ICSU Regional Office for Africa

AFRICA SCIENCE PLAN

Natural and Human-induced Hazards and Disasters

Strengthening international science for the benefit of society

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

Strengthening international science for the benefit of society

ICSU
International Council for Science

- International NGO
- Founded in 1931
- **Membership**:

  120 National Scientific Members representing 140 countries (29 of which are from Africa); and 31 International Scientific Unions

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

REGIONAL OFFICES

Ensure that

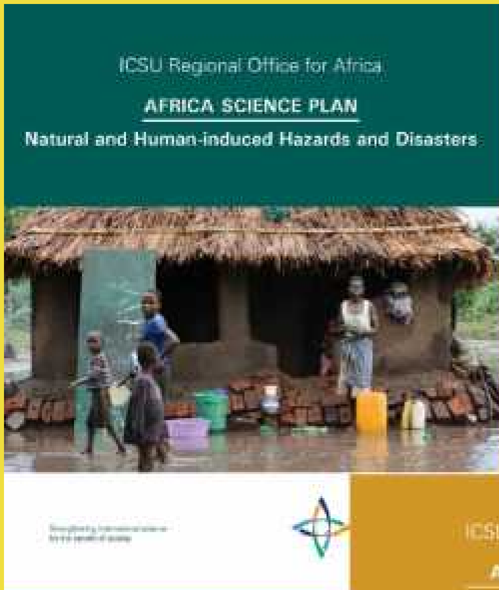
- The voice of developing countries influences the international agenda, and
- Scientists from the developing nations are fully involved in international research guided by regional priorities

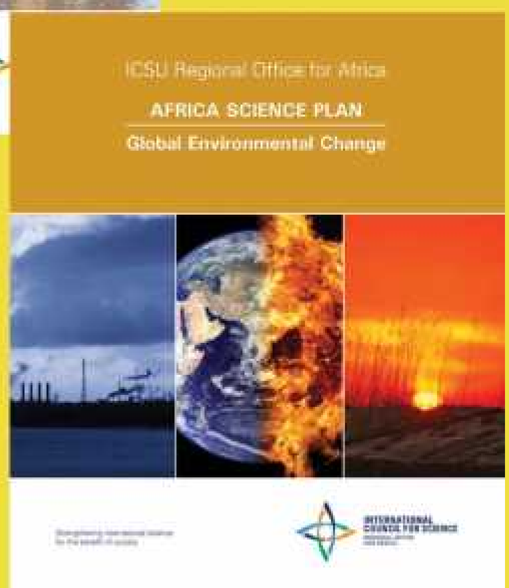
AFRICAN CHALLENGES

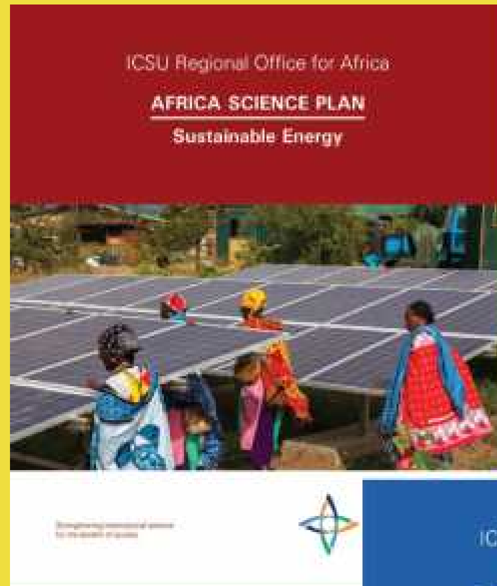
- 35 of the WORLD's 50 least developed countries are on the AFRICAN continent
- Sub-Saharan Africa contributes about 2.3% of the world GDP, but is responsible for only 0.4% of global expenditure in research and development (R&D)
- Generally, there are weak links between industry (especially technology-based), academia and government, which results in uninformed national policies

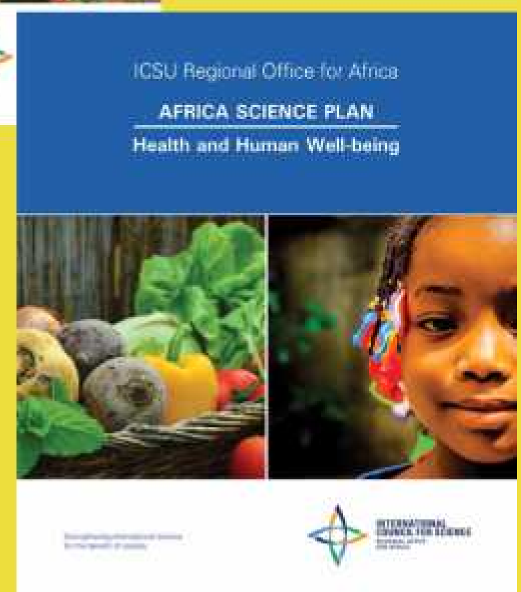
INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

SCIENCE PLANS 2017









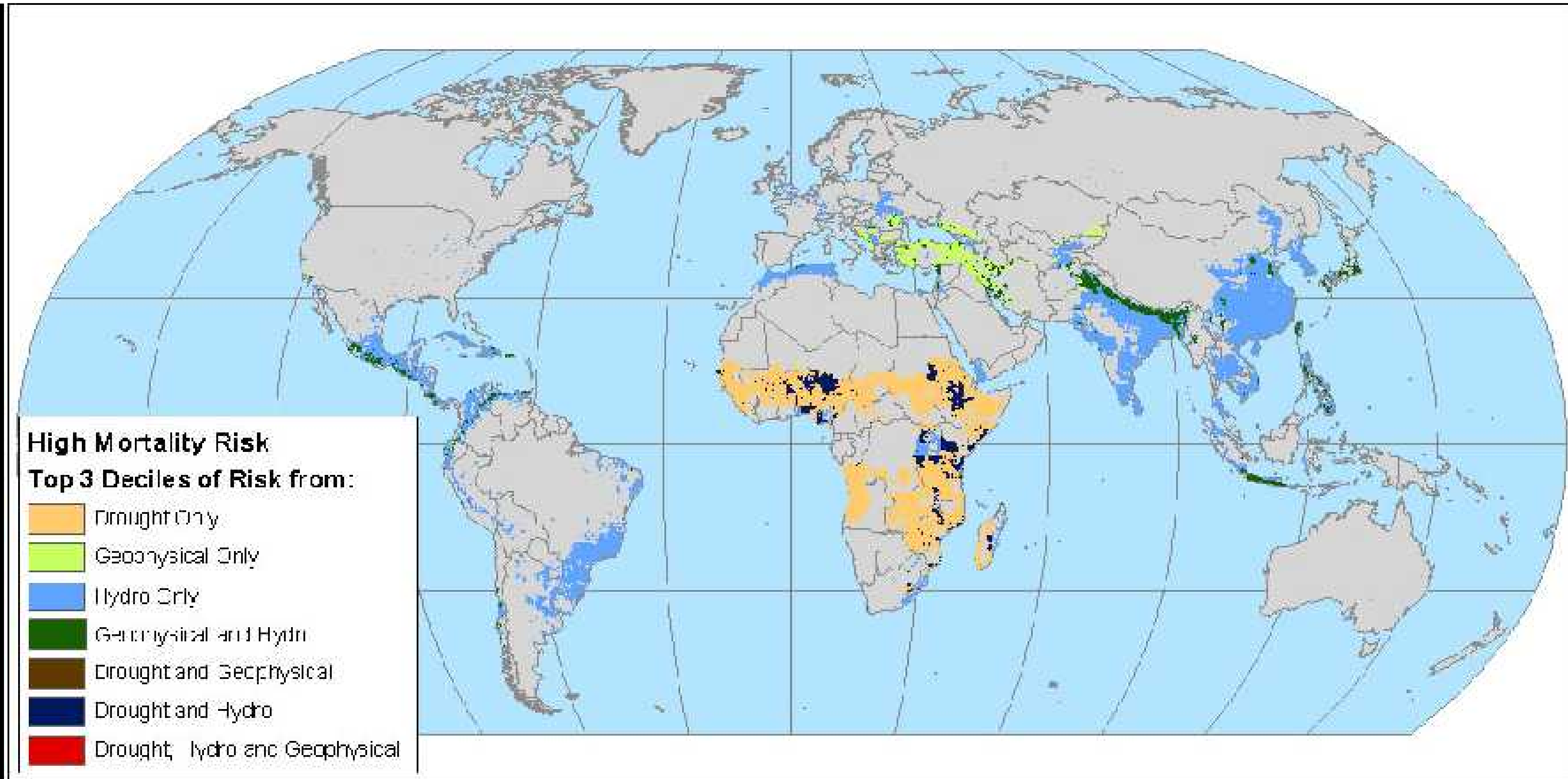
ICSU Regional Office for Africa

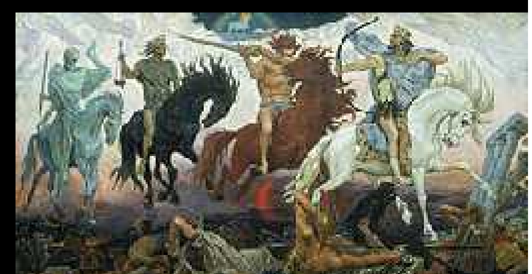
AFRICA SCIENCE PLAN

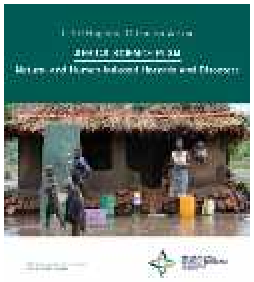
Natural and Human-induced Hazards and Disasters

Strengthening international science for the benefit of society

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA


High Mortality Risk
Top 3 Deciles of Risk from:
Drought Only
Geophysical Only
Hydro Only
Geophysical and Hydro
Drought and Geophysical
Drought and Hydro
Drought, Hydro and Geophysical





AUTHORS

Prof Genene Mulugeta, Uppsala University, Sweden

Prof Ray Durrheim, Witwatersrand University, South Africa

Prof Abdourahamane Konare, Ministère de l’Enseignement Supérieur et de la Recherché Scientifique, Ivory Coast

Dr Paulina E. Amponsah, Ghana Atomic Energy Commission, Ghana

Prof Samuel N. Ayonghe, University of Buea, Cameroon

Prof Djillali Benouar, University of Science and Technology Houari Boumediene, Algeria

Prof Bhanooduth Lalljee, University of Mauritius, Mauritius

Dr Emmanuel Mashonjowa, University of Zimbabwe, Zimbabwe

Prof Ellis M. Njoka, Kenya Methodist University, Kenya

Prof Beneah Odhiambo, University of Venda, South Africa

Dr Kifle Woldearegay, Mekelle University, Ethiopia

Kylah Genade, Disaster Management School, South Africa

Prof Effiom E Antia, University of Calabar, Nigeria

Dr Mitulo Silengo, Mulungushi University, Zambia

Dr Richard Glover, ICSU Regional Office for Africa, South Africa

Box 1. The Five Hyogo Framework for Action Commitments (2005-2015)[16]

Make disaster reduction a priority.

Governments should integrate disaster risk reduction into their laws, programmes and plans, and ensure the participation of local communities in planning.

Know the risks and take action.

Countries should define and understand potential risks so that they can develop early warning systems adapted to the needs of each community.

Build understanding and awareness.

Governments should provide information, include disaster reduction in formal and informal education, and ensure that invaluable local knowledge about disaster risks is preserved and transmitted.

Reduce risk.

Countries should apply safety codes to ensure that schools, hospitals, homes and other buildings do not collapse in earthquakes; avoid siting communities in hazard-prone areas such as flood plains; and protect forests, wetlands and reefs that act as a natural barrier to storms and flooding.

Be prepared and ready to act.

Governments and regional or local authorities should conduct risk assessments, adopt contingency plans, test preparedness by such measures as evacuation drills and ensure emergency services, response agencies, policy makers and development organisations are coordinated.

INTERNATIONAL CONTEXT

Chart of the Sendai Framework for Disaster Risk Reduction
2015-2030

Scope and purpose

The present framework will apply to the risk of small-scale and large-scale, frequent and infrequent, sudden and slow-onset disasters, caused by natural or manmade hazards as well as related environmental, technological and biological hazards and risks.
It aims to guide the multi-hazard management of disaster risk in development at all levels as well as within and across all sectors

Expected outcome

The substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries

Goal

Prevent new and reduce existing disaster risk through the implementation of integrated and inclusive economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional measures that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus strengthen resilience

INTERNATIONAL CONTEXT

Targets

Substantially reduce global disaster mortality by 2030, aiming to lower average per 100,000 global mortality between 2020-2030 compared to 2005-2015	Substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100,000 between 2020-2030 compared to 2005-2015	Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030	Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030	Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020	Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of this framework by 2030	Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030

Priorities for Action

There is a need for focused action within and across sectors by States at local, national, regional and global levels in the following four priority areas.

Priority 1 Understanding disaster risk	**Priority 2** Strengthening disaster risk governance to manage disaster risk	**Priority 3** Investing in disaster risk reduction for resilience	**Priority 4** Enhancing disaster preparedness for effective response, and to «Build Back Better» in recovery, rehabilitation and reconstruction
Disaster risk management needs to be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment	Disaster risk governance at the national, regional and global levels is vital to the management of disaster risk reduction in all sectors and ensuring the coherence of national and local frameworks of laws, regulations and public policies that, by defining roles and responsibilities, guide, encourage and incentivize the public and private sectors to take action and address disaster risk	Public and private investment in disaster risk prevention and reduction through structural and non-structural measures are essential to enhance the economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment. These can be drivers of innovation, growth and job creation. Such measures are cost-effective and instrumental to save lives, prevent and reduce losses and ensure effective recovery and rehabilitation	Experience indicates that disaster preparedness needs to be strengthened for more effective response and ensure capacities are in place for effective recovery. Disasters have also demonstrated that the recovery, rehabilitation and reconstruction phase, which needs to be prepared ahead of the disaster, is an opportunity to «Build Back Better» through integrating disaster risk reduction measures. Women and persons with disabilities should publicly lead and promote gender-equitable and universally accessible approaches during the response and reconstruction phases

INTERNATIONAL CONTEXT

Guiding Principles

Primary responsibility of States to prevent and reduce disaster risk, including through cooperation

Shared responsibility between central Government and national authorities, sectors and stakeholders as appropriate to national circumstances

Protection of persons and their assets while promoting and protecting all human rights including the right to development

Engagement from all of society

Full engagement of all State institutions of an executive and legislative nature at national and local levels

Empowerment of local authorities and communities through resources, incentives and decision-making responsibilities as appropriate

Decision-making to be inclusive and risk-informed while using a multi-hazard approach

Coherence of disaster risk reduction and sustainable development policies, plans, practices and mechanisms, across different sectors

Accounting of local and specific characteristics of disaster risks when determining measures to reduce risk

Addressing underlying risk factors cost-effectively through investment versus relying primarily on post-disaster response and recovery

«Build Back Better» for preventing the creation of, and reducing existing, disaster risk

The quality of global partnership and international cooperation to be effective, meaningful and strong

Support from developed countries and partners to developing countries to be tailored according to needs and priorities as identified by them

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

INTERNATIONAL CONTEXT

http://www.interacademies.net/default.aspx?id=10877

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

INTERNATIONAL CONTEXT

Académie des Sciences et Techniques du Sénégal

EST. 1999
61, Boulevard Djily MBAYE
Dakar BP 4344 RP, Senegal

Phone: (221) 33 849 10 99
Fax: (221) 33 849 10 96
E-mail: academ.sc@orange.sn

The Senegal Academy of Science and Technology (ANSTS) was created at the end of the constitutive General Assembly on 9 November 1999. ANSTS is a consultative structure, a consultation and assistance body for both, public and scientific authorities, a centre of competence and expertise for the design of knowledge and the indispensable renewal of knowledge and thinking. It has ...

Academy of Science of Mozambique

EST. 2009
Praca 25 de Junho, 3rd Floor
Maputo P. O. Box 257, Mozambique

Phone: + 258 2142-8128
Fax: + 258 2142-8196
E-mail: oquilambo@rei.uem.mz

The Academy of Science of Mozambique was created after a national consultation of scientists and academicians in the whole country, organized by an special committee jointly created by the Ministry of Science and Technology. After several consultative meetings, the Statutes and the creation of the Academy of Science were approved by the Council of the Ministers. In this ...

Academy of Science of South Africa (ASSAf)

EST. 1996
PO Box 72135 Lynnwood Ridge
Pretoria 0040, South Africa

Phone: +27 12 349 6600
Fax: +27 12 349 5461
E-mail: admin@assaf.org.za

The Academy of Science of South Africa (ASSAf), in its unique position as the only national science academy that is officially recognised by the South African government through the ASSAf Act (Act 67 of 2001), as amended, aims to provide evidence-based scientific advice on issues of public interest to government and other stakeholders. ASSAf regularly publishes ...

Academy of Scientific Research and Technology. (ASRT)

EST. 1971
101 Kasr El Ainy St. Kasr El Ainy
Cairo 11516, Egypt

Phone: + 20 2 27921263, + 20 2 27921264
E-mail: info@asrt.sci.eg

The Academy of Scientific Research and Technology (ASRT) was established by Presidential Decree No. 2405 of September 1971 as the national body responsible for science and technology in Egypt, and was affiliated to the Prime Minister. However, the ASRT changed its affiliation several times. The ASRT is affiliated at present, and since 1986, to the Minister of State for ...

