



Summary of ICSU ROA Projects on Global Environmental Change (including Climate Change and Adaptation)

Introduction

All nations are directly or indirectly affected by changes in the global environment. Climate change is one of the greatest environmental challenges facing the world today as the shifting of parameters such as rainfall and temperature regimes can trigger changes of other phenomena such as land cover changes, land degradation and biodiversity. The degradation of land and biodiversity loss threaten human health as well as the survival of flora and fauna that adversely affecting the ability of the ecosystem to prevent and recover from a variety of natural disasters.

The African continent has been prone to natural hazards during very recent years, causing unpredictable damages, loss of lives and required millions of dollars in terms of humanitarian aid, especially in sub-Saharan Africa and the Indian Oceans Islands. The severity, spatial distribution and frequency of occurrence of these natural hazards have been observed to be increasing over the past few decades. There is an urgent need for all countries in the region to use resources, innovation abilities and competitiveness to devise means of coping with these challenges. Research activities and resources need to be directed towards relevant problems and model solutions for responses to global environmental change, especially climate change. The region requires a comprehensive early warning system for monitoring, early detection and response to environmental threats and natural disasters.

The changes in the temporal and spatial distribution of rainfall in Africa has adversely affected agriculture and food production of farming communities both directly through changes in agro-ecological conditions; and indirectly by affecting growth and distribution of incomes; and thus demand for agricultural produce. The increase in ambient temperature will have a direct impact in the spread of diseases and disease vectors in the region. Hence it is important for the region to have solid research base whose researchers are in constant contact with the decision and policy makers. Together they will be in a position to formulate effective adaptation policies aimed at reducing the risks of climate change on natural and human systems. These policies should involve diverse adaptation and mitigation actions.

Project GC01: The impact of land degradation and biodiversity loss on human well-being in Africa

Project leader: Prof Harold Annegarn, University of Johannesburg, South Africa

The adverse effects of land degradation and biodiversity loss on human well being constitute a key issue on land, in freshwaters and coastal regions. Land degradation has regional and global consequences, including impacts on the climate system through changes in emissions of greenhouse gases and aerosols, surface albedo, loss of biodiversity, and the displacement of people no longer able to sustain a livelihood in the degraded lands. However, there are no existing methods to date for measuring environmental degradation (on a global scale). Loss of biodiversity is directly detrimental to the well-being of Africans. Many natural resources, including fish, firewood, timber, medicinal plants, and wild foods, are increasingly scarce. Biodiversity research in Africa must be people-orientated, with a focus on the sustainable use of natural resources and the persistence of viable levels of diversity at the gene, species, and ecosystem levels within terrestrial, freshwater, or coastal ecosystems, especially those that are inhabited and used by people.

Objectives

- ◆ To improve earth observation systems that will help to determine the causes and indicators of biodiversity losses.
- ◆ To document the land cover changes using remotely sensed data and how these changes affect local, regional and global climate.
- ◆ To integrate climatological research in Africa on land surface changes, ocean temperature and ocean circulation.
- ◆ To produce a harmonised (international standard) for measuring climate change impact on land degradation.
- ◆ To document biodiversity loss trends in Africa using climatological and remotely sensed data
- ◆ To investigate the influence of the increase in temperature on the spread of disease and disease vectors.

Activities

- ◆ Documenting the interlocking drivers and stresses that shape land use and land cover changes.
- ◆ Exploring the spatial and temporal dynamics of land use and land cover changes and their interactions.
- ◆ Establishing the links between biodiversity, ecosystem function, ecosystem services, and human well-being.
- ◆ Projecting patterns and trends in biodiversity distribution in the short and long term.
- ◆ Developing strategies for conservation and sustainable use of biodiversity-based natural resources in Africa and its surrounding oceans.
- ◆ Developing sustainable alternative livelihood options that can be used by the rural communities for their subsistence, thereby reducing pressure on existing biodiversity.

Expected outcomes

- ◆ Adaptive measures to build the socio-ecological system resilience.
- ◆ Earth observation systems to determine the causes and indicators of biodiversity losses.
- ◆ Maps and inventories of endemic and endangered species and ecosystems.
- ◆ Documentation showing insights into the interlocking drivers and stresses shaping land use and land-use change.
- ◆ Maps showing the spatial and temporal dynamics of land use and land cover changes
- ◆ Spatial patterns and trends in biodiversity distribution in the short and long term.
- ◆ Sustainable alternative livelihood options for subsistence for the rural communities.

