



Summary of ICSU ROA Projects on Natural and Human-induced Hazards and Disasters

Project HD 01: Geohazards in sub-Saharan Africa

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Background

Sub-Saharan Africa is prone to many types of hazards and disasters, of which hydro-meteorological and geo-hazards occur most commonly and have the most devastating effects. The common geological hazards encountered on the continent include earthquakes, volcanic activity.

With a few exceptions, countries in sub-Saharan Africa lack the capacity to conduct research on natural and human-induced hazards and disasters, or to apply existing knowledge in deploying technologies to mitigate disasters. There is a good deal of research activity in Africa but in many countries, such research is often interrupted either as a result of irregular funding or in some cases, due to civil unrest. This results in gaps in the availability and quality of scientific data and information, and where these are available they are often insufficiently shared. The continent lacks sufficiently incapacitated institutions that can play a leading role in geohazard research, especially with regard to assessment, prediction and mitigation of the events. Furthermore, there are many other competing claims to limited resources, and the proportion of GDP devoted to scientific research lags far behind the 1% internationally agreed on.

Interestingly, many African communities are still not aware of the occurrence of geohazards, as they are still perceived as unpredictable events with no practical mitigation measures. In addition, many African countries do not have proper policies for hazard management and most actions are limited to emergency responses, often involving evacuation and resettlement of affected populations. The socio-economic costs of hazards and disasters are often not properly assessed because the magnitude of the events is poorly recorded or inaccurately reported. Besides, there is insufficient human capacity to do such evaluations. There is therefore a need to improve community education and awareness-raising, and to intensify human capacity development for research to advice policy- and decision-making.

Objectives:

The main goal of the geohazards project is to improve research skills in sub-Saharan Africa and facilitate coordinated efforts by integrating existing disparate research activities on hazards and disasters on the continent. This will be done by strengthening the human and infrastructural capacities of Universities and research institutions for disaster preparedness and management. The project also aims at facilitating and strengthening interdisciplinary and international scientific collaboration and networking to promote the sharing of scientific data and information on geohazards, while supporting the participation of young African scientists and researchers in high-level scientific networks. The specific objectives of the project will include:

- Building strong research and training institutions in Africa at regional and national levels
- Strengthening the capacity of African institutions to collect, analyze, properly interpret, and disseminate data on hazards and disasters
- Strengthening the link between scientific research and policy- and decision-making
- Promoting and encouraging multidisciplinary research on a pan African scale
- Establishing a network of researchers and research institutions to develop the science of vulnerability to hazards and disasters
- Training young African scientists and facilitating their free movement within the continent
- Providing an interdisciplinary forum to share knowledge and information on geohazards in Africa
- Promoting outreach activities to improve resilience to disaster risks

Sub-projects:

The geohazards project is sub-divided into five sub-projects. The proposed activities of each sub-project are presented below, together with the expected outcome and estimated budget.

1. Assessing and mitigating earthquake hazards in Africa

Activities

- (i) Expand the human and physical capacity for seismic monitoring and hazard assessment in Africa by:
 - Linking African seismologists with each other and with the international scientific community through common projects,
 - Training a new generation of African seismologists through postgraduate research projects addressing African problems. The target is to produce 5 new PhD and 15 new MSc graduates within 5 years,
 - Providing advanced and specialised training for seismic network operators and analysts,
 - Expanding the backbone network of permanent seismic stations,
 - Establishing a pool of seismographs for temporary deployments to address specific research questions, and
 - Integrating the AFREF space geodetic network and the AfricaArray seismic network
- (ii) Compile a comprehensive catalogue of African earthquakes,
- (iii) Compile a seismotectonic map of Africa,
- (iv) Assess the seismic hazard in Africa, with a focus on large cities and critical lifeline infrastructure
- (v) Execute pilot projects
 - Integrated seismic hazard assessment (seismic monitoring, geodetics, remote sensing, palaeoseismology, neotectonics, etc) for Mozambique
 - Historic-parametric Seismic Hazard Assessment for Angola, DRC and Ethiopia

- (vi) Use the seismic and other data to develop models of the Earth's structure and evolution that will address fundamental problems in global tectonics and assist mineral exploration.
- (vii) Increase the awareness of geoscience challenges and solutions amongst decision makers and the public through outreach activities, especially through the International Year of Planet Earth.