Table 1. African disaster victims and losses by hazard type

Hazard Type	Biological	Climatological	Geophysical	Hydrological	Meteorological	Total
Occurrences	862	303	85	925	244	2419
Deaths	164 763	697 418	32 114	24 734	5 191	914 220
Affected	15 698 034	373 440 132	2 202 201	69 844 718	17 585 306	478 770 391
Damage ('000 $)	5 200	3 424 593	12 355 949	7 528 723	4 329 827	27 644 292

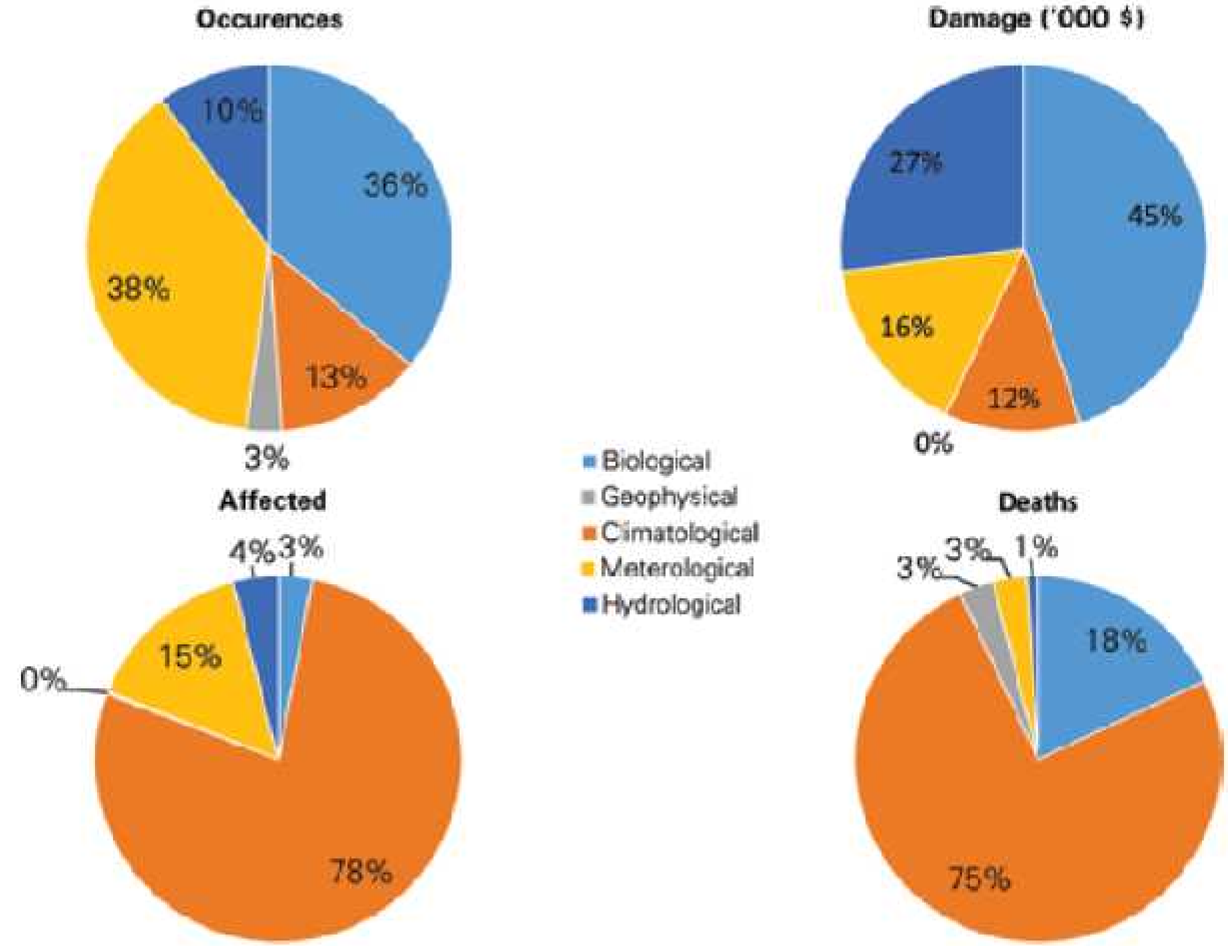
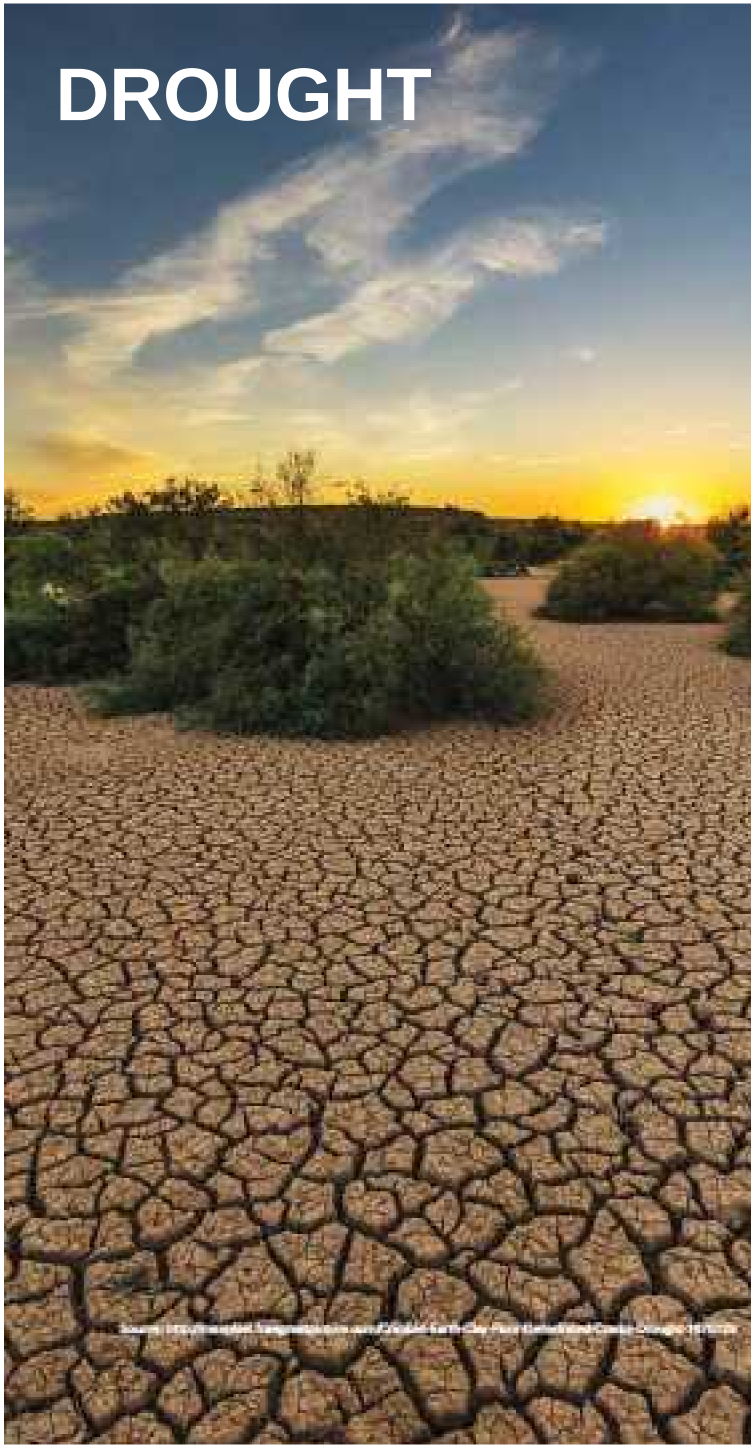


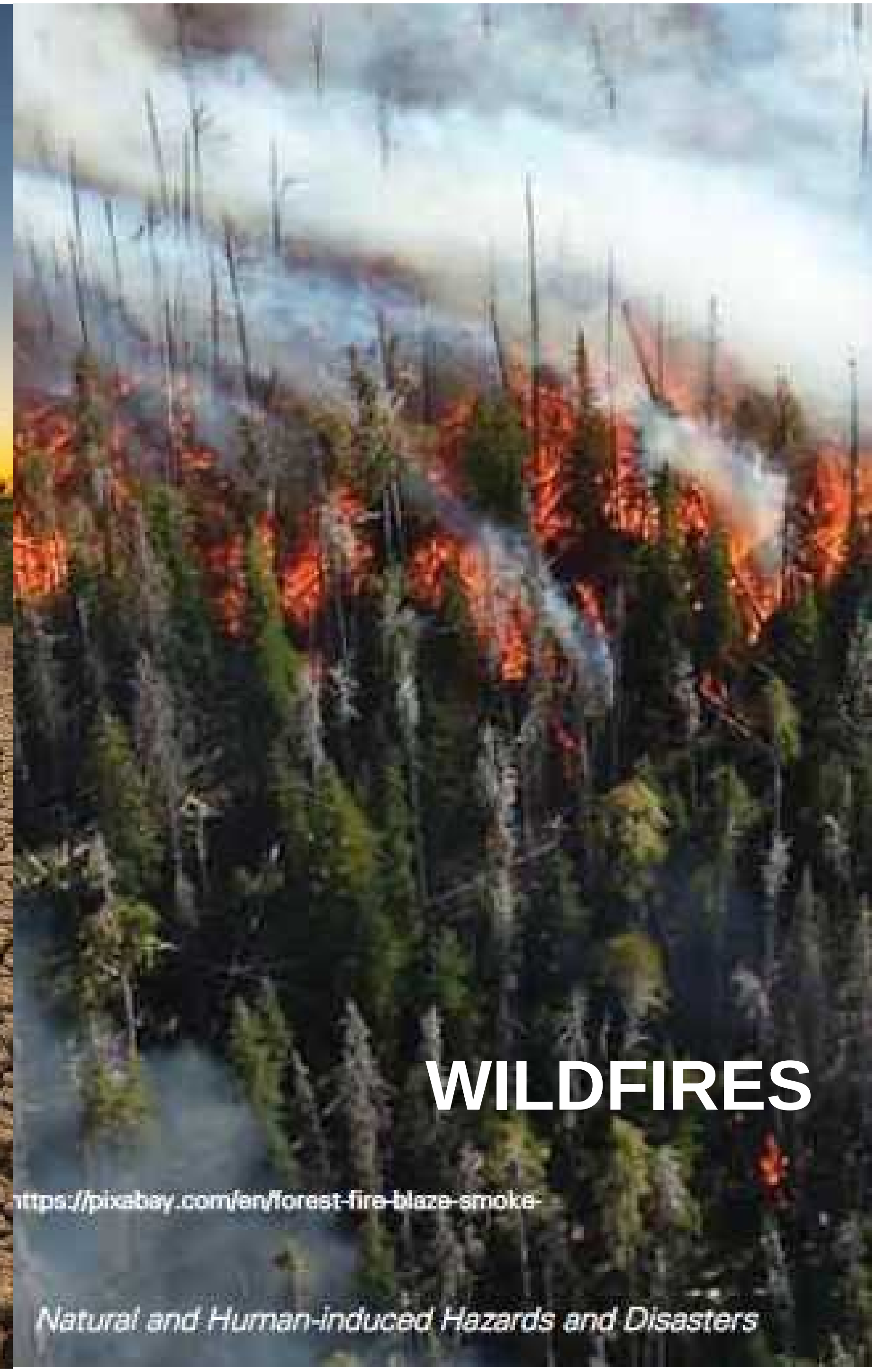
Figure 1. Disaster occurrences, damages, victims and mortality by hazard type (based on Table 1 data)

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

5.1 CLIMATOLOGICAL

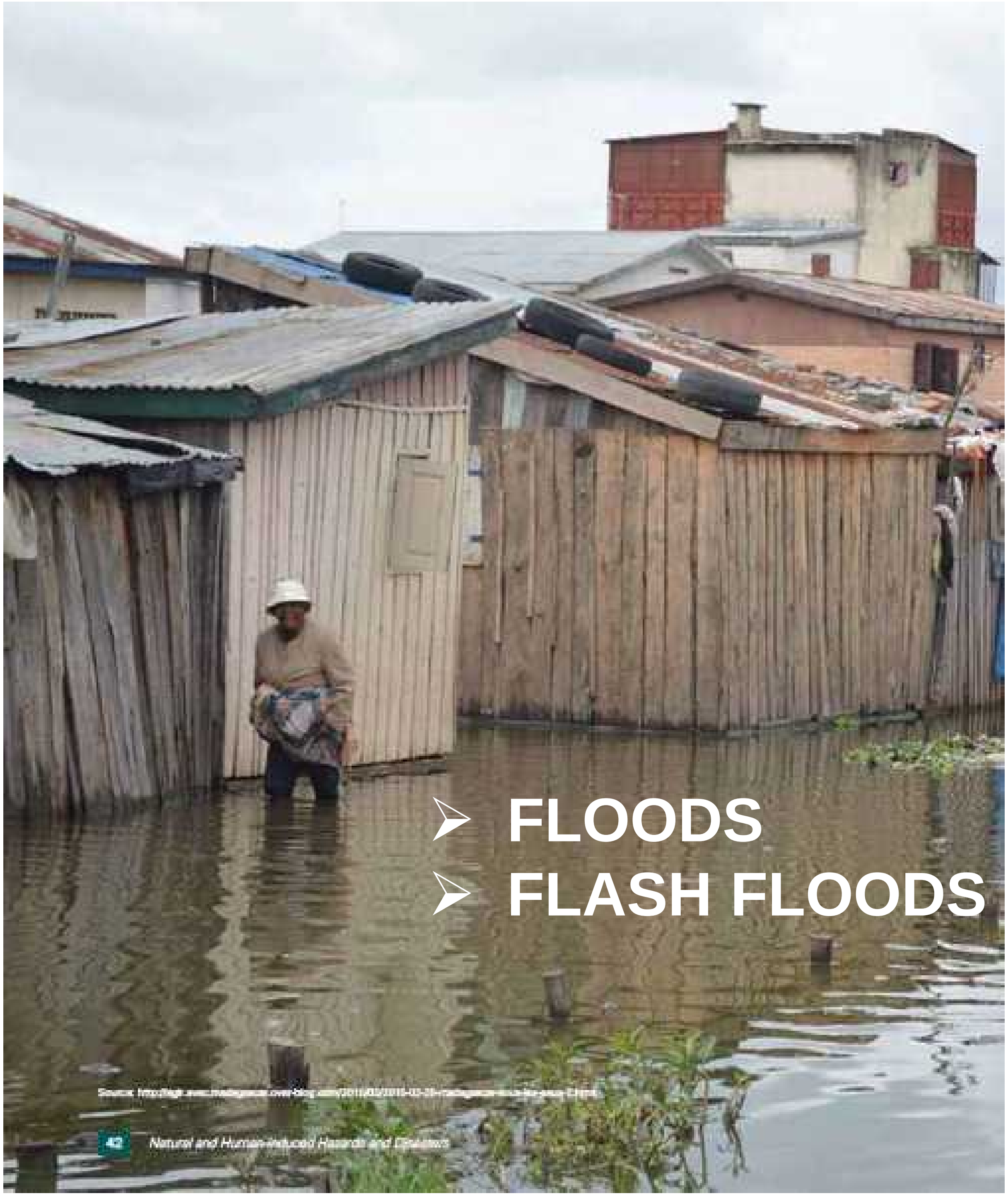
INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA





5.2 HYDROLOGICAL

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA



- FLOODS
- FLASH FLOODS

5.3 METEROLOGICAL

Cyclone Guito in the Mozambique channel (February 2014

- Tropical cyclones and hurricanes
- Severe storms
- Heat waves
- Dust storms

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

5.4 GEOPHYSICAL

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

- EARTHQUAKES
- VOLCANOES
- EXPLOSIVE CRATER LAKES
- MASS MOVEMENTS

http://http://scottplume.com/african-gorillas-and-volcanoes/

5.5 BIOLOGICAL

http://www.carbonated.tv/news/locust-plague-in-madagascar

- **Epidemics**
- **Pests**

6. HUMAN-INDUCED

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA


Flood
Natural and Human-Induced
Hazards and Disasters in Africa

1. OVERVIEW

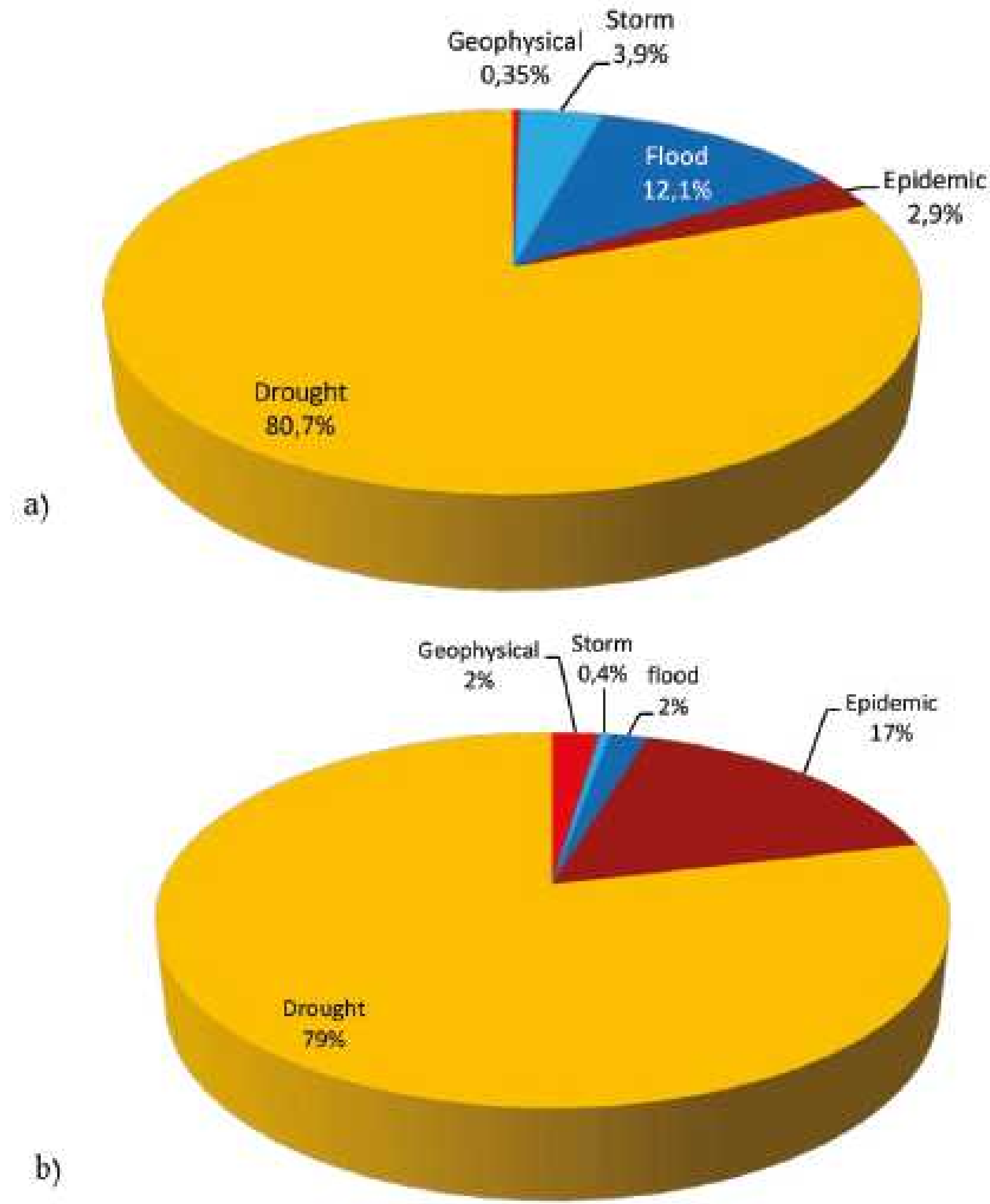


Figure 1.1: Disaster victims and fatalities by type (1960-2009). a) Affected; b) Killed.

