

Helpdesk Research Report

Assessing seismic risk in Ethiopia

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20.01.2013

Question

Identify data on, or ways to assess, seismic risk in Ethiopia. Where possible, identify what the data suggests about the absolute levels of risk, the relative levels of risk compared to other countries, and which populations are particularly vulnerable.¹

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1. Overview

This report identifies data, literature and maps on seismic risk in Ethiopia. In this report seismic risk, as a concept, is understood to be the product of seismic hazard (the probability of harmful seismic phenomena) and seismic vulnerability (the degree of loss from seismic phenomena – human and economic).²

There is **limited literature available** in this area. Abeye (2012) argues that an updated seismic hazard map of Africa is long overdue. In a case study analysis of the Ethiopian capital Addis Ababa, a 1999

¹ This is the second GSDRC query examining seismic risk in East Africa, the first paper focussed on Kenya. See - <http://www.gsdrc.org/go/display&type=Helpdesk&id=964>

² See -

<http://www.ehs.unu.edu/elearning/mod/glossary/view.php?id=8&mode=letter&hook=R&sortkey=&sortorder>

UNIDSR report identified challenges such as an absence of previous seismic risk assessment, few specialists and limited practice in seismology and earthquake engineering, low awareness of earthquake disaster risk at the political level, and limited financial resources (UNIDSR, 1999, p.23).

Key findings include:

- In terms of overall seismic risk, the presence of part of the East African Rift, which runs through the centre of the country, means that Ethiopia is prone to seismic activity and related natural disasters: earthquakes and volcanic eruptions (Abebe, 2010). As a landlocked country, it is not at risk from tsunamis.
- The centre of Ethiopia faces a **medium risk of earthquake hazard** – more so than its neighbouring countries. The country has experienced a number of earthquakes and these have caused some deaths, and damage to buildings. According to the EM-DAT database, from 1900 to 2013 earthquakes in Ethiopia have caused a total of 93 deaths, 165 injured, 420 homeless, and affected 11,000 people, and a total estimated economic cost of more than US\$7 million.³
- Ethiopia, and neighbouring countries, have a number of **active volcanoes** and Ethiopia has experienced some volcanic eruptions which have caused death and damage to buildings.
- In terms of **vulnerability**, data suggests that:
 - 46 per cent of the population has a “medium” exposure to seismic hazard;
 - 20 per cent of the population has a “low” exposure; and
 - 26 per cent has a “very low” exposure. No people are identified as facing a “high” or “very high” exposure.
 - Most vulnerability analyses do not cite seismic hazards and so not identify specific vulnerable communities.
- **Urban areas** are also identified as facing seismic vulnerability. The capital Addis Ababa is located close to the western edge of the Ethiopian Rift Valley. Despite only facing moderate seismicity, the urban public there are more vulnerable to disasters due to weak infrastructure and lack of preparedness.
- **Disaster management activities** in Ethiopia have tended to focus most on drought disaster management. Less attention has been paid to other types of disasters, like earthquakes and volcanic eruptions (Abebe, 2010).

A list of suggested websites is presented at the end of the report.

2. Seismic risk

Assessing ‘risk’ – as a forward looking concept - means assessing events that could potentially occur, quantifying the likelihood of it occurring, and evaluating the potential consequences of this (UNIDSR, 2013). It also includes assessment of past events and consequences. And is contingent on availability and quality of data (ibid).

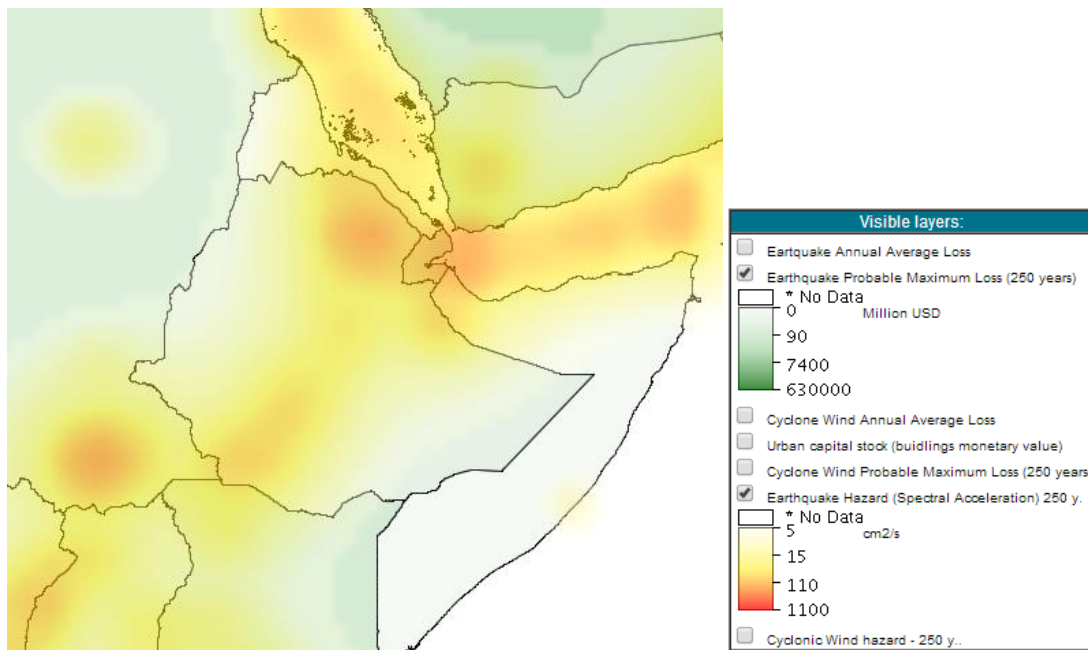
In East Africa there are three main zones of seismic weaknesses in the crustal segments: the East African rift system, the Gulf of Aden, and along the Red Sea (Haile, 2004). These three zones make up the Afar