Expected Outcomes

- (i) An expanded and homogenized African Catalogue of Earthquakes,
- (ii) A Seismo-Tectonic Map for Africa that incorporates the latest seismic, geodetic and neotectonic information.
- (iii) A Parametric-historic Seismic Hazard Analysis Map for Africa
- (iv) An Integrated Seismic Hazard Assessment of vulnerable areas.
- (v) An enlarged cadre of highly-trained African seismologists and other geoscientists,
- (vi) Improved public domain Earth monitoring networks (seismic, geodetic, etc), data sets (seismic, geodetic, neotectonic, remote sensing), and data processing and interpretation software (e.g. Historic-parametric Seismic Hazard Assessment)

2. Monitoring Hazards from Volcanoes and Explosive Crater Lakes

Activities

- (i) Identify and locate the most active volcanoes, review their past and current status, and characterise their behaviours based on the synthesis of published information.
- (ii) Design methods for monitoring active volcanoes, especially those in densely populated areas, using appropriate Remote Sensing (RS) techniques, and relevant ground-truthing studies.
- (iii) Assess and document the locations and periodicities and impacts of CO₂ emissions from crater lakes within volcanically active regions
- (iv) Establish structural and morphological links between such crater lakes and nearby active volcanoes where appropriate, using RS imagery techniques and ground-truthing studies.
- (v) Periodically monitor the physico-chemical characteristics of water in identified explosive crater lakes as well as the types of gaseous emissions from such lakes using appropriate RS and ground-truthing techniques.
- (vi) Provide human and infrastructural capacity to countries prone to hazards from active volcanoes and explosive crater lakes and integrate experts, policy/decision makers, and the community in all stages of execution of this project.
- (vii) Mapping of volcanicity and CO₂ emission from crater lakes, and developing strategies for education and public awareness-raising for the communities at risk of these hazards.
- (viii) Design approaches of awareness-raising for specific areas of concern to educate policy makers and the local communities about the hazards in such areas and where necessary, recommend evacuation of communities from lowland risk zones.
- (ix) Preparation of background studies covering the entire continent and identification of hotspots of volcanic eruptions and CO₂ explosive crater lakes.
- (x) Identification of experts (especially from countries prone to these hazards), international partners, existing centres of excellence, communities exposed to these hazards (based on internet search, contacts and recommendations from other scientists)
- (xi) Periodic analyses of the physico-chemical characteristics of the crater Lake water, CO₂ and associated gases, and considerations of possible future uses of the CO₂ based on its concentration/volume being emitted

Expected outcomes

- Characterization of the active volcanoes and explosive crater lakes by scientists/experts based on their collective efforts and experience, and compilation of results for publication in a book.
- Design of RS and ground-truthing techniques to be utilized for each volcano, based on its styles of eruptions and associated hazards and its associated explosive crater lakes where applicable.
- Preparation of volcanic and CO₂ hazards maps based on the types, sizes, and distributions of lava and pyroclastic flows, the quiescence periods, and the petrochemical characteristics of the volcano in question, and the risks from the crater lakes. Consideration of the most likely hazards (primary and secondary) from each volcano will be utilized in conceiving approaches of education, sensitization, and awareness creation on these hazards.
- Determination of the tectonic setting and structural relationships between the localization of active volcanoes and explosive crater lakes by appropriate RS techniques and ground-truthing studies.
- Setting up of RS facilities for monitoring of changes on the surface and within the crater lakes using the Moderate-Resolution Imaging Spectrometer, (MODIS) and/or Correlation Spectrometers (COSPEC, LICOR) and infrared analysers, as well as other RS methods.
- Validation of the most appropriate RS and ground-truthing techniques to be used for monitoring each volcano and explosive crater lakes.
- Developed capacity building approaches for monitoring volcanoes and crater lakes at national/regional levels.
- Developed appropriate and relevant approaches for raising awareness for each group of volcanoes and crater lakes, with due considerations of their locations and characteristics.