1. OVERVIEW

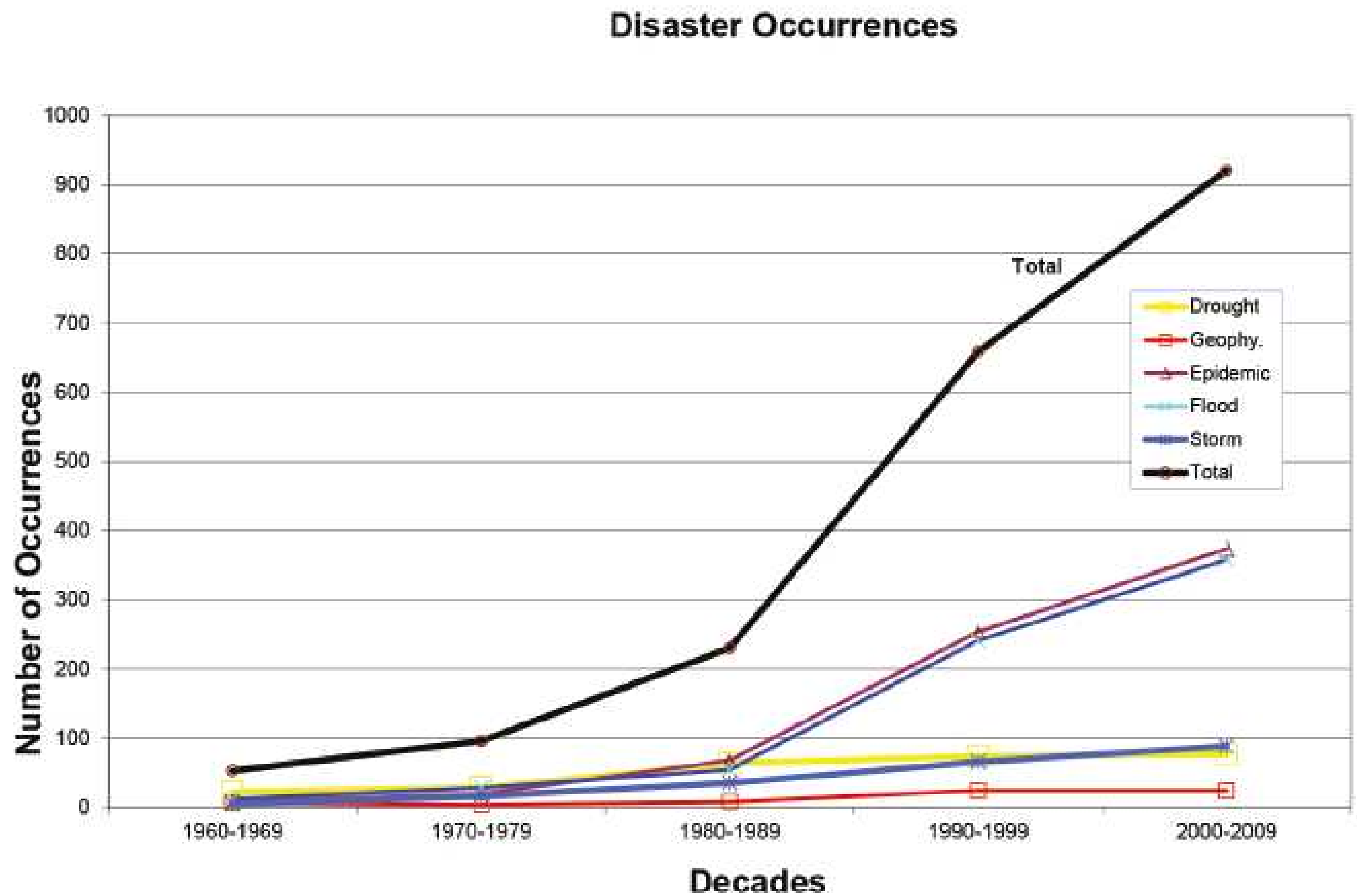


Figure 1.2: Frequency of hazards by type (1960-2009).

1. OVERVIEW

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

Types of Hazards	Impacted Countries
1	None
2	Libya, Sao Tome et Principe, Tunisia
3	Mauritius, Namibia, Reunion, Sierra Leone, Zambia, Angola, Burkina Faso, Cote d Iviore, Eritrea
4	Ethiopia, Benin, Botswana, Cameroon, Central African Republic, Chad, Congo, Djibouti, Egypt, Gambia, Ghana, Guinea Bissaw, Leshoto, Liberia, Madagascar, Mauritania, Niger, Nigeria, Rwanda, Senegal, Seychelles, Sudan
5	Algeria, Cape Verde Is., Comoros, Guinea, Kenya, Malawi, Morocco, Mozambique, Somalia, S. Africa, Tanzania, Uganda, Zaire

Table-1. Number of impacted countries by hazard type.

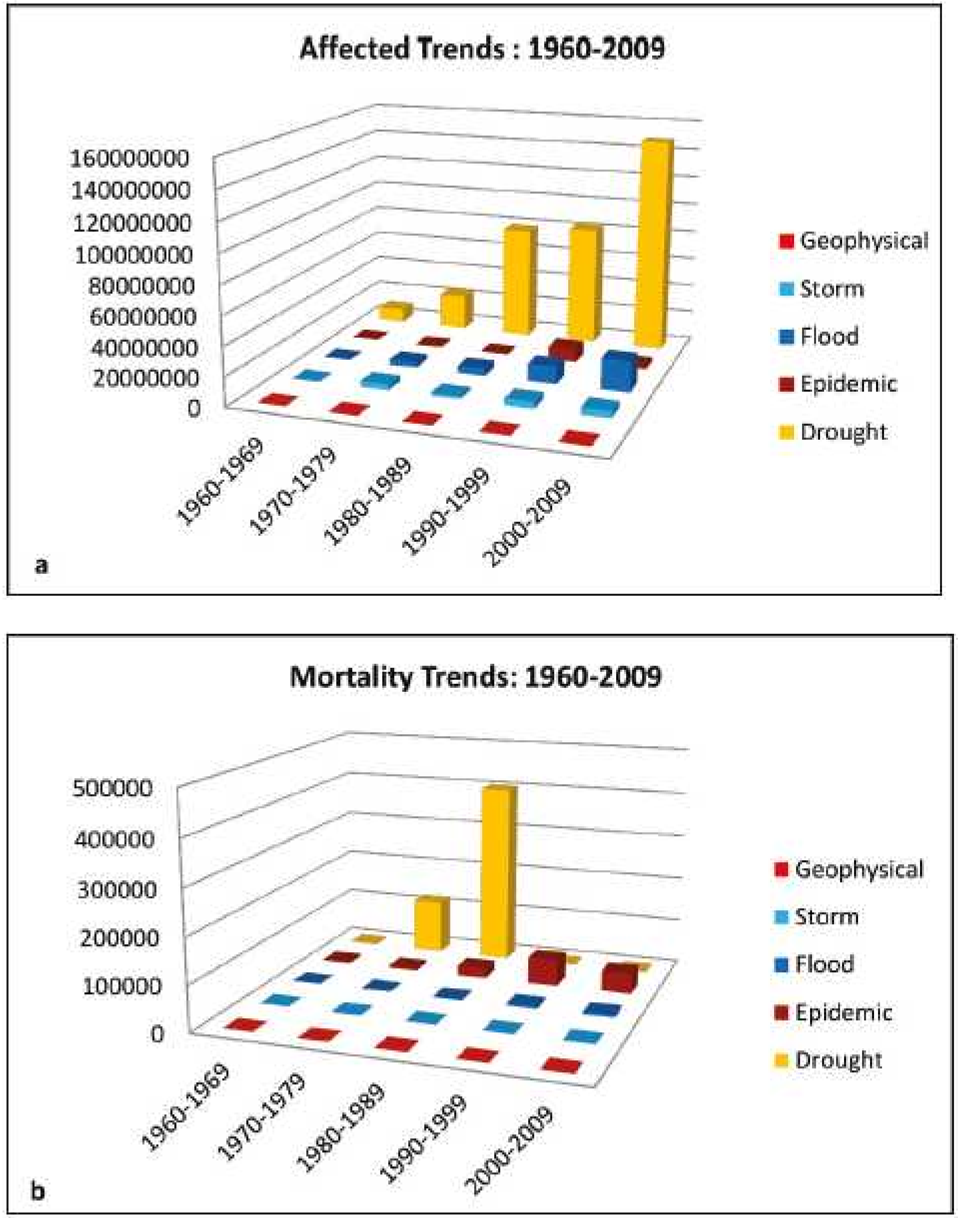


Figure 1.3: Trends in disaster victim numbers and mortality (1960-2009):
a) Victims; b) Mortality.

Causes of earthquakes

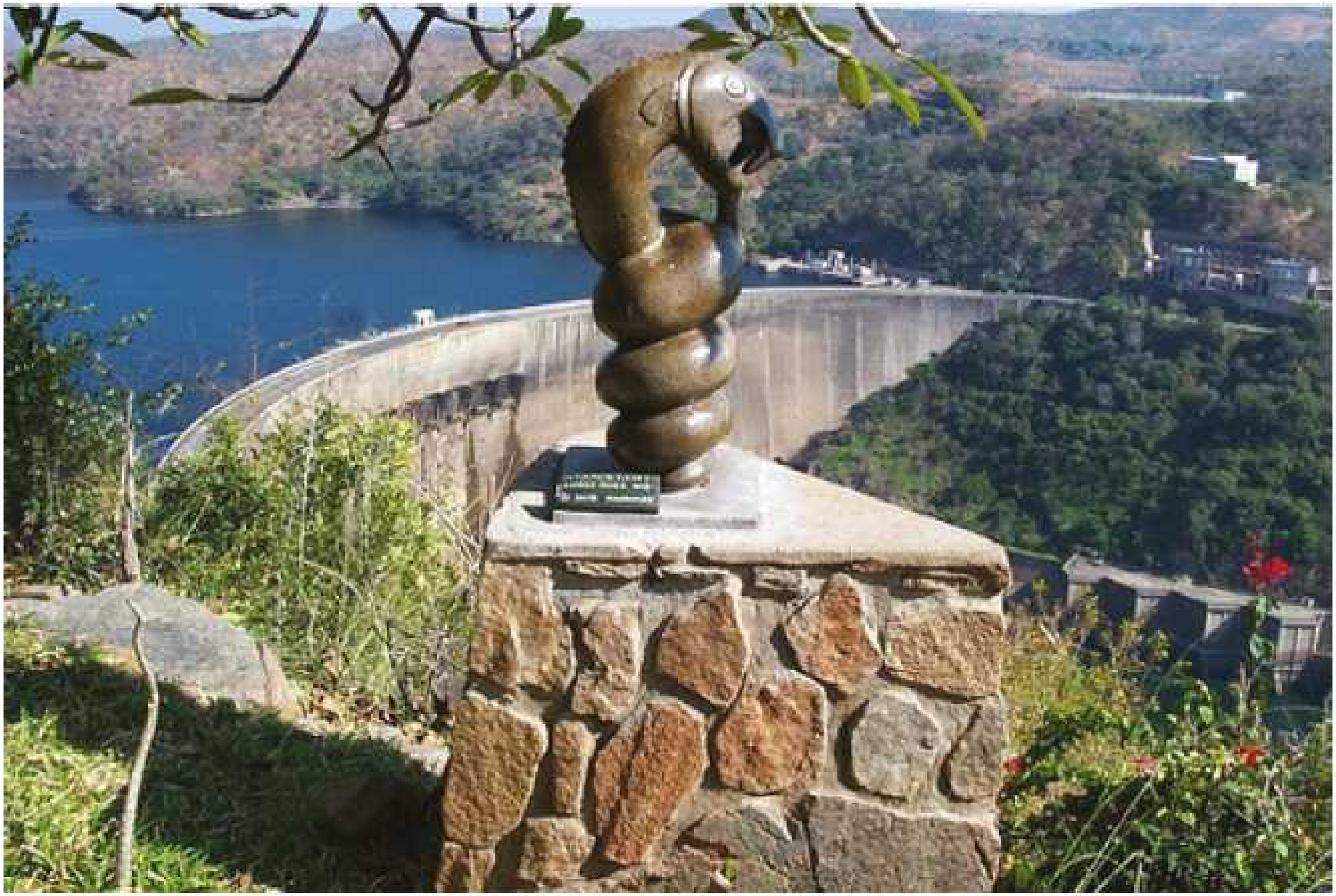


Figure 2.1: A carving of Nyaminyami, the river creature traditionally believed to cause earthquakes, which overlooks Kariba Dam.[9]

Causes of earthquakes

Apep or Apophis was an evil god in Egyptian mythology, the deification of darkness and chaos (ỉzft in Egyptian), and thus opponent of light and Ma'at (order/truth), whose existence was believed from the 8th Dynasty (mentioned at Moalla) onwards. In a bid to explain certain natural phenomena it was said that occasionally Apep got the upper hand. The damage to order caused thunderstorms and earthquakes. http://en.wikipedia.org/wiki/Apep

Global geodynamic framework

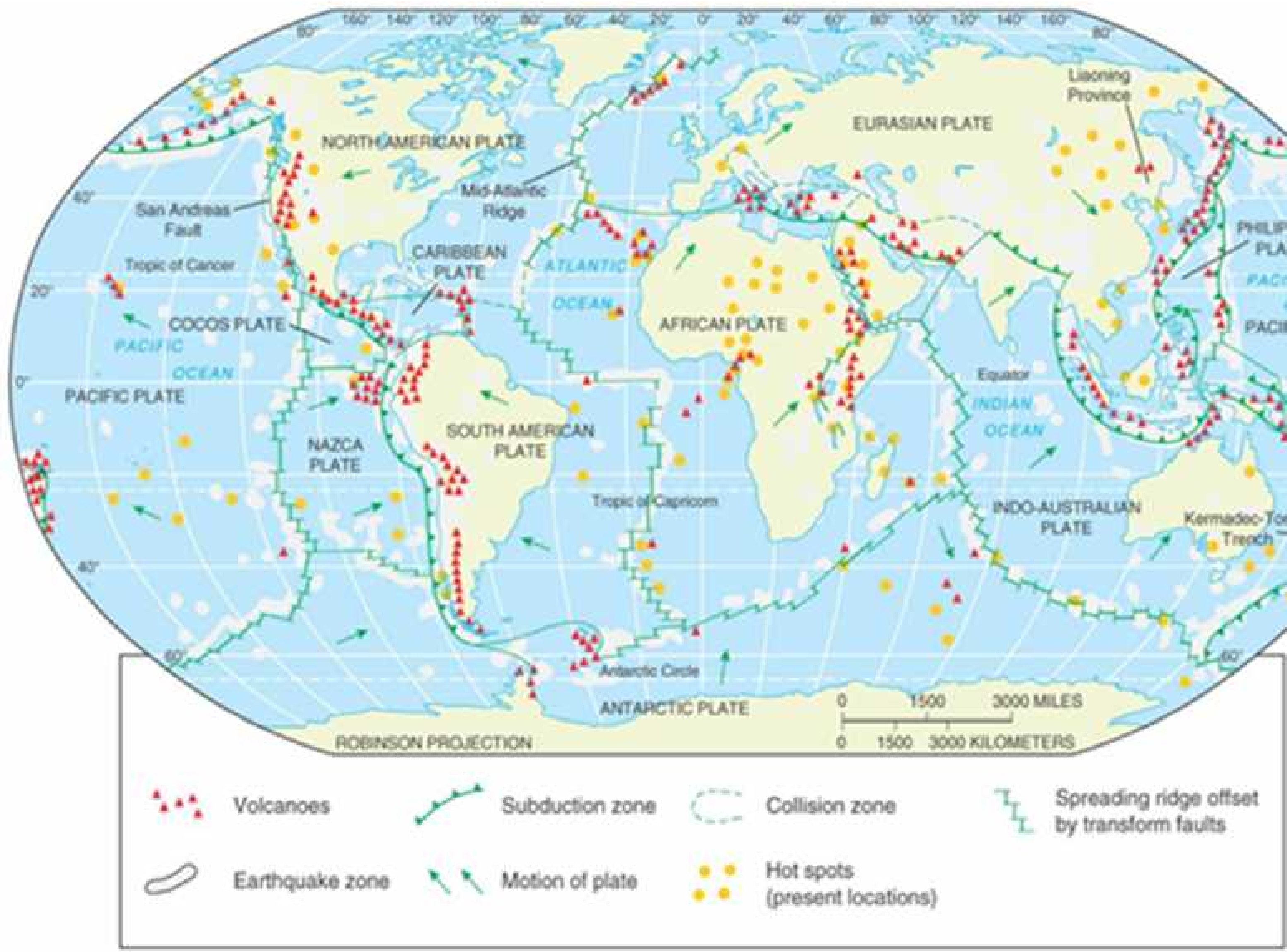


Figure 2.2: The East African Rift, an example of a divergent continental plate boundary.[12]