³ See - [http://www.emdat.be/result-country-profile?disgroup=natural&country=eth&period=1900\\$2013](http://www.emdat.be/result-country-profile?disgroup=natural&country=eth&period=1900$2013)

Triangle (Ayele & Kuthanek, 2007). Movement in these zones has made the region an active tectonic and volcanic zone (Haile, 2004). In Ethiopia, 90 per cent of the seismicity and volcanic activity is related to the East African rift system. The East African Rift System is a 50km to 60km wide zone of volcanoes and faults that extend north to south in Eastern Africa for more than 3000km (1864 miles), from Ethiopia in the north to the Zambezi in the south. It cuts through Ethiopia in a NE-SW direction (ibid; Ayele & Kuthanek, 2007). The seismic energy is released as micro-earthquakes (Ayele & Kuthanek, 2007).

Based on data from the Global Assessment Report on Disaster Risk Reduction 2013, Figure 1 illustrates the level of earthquake risk in Ethiopia and surrounding countries (by combining seismic hazard and seismic vulnerability).⁴ Figure 2 focuses closer on Ethiopia. In these maps, the yellow to red colour represents the degree of earthquake hazard with red being the most significant and yellow being less significant. The green represents the degree of vulnerability to earthquake loss with darker green meaning more significant loss.

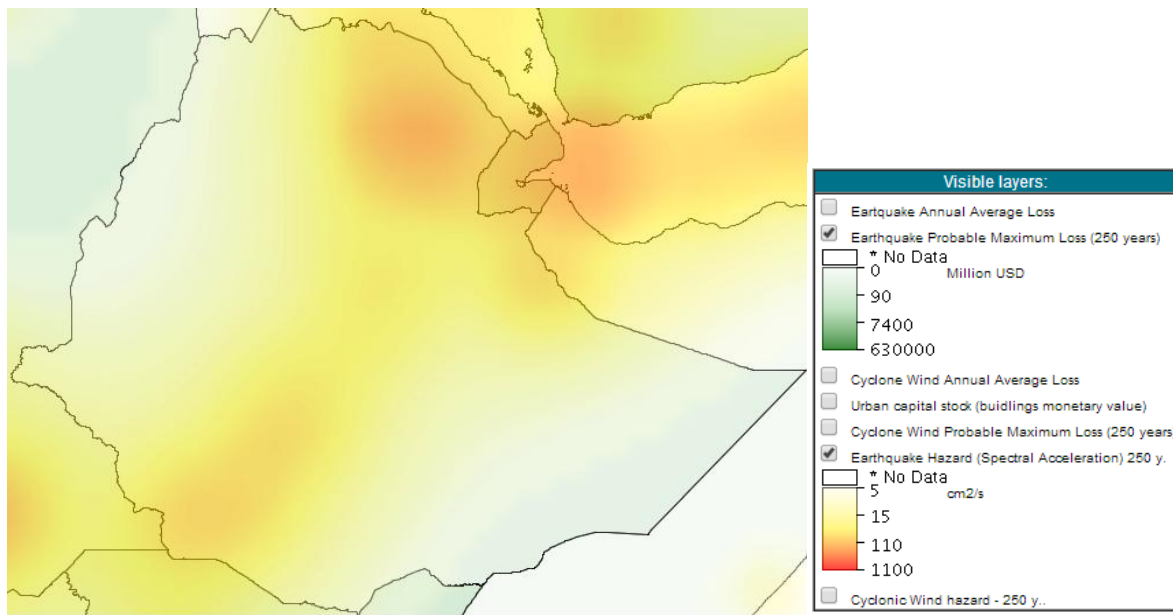
Figure 1: Earthquake risk for Ethiopia and surrounding countries



Source: Map generated from the Global Assessment Report on Disaster Risk Reduction 2013, Risk Data Viewer on 17 January 2014, <http://risk.preventionweb.net>

⁴ Note that maps can be created on the website for seismic hazard and seismic vulnerability separately.

