

HORN OF AFRICA: NATURAL HAZARD PROBABILITY AND RISK

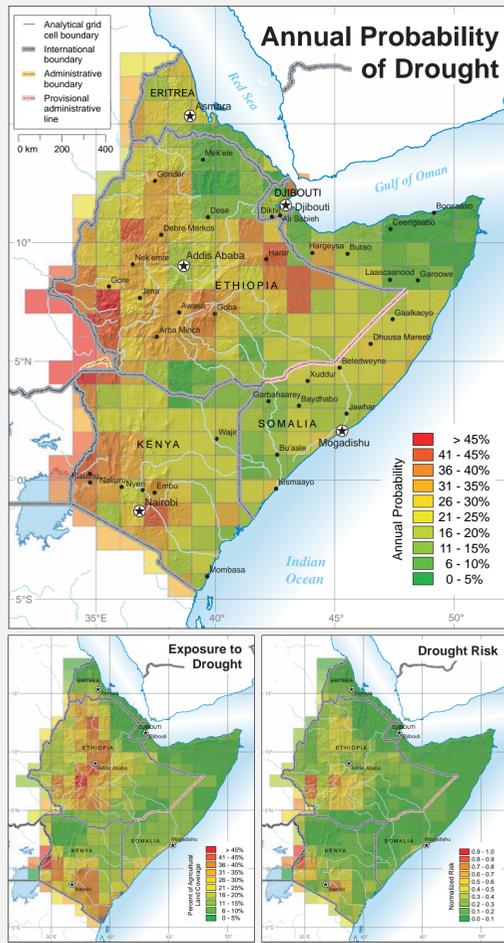
INTRODUCTION:

The Horn of Africa (HOA), composed of Djibouti, Eritrea, Ethiopia, Kenya, and Somalia, suffers frequent natural disasters that commonly result in losses of life, destruction of infrastructure, and reduction of agricultural production. Formulating effective contingencies to respond to such emergencies is constrained by a limited understanding of the likelihood of a natural hazard occurring within a particular region and risks associated with that hazard. Robust early warning systems exist for national response and "hot spot" maps of risk have been produced at a global level; this level of resolution, however, is often not sufficient for sub-national resource distribution. This study presents the probabilities of natural hazards and the risk to populations or agricultural systems within the HOA, calculated on 1° by 1° grid cells. Such an analysis can provide a regional understanding of the probability of natural hazards as well as a more specific local characterization of the associated risks.

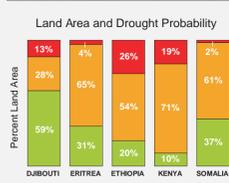
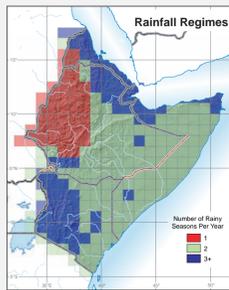
METHODOLOGY:

The probability of one or more hazard events occurring within a grid cell is given by $P(1 \text{ or more events}) = 1 - \exp(-E[N(H)])$, where $E[N(H)] = \lambda(H) * T$. E is the expected number of events within time T given historical rate of occurrence λ . The summation is over all events within a given grid cell. This calculation assumes a Poissonian, or time-independent, distribution of probability. This means that the probability of a future event is independent of the timing and magnitude of the most recent events in the region. The measure of risk $R(H)$ is obtained by combining the probability $P(H)$ of a hazard occurring with the societal exposure $X(H)$, or exposure, to that hazard: $R(H) = \text{Probability of hazard occurring } [P(H)] * \text{Societal exposure to that hazard } [X(H)]$.