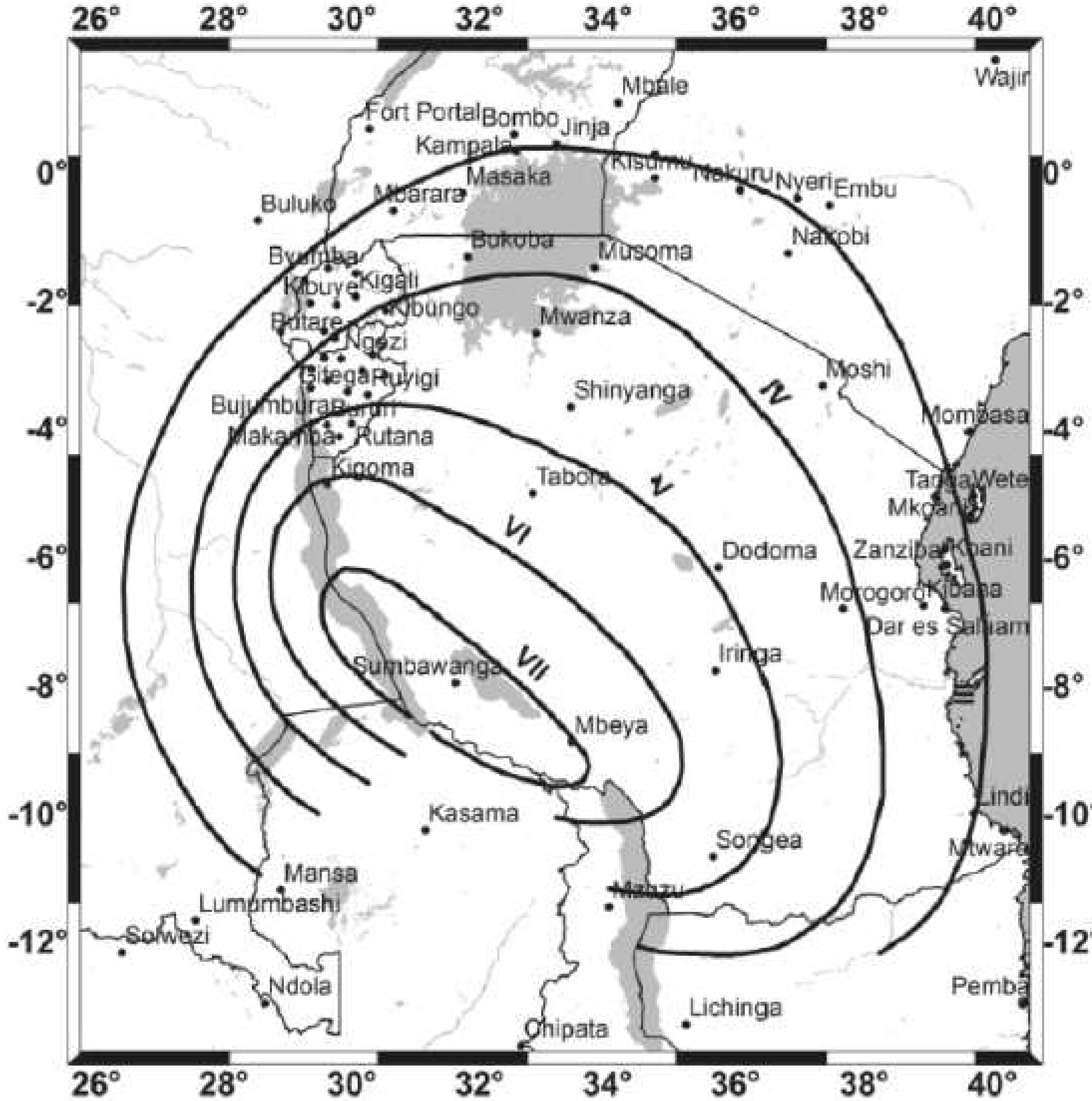
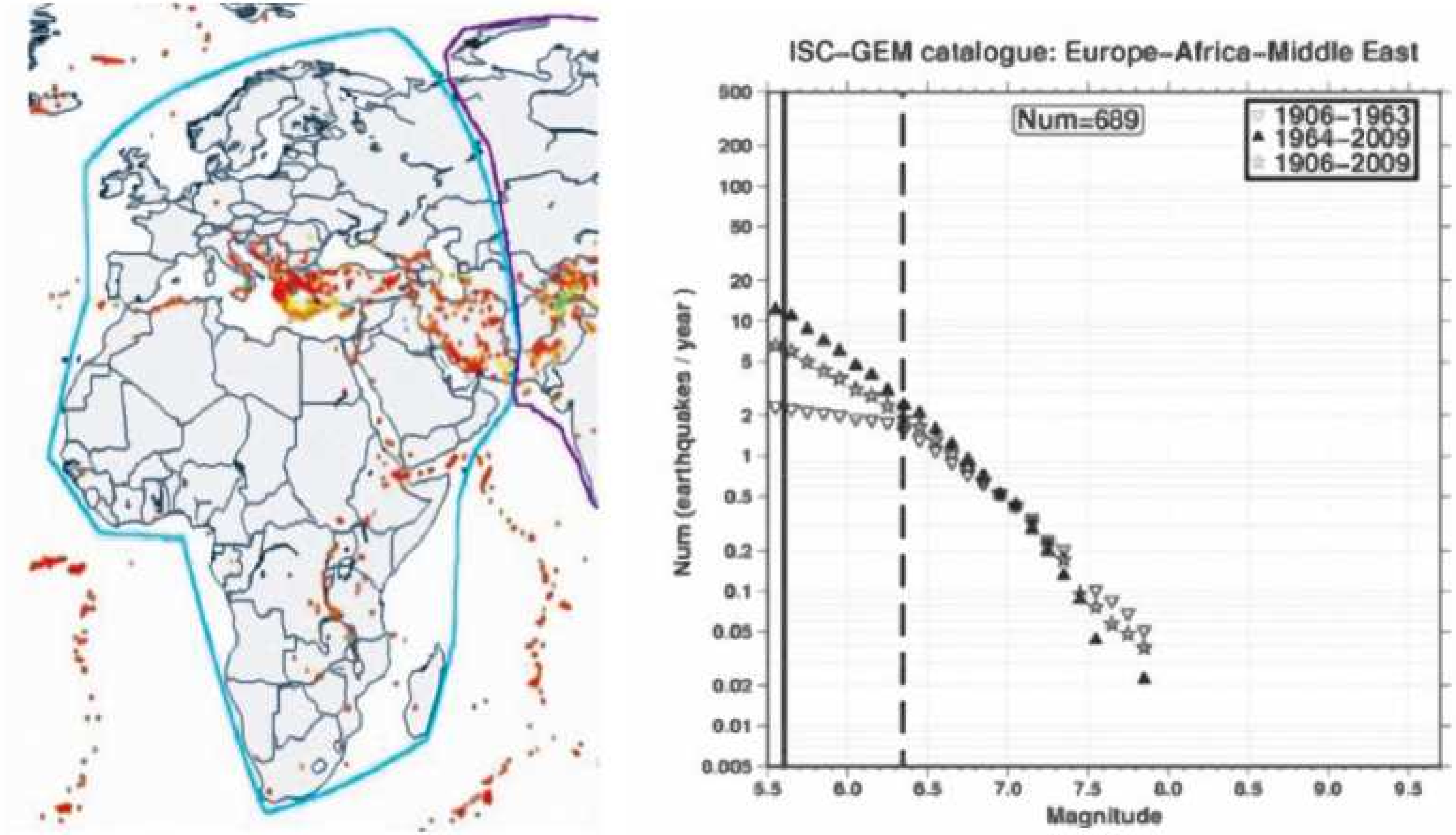
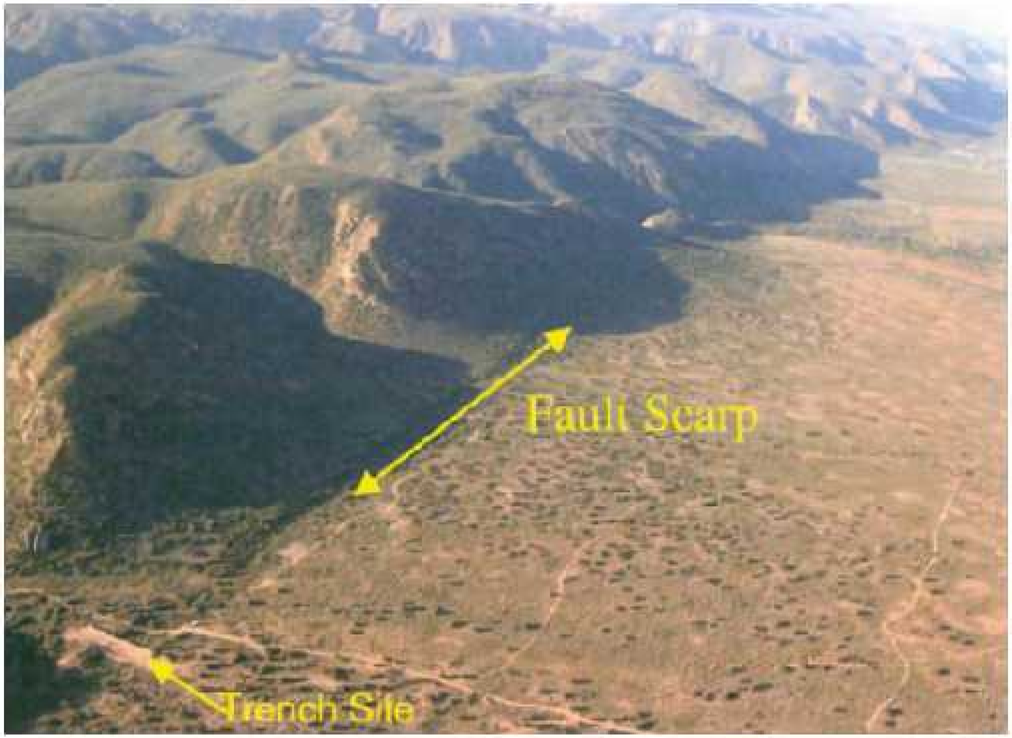


Figure 2.3: Intensity map for the Rukwa earthquake that struck Tanzania on 13 December 1910.[14]

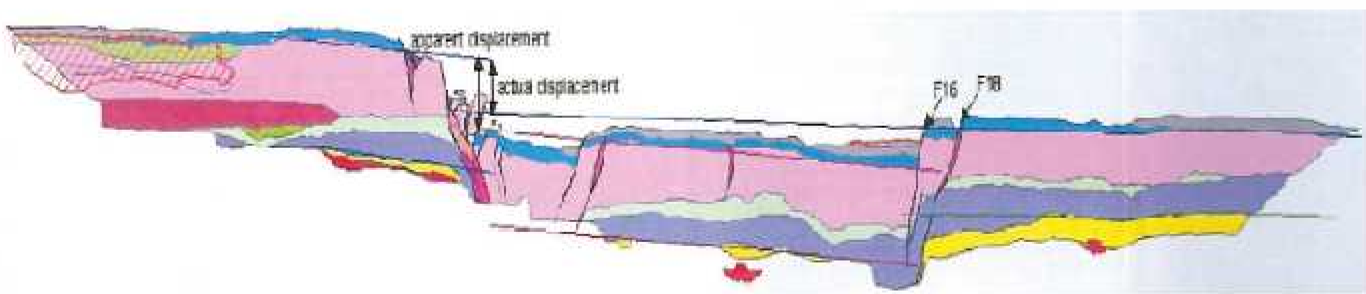


(a) (b)

Figure 2.4: (a) Map showing the locations of events in the ISC-GEM earthquake catalogue;[15] (b) Cumulative frequency-magnitude distributions for the Europe – Africa – Middle East region for 1906-1963, 1964-2009 and 1906-2009.



(a)



(b)

Figure 2.5: Paleoseismic investigation of the Kango Fault, Cape Fold Belt, South Africa.[27] (a) Part of the 84 km long and 2 m high fault scarp produced by a M_w7.4 event about 10 600 years ago, and the trench site. (b) Geological map of the trench wall (80 m long x 6 m deep).

2. EARTHQUAKES

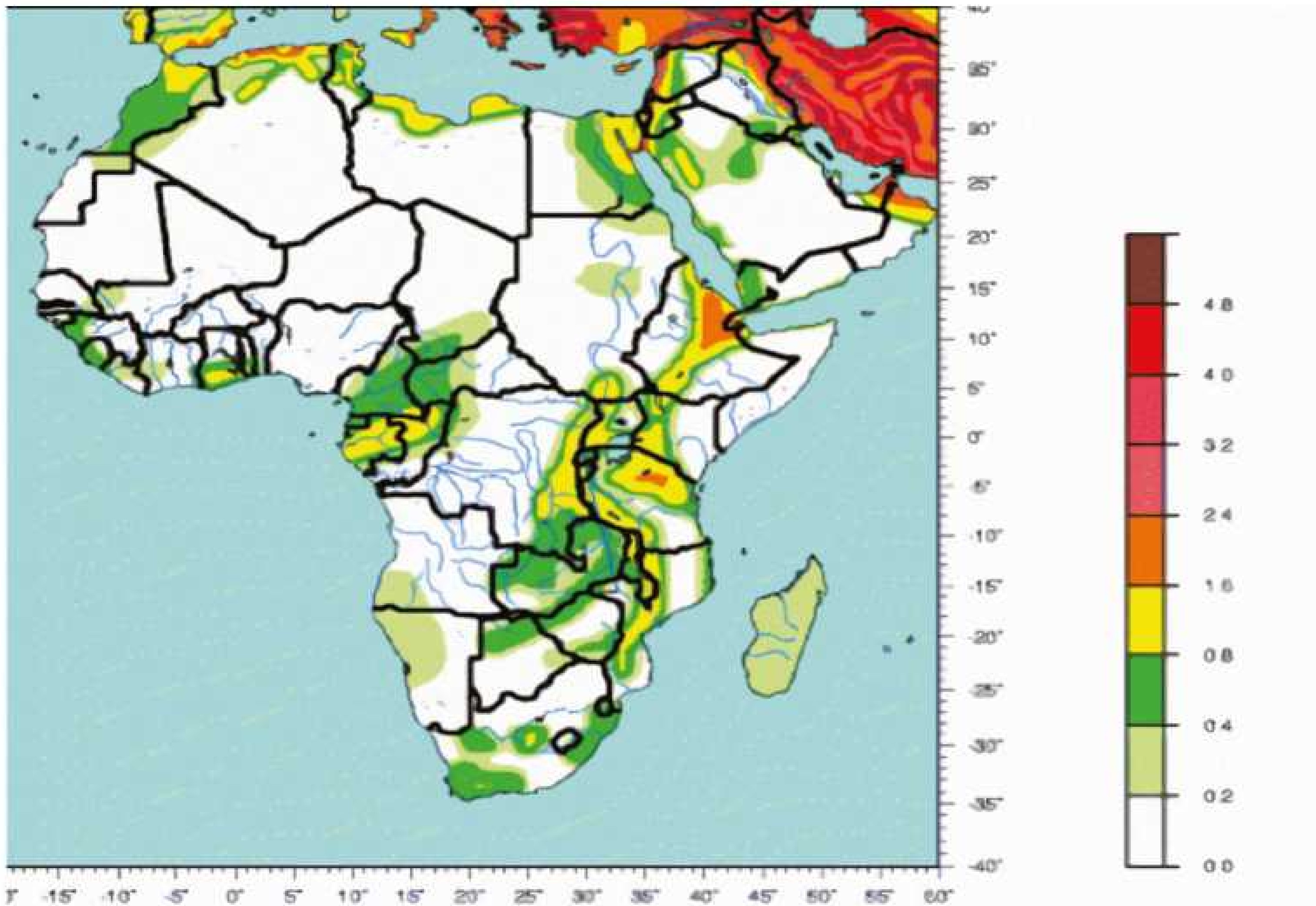


Figure 2.6: GSHAP seismic hazard assessment for Africa, showing the peak ground acceleration (m/s²) with 10 per cent probability of exceedance in 50 years.[33]

Figure 2.7: Damage caused by the M6.4 earthquake that struck Al Hoceima, Morocco on 24 February 2004.[38]

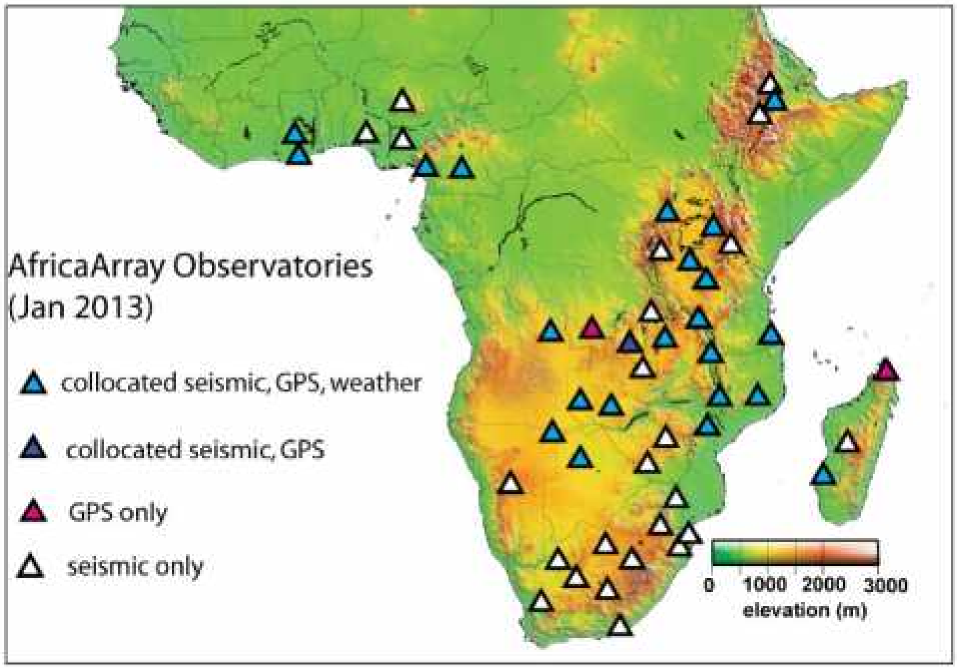
Figure 2.8: Surface rupture of the M_w7.0 earthquake that struck the Machaze district, Mozambique, on 22 February 2006.[42,43]