Figure 2: Earthquake risk for Ethiopia



Source: Map generated from the Global Assessment Report on Disaster Risk Reduction 2013, Risk Data Viewer on 17 January 2014, <http://risk.preventionweb.net>

3. Seismic hazard

3.1 Seismic hazard in Ethiopia

The active Great Rift Valley makes Ethiopia susceptible to two types of seismic hazard: earthquakes and volcanic eruptions. As a landlocked country, it is not at risk from tsunamis. Using data from one of the best known disaster databases – the EM-DAT database – Table 1 shows that from 1900 to 2013 there were a total of ten earthquakes and eruptions – leading to a total of 93 deaths, 165 injured, 420 homeless and affecting 11,000 people. These are estimated to have an economic cost of more than US\$7 million.⁵

It is important to note that data in these areas is often limited and is expected to be highly underreported.⁶ Other sources of data and literature report different figures – for example Kinde (2002) explains that Gouin estimates 15,000 tremors occurred in Ethiopia and the Horn of Africa in the 20th century, while another study by Kebede identified a total of 16 recorded earthquakes of magnitude 6.5 and higher in Ethiopia in the same period.

⁵ See - [http://www.emdat.be/result-country-profile?disgroup=natural&country=eth&period=1900\\$2013](http://www.emdat.be/result-country-profile?disgroup=natural&country=eth&period=1900$2013)

⁶ For a critique of this, and other, data sources see – UNISDR (2013).

Table 1: Number and impact (human and economic) of earthquakes and volcanos in Ethiopia (1900-2013)

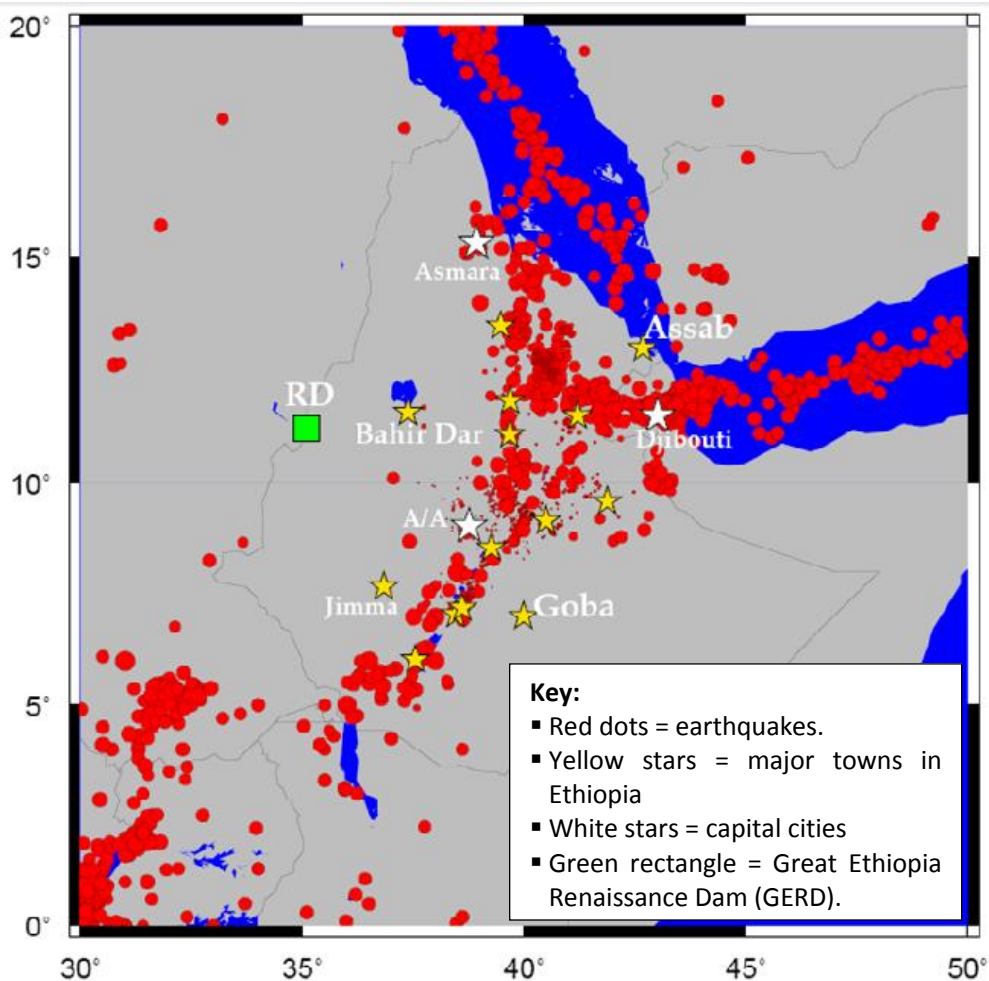
Disaster type	Number of disasters	Number of people killed	Number of people injured	Number of people affected	Number of homeless	Total number of people affected	Total economic damage (US\$ '000)
Earthquake	7	24	165	0	420	585	7070
Volcano	3	69	0	11000	0	11000	0
Total	10	93	165	11,000	420	11,585	7,070