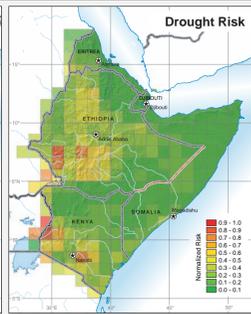
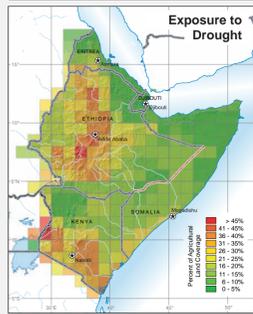
DROUGHT



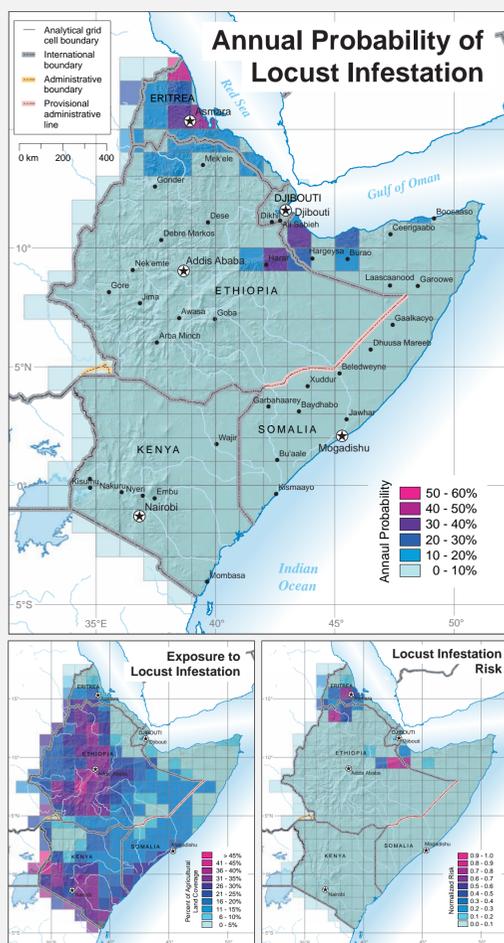
The Horn of Africa is known for frequent and severe droughts. On average, a severe drought may be anticipated once every couple of years during the months that comprise the rainy season(s). Most recently, a two-year drought occurred in an area that covered much of eastern Ethiopia, northeastern Kenya, and southern Somalia. These droughts affect hundreds of thousands of residents and are exacerbated by the extreme poverty and persistent conflict.



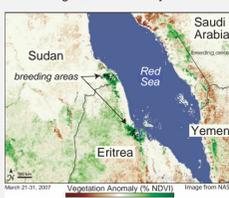
This project uses the Standardized Precipitation Index (SPI) to determine the occurrence of drought within the historical record. The SPI method provides a statistical characterization of anomalous rainfall in the historical data (CSU, 2005; Husak, 2005). Only droughts that occur during the agriculturally important rainy seasons are counted. Rainy seasons were uniquely defined for each grid cell based upon monthly rainfall frequencies over the period of analysis (1986-2006).



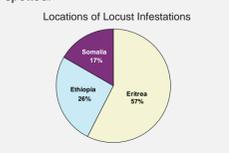
LOCUSTS



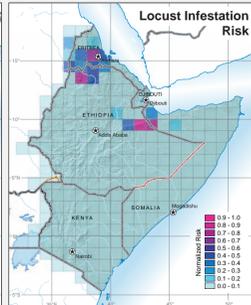
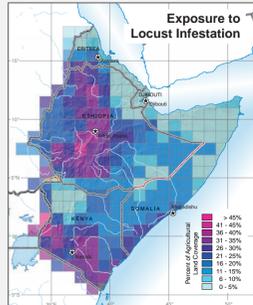
Locust infestations occur periodically and are endemic to a broad band covering northern Africa that extends east to the margins of the Red Sea. A single swarm can cover 1200 square kilometers and can contain between 40 and 80 million locusts per square kilometer. With each insect capable of eating its own body weight in vegetation each day, a swarm that size could consume 192,000 metric tons of vegetation each day.