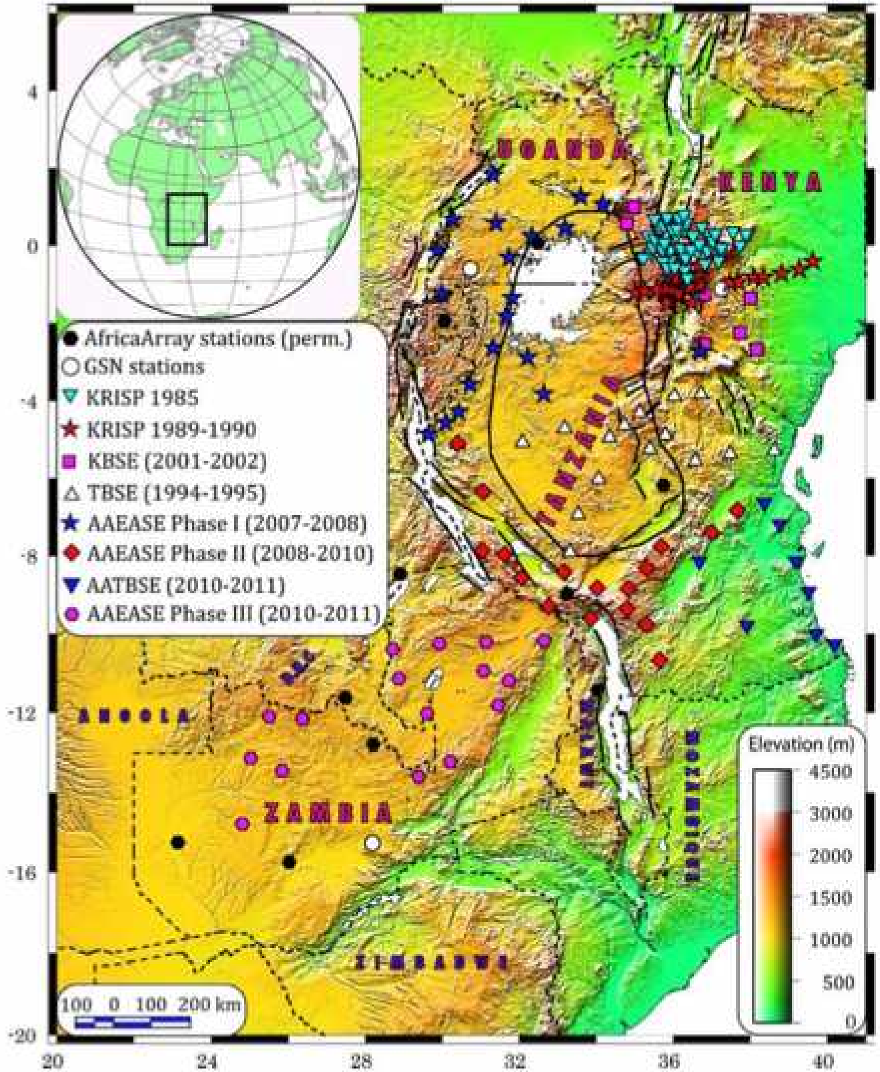
Figure 2.9: Damage in Bukavu, DRC, caused by the M_w5.9 earthquake that struck the Lake Kivu region on 3 February 2008.[45]

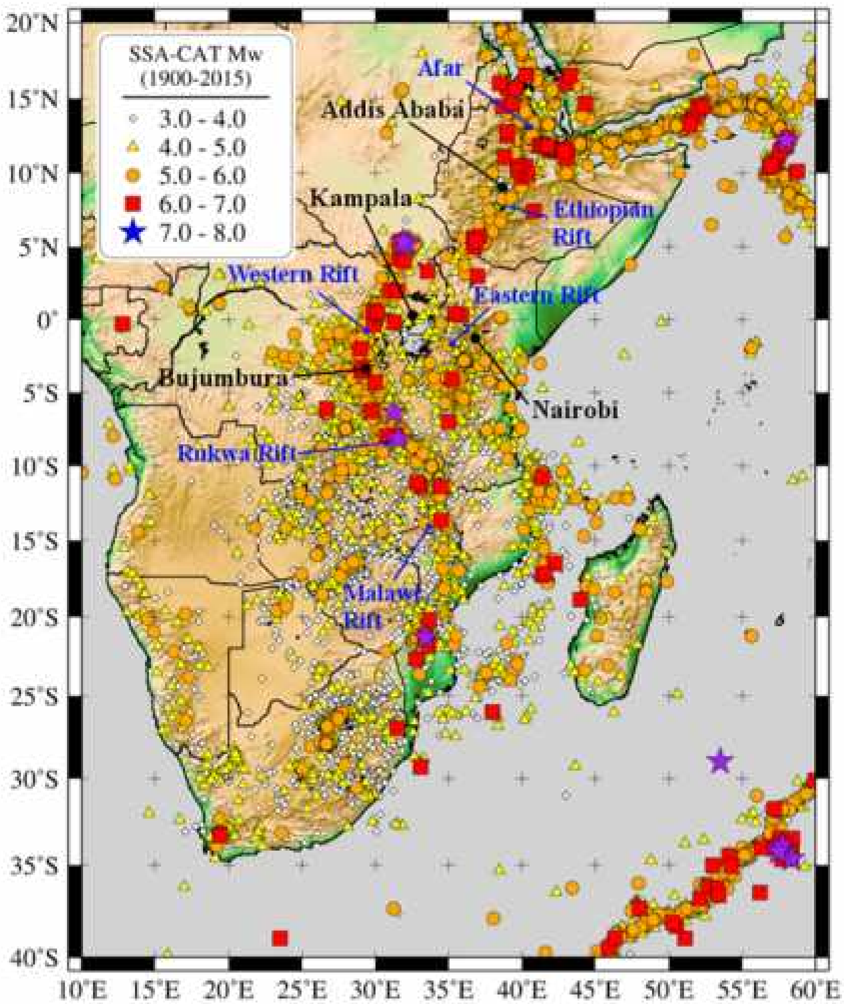
2. EARTHQUAKES
Mining-induced

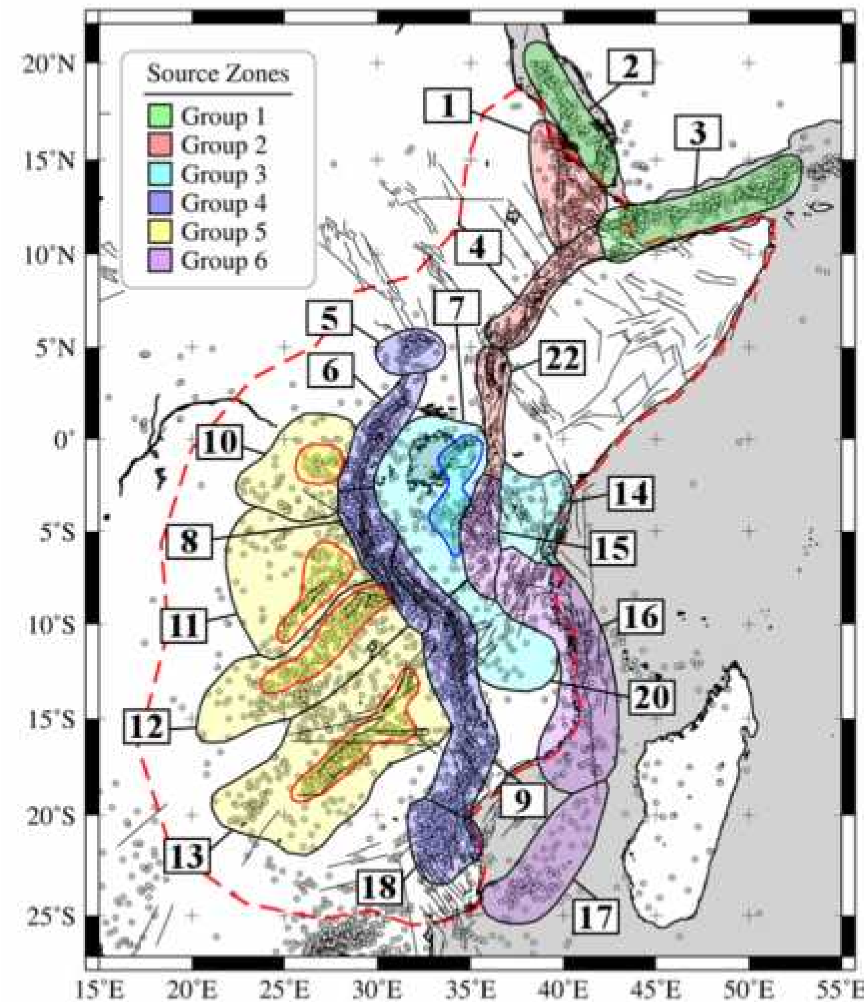
Figure 2.10: Effects of mining-related tremors in Welkom (M_L5.2, 8 December 1976)[51] and Stilfontein, South Africa (M_L5.3, 9 March 2005).[52]

Figure 2.11: Poster showing the earthquake drill of: DROP, COVER and HOLD.[57]

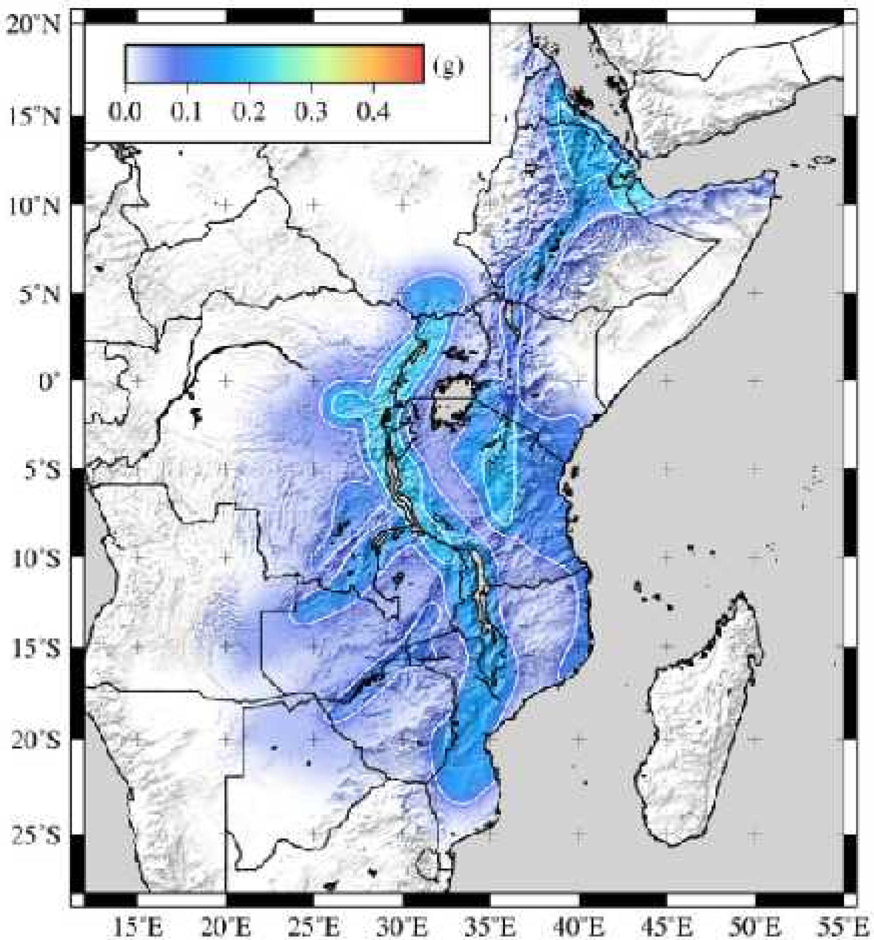

AfricaArray Observatories
(Jan 2013)
collocated seismic, GPS, weather
collocated seismic, GPS
GPS only
seismic only
0 1000 2000 3000
elevation (m)


AfricaArray stations (perm.)
GSN stations
KRISP 1985
KRISP 1989-1990
KBSE (2001-2002)
TBSE (1994-1995)
AAEASE Phase I (2007-2008)
AAEASE Phase II (2008-2010)
AATBSE (2010-2011)
AAEASE Phase III (2010-2011)
UGANDA
KENYA
TANZANIA
ANGOLA
ZAMBIA
ZIMBABWE
Elevation (m)
4500
3000
2000
1500
1000
500
0
100 0 100 200 km
20 24 28 32 36 40
4 0 -4 -8 -12 -16 -20

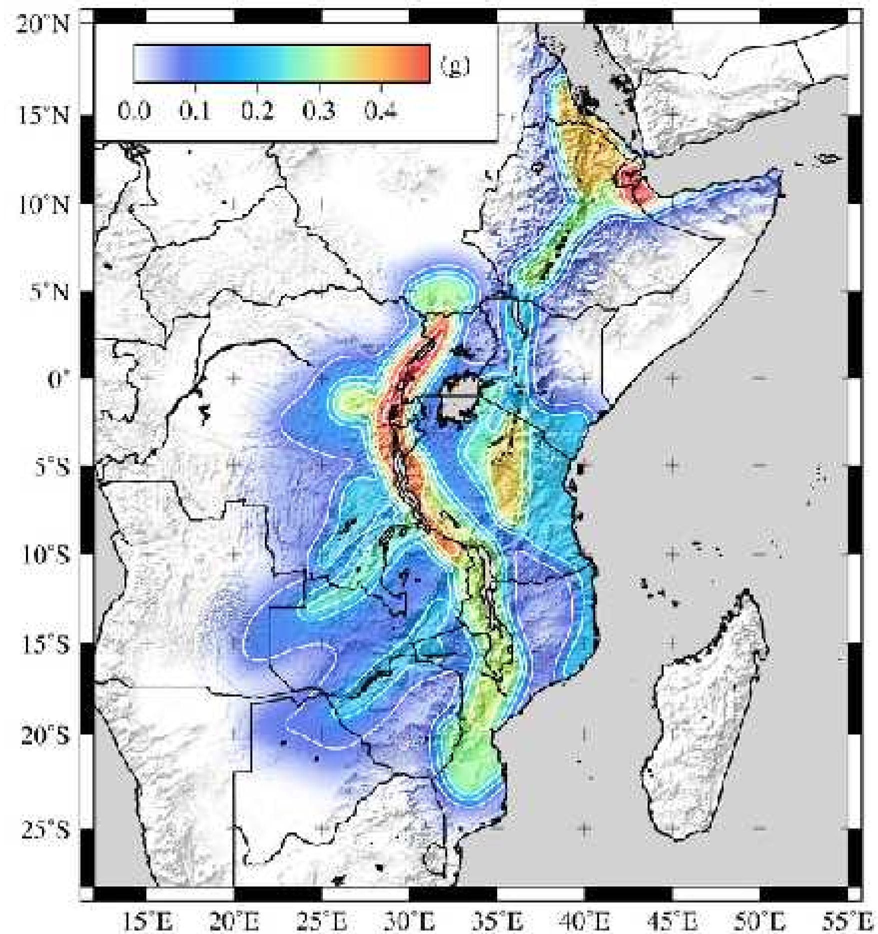




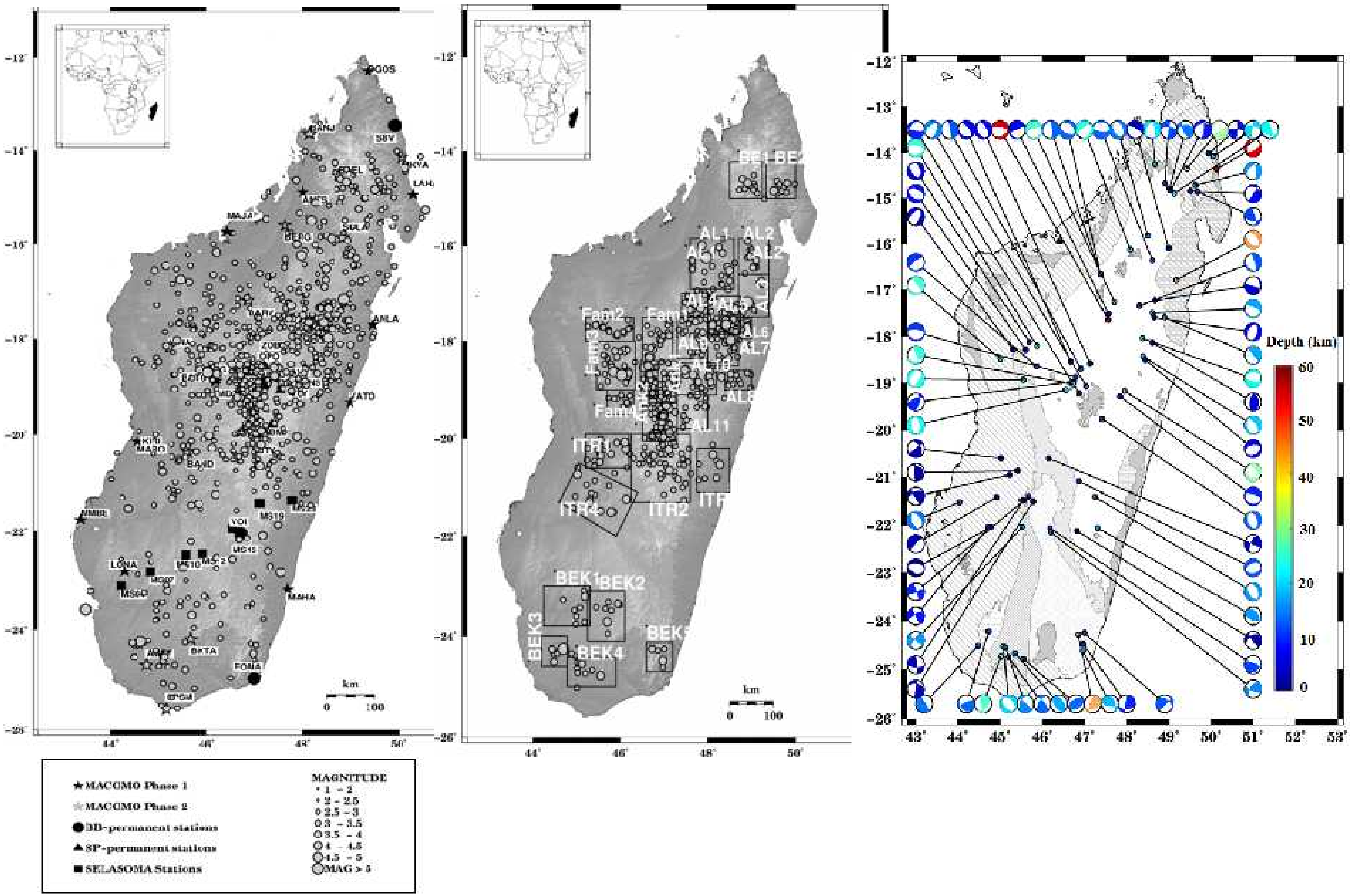
Distribution of earthquakes ($M_W \geq$ 3) from the homogenised SSA-GEM earthquake catalogue.