Project GC02: Impact of climate change on rainfall and water resources in Africa

Project leader: Prof. Jonathan I. Matondo, University of Swaziland, Swaziland

Project GC02.1: Sustainable adaptation to changes in rainfall patterns for food security in Africa

Food insecurity in Africa arises from a combination of factors that range from poor governance, weak science-policy links, inadequate agricultural infrastructure, a rapidly growing population, widespread poverty, war and conflicts to unfavourable soils and changes in rainfall regimes. The variability in spatial and temporal distribution of rainfall significantly impacts on the shifting of agro-ecological zones which in turn will affect the agricultural patterns, food security and demography. As most communities in the rural Africa depend on rain-fed agriculture, any changes in the rainfall patterns will increase the vulnerability of rural agro-ecological systems and hence, the rural poor that depends on it. The science community in the region should devise new methods and ways for adapting the vulnerable populace and communities to climate change. This project aims to apply modern techniques, tools and information to devise methods for reducing the vulnerability of local communities to global environmental challenges.

Objectives

- ◆ To map changes in the agro-ecological zones in Africa.
- ◆ To improve adaptive capacity and resilience of socio-ecological systems.
- ◆ To develop strategic tools for adaptation rather than just reaction to changes to social and ecological systems.
- ◆ To build a database for the resilience of Africa's social and ecosystems.
- ◆ To explore the potential for crop and cropping systems diversification options in reducing the risks associated with global environmental changes and in increasing the communities' adaptive capacities.

Activities

- ◆ Developing new agro-ecological zones using a combination of meteorological, agricultural and remotely sensed data.
- ◆ Developing adaptive measures to build the socio-ecological system resilience.
- ◆ Establishing a databases and strategic tools for monitoring climate change, agricultural production and design adaptive scenario measures.

Expected outcomes

- ◆ Rainfall patterns and their correlation to other parameters such as sea-surface temperature.
- ◆ Agro-ecological zone map for Africa.
- ◆ Establishment of policy interventions to improve food security.
- ◆ Sustainable crop and cropping system adaptation options to ensure food security in the region.
- ◆ Database for the resilience of the regional socio-ecosystems

GC02.2 Integrated trans-boundary water resource management in the context of climate change in Africa

Most of African regions consist of arid or semi-arid zones which has faced severe droughts during the past 30 years and progressive desertification. Economic life of these zones is dominated by traditional rain-fed agricultural, pastoral and fishing activities. The survival of the populations depends on the abundance of the rainy season and the proper management of water resources. The variability of the rainfall impacts on almost every component of the regional socio-economy that include water resources; health (availability of clean water for washing and drinking, creation of mosquito breeding sites); food security; and energy (rivers/dams for hydropower) are critical issues to tackle.

In these regions, the issue of water use and management is central in order to make a proper use of the resources for sustainable development. Arid and semi-arid region of Africa are shared by different nations which rely heavily on the trans-boundary waters. There is, however, inadequate information regarding the recharge of groundwater, river flow measurements and their dependence on rainfall variability and on land use. Early warning systems and adaptive strategies must be founded on a strong body of knowledge. The critical mass of expertise could not be sufficient locally but this could be supplemented by the other expertise in northern or southern African countries or even elsewhere and the capacity building will be one component of the project.

Objectives

- ◆ To understand the availability and nature of water resources
- ◆ To establish the potential uses and users of water, and map vulnerability sectors
- ◆ To promote communication between stakeholders and community involvement

Activities

- ◆ Analyses of water resources and uses including the assessment of water resources variability; water use and the driving forces that induce changes and pressures on water resources as well as the impacts and responses; and catchments analysis using hydrological, hydro-geological and socio-economic models
- ◆ Evolution in Climate Change using downscaling of Scenario models to assess the potential impacts and vulnerability of the water resources as well as mapping up the adaptation measures
- ◆ Governance – making an analysis of local, national and international stakeholders ; institutional and legal frameworks analysis; and participation and involvement of deferent actors in the process of water management
- ◆ Using Geographical Information Systems to map the changes in the water resources and well as the vulnerability maps for the continent

Expected outcomes

- ◆ Physical and biological metadata
- ◆ Strength, weaknesses and threats for existing institutional and legal frameworks of water management
- ◆ Hydrological and hydro geological and socio-economic models,
- ◆ Downscaling of scenarios for the evolution of climate in the region
- ◆ Decision Support System based on GIS and Map of vulnerability

Project GC03: Air Pollution and health impact in urban areas in Africa

Project leader: Dr Albert K Sunnu, Kwame Nkrumah University of Science and Technology, Ghana

Background

The accumulation of atmosphere substances, in sufficient concentrations, compromises the air quality, and endangers human health and the natural ecosystem. Due to high rising traffic, industrial processes and coal power generation in Africa's towns and cities, the urban population in the region is increasingly subjected to high pollutant levels. Dependence on old technology, recondition vehicles and inefficient waste management system, emissions such as carbon monoxide, hydrocarbons, nitrogen oxides, ozone, sulphur dioxide and volatile organic compounds pose great health danger to urban population. The increase of some of these substances in the atmosphere has become a major source of concern especially considering their implications on a human health.