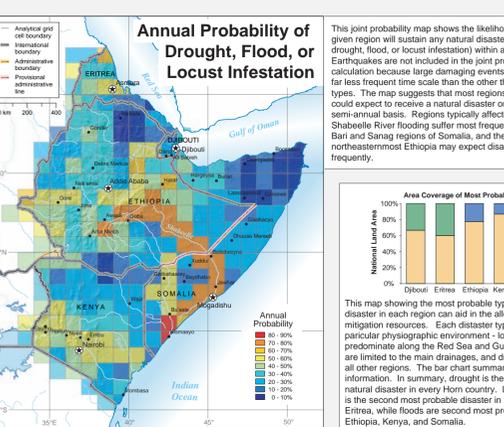
Along the Red Sea coast, the locusts' winter breeding area, swarms develop when rain falls on the sandy soil to initiate the hatching of locust eggs. If plenty of water and vegetation for food exist in the locust breeding areas, a large number of the insects hatch and form swarms. This SPOT satellite image shows in green where vegetation was more thick and lush in March 2007 than the average March in 1999 - 2006. Strips of dark green line the shores of the Red Sea in the same areas where locust swarms were spotted.



This locust risk analysis incorporates data from 1992-2006 on gregarious populations of hoppers and adults compiled by the FAO Locust Control Office. Infestation frequency and probability are aggregated to the corresponding one-degree grid cells. Societal exposure is based upon the intensity of crop and livestock activities in the region.



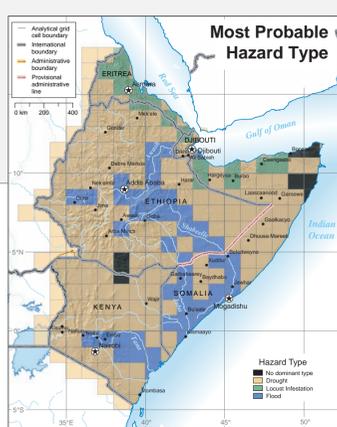
COMBINED



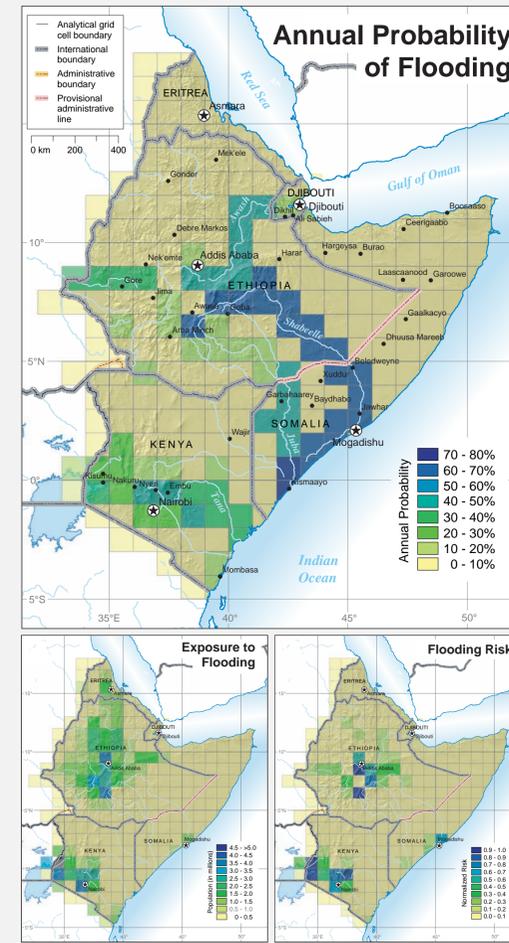
This joint probability map shows the likelihood that a given region will sustain any natural disaster (i.e., drought, flood, or locust infestation) within any given year. Earthquakes are not included in the joint probability calculation because large damaging events occur on a far less frequent time scale than the other three hazard types. The map suggests that most regions of the Horn could expect to receive a natural disaster on an annual to semi-annual basis. Regions typically affected by the Shabelle River flooding suffer most frequently, while the Bari and Sanag regions of Somalia, and the northeasternmost Ethiopia may expect disasters least frequently.



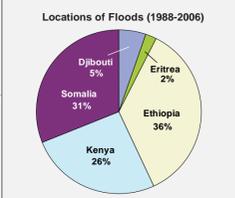
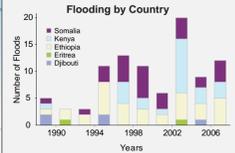
This map showing the most probable type of natural disaster in each region can aid in the allocation of mitigation resources. Each disaster type dominates in a particular physiographic environment - locusts predominate along the Red Sea and Gulf of Aden, floods are limited to the main drainages, and droughts dominate all other regions. The bar chart summarizes the map information. In summary, drought is the most probable natural disaster in every Horn country. Locust infestation is the second most probable disaster in Djibouti and Eritrea, while floods are second most probable in Ethiopia, Kenya, and Somalia.