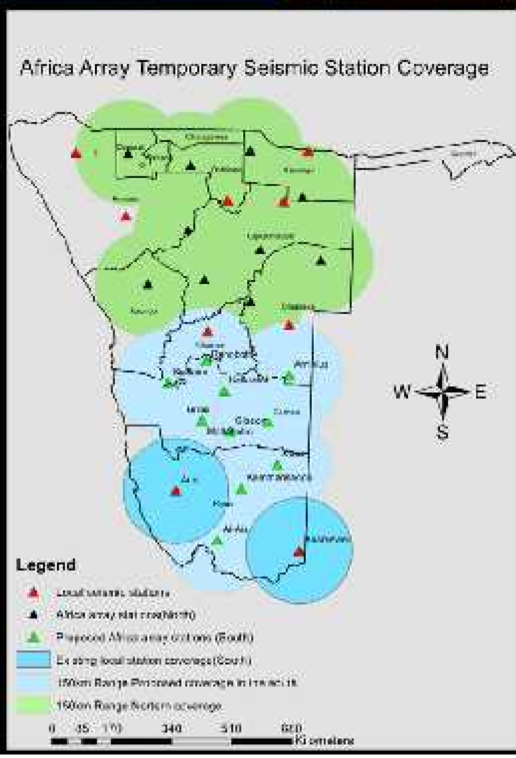
PGA (g) for 10% probability of exceedance in 50 years

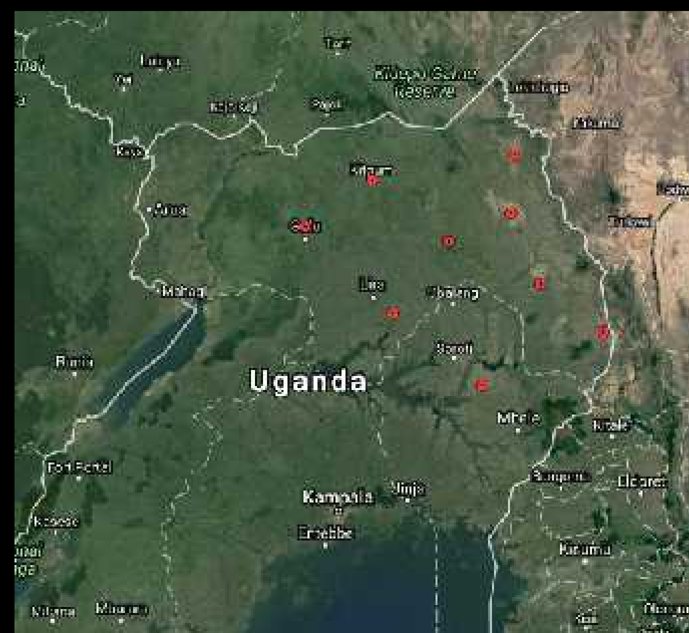


Spectral acceleration (g) at 0.1 s / 10 Hz
10% probability of exceedance in 50 years


MACOMO Phase 1
MACOMO Phase 2
3D-permanent stations
SP-permanent stations
SELASOMA Stations
MAGNITUDE
1 - 2
2 - 2.5
2.5 - 3
3 - 3.5
3.5 - 4
4 - 4.5
4.5 - 5
MAG > 5
km
0 100
BE1
BE2
AL1
AL2
Fam2
Fam3
Fam4
AL6
AL7
AL8
AL10
AL11
ITR1
ITR2
ITR4
BEK1
BEK2
BEK3
BEK4
Depth (km)
0
10
20
30
40
50
60


OPUWO
HAO
NEPA
RUDU
OMUT
TSUN
KANO
206
204
205
215
207
214
KJAB
OTJO
OKAM
GAMM
KBH
216
218
WEWE
BAHE
HOCH
210
209
217
Windhoek
WIN
Gobabis
208
203
211
Botswana
219
Kalahari Desert
212
220
202
201
Gaborone
213
221
AUSN
AFMS


Africa Array Temporary Seismic Station Coverage
N
W
E
S
Legend
Kilometers


Uganda
Kampala
Entebbe
Jinja
Gulu
Lira
Soroti
Mbale

3. VOLCANOES

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

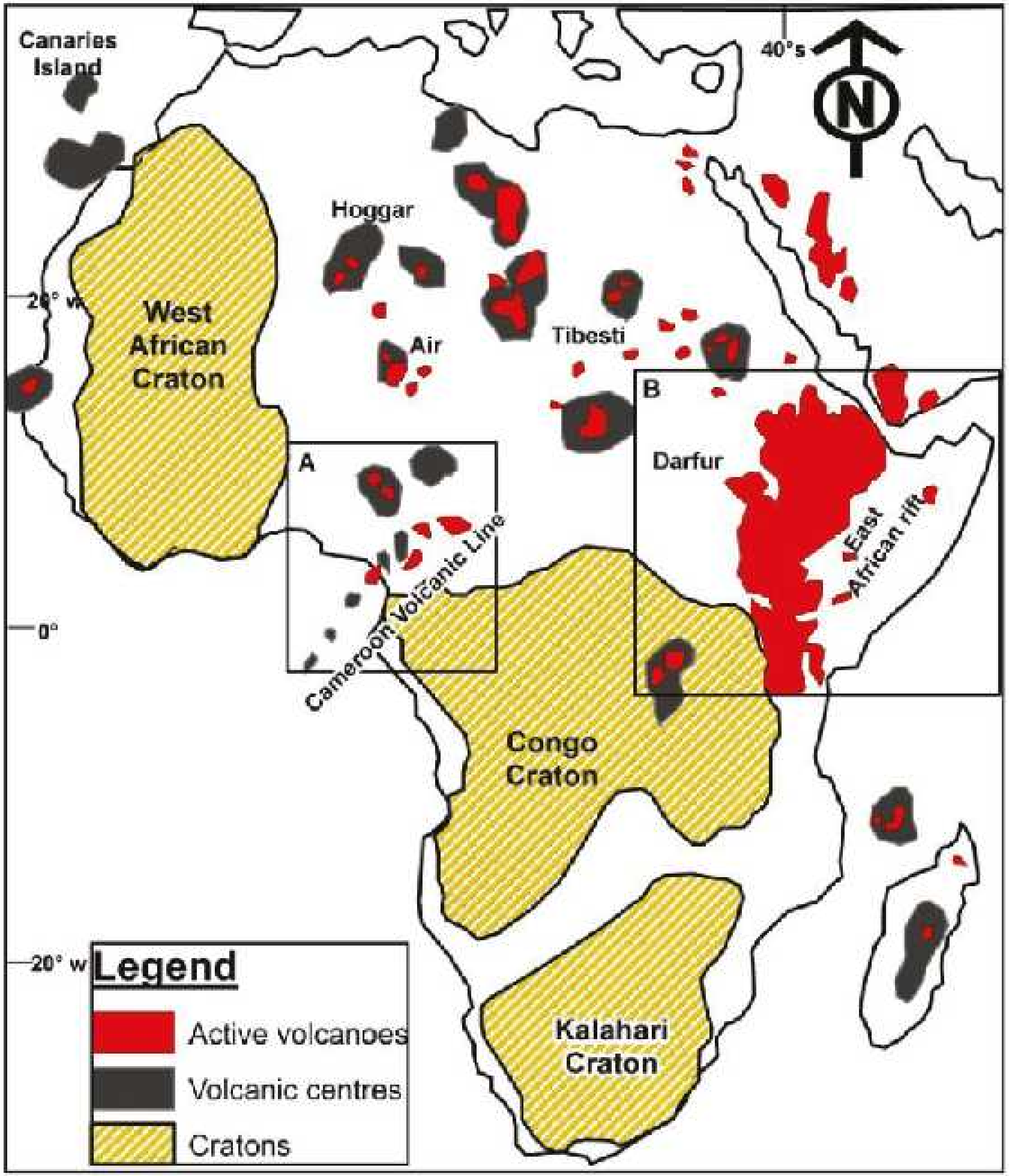


Figure 3.1: Map showing African cratons, zones with presently active volcanoes, and the Cameroon Volcanic Line (A) and the East African Rift System (B).

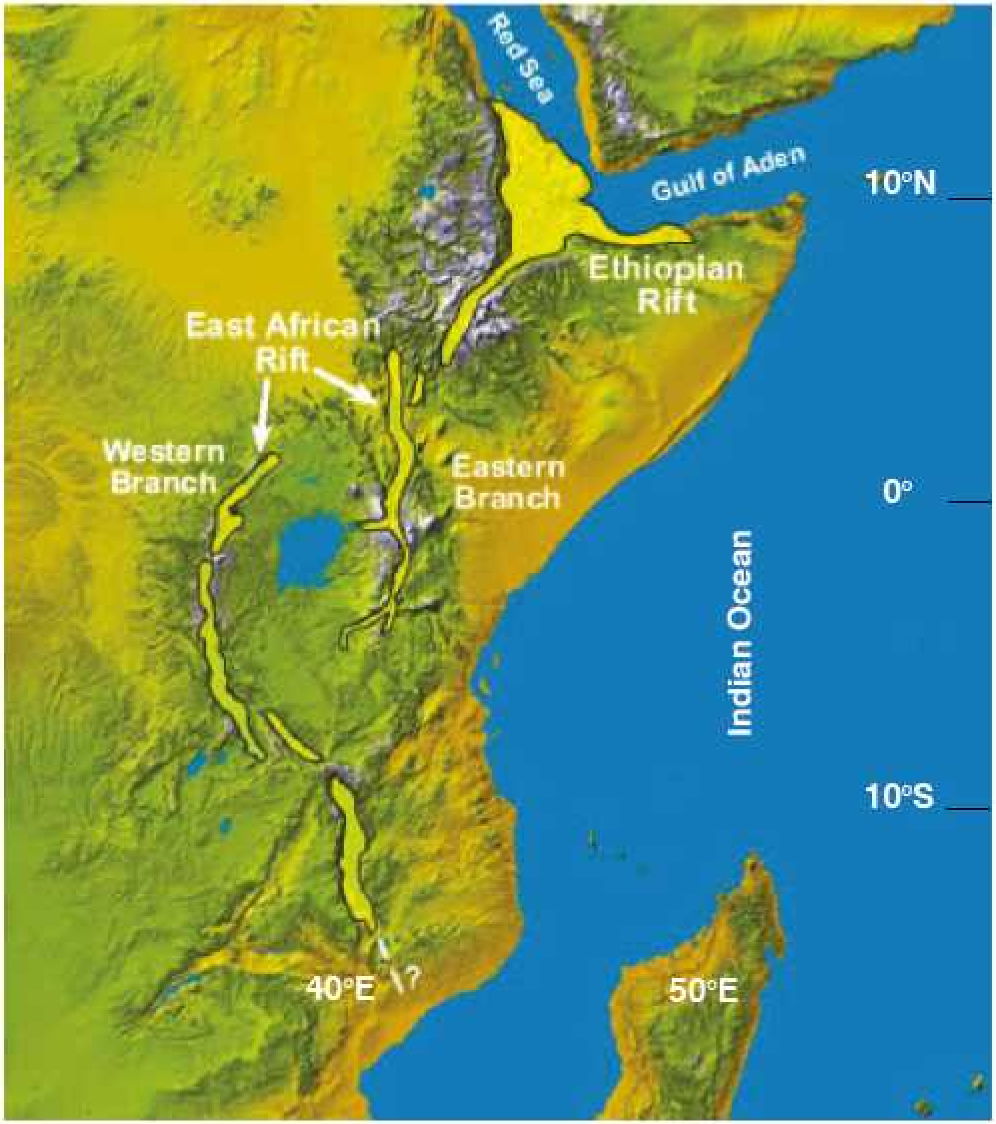


Figure 3.2: Space shuttle radar topography image (NASA) showing the East African Rift System (EARS) and its branches. The names given to the main rift segments change, depending on the source.

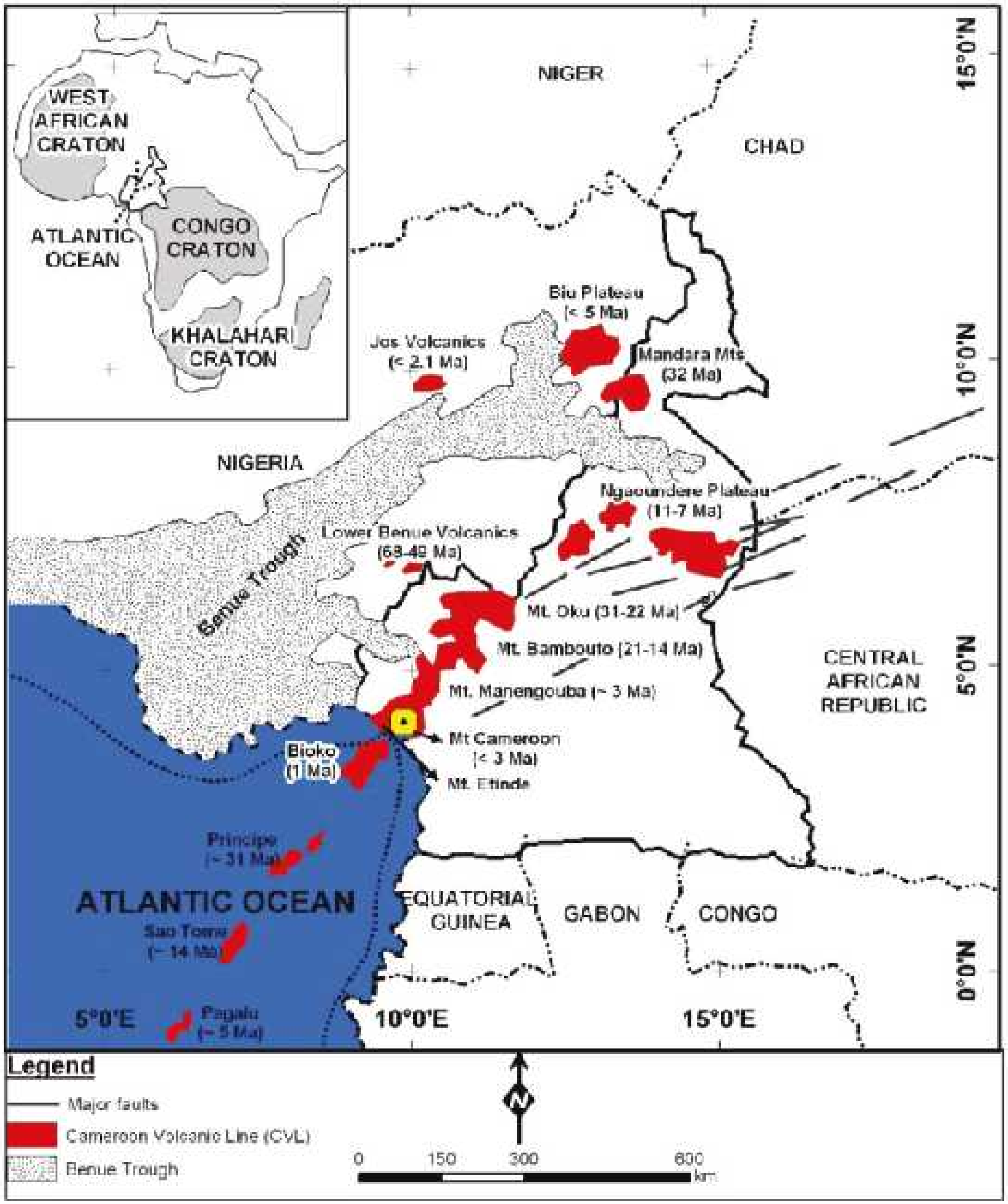


Figure 3.3: Sketch map of Cameroon showing Mount Cameroon and the Cameroon Volcanic Line (CVL). Inset is the CVL and Cameroon within the African continent.[55]

3. VOLCANOES

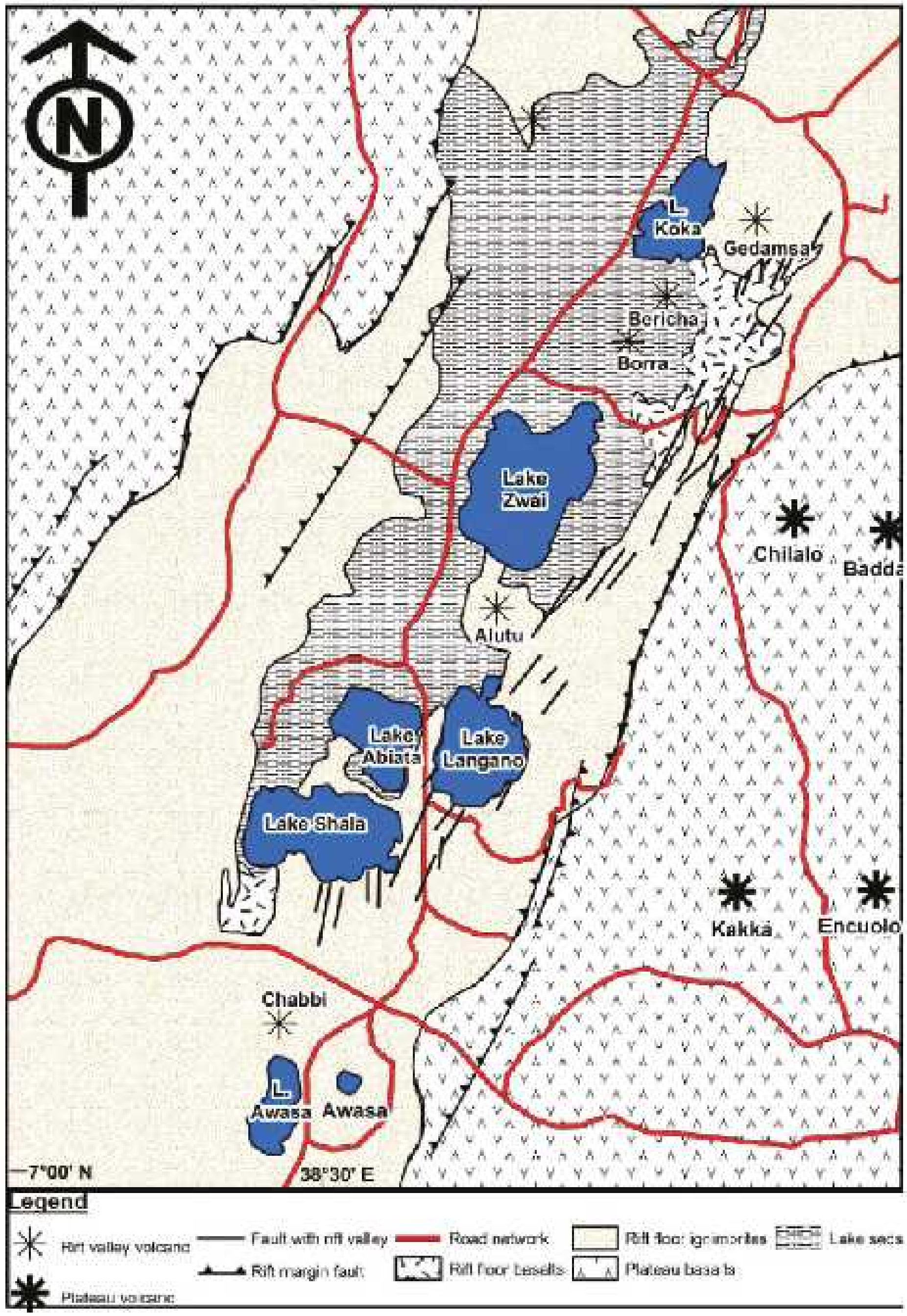


Figure 3.4: Geological sketch map of the Central Ethiopian Rift (modified from Williams and Mohr, 2011).[36]