Source: Data downloaded from EM-DAT database on 17 January 2013.⁷

3.2 Earthquake hazard – Ethiopia compared to its neighbours

Earthquakes occur along the Ethiopian rift system. Figure 3 depicts the seismicity of the Horn Africa region by mapping the earthquakes that have occurred in the region from 1900 to 2010 (Atalay Ayele, private correspondence). The size of the red dots represent the magnitude of earthquakes – ranging from 3.5 to 7.2. The yellow stars are the major towns in Ethiopia – revealing that the seismic areas are often inhabited areas (ibid).

Figure 3: Earthquakes recorded in the Horn Africa region from 1900 to 2010.



⁷ See - [http://www.emdat.be/result-country-profile?disgroup=natural&country=eth&period=1900\\$2013](http://www.emdat.be/result-country-profile?disgroup=natural&country=eth&period=1900$2013)

Source: Atalay Ayele (Addis Ababa University), via private correspondence on 15 January 2014, based on data from: Institute of Geophysics Space Science and Astronomy of Addis Ababa University; United States Geological Survey; and International Center of Seismology in UK.

It is not possible to compare Ethiopia to all its six neighbours – Somalia, Sudan, South Sudan, Kenya, Eritrea and Djibouti – as EM-DAT data is only available for Kenya, Somalia and Sudan. Table 2 compares the EM-DAT earthquake data available for these four countries and finds that Ethiopia has experienced the most earthquakes of all these countries (with seven earthquakes in Ethiopia compared to two or one for the other countries). However, the earthquakes in Kenya and Somalia led to more estimated economic damage.

Table 2: Number and impact (human and economic) of earthquakes and volcanos in Ethiopia (1900-2013)

Country	Disaster type	Number of disasters	Number of people killed	Number of people injured	Number of people affected	Number of homeless	Total number of people affected	Total economic damage (US\$ '000)
Ethiopia	Earthquake	7	24	165	0	420	585	7,070
Kenya	Earthquake	2	1	0	0	0	0	100,000
Somalia	Earthquake	1	298	283	104,800	0	105,083	100,000
Sudan	Earthquake	2	3	15	8,000	0	8,015	0

Source: Data downloaded from EM-DAT database on 17 January 2013.⁸

3.3 Earthquake hazard in Ethiopia

According to the EM-DAT database – from 1900 to 2013 there were a total of seven earthquakes, killing a total of 24 people, affecting 585 people and causing more than US\$7 million in economic damage (see Table 1). As Addis Ababa is located 75-100kms from the western edge of the Ethiopian Rift Valley – it is often affected by earthquakes.

⁸ See - [http://www.emdat.be/result-country-profile?disgroup=natural&country=eth&period=1900\\$2013](http://www.emdat.be/result-country-profile?disgroup=natural&country=eth&period=1900$2013)

