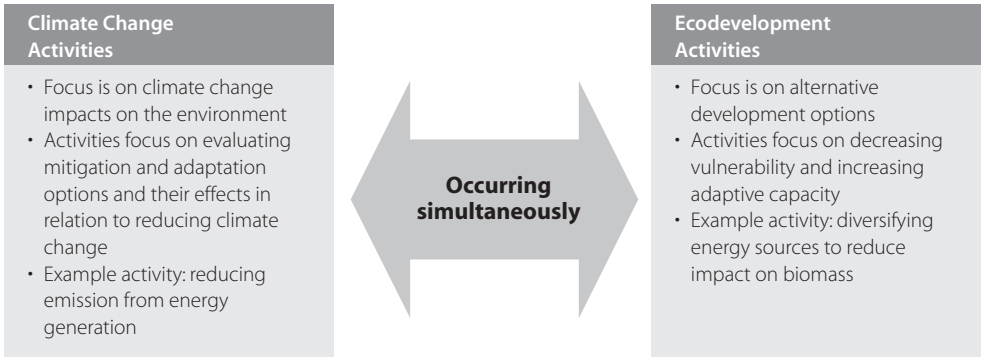
Although climate change seems marginal compared to the pressing needs of poverty alleviation, health, hunger and economic development, it is becoming increasingly clear that achieving development goals, such as those related to food, water and energy, can be seriously impeded by climate impacts. As a result, linkages between climate change and development are receiving more attention in political and scientific circles. Development can and should be planned in such a way that development goals are achieved, while simultaneously reducing vulnerability to climate change.

It is essential that the potential impacts of climate change be mitigated in Africa where levels of poverty will be worsened by extremes of climate change. Countries with the fewest resources are most likely to bear the largest burden of climate change in terms of morbidity, loss of life, adverse effect on income and growth and damage to general living standards, such as access to safe water, energy and shelter.

The extent to which a community is able to adapt to climate changes will depend on its relative vulnerability and adaptive capacity.

The connection between climate change and sustainable development works in two directions: first, through mitigating[9] greenhouse gas emissions; second, by adapting[10] to the projected impacts due to global warming. As is illustrated in Figure 1, Africa must explore mitigation options against greenhouse gases (GHG) emissions by developing solar, wind, hydro- and bio-energy sources; simultaneously the region must also consider the impacts of climate change on these energy sources.

Figure 1: Two-way Interaction Between Climate Change and Ecodevelopment



The Significance of Adaptation

The extent to which a community is able to adapt to climatic changes depends on its relative vulnerability—the degree to which a community is susceptible to the adverse effects of climate change—and adaptive capacity.

Adaptive capacity is the ability of a community to adjust to the evolving challenges of climate change. It is also the ability of a community—or system—to adjust to climate change, to take advantage of opportunities, or to cope with the consequences.

9 Mitigation refers to the reduction of GHG emissions; mitigation activities aim to reduce the sources of GHG emissions.

10 Adaptation recognises that some climate change is inevitable; action is needed to help vulnerable communities adapt or improve current practices to better withstand the negative consequences of climate change.

A community's capacity to adapt can be assessed by evaluating the potential of its key assets.

- Economic resources – low economic resources decrease adaptive capacity and potential options.
- Geographic context – absence of rivers, lakes, mountains increases vulnerability of water supply.
- Technology – lack of technological capacity limits potential adaptation options.
- Information and skills – lack of information decreases the likelihood of timely and appropriate adaptation interventions.
- Infrastructure – limited infrastructure inhibits adaptation since it restricts available options and equitable access.
- Institutions and networks – poorly developed institutions inhibit adaptive capacity and planning.
- Equity – inequitable distribution of resources reduces adaptive capacity in the poorer communities.

To be successful, adaptation responses must be consistent with sustainable development. However, historically, little reference is made to climate impacts in development plans other than in disaster management plans for droughts and floods. Most of the work done to date looks at the impacts on natural resources that affect the livelihoods of Africans. While energy has received lots of attention, the main focus has been on energy access and ensuring a sustainable energy path for Africa. The linkage between sustainable energy and climate impacts has not been explicitly made. Longer-term impacts due to climate change, such as the gradual change in rainfall patterns, do not fit into most planning horizons which are usually politically and financially constrained. The uncertainty of future projections such as population growth, energy demand and future energy supplies, further complicates adaptation responses.

The linkage between sustainable energy and climate impacts has not been explicitly made.