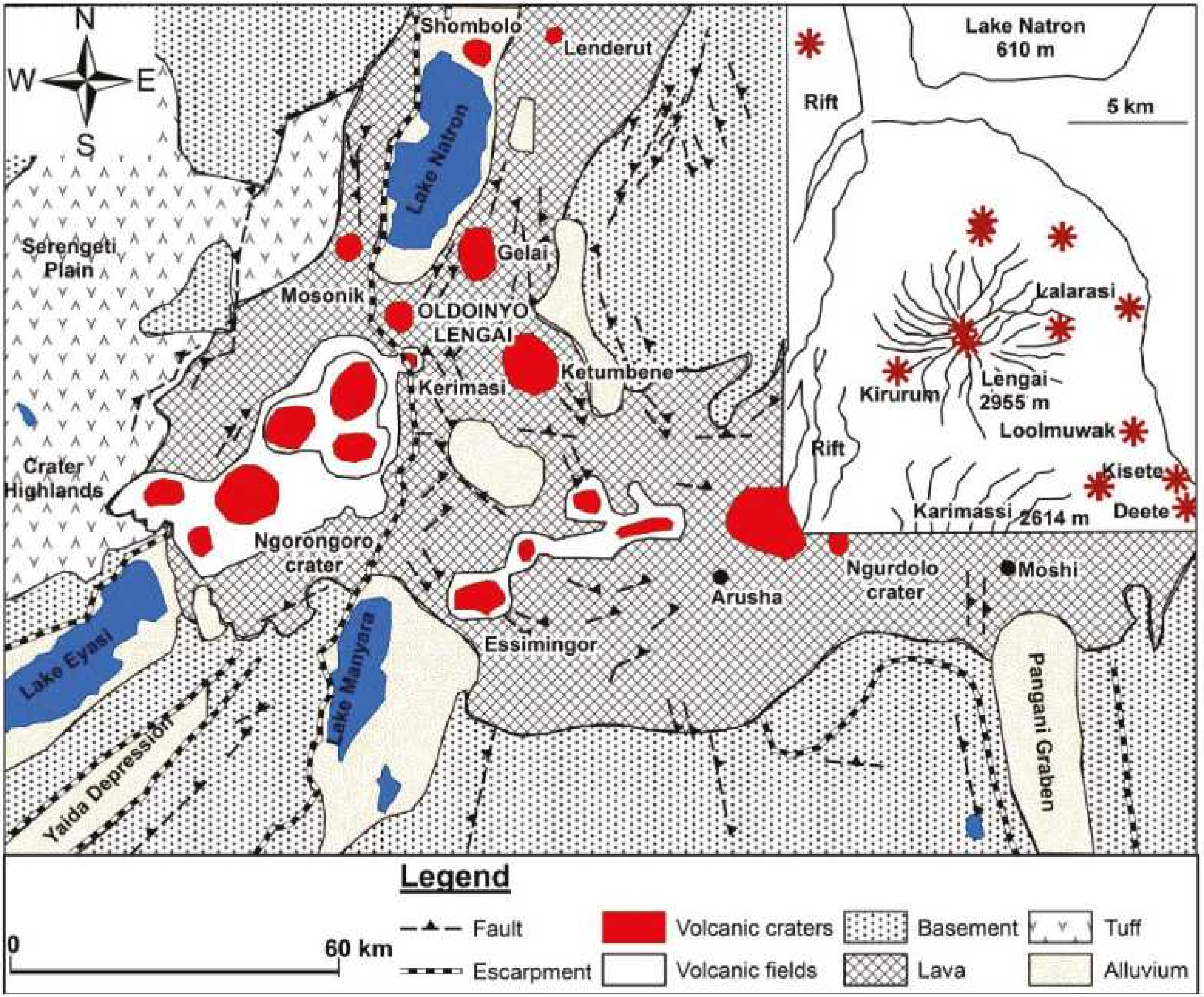


Figure 3.5: Regional geological context of the northern Tanzanian section of the EARS. Inset is a sketch map of the Lengai area (modified from Kervyn et al., 2008).[14]

3. VOLCANOES

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

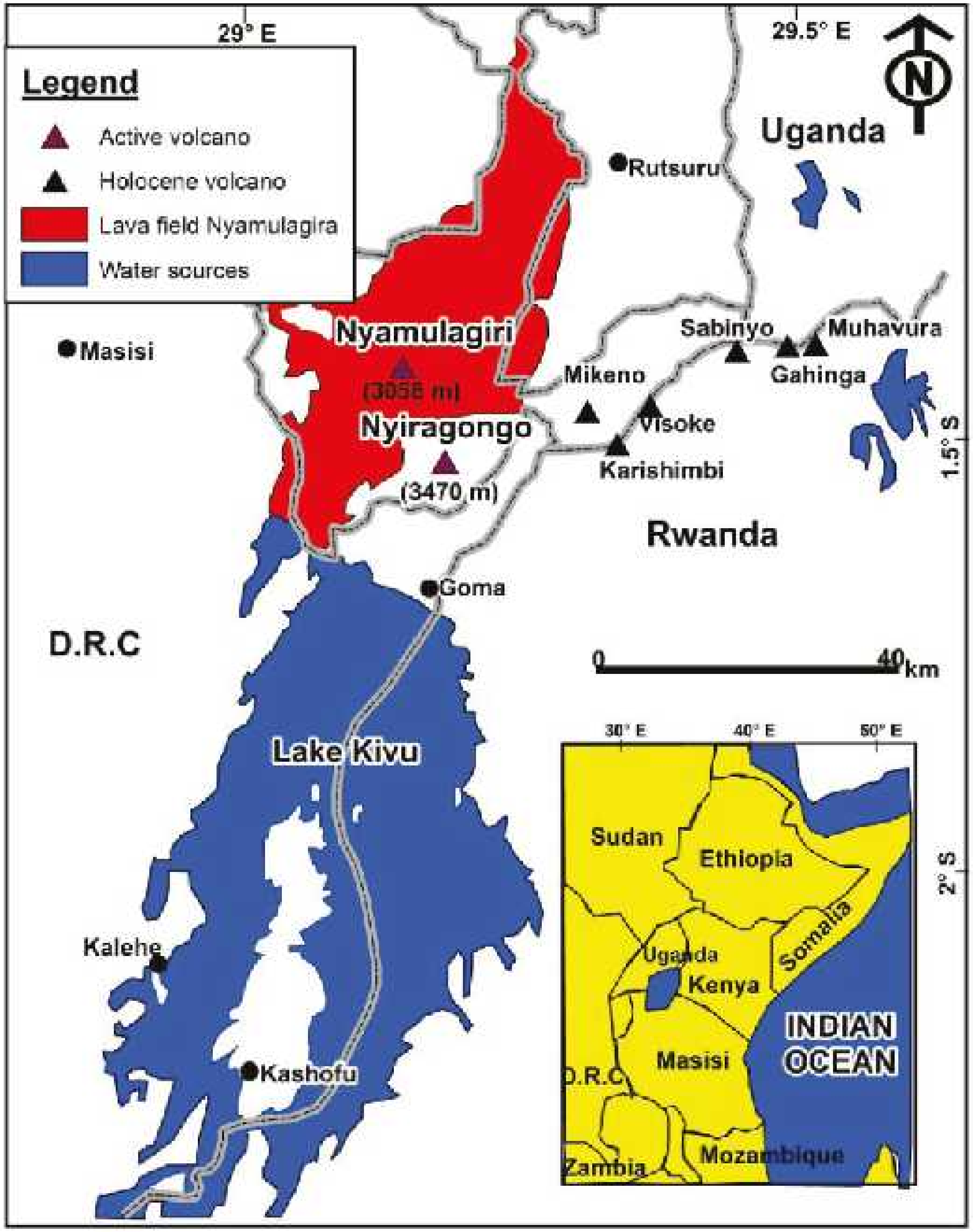


Figure 3.6: Location of Nyamulagira, Nyiragongo and the VVP. Inset is a map that shows countries within the EARS (modified from Smets et al., 2010).[45]

3. VOLCANOES

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

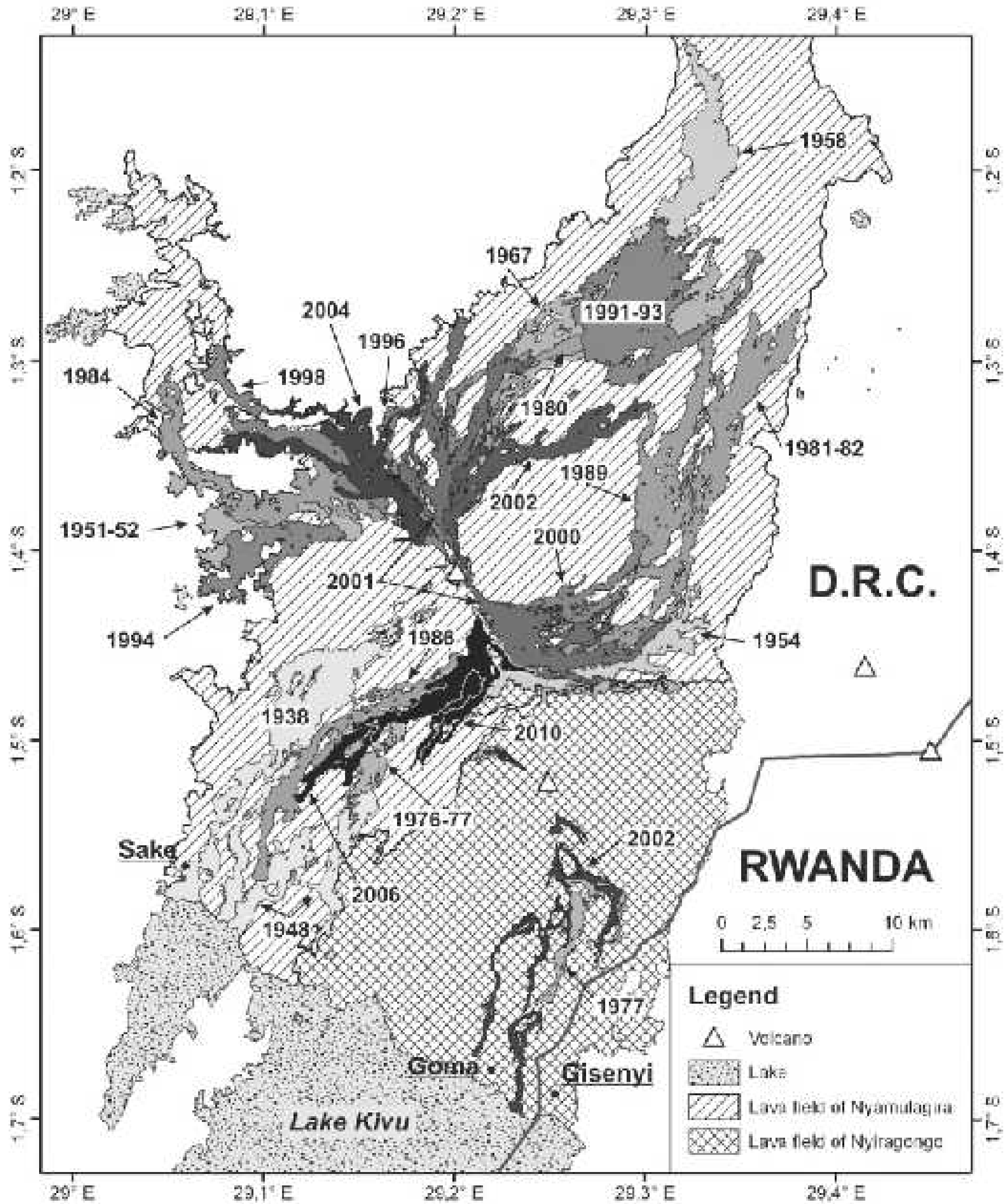


Figure 3.7: Map of most recent (1938–present) lava flows from Nyamulagira. (The darker flows are the most recent.) The Nyiragongo lava field is also identified with its two most recent flows, from the 1977 and 2002 eruptions (Smets et al., 2010).[45]

2. VOLCANOES

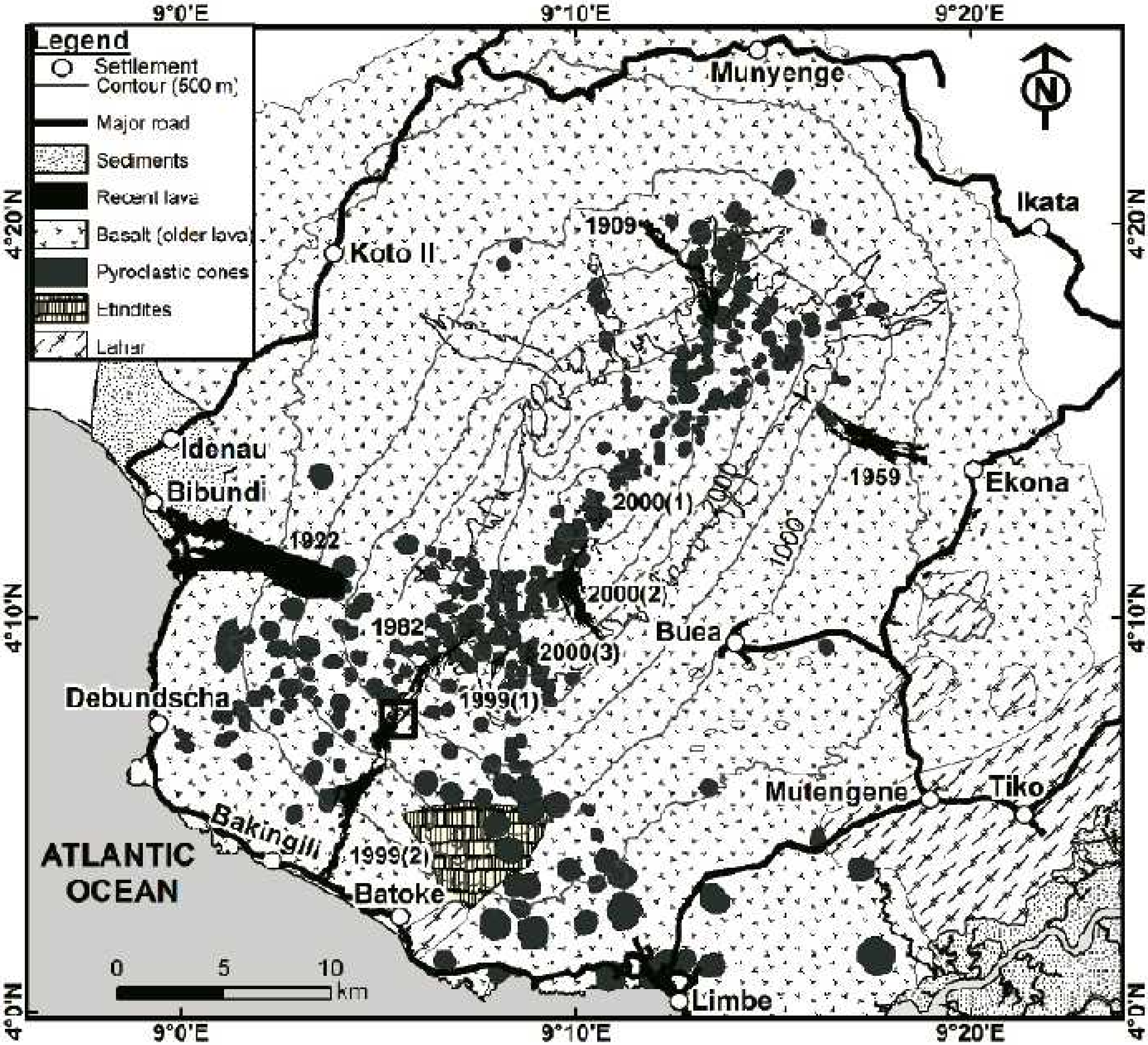


Figure 3.8: Geologic map of Mount Cameroon Volcano and surroundings, showing the 20th Century and 21st Century lava flow fields and scoria cones (~ 340).