Examples of earthquakes in Ethiopia identified in the literature include:⁹

- **1906 Langano earthquake** – intensity of 8 on the Mercalli scale, and a magnitude of 6.75.¹⁰ Epicentre 100-110km from Addis Ababa¹¹ (UNISDR, 1999, p.21). No deaths are reported to have occurred, however, the earthquake is reported to have caused “widespread panic” (Gouin in Kinde, 2002; Ayele, 2012). An estimated US\$6,750,000 of economic damage resulted – this is considered a low level in the literature as the affected areas did not have a great deal of infrastructure (Addis Ababa, for example, was only 10 years old) (Gouin in Kinde, 2002).¹²
- **1961 Kara Kore earthquake** – intensity of 7 on the Mercalli scale. Epicentre 200-150km from Addis Ababa. In terms of vulnerability, buildings in the capital city were damaged (UNISDR, 1999, p.21; Gouin in Kinde, 2002).
- **1969 earthquake** – intensity of 6.4. High levels of damage occurred to the town of Sardo - 24 people were killed, 165 injured, 100 huts were destroyed (made of mud). The 300 villagers that survived moved to the nearby town of Loggia. Several aftershocks were noted, but none were damaging.¹³
- **1983 Wondo Genet earthquake** – 300km from Addis Ababa (Kinde, 2002).
- **1985 Langano earthquake** – magnitude of 6.2. 110km from Addis Ababa (Kinde, 2002).
- **1987 Rift Valley Area earthquake** – magnitude of 6.2. 200km from Addis Ababa (Kinde, 2002).
- **1989 Dobi graben earthquake** – magnitude of 6.2. 200km from Addis Ababa. Several bridges damaged (Kinde, 2002).
- **1993 Nazret earthquake** – possible magnitude of 6. Less than 100km from Addis Ababa (Kinde, 2002).
- **1977, 1984 and 1985 earthquakes** – smaller magnitude (Haile, 2004, p.2).
- **1997 earthquake** – magnitude of 4. Epicentre 22km from Addis Ababa (Haile, 2004, p.2).
- **2007 earthquake** – 5 killed.¹⁴
- **2011 earthquake** – magnitude of 5.¹⁵

Figure 4 shows Ethiopia’s major cities in relation to seismic hazard. Notably the three most populous cities – Addis Ababa (3 million), Dire Dawa (273,600), and Mek’ele (271,600)¹⁶ – are found in the most seismically hazardous areas – marked in yellow in the centre of the country and categorised as having a “medium” risk of seismic hazard. The cities Addis Ababa, Nazret, Dire Dawa and Awassa are very near main fault lines (e.g. the Wonji fault, Nazret fault, Addis-Ambo-Ghedo fault, and Fil Woha fault) where many earthquakes have previously occurred (Kinde, 2002).

⁹ Notably, some of the literature reports the magnitude of earthquakes, while other literature reports the intensity of earthquakes. “Magnitude and Intensity measure different characteristics of earthquakes. Magnitude measures the energy released at the source of the earthquake [and is]... determined from measurements on seismographs. Intensity measures the strength of shaking produced by the earthquake at a certain location. Intensity is determined from effects on people, human structures, and the natural environment” (see - http://earthquake.usgs.gov/learn/topics/mag_vs_int.php).

¹⁰ The Mercalli scale ranks the intensity of earthquakes from 0 to 12 - with 1 the lowest intensity (i.e. “not felt except by a very few”) and 12 the highest intensity (i.e. “damage total...objects thrown into the air”) (see - <http://earthquake.usgs.gov/learn/topics/mercalli.php>).

¹¹ The literature reviewed for this query sometimes reports slightly different distances between the epicentre and Addis Ababa.

¹² See - [http://www.emdat.be/result-country-profile?disgroup=natural&country=eth&period=1900\\$2013](http://www.emdat.be/result-country-profile?disgroup=natural&country=eth&period=1900$2013)

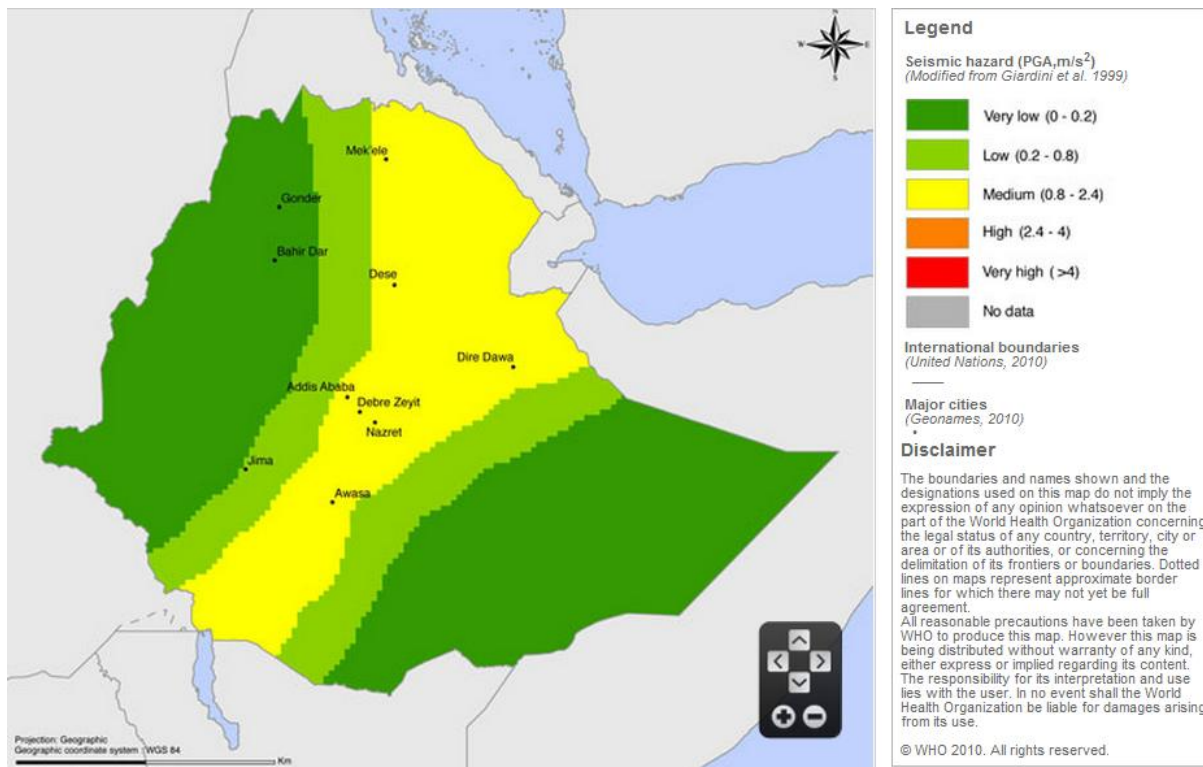
¹³ See - <http://earthquake.usgs.gov/learn/today/index.php?month=3&day=29&submit=View+Date>