3. Mitigating the impact of landslides

Activities

- (i) Establishing research centres
- (ii) Developing policies and guidelines for landslide management
- (iii) Initiating comprehensive landslide mapping and assessment of losses
- (iv) Initiating comprehensive research on landslides
- (v) Initiating and promoting regional landslide forecasting and monitoring
- (vi) Capacity building programmes at all levels
- (vii) Education and outreach activities

Expected Outcomes

- (viii) Well equipped centres for research and monitoring of landslides
- (ix) Appropriate policy frameworks for managing landslide disasters
- (x) Concise map of landslide prone areas on the continent
- (xi) Improved human and institutional capacity for monitoring and assessing the risks and impacts of landslides
- (xii) Better informed communities on the risks of landslides and the possible mitigation strategies

4. Causes and consequences of sea level changes, coastal erosion and ocean pollution

Activities

- (i) Pilot studies on the impact of climate change-enhanced eustatic sea level rise on coastline vulnerability (physical landscape, coastal resources and livelihood of coastal inhabitants)
- (ii) Catalogue and evaluate the current strategies for response to sea level rise
- (iii) Development of options for adaptation to sea level rise
- (iv) Diagnosis of coastal erosion along critical and oceanographically distinct regions of the coastal states of sub-Saharan Africa. This will involve:
 - Topographic profiling of representative transects of occupied coastal segments, running from the established backshore to safe water depths during low tides
 - Measurement of littoral processes, including wind velocity and direction; wave parameters (period, height, shoaling angle, breaker position and water depth, breaker pattern and period, etc); and longshore current velocity and direction.
 - Coastal sediment analysis
- (v) Developing models for coherent abatement of coastal erosion
- (vi) Develop appropriate policy frameworks for abatement of coastline erosion
- (vii) Determine oceanographic processes that drive pollution of coastal ecosystems
- (viii) Assess vulnerability of coastal zones to various forms of pollution
- (ix) Assess heavy metal and hydrocarbon loading in sea bed sediments
- (x) Define and model pollutant dispersal patterns and pathways as well as the stranding potential of pollutants in coastal ecosystems
- (xi) Assess the geological and physical characteristics of coastal ecosystems to determine to determine and model their carrying capacity and longevity of stranded pollutants
- (xii) Training workshops for researchers and data collectors

Expected Outcomes

- An understanding of the impact of sea level rise on the coastal landscape as well as on the coastal resources including ground water
- Appreciation of the impact of sea level rise on socio-economic well-being of coastal inhabitants
- Viable options for response and adaptation to the effects of sea level rise
- Appropriate policy frameworks for better adaptation to the impact of sea level rise
- Improved understanding of coastline retreat rates and patterns
- Good knowledge of the mechanisms of coastal sediment transport
- Reliable documentation of littoral processes
- Understanding of the anthropogenic impacts on coastline retreat
- Coastal erosion abatement strategies and policies
- Understanding of the status of pollution in coastal environments, and of the sources of the pollutants

- Understanding of the processes and factors that define pollution longevity in coastal ecosystems
- Predictive models of coastal vulnerability to pollution
- Inputs to contingency planning for marine and coastal pollution.

5. Integrated modelling of the African Lithosphere deformation and the implications for geohazards (in preparation)

Project HD 02: Hydrometeorological Hazards and Disasters in sub-Saharan Africa: Vulnerability and Resilience