The Importance of Integration

The integration of adaptation policy into ongoing sectoral planning, budgeting and decision-making processes is not evident in sub-Saharan Africa. To date, support for adaptation is fragmented and piecemeal. Efforts have been made to mainstream adaptation to climate change have proven relatively successful in the agriculture sector, a sector which has a long history of mitigating drought impacts. Unfortunately, this has not been the case for the water and energy sectors as traditional government structures inhibit mainstreaming. Climate change is usually housed in the Environment ministry which has limited influence with other ministries, especially Finance or Energy. As a result, very few countries have prioritised adaptation in key planning documents on poverty reduction, integrated resource management, etc.

All levels of government should ensure that policies, programmes, budget frameworks and projects take account of climate change and adaptation strategies. To date, much has been invested in Africa in terms of capacity building; however, more new efforts are needed to enhance the adaptive capacity of institutions, organisations and individuals. Senior government officials and most members of civil society do not understand the climate issue very well. Development of a sound climate change response strategy can occur only when the stakeholders foresee potential consequences that could jeopardise national efforts to achieve ecodevelopment. Stakeholders also need to be organised in civic bodies that are able to contribute to energy planning decision-making processes. Even where climate change is recognised as a crucial concern, it is viewed as a long-term issue and therefore not consistently considered.

As international aid has fallen in both absolute and relative terms over the past decade, Africa cannot rely on these sources of funding to improve its resilience to climate impacts. As adaptation activities can be capital intensive and the benefits highly localised and immediate, the real challenge lies in securing adequate and stable funding to meet priorities. Strategies that emphasize a bottom-up approach—recognising local coping strategies and initiatives—together with indigenous knowledge and technologies hold the most promise as these will fit best with local adaptive capacity.

The emphasis of energy policy development in the face of climate impacts should be on mobilising African civil society to contribute to organising and supporting the transition to more resilient energy systems. There already exist energy options that are easy to implement, involving local capacity and low operational costs. Technologies that match the high impact, low cost, scaleable profile—such as modern biomass, improved cook stoves in combination with smoke hoods, liquefied petroleum gas (LPG), and mini-hydro—are commercially available. This kind of "no regrets" energy planning fits in well with plans for helping all of Africa adapt to climate change.

The following table represents illustrative examples of how Africa can address both energy access and reduce the vulnerability of energy systems to projected climate impacts.

Examples of Policy Intervention	Possible Action
Reduce vulnerability from climate impacts and extremes	• Introduce and refine early warning systems • Incorporate climate impacts when planning hydro and bio-energy schemes
Increase diversification of energy supply	• Facilitate energy sector reform moving from a centralised system based on conventional fuels to one that is decentralised and includes local governance • Include grid and off-electricity, mini-hydro, solar energy, wind, geothermal, natural gas and LPG • Set national power grid feed-in tariffs for renewable energy-generated electricity • Substitute imported petroleum products with indigenous energy sources • Diversify and intensify crop production to produce ethanol to reduce the importation and consumption of petroleum without competing with food crops or harming biodiversity • Incorporate energy needs into local development projects • Provide incentives to investment in new renewable energy sources • Develop regional energy co-operation and planning to balance the surplus-loss of available electricity
Increase access to sustainable energy	• Widen the access to cleaner fuels and biomass, especially in rural areas • Increase the usage of improved firewood and charcoal stoves • Improve the access to grid and off-electricity, mini-hydro, solar energy, wind, geothermal, natural gas and LPG • Subsidise biomass substitution with LPG and other fuels
Develop human capacity	• Improve institutional planning and management capacity • Support the implementation of localised decision-making concerning power generation involving environmental non-governmental organisations and women's groups • Strengthen the energy extension services to rural areas
Mobilise energy investments	• Introduce institutional reform in the banking, legal and business sectors • Promote micro-finance • Encourage synergies between local projects and national development objects • Create markets for biomass production and use
Improve access to technology and technology development	• Create an enabling environment to receive new technologies • Develop CDM projects to attract investment and develop clean energy supplies • Promote further research into energy usage and energy alternatives at household level • Encourage investment in renewable energy sources—wind and solar—by offering special tariffs for each kWh produced
Improve energy efficiency (EE)	• Introduce regulations for commercial and industrial EE implementation • Promote EE education at the household level and by the creation of citizens councils

Section IV.