¹⁴ See - [http://www.emdat.be/result-disaster-profiles?disgroup=natural&dis_type=Volcano&period=2004\\$2013](http://www.emdat.be/result-disaster-profiles?disgroup=natural&dis_type=Volcano&period=2004$2013)

¹⁵ See - <http://earthquake.usgs.gov/earthquakes/dyfi/events/us/c000275x/us/>

¹⁶ See - http://en.wikipedia.org/wiki/List_of_cities_and_towns_in_Ethiopia

Figure 4: Seismic Distribution Map, Ethiopia



Source: World Health Organization, 2010. (<http://www.who-eatlas.org/africa/countries/ethiopia/ethiopia-seismic-map.html>)

3.4 Volcanic hazard in Ethiopia

There is some volcanic activity in the Great Rift Valley – and many volcanos in Ethiopia (active and extinct). According to the EM-DAT database, from 1900 to 2013 in Ethiopia there were a total of three volcanic eruptions, killing 69 people, and affecting 11,000 people (See Table 1). Notably the damage to human lives is greater than the damage caused by the more frequent earthquakes. No calculation is made of economic damage (ibid). The EM-DAT database does not have information about volcanic activity in Ethiopia’s six neighbours.

Mount Erta Ale has caused frequent lava flows in recent years, and is Ethiopia’s most active volcano.¹⁷ In 2001 the Nabro volcano (located in Eritrea) erupted following a series of earthquakes (including two at magnitude 5.7), with spill-over affects in Ethiopia. Eight villages in the Biddu district of Ethiopia were affected by volcanic ash, affecting at least 5,000 people and polluting water sources.¹⁸ Mount Dabbahu became active in 2005, causing evacuations.¹⁹ Other historically active volcanoes include Alayta, Dalaffilla, Dallol, Dama Ali, Fentale, Kone, Manda Hararo, and Manda-Inakir (ibid).

¹⁷ See, CIA Factbook, 2013 - <https://www.cia.gov/library/publications/the-world-factbook/geos/et.html>

¹⁸ See – <http://www.bbc.co.uk/news/world-africa-13847054>

¹⁹ See, CIA Factbook, 2013 - <https://www.cia.gov/library/publications/the-world-factbook/geos/et.html>

4. Vulnerable populations in Ethiopia

Natural and human-made hazards can create disasters when communities and/or property are vulnerable to losses (Abebe, 2010). There are many factors – physical and socioeconomic in nature – that determine the susceptibility of community to threats of disasters. (Ayele, 2009, p.65). The literature found in the course of this rapid literature review did not identify specific vulnerable groups to seismic risk. However, there is information that quantifies the number of people that could be exposed to seismic hazard (see Table 3), and a subset of literature examines seismic vulnerability in regards to urban populations.

Abebe (2010) notes that almost all actors involved in disaster management in Ethiopia have focussed most on drought disaster management – in recognition of drought being the cause of most deaths, and most economic damage, in Ethiopia, compared to other natural disasters.²⁰ Meanwhile, “little or no attention” has been focused on other types of disasters (p.238).