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

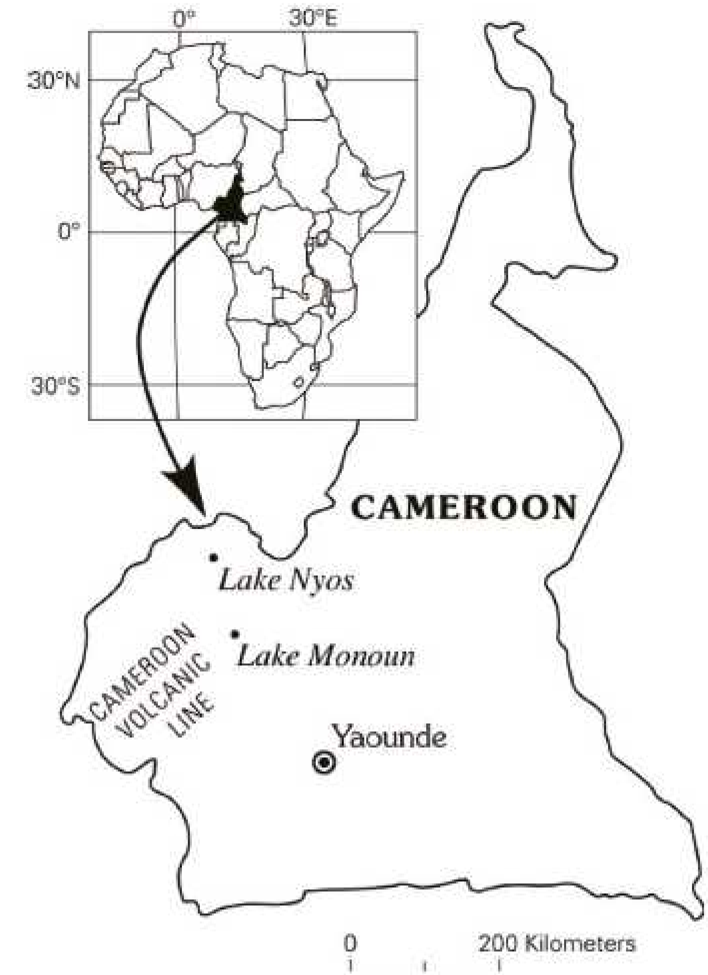


Figure 4.1: Map of Cameroon, showing position of Lake Nyos and Lake Monoun, both found along the Cameroon Volcanic Line.[5]

4. CRATER LAKES

Figure 4.2: Photograph of the Lake Nyos disaster showing: a) change in colour of water in Lake Nyos after CO2 explosion (inset shows lake colour before explosion); b) livestock killed by CO2 explosion in Lake Nyos.

b)

4. CRATER LAKES

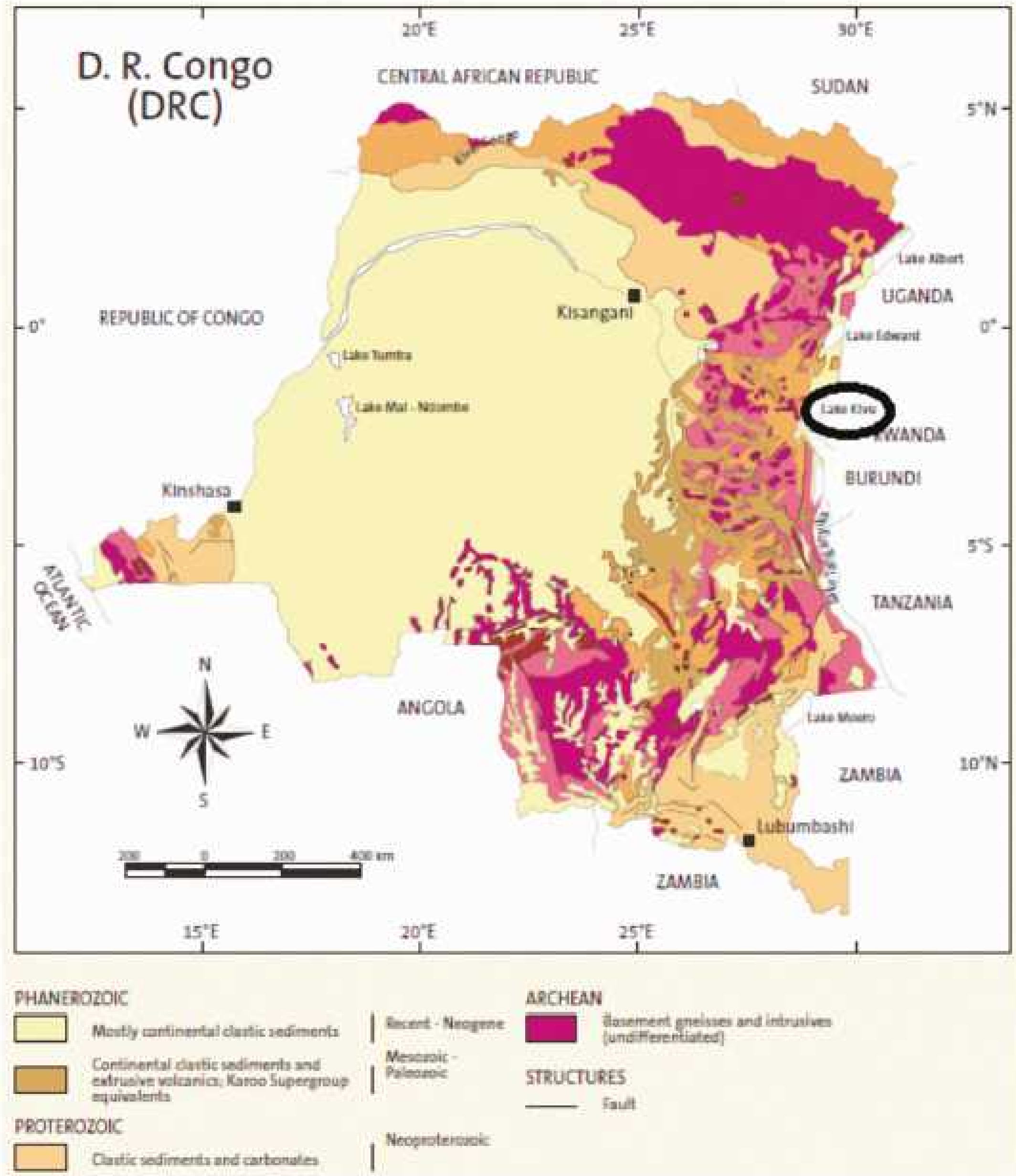


Figure 4.3: Geological overview of DR Congo showing Lake Kivu and other lakes.[18]

Figure 5.1: Landslide at Nametsi Village, Uganda, where over 300 people, homes and a community health centre were buried by the debris flow[25].

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

5. MASS MOVEMENTS

- ‘Landslide’ and ‘slope failure’ are used synonymously.
- Down-slope movement of soil and rock under the influence of gravity, without the primary assistance of a fluid transporting agent.
- Creep (< 0.15 mm/year) to instantaneous and catastrophic slides (1.5 m/s).
- Fairly successfully predictable.
- Expected to continue world-wide in the 21C
  - (a) increased urbanisation and development in landslide-prone areas;
  - (b) continued deforestation of landslide-prone areas; and
  - (c) increased precipitation caused by changing climatic conditions

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

Figure 5.2: Partial view of the 2006 landslide in the Tarmaber area, Ethiopia. Over 3 000 people were displaced as a result of the large-scale landslide (areal size: 5 km * 8 km).

CONTROLS & TRIGGERING FACTORS

- Bedrock type
- Slope gradient
- Slope shape
- Slope modification
- Vegetation cover

5. MASS MOVEMENTS

Figure 5.3: Mass movement affecting express highway in Onecha City, Nigeria, which is associated with gully erosion development.

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

Figure 5.4: View of a rotational landslide at Kie Village developed on weathered pyroclastic cone characterised by reddish to reddish-brown soils. The green structure at the centre-left edge of the picture is a 300 m³ water tank, which is partially buried by slide debris[44].

Figure 5.5: Typical example of effect of stream or river incision on landslide in Adishu area, northern Ethiopia, which is affecting agricultural fields.

5. MASS MOVEMENTS

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

CONCLUSIONS

- ➢ **Most landslides in SSA triggered by rainfall**
- ➢ **Most mountainous terrain in SSA is highly fragile**

6. ARTISANAL MINING

Table 6.1: Mining and prospecting operations in Kenya[4]

No. of Companies	Types of minerals mined	District found
11	Base metals (gold, silver, copper minerals, iron ore, lead, chromite)	Transmara, Migori, Homabay, West Pokot, Turkana, Siaya, Kakamega, Vihiga, Kuria, Nandi, Saburu, Kilifi, Kwale, Taita Taveta, Meru
23	Industrial Minerals (Fluospar, Titanium minerals, Diatomite, Vermiculite, Limestone, Gypsum, Silica, Feldspar, Clay minerals, Magnesite, Quartz)	Marakwet, Kwale, Nakuru, Samburu, Kajiado, Machakos, Kilifi, Turkana, West Pokot, Nandi, Tana River, Wajir, Makueni, Taita Taveta, Kiambu, Nyeri, Kisii
112	Gemstones (Ruby, Saphire, Rhodolite, Tsavorite, Tuormaline, etc)	Taita Taveta, West Pokot, Kwale, Isiolo, Machakos, Kilifi, Mwingi, Turkana, Kajiado, Meru, Samburu, Baringo)
5	Chemical Minerals (Soda Ash, Salt, Carbon Dioxide, Hydrocarbons)	Kiambu, Kajiado, Mombasa, Kilifi, Malindi, Mwingi)
18	Dimension Stone (Granite, Marble, Limestone)	Vihiga, Nandi, Marakwet, Mombasa, Kilifi, Machakos, Kajiado)

Table 6.2: Gold production in Kenya from 1990 to 2006[6]

Year	1990	1991	1992	1993	1994	1996	1997	1998
Gold Production (kg)	25	20	20	154	154	300	300	388
Year	1999	2000	2001	2002	2003	2004	2005	2006
Gold Production (kg)	990	950	1545	1477	1543	567	616	432

Figure 15.1: Example of mine entrance in artisanal mining
(© Dr Charity Chenga).

6. ARTISANAL MINING

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

Plate 6.2: A youth shows his working station in the area.

6. ARTISANAL MINING

Plate 6.4: A miner shows a sample of mercury unaware of its health hazards

Figure 15.3: Unprotected artisan miner handling raw mercury – used in processing gold
(© Dr Charity Chenga).

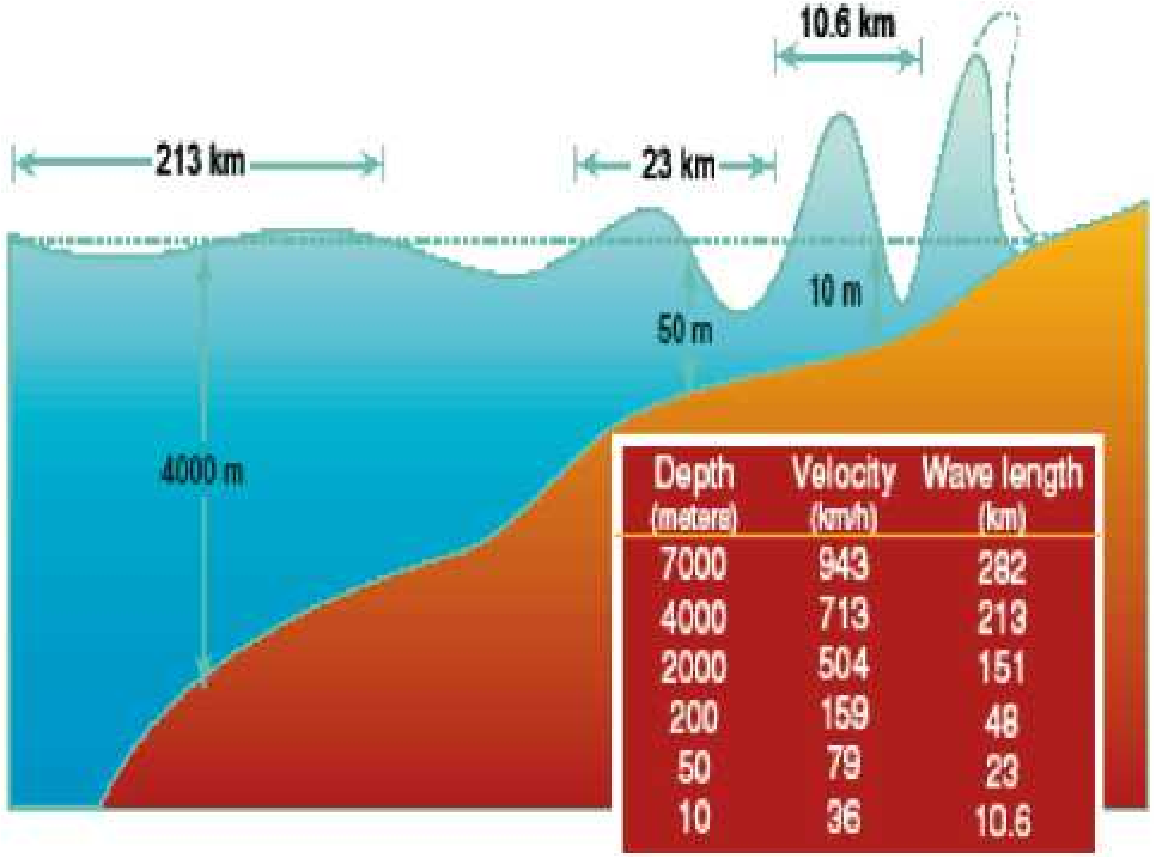
INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

Plate 6.5: Abandoned open cast mine has filled with water, are a risk to people and animals

Plate 6.6: Landslides on slopes caused by gold mining activity

Plate 6.7: Panning along flowing streams results in contamination of river water

Figure 15.4: Land degradation derived from artisanal mining activities
(© Dr Charity Chenga)



Depth (meters)	Velocity (km/h)	Wave length (km)
7000	943	282
4000	713	213
2000	504	151
200	159	48
50	79	23
10	36	10.6

Figure 13.6: Enhancement of a tsunami wave[12]

13. COASTAL HAZARDS

A man praying on the remains of his local mosque shortly after the tsunami struck the Somali village of Hafun.
http://www.unhcr.org/43a2caad4.html

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

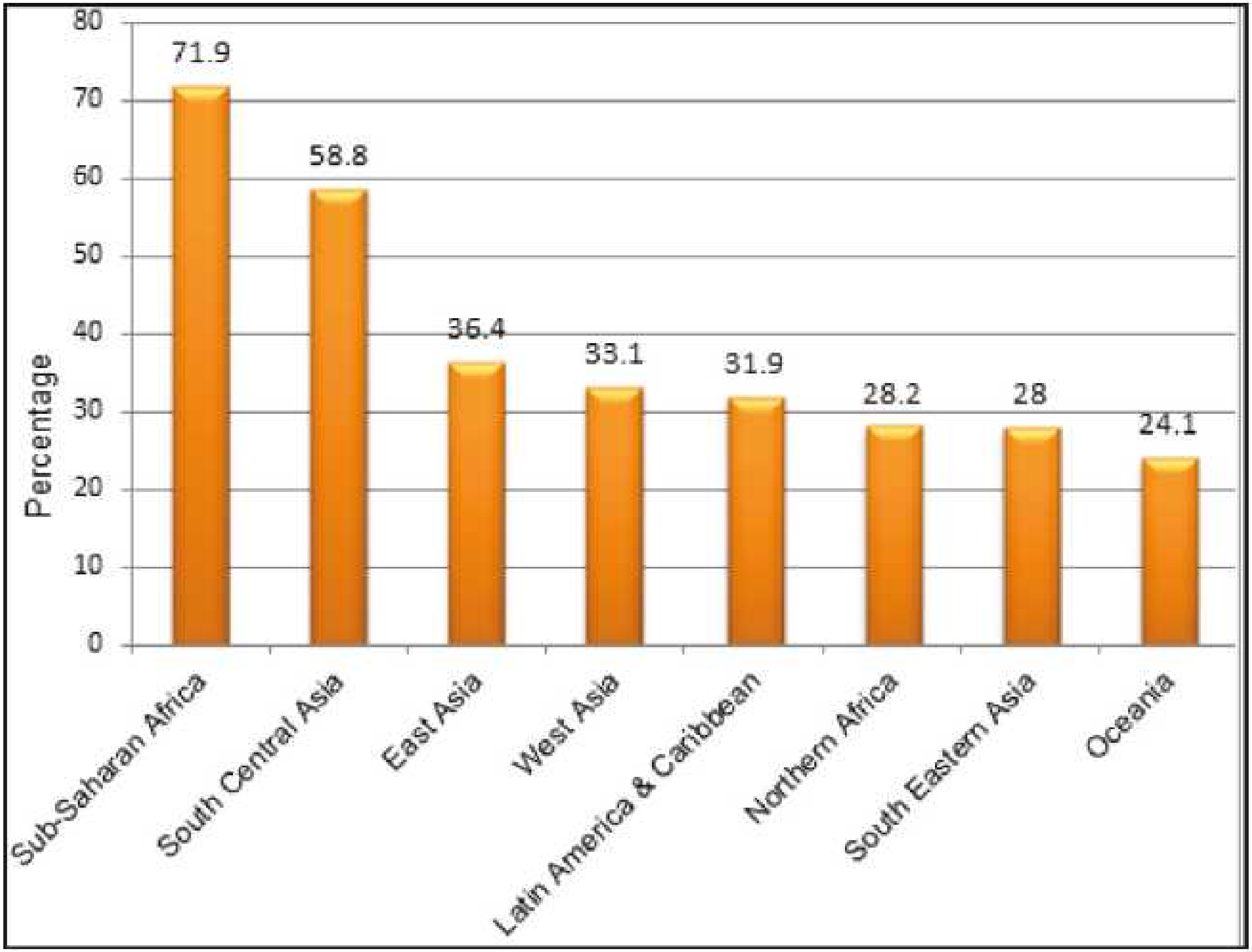


Figure 14.1: Slum dwellers as a proportion of urban population (2003).[47]

Figure 14.2: Housing type in Makululu, Kabwe, Zambia. Figure 14.3: Collapsed house in Makululu after rains.

© Adrian Phiri/DMTC 2012[70]

Figure 14.4: Uncollected solid waste in Kanyama.

© Mitulo Silengo/DMTC[81]

Figure 14.5: Solid waste in open drains in Kanyama, Lusaka.

14. RURAL VULNERABILITY

INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

CONTROLS & TRIGGERING FACTORS

- **Lack of access to resources**
- **Weak individuals or buildings**
- **Degree of dependence on the environment and ability to access it**
- **Lack of access to information and knowledge**
- **Lack of public awareness**
- **Limited access to political power and representation**
- **Certain beliefs, customs and the disintegration of social patterns**

INTERNATIONAL
COUNCIL FOR SCIENCE
REGIONAL OFFICE
FOR AFRICA

ICSU Regional Office for Africa

AFRICA SCIENCE PLAN

Natural and Human-induced Hazards and Disasters

Strengthening international science
for the benefit of society

INTERNATIONAL
COUNCIL FOR SCIENCE
REGIONAL OFFICE
FOR AFRICA

Natural and Human-Induced
Hazards and Disasters in Africa