First Steps: Initial assessment and recommendations for sub-Saharan Africa

Adaptation of energy policies and systems and building up community resilience must be central components of any development action. Below is a summary of key vulnerabilities and corresponding recommendations for eight sub-Saharan countries: Burkina Faso, Democratic Republic of Congo, Mali, Nigeria, Senegal, South Africa, Tanzania and Uganda. These assessments were carried out by in-country reporters.[11] Collectively they conclude that, under the threat of climate change, energy development for Africa will require an even greater emphasis on decentralised, diversified supplies and systematic involvement of local communities.

Country	Key Vulnerabilities	Preliminary Recommendations for Increasing Resilience
Burkina Faso	• Only 12% of households have access to the grid • Demand for charcoal increases at an annual rate of 8.3% • 83% of energy consumed comes from biomass,16% from hydrocarbons and 1% from hydroelectricity • Heavy dependence on imported energy including electricity from neighbouring countries • 12% of electricity generated is lost through inefficiencies in production and distribution • 40% of the GDP comes from agriculture sector; livestock contributes an additional 10% • Cotton and livestock make up 90% of exports • Schooling and literacy rates are among the lowest in West Africa • 37% of all children suffer from delayed development • Approx. 28% of the total population migrates to other countries	• Give local collectives the authority to manage and maintain natural resources including the raising and sharing of revenues • Promote increased energy efficiency by providing incentives for higher efficiency, less polluting technologies • Diversify renewable energy resources to include solar, wind, geothermal, biomass and ensure their inclusion in the national energy plan • Carry out in-depth studies that can better pinpoint areas of vulnerability and outline anticipated adaptation costs • Support a large-scale effort to increase household energy efficiency via passive solar water heaters, solar cookers, etc. • Promote the use of alternative energy, e.g., butane, solar, etc., to reduce consumption of traditional energy sources
Democratic Republic of Congo	• Presence of continuing armed conflict in eastern part of the country • Destruction of social network due to 4-year civil war (approx. 3 million dead) • Over 70% of the population depends on agriculture as its source of income • More than 85% of total energy consumption is from biomass • 70% of fossil fuel imports are consumed by transportation sector • Rural electrification is approx. 1%	• Carry out site identification for solar and wind applications to offset current consumption from biomass • Raise the installed capacity of the national electricity company from 30% to 60% • Improve the collection and application of vegetal and animal waste to help with soil enrichment • Decentralise and involve local organisations in the development and management of health and education services • Construct micro-hydro installations

11 These reporters are energy experts in their respective countries and work on the energy/development interface. A list of the authors' names and contact information is listed in the inside cover of this publication.

Country	Key Vulnerabilities	Preliminary Recommendations for Increasing Resilience
	• Fossil fuel distribution occurs primarily via river networks • Approx 50% of the country's 8.8GW hydroelectric generation capacity is located at one facility • Increasing dependence on diesel generators for electricity supply • Sewage treatment facilities are very poor or non-existent resulting in contamination of river system • Erosion of coastline is approx 1.3m/year	• Support the development of small well installations to reduce illness from contaminated river waters • Diversify and intensify cereal crop production to produce ethanol to reduce the importation and consumption of petroleum • Implement public awareness campaign about solid and liquid waste management
Mali	• 80% of the population is employed in agriculture • 44% of the country's GDP comes from agriculture, animal husbandry and fishing • Over 90% of energy consumed comes from biomass • Substantial rise in the informal wood fuel supply sector is accelerating ecosystem deterioration • Anticipated development of 20 dams along the Niger River, a resource shared between four countries • Proposed dam impacts assessments do not look at the effects of climate change on anticipated water flows • No coordinated emergency/disaster management system exists • Lack of information regarding risks and associated economic impacts	• Intensify and diversify agriculture production • Educate farmers to use agriculture techniques that are not heavily dependent on imported inputs • Further develop hydroelectric capacity of the country • Develop the renewable energy sector including the production of bio-fuels • Promote energy efficiency • Develop agricultural waste as a viable energy source • Promote cooperative management of forests • Correct the inequalities in the education system to increase educational access for young women and provide opportunities for informal adult education • Provide financing to ensure good affordable local health care and develop community networks to support it • Promote gender equality • Support the growing sector of micro-financing
Nigeria	• Agriculture is rain-fed—only 1% of the 33% of arable land is under irrigation • 70% of the population is employed in agriculture • 30.1% of energy consumed is from biomass; 43.3% is from petroleum products • 80% of the population use biomass for their energy needs • Modern renewable energy production represents less than 5% of country's energy consumption • Volatility in the Niger Delta generates instability in upstream petroleum supply industry • 50% of oil production is off-shore • Oil pollution and gas flaring has damaged surrounding marine ecology and agricultural lands irreversibly • Country's financial hub—Victoria Island—is vulnerable to impacts of sea level rise • 850km of low-lying coastline	• Improve the effectiveness of existing dams and invest in small and medium-sized dams to hedge against water scarcity during droughts • Inform and support private sector involvement on climate change impacts and related business opportunities • Support public/private partnerships to address power generation needs and affordable access • Support local self-organising networks and NGOs to deliver social services and coordinate on disaster management • Harness the potential of the educated workforce by stimulating employment through public works programmes • Align ecodevelopment concerns with the second phase of Nigeria's economic empowerment and development strategy • Facilitate energy sector reform by moving from centralised system based on conventional fuels to a decentralised system that includes local governance and supply diversity