4.1 Percentage of people exposed to seismic hazard

Table 3 identifies that in Ethiopia, 46 per cent of people have a “medium” exposure to seismic hazard; 20 per cent of the population has a “low” exposure; and 26 per cent has a “very low” exposure. No people are identified as facing a “high” or “very high” exposure. The data source does not disaggregate this data according to geographical region, or other criteria.

Table 3: Seismic Hazard intensity levels and number and percentage of people exposed, Ethiopia

Hazard	Hazard intensity levels and number and percentage of people exposed					
	Very high <i>No. exposed</i> (%)	High <i>No. exposed</i> (%)	Medium <i>No. exposed</i> (%)	Low <i>No. exposed</i> (%)	Very low <i>No. exposed</i> (%)	No data <i>No. exposed</i> (%)
Seismic	0 (0.00%)	0 (0.00 %)	39 035 265 (45.94 %)	20 409 928 (24.02 %)	25 530 413 (30.04 %)	0 (0.00 %)

Source: World Health Organization, 2011.

4.2 Urban populations

Population and economic growth have led to increased urbanisation, and more people are living close to active rift margins in the sub-Saharan Africa region – however there is little awareness or preparedness in regards to potential earthquakes and volcanic hazards (Ayele, 2012). Poor building structures in seismic zones and low risk perception and/or absence of alert systems make the urban public more vulnerable to disasters (IGNOU, 2006 in Abebe, 2010). In Ethiopia, national earthquake resistant regulations exist since 1992, however are often not enforced, leaving communities vulnerable (UNISDR, 1999; Kinde, 2002).

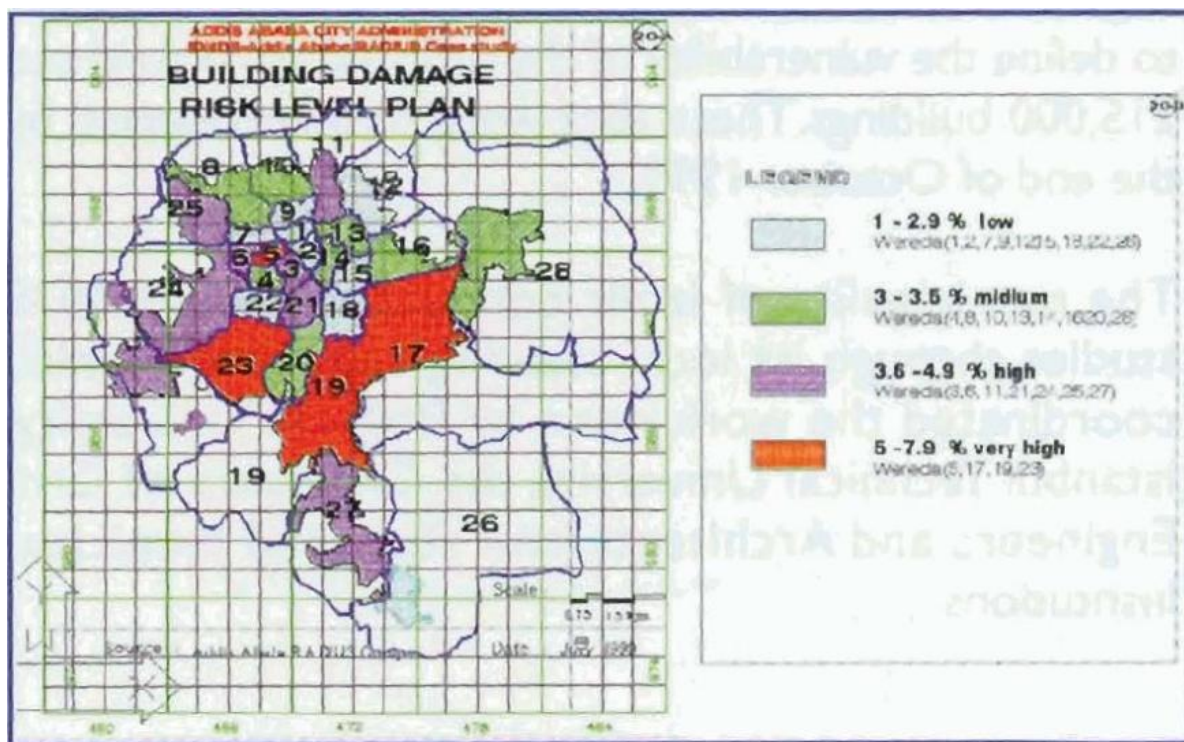
Addis Ababa

The capital Addis Ababa is located 75-100kms from the western edge of the Ethiopian Rift Valley – within the seismic region of the country – and has “moderate seismicity” (Haile, 2004, p.3; Kinde, 2002). In

²⁰ See - [http://www.emdat.be/result-country-profile?disgroup=natural&country=eth&period=1900\\$2013](http://www.emdat.be/result-country-profile?disgroup=natural&country=eth&period=1900$2013)

terms of vulnerability, UNISDR (1999, p.21) identifies that the buildings in Addis Ababa have a high vulnerability as they are made from wood, mud, thatch, and reeds, and are often not built in respect of building regulations. Figure 6 shows a map of risk of building damage in Addis Ababa. The areas coloured red are at “very high” risk of building damage, the areas coloured blue have a “high” risk of building damage; the green coloured areas have a “medium” level of risk, and the white areas are at a “low” risk of damage (UNISDR, 1999, p.23).