Although a lot has been done in Africa to reduce air pollution, there are no existing mechanisms in place to continuously measure/monitor ambient concentration levels of toxic pollutants. As a result, very few nations in the region have statutory laws in place to enforce air pollution regulations on major ambient polluters. This project aims to develop a network of atmospheric pollution researchers across Africa that will continuously monitor ambient concentration levels of harmful substances and assess the impacts of air pollution on people, crops and natural systems. It consists of the following sub-projects:

GC03.1 Air pollution assessment mega-cities in Africa

Objectives: The main objective of this sub-project is to assess the air quality of major African cities and conduct case studies on impacts of air pollution on health and corrosion of structural materials

Activities

- ◆ Select African cities from the five regions of Africa (Western, Eastern, Central, Southern, and north Africa) for urban pollution monitoring
- ◆ Conduct training workshops on the rapid urban air quality assessment (RUA) methodology
- ◆ Conduct rapid urban assessments in the cities using mini-vols in conjunction Dust-traks for particulate matter and passive samplers for the other pollutants
- ◆ Conduct training on local dispersion modelling (using e.g. TAPM model), integrated assessment modelling using the Simian model and scenario building
- ◆ Model the results from the assessments
- ◆ Conduct epidemiological case studies on impacts of air pollution on health in hotspot areas determined by the assessments
- ◆ Conduct case studies on impacts of air pollution on corrosion of structural materials and conduct a 'stock at risk' assessment
- ◆ Carry out a cost-benefit analysis of impacts of air pollution on health using SIMair as well as co-benefit analysis of reducing air pollution and study outcomes of using different fuel types
- ◆ Develop Strategic Frameworks on Air Quality management for the cities

Expected outputs

- ◆ Reports on the urban assessments incorporating different scenarios for managing air pollution in the cities

- ◆ Scientific papers on the results of the assessments
- ◆ Strategic Frameworks for Air Quality Management for the six cities including recommendations on town planning and management of traffic in the cities
- ◆ Case study reports on impacts of air pollution on health with recommendations on mitigation of pollution
- ◆ Case study reports on impacts of air pollution on corrosion including results of the “stock at risk” assessment and cost benefit analysis of reducing air pollution
- ◆ Policy briefs

GC03.2: Monitoring and modelling of trans-boundary atmospheric aerosols due to anthropogenic and natural sources in Africa

Objective: To monitor trans-boundary transportation and deposition of particulate matter in Africa and its impacts on climate change, human health and structural materials

Activities

- ◆ Carry out a scoping study on sources and work done on black carbon, desert dust, volcanic particles and other important aerosols in Africa, and link up with existing initiatives
- ◆ Determine the aerosols’ characteristics of the continent and study the atmospheric circulation pattern flow of particulate matter from rural to urban areas and vice versa
- ◆ Determine the emission sources , transfer, deposition, concentration of PM2.5 including indoor signal at urban and regional scales
- ◆ Monitor and model the deposition of the aerosol and determine their sinks
- ◆ Assess the impacts of aerosols on their various sinks such as water bodies, solar radiation balance, structural materials, visibility, ecosystems and human health
- ◆ Come up with mitigation measures and monitor their effectiveness
- ◆ Disseminate information on aerosols and their impacts to all levels of stakeholders

Outputs

- ◆ Scoping report on sources and work done on black carbon, desert dust, volcanic particles and other important aerosols in Africa
- ◆ Scientific publications on the aerosols’ characteristics and their sources, transfer and deposition.
- ◆ Scientific publications on impacts of aerosols on their various sinks such as water bodies, solar radiation balance, structural materials, visibility, ecosystems and human health
- ◆ Adaptation and mitigation measures to reduce the impacts of aerosols

GC03.3: Ground level ozone in Africa and its impacts on crops, food security and ecosystem services

Objective: To determine the spatial distribution of ozone in Africa and its impacts on crops, food security and ecosystem services