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Background

Africa is a continent prone to a wide variety of natural and human-induced hazards and disasters, as they often cause extensive damage to livelihoods, property and infrastructure. Hydrometeorological hazards account for most of the disasters in sub-Saharan Africa, and they impact on nearly every country. These include floods, tropical cyclones, storm wave surges, droughts, extremely high temperatures (global warming), wildfires, sand or dust storms, and landslides and avalanches. In the period 1975–2002, disasters of hydro meteorological origin constituted 59% of the total number of natural disasters that occurred in sub-Saharan Africa, with floods accounting for 27%, and droughts for 21% of the total number of events. Global climate change will continue to alter the risk associated with hydro-meteorological hazards, rendering their prediction and management even more difficult. Further more mitigation of hazards and disasters is of relatively low priority for African decision- and policymakers, as these events often pale into insignificance when compared to other pressing issues such as poverty and HIV/AIDS. In most cases, disaster management is limited to humanitarian assistance as a post-disaster response. It is necessary to focus more on reducing the risks of disasters or the damage they cause when they occur. Reducing disaster risk through preventive measures is a central concern for Africa's sustainable development. Unfortunately, however, the implementation of various programmes to mitigate the effects of natural disasters *is* seriously hampered by a lack of adequate resources, technical know-how and capacity to mobilize even the little that is available. It is therefore vitally important that African countries adopt cost-effective policies to lower risk and allocate appropriate resources for hazard and disaster mitigation.

Objectives

The objective of this project is to assess the vulnerability of socio-ecological systems in sub-Saharan Africa to hydro-meteorological hazards and disasters, and the resilience of communities to these events. The project also aims at strengthening the capacities of developing countries for disaster planning and management, and for promoting and facilitating transfer of early warning technologies to disaster-prone communities. Essential tools for achieving this objective include the creation and maintenance of a hazards and disasters database which will serve for integrated modelling of multiple events. At the initial stage particular attention will be given to drought and flooding which are the two major hydro-meteorological hazards in the continent, but the project also covers fires (wild and urban), and dust storms. The specific objectives of the project include:

- development of early warning systems and devising efficient communication strategies for timely information on the occurrence of disasters;
- improving technological preparedness in areas prone to specific types of hazards such as floods and tornadoes;
- developing methodologies for risk assessment and management, resilience of socio-ecological systems, and environmental degradation;
- minimizing the cost of hazards and disasters
- producing hazards and disaster vulnerability maps for sub-Saharan Africa.
- providing useful decision-making tools to guide policy- and decision makers in development planning activities.

Sub-projects:

The project is sub-divided into five sub-projects. The proposed activities of each sub-project are presented below, together with the expected outcome and estimated budget.

1. Drought events in sub-Saharan Africa

Activities

- Investigating the impacts of climate change and droughts in the Sahel, including the effect on agriculture, water resources, air quality, cattle production, ecosystems, and health
- Set up a long-term warning and monitoring system for climate change, drought and desertification
- Develop human and institutional capacity building initiatives at the country and regional levels
- Design of advanced early warning and monitoring systems for environmental changes and agricultural production
- Strengthening networks of research scientists
- Implementation of research protocol at the farm level, with the involvement of the beneficiary community
- Involvement of the public and private sectors in the research activities, and communication of information to all stakeholders, including the practical tools needed to enhance decision-making capability.

Expected outcomes

- Enhancement of scientific knowledge on impacts of climate change and droughts on the Sahel
- Accurate and complete hydrologic, agro-meteorological, climatic, and environmental data sets for future reference in monitoring the evolution of the impact of climate change.
- Enhanced human and institutional capacity for research
- Established strategies for adaptation to drought in the region, particularly with regard to agricultural production techniques (e.g. farmers' practical guides)
- Established monitoring and early warning technologies and strategies
- Improved public awareness of the risks of droughts as influenced by human activity and climate change

2. Floods in sub-Saharan Africa (pilot studies on the Nile and Volta basins)

Activities

- Inaugural partner meeting and stakeholder perception analysis
- Compilation of related intelligence (databases, literature review)
- Selection of study areas for detailed field surveys
- Field surveys
- Climate and Hydrological modelling and analysis
- Development of the spatial decision support system
- Socio-economic data analysis and interpretation
- Cross-Cutting Scientific Capacity Development
- Activity 9 Dissemination of results and public awareness