Figure 6: Map of risk of building damage in Addis Ababa



Source: UNISDR, 1999, p.23.

5. Suggested websites

Websites that include substantial information about seismic activity in Ethiopia

- Institute of Geophysics Space Science and Astronomy of Addis Ababa University (formerly called the Geophysical Observatory) - <http://www.aau.edu.et/index.php/academics/institutes/institute-of-geophysics-space-science-and-astronomy>
- Ethiopian government department - Disaster Management and Food Security Sector - <http://www.dppc.gov.et/projects/Public/>
- Emergency Events Database EM-DAT - <http://www.emdat.be/>
- World Health Organisation E-Atlas, Ethiopia - <http://www.who-eatlas.org/africa/countries/ethiopia/ethiopia-hazard.html>
- Global Assessment Report on Disaster Risk Reduction 2013 Data Platform: <http://www.preventionweb.net/english/hyogo/gar/2013/en/home/data-platform.html>
- Global Seismic Hazard Assessment Program (GSHAP) (from 1992 to 1999) - <http://www.seismo.ethz.ch/static/GSHAP/>

Websites that include information on seismic activity²¹

- United States Geological Survey (USGS) - <http://www.usgs.gov/>
- International Center of Seismology - <http://www.isc.ac.uk/>
- Volcanic Ash Advisory Center (VAAC) - <http://www.metoffice.gov.uk/aviation/vaac/>
- Disaster Inventories - <http://online.desinventar.org/desinventar/>
- International Airways Volcano Watch (IAVW) - http://www.paris.icao.int/news/20100415_IAVW_ICAO.htm
- MCEER Earthquake Engineering to Extreme Events - http://mceer.buffalo.edu/about_MCEER/default.asp
- Bureau de Recherches Géologiques et Minières (BRGM) - <http://www.brgm.fr/>
- GeoHazards International (GHI) - <http://geohaz.org/>

6. Additional references

- Abebe, M. (2010). Disaster management in Ethiopia: A review of its checkered history, its transformation and some implications for a vibrant disaster management system, 1975–2008. *Journal of Sustainable Development in Africa*. 12(4), 237-254. [http://jsd-africa.com/Jsda/V12No4_Summer2010_B/PDF/Disaster%20Management%20in%20Ethiopia%20\(Abebe\).pdf](http://jsd-africa.com/Jsda/V12No4_Summer2010_B/PDF/Disaster%20Management%20in%20Ethiopia%20(Abebe).pdf)
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- Kinde, S. (2002). *Earthquake Risks in Addis Ababa and other Major Ethiopian Cities - Will the Country be Caught Off-guarded?* MediaETHIOPIA. http://www.mediaethiopia.com/Engineering/EarthquakeHazard_ET.htm

²¹ These websites do not include extensive information on seismic risk in Ethiopia. However, these websites are included in this query to inform potential discussions about organisations that carry out research on seismic risk.

OCHA. (2007). *Earthquake Risk in Africa: Modified Mercalli Scale*. United Nations Office for the Coordination of Humanitarian affairs (OCHA) Regional Office for Central and East Africa. http://www.preventionweb.net/files/7483_OCHAROCEAEarthquakesv2071219.pdf

UNISDR. (2013). *Gar Global Risk Assessment: data, sources and usage*. UNISDR. http://www.preventionweb.net/english/hyogo/gar/2013/en/gar-pdf/Annex_1.pdf

United Nations Office for Disaster Risk Reduction (UNISDR). (1999). *RADIUS: risk assessment tools for diagnosis of urban areas against seismic disasters*. UNISDR. http://www.geohaz.org/news/images/publications/RADIUS_Report

World Health Organization (WHO). (2011). Ethiopia. WHO. <http://www.who-eatlas.org/africa/statstics/ethiopia-stats.pdf>

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Suggested citation

Herbert, S. (2014). *Assessing seismic risk in Ethiopia*. GSDRC Helpdesk Research Report 1087. Birmingham, UK: GSDRC, University of Birmingham.

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