Country	Key Vulnerabilities	Preliminary Recommendations for Increasing Resilience
	• Lake Chad—an important fresh water source for the 4 countries that surround it—is only 5% of its original size	
Senegal	• Agriculture is rain-fed • Substantial volumetric reduction from 650m^3 to 250m^3 in the Senegal River, the country's main hydroelectric source • 43.5% of all energy consumed comes from biomass • 90% of all electricity produced comes from hydrocarbons • 1/5th of electricity generated is wasted due to technical inefficiencies • Petroleum imports account for more than 43% of revenue exports, making the country vulnerable to fluctuating oil prices • Rising sea level is causing the salinisation of fresh water table • 1350km coastline with flat interior terrain • Over 75% of the population lives less than 60km from the coastline	• Increase food and fuel security by expanding crop base and cross-linking production efforts • Include local groups in agricultural-based adaptation measures, e.g., water retention and conservation, crop diversification, etc. • Decentralise and designate natural resource management to local entities • Encourage investment in renewable energy sources—wind, solar—by offering special tariffs for each kWh produced • Support regional water management to ensure fair distribution for agriculture and electricity production • Promote energy efficiency to optimise energy distribution and reduce energy loses • Develop mixed supply and demand approaches to better manage key natural resources, e.g., simultaneous application of resource management—forests—and technology transfer—fuel efficient cook stoves • Incorporate energy needs into local development projects • Implement butane gas subsidies to reduce pressure on local vegetation
South Africa	• Extensive, populated coastline • 70% of total grain production comes from maize • Only 13% of the country is considered arable • Heavy dependency on revenues from coal exportation • 68% of total primary energy supply comes from coal • Country's size makes it heavily dependent on regional and national road infrastructure	• Reduce industrialised mono-cropping and replace it with crop diversification and water conservation techniques • Develop agricultural cooperatives to support independent producers • Apply stiffer mandatory renewable energy deployment targets • Set national power grid feed-in tariffs for renewable energy-generated electricity • Support the implementation of localised decision-making concerning power generation • Implement improved building standards, e.g., energy efficiency, including the deployment of passive solar water heating systems • Implement an efficient public transport system • Establish a Basic Income Grant to assist the poor • Implement a nationwide, locally-based emergency network to disseminate and collect information and facilitate action
Tanzania	• 50% of GDP and 85% of all exports come from agriculture, the majority of which is rain-fed • High dependency on biomass energy resources • Disappearance of Mt. Kilimanjaro glaciers is affecting hydropower	• Include local population in implementation and design of sustainable energy investments • Mobilise financial resources to implement a sustainable rural energy strategy • Strengthen energy extension services

Country	Key Vulnerabilities	Preliminary Recommendations for Increasing Resilience
	and agricultural production in Pangani Basin, the country's most agriculturally productive area • Marine fishery production is threatened • Spread of malaria to higher altitude areas	• Support the Saving and Credit Cooperative Societies (SACCOA) to provide "soft" loans to assist with local economic development • Improve current traditional irrigation systems • Substitute imported petroleum products with indigenous energy sources • Development/rehabilitation of rural road network to allow for transport of goods/services to offset anticipate migration because of climate-induced resource constraints
Uganda	• 93% of energy consumed comes from biomass • 85% of the population depends on agriculture for its livelihood • Rain-fed agriculture • Populations in internal displacement camps—due to regional conflicts • Hydro power generation is dependent on rain-fed, river flows • Highly centralised energy infrastructure • High investment costs for the large-scale conventional energy sector but low population outreach • High energy costs results in illegal connections • Large petroleum import bill makes country vulnerable to external price shocks • Very complex energy system architecture that requires levels of expertise and equipment that is sourced from outside the country	• Offer tax reductions/exemption on capital equipment for electricity generation • Reduce taxation on key petroleum products, e.g., diesel, to support power needs for small rural business and activities such as local crop irrigation • Provide investment incentives for new renewable energy sources • Adapt energy policies and strategies to take into account regional variations, e.g., disparities, constraints • Increase the visibility of energy in the country's Poverty Eradication Action Plan (PEAP), including better defining how energy can be used to drive rural development • Employ mixed crop use to offset complete harvest failure • Support social networks amongst farmers to share production costs and risks; women are particularly involved in these networks thus support also strengthens position of women in the community • Support micro-financing and insurance using liquid saleable assets such as livestock