Expected outcomes

- A basin-wide early warning system for disaster risk reduction
- Map of existing and potential hotspots in the Volta and Nile basins
- Available information for disaster managers and planners to identify hotspots for rapid response
- A network of multidisciplinary disaster management expertise and related scientific and technological capacity for disaster management research
- Increased resilience of communities to cope with floods
- Identified biophysical, social and economic consequences of floods at various scales
- Identified strategies and measures that effectively mitigate the impacts of floods

3. Climate change and socio-economic determinants for anthropogenic fires in African savannahs

Activities

- Investigate the impact of Bushfire-induced land use and atmospheric composition changes on physical and human systems, using a combination of biomass burning measurements and computer simulations on pilot sites consisting of various land use and land cover types.
- Use biomass burning measurements to develop regional climate models whose output would be used to drive air chemistry models. The models would be validated with measurements and a series of long-term evolution of the climate and hydrological cycle simulated under a series of biomass burning scenarios.
- Socio-economic studies of the behaviour of farmers in relation to biomass burning, using multi-agent based modelling, for use in the quantification of emissions into the atmosphere and their impact on the climate.
- Use modelling results to identify hotspots where important changes are likely to occur.
- Developed a decision support system consisting of a suite of decision support tools that uses the modelling results to assess the impact on, and vulnerability of agriculture, hydrology, health and air pollution; and to develop plausible adaptation strategies to mitigate the impacts of biomass burning
- measure various gases, particulate matter and associated emission factors, transport parameters and deposition (wet and dry) of constituents produced from biomass burning in selected land use and land cover types in fire-prone regions
- Develop an effective mechanism for the dissemination of the research results to decision- and policy-makers, development agencies and the beneficiary communities at local, regional, national and continental levels
- Provide suitable recommendations for developing adaptation strategies to mitigate the impacts of biomass burning, based on the research findings
- Capacity building across various disciplines of interest, through PhD and MSc. training.

Expected outcomes

- A decision support system consisting of a suite of decision tools (e.g. agriculture, health, water resources, air pollution, etc) that would aid decision makers and researchers develop adaptation solutions for the region
- An integrated system for modelling and understanding the physical processes associated with biomass burning and how it influences the local-to-regional climate
- A database of physical parameters, inventory of emissions, land use change and related information on biomass burning

- A capacity building program to provide a spectrum of training services. This would include in-service training of agricultural, health, socio-economists and hydro-meteorological professionals in the region of interest
- Decision-guiding information packages made available to national environmental, agricultural and related control programs through local, regional and international organizations
- Increased public awareness by dissemination of project results through internet web portals, DVDs, and other forms of publication including the local print and electronic media, as well as radio and TV programs.

4. Dust events and related hazards in sub-Saharan Africa

Activities

- Detailed analysis of multi satellite sensor data at spatial and temporal scales, of past African dust storm events to study the aerosol parameters, meteorological parameters and air quality that will provide inter-annual variability of dust and its dispersion.
 - The physics, mechanics and processes of dust storms in Africa
 - Key factors contributing to dust storm formation, and how they vary over time and space
- Analyze and map dust storm related risks in sensitive regions and develop probabilistic mapping and early warning systems, as well as climate change scenarios for African dust storms.
- Carry out back trajectory modelling to study the origin and path of dust storms.
- Develop strategies for long-term reduction of the risk of dust storms, and viable recovery operations when storms occur
- Analysis of normalized difference vegetation index (NDVI) to study the impact of dust storms on the vegetation.
 - Analyze TRIMM data to study the changes in dust storms and their effect on rainfall.
 - Analyze ocean colour parameters to study the impact of dust storms.
 - Correlation of dust storms with sea surface temperatures.
 - Correlation of dust storms with the build up of hurricanes in the Mid Atlantic region
- Workshop to review the 'state of the science' of dust storms in Africa

Expected outcomes

- Understanding of the science of dust storms for informed decisions on how to mitigate their impacts
- Reliable operational tools for now-casting of dust storm events and for guidance of management decisions to reduce their impacts on the population.

5. Physical and socio-economic approaches for supporting adaptive water management in sub-Saharan Africa (in preparation)