Activities

- ◆ Carry out a passive sampler campaign across Africa including active monitor measurements at selected sites. The active monitors would be important to show diurnal fluctuations and ozone peaks that could damage plants species
- ◆ Determine the volatile organic compounds and NO_x emissions from vegetation, fires, transport and industry
- ◆ Carry out modelling using measured monitoring data
- ◆ Perform high and low technology experiments to determine the impacts of ozone on crops and ecosystems. High tech experiments would include Ozone Transport Commission (OTC) facilities e.g. those found at Potchefstroom, South Africa where ozone levels can be controlled and different staple food crops can be grown under a range of ozone concentrations and different water regimes to understand the impact of ozone under different climatic conditions
- ◆ Carry out experiments with carefully selected important crops at strategically selected sites across Africa to encompass both high and low ozone regions. The experiments could potentially use resistant and non-resistant variants of a bean bio-monitor developed in Europe as well as the use of the chemical protectant (EDU) to conduct experiments on locally important crops.
- ◆ Perform socio-economic risk assessment of impacts of ozone and climate change on crop yields and food security
- ◆ Identify ecosystem risk areas by overlaying risk maps of ozone, acidification and N deposition, drought and temperature change
- ◆ Conduct training workshops on ecosystem assessment methods
- ◆ Carry out case studies on air pollution impacts at high risk sites
- ◆ Assess mitigation measures and carry out an integrated assessment linking to future emission scenarios.

Outputs

- ◆ Scientific publications on ozone concentration and dispersion
- ◆ Scientific publications on impacts of ozone and climate change on crops under different scenarios
- ◆ Scientific publications on impacts of ozone and climate change on ecosystem services
- ◆ Policy briefs

Project GC04: Project title: Monitoring strategies for adaptive management and governance within the coastal zones and large marine ecosystems

Project leader: Dr Regina Folorunsho, Nigerian Institute for Oceanography and Marine Research, Nigeria

Background

Effective management and governance of large marine ecosystems requires an adaptive management approach based on comprehensive and comparable updates of the science (data and information) relating to oceanography, ecosystem health and environment variability (including climate change). This data and information needs to address both those parts of the marine ecosystem that fall within the national jurisdictions as well as those of the ecosystem that are beyond national jurisdiction. The oceanic region south of Africa is a critical crossroad for the inter-ocean communication where exchange of water, salt, heat, biota, and anthropogenic tracers occurs between the sub-tropical Indian and South Atlantic gyres.

This project would establish a long-term scientific monitoring system that includes partnerships between Africa, EU countries and other countries with special expertise in appropriate large marine ecosystems. These partnerships will assist and support long-term monitoring and assessment of large marine ecosystems, transfer technologies and skills for handling and analysing data, and provide support in terms of specialised equipment (including moored arrays, drifters, gliders, etc) and platforms for data collection (ships and remote sensing satellites). This will also provide a mechanism for measuring environmental variability and thus links into an early warning system for climate change and threats to community welfare and stability.

Objectives

- ◆ To establish long-term scientific monitoring system involving north-south participation with partnerships between Africa and the EU countries.
- ◆ To gaining a better understanding of Indo-Atlantic inter-ocean exchanges, and their impact on the global thermohaline circulation and on global climate systems.
- ◆ To adoption of a long-term monitoring approach for large marine ecosystems to guide and advice adaptive management which will address 'ecosystem' governance.
- ◆ Improved capacity building and training in data collection, analysis as well as the translation of such information into management guidelines and policy briefs.
- ◆ To examination the role of the Indo-Atlantic connection on elevated biological activity and regional biodiversity, and as bio-geographic barriers to the distribution of plankton.
- ◆ The development of more effective and appropriate technologies (taking into consideration cost and user-friendliness) including in-field and remote techniques for overall large marine ecosystems monitoring and assessment.
- ◆ Development of effective data ownership, access and management agreements to cover these partnerships.

Activities

- ◆ Developing long-term partnerships between African institutions and EU counterparts as well as with specialist institutions elsewhere in the world.
- ◆ Providing vital information on ocean conditions, the well-being and sustainability of large marine ecosystems, and their linkages to environmental variability (particularly climate change) and thus to coastal community welfare.

Expected outcomes

- ◆ Protocols and standards for marine data ownership, access and management, and feed the results to management decisions and policy-making.
- ◆ Sustained observations that integrate the atmosphere, oceans, and land processes around Africa.
- ◆ Management guidelines and policy briefs.
- ◆ Effective data ownership, access and management agreements to cover these intra-and inter continental partnerships.