Section V.

Where to Go From Here: Next steps

Africa has a huge burden to bear: it has been deemed "the continent most vulnerable to the impacts of climate change" by the UN Intergovernmental Panel on Climate Change. Political, social, environmental and economic realities complicate the problem despite, or because of, the region's abundant natural resources. One thing is clear however: Africa must not be allowed to slip into climate-induced chaos because of the industrialised world's addiction to fossil fuels.

From the country reports, we can see that energy development for Africa in a changing climate will require greater emphasis on small-scale, decentralised and diversified supply and increased distribution to households and enterprises alike. As has been discussed, hydro-dependency will become problematic if rain patterns change. Similarly, renewable technologies such as wind and solar could be affected by changing climate patterns. A diversified and distributed energy mix is the best insurance policy against climate change.

But adaptation of energy policies and systems is only part of the solution; building up the resiliency of local populations and energy systems is equally important. So what should be the priorities?

- **Harness the value of indigenous knowledge to plan and achieve resilience**

  The ability of people to manage their energy resources within the constraints of the fuels and appliances they have access to is a behavioural resource that can—with the right encouragement—be applied to the management of modern energy services. Such behavioural resources are valuable for the successful management of energy systems as well as ensuring successful technology transfer of clean, sustainable energy services and adaptation technologies. Indigenous knowledge and practices, especially among women, have the potential to increase resilience and therefore security at household, regional and national levels. In building on this local knowledge base, energy and adaptation technologies—hardware, software and institutions—can be readily received and implemented.

- **Mobilise adequate and stable financial resources**

  With the rise of neo-liberalism and globalisation, investment in energy networks has shifted from the public to private sector, with the ensuing disengagement of state governments from the provision of basic services. This is making it increasingly difficult to secure enough financing for energy and transport infrastructure development in Africa, as the risk is considered very high. Without the underlying development resources to establish decentralised, diversified energy infrastructure, incremental contributions to "climate-proof" development are meaningless.

- **Mainstream adaptation and resilience in the development process**

  Approaches that address multiple environmental stresses and factors hold the greatest promise for Africa. Adaptation, efficiency and resiliency measures must be mainstreamed into all aspects of the development agenda through the coordinated implementation of policies that address land degradation, loss of biological diversity, ecosystem services, energy, etc. Compartmentalisation of the development agenda can only provide a temporary solution that will not withstand the test of climate change.

- **Develop policies to institutionalise and mobilise "social capital"**

  Lack of reliable information, and application knowledge, inadequate dissemination strategies, poor management of community schemes and undemocratic governance all contribute to partial or failed implementation of energy systems. Energy users must be a constitutive part of the decision-making process as they know what their needs are and, ultimately, they pay the price; financially, socially and personally.

Despite the obstacles facing Africa, hope is not lost. There are numerous positive characteristics upon which successful programmes can—and should be—built. Culturally, Africa has strong social networks. These networks serve an important function in educating communities, disseminating information and serving as substitutes for collateral in micro-loans. Women—in particular—play an important role in the management of natural resources. As primary collectors and users of biomass and water, women are well-placed to monitor and manage resources, spur innovation on adaptive techniques and experiment with new management approaches. Ironically, it may be Africa's decades-long experience coping with poverty that may be its strongest resource. By its collective survival the region has shown itself to be adaptive and resilient despite enormous obstacles. It is now our collective responsibility to ensure that this rich, diverse region develops to its fullest potential.

Section VI.
Resources

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Africa

Countries studied for this report

❶ Burkina Faso	❸ Mali	❺ Senegal	❼ Tanzania
❷ Democratic Republic of Congo	❹ Nigeria	❻ South Africa	❽ Uganda