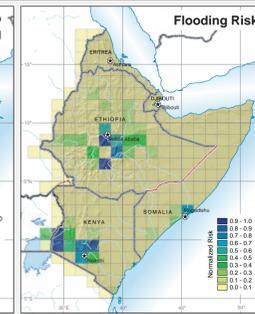
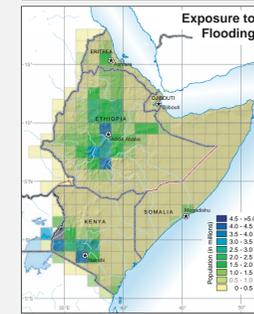
FLOODING



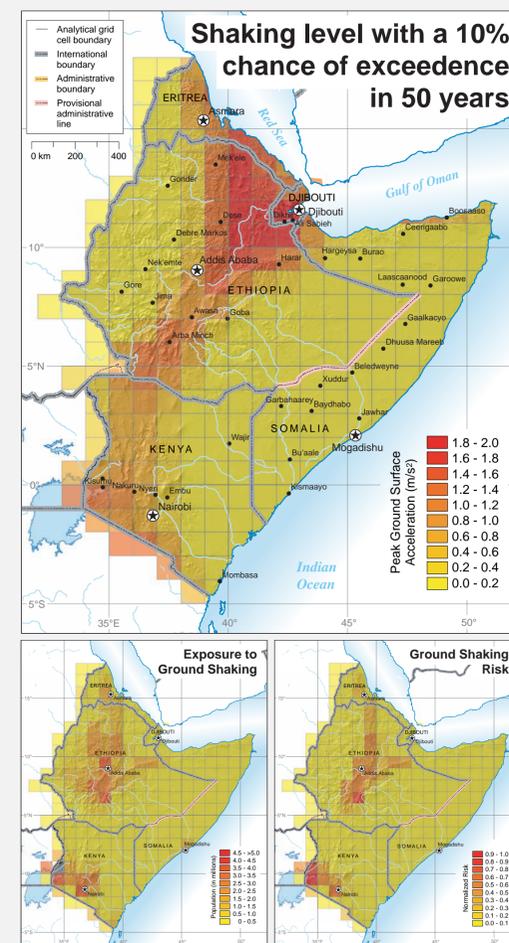
In the period from 1988-2006, the Shabelle (20 floods), Juba (12), Awash (11) and Tana Rivers (9) were the most flood-prone rivers within the Horn of Africa. On average, the Shabelle floods once a year and the Juba and Tana flood once every two years. Worst effects of flooding include human deaths (typically 10s to 100s), displacements (typically 1k to >100k), destroyed homes, submerged agriculture, and waterborne diseases (e.g. malaria, diarrhea, and Rift Valley fever).



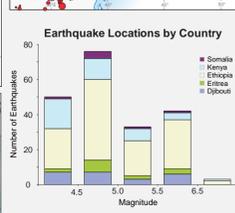
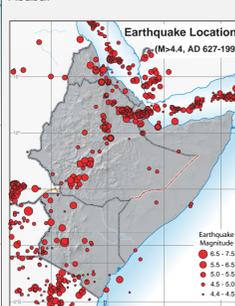
Data from the Dartmouth Flood Observatory is the basis for calculating flood probability. A grid cell is considered to have flooded anytime a river intersecting that cell has flooded. Flooding in the HOA often leads to drowning, disease (cholera, malaria, Rift Valley fever), disrupted transportation and food supply, and infrastructure damage. Heavy rains, however, are often followed by bumper crop yields. The largest recent floods in the region occurred in 2006, 2001, 1998/1997, 1996, and 1988. Population density, derived from the Landsat dataset, is the measure for societal exposure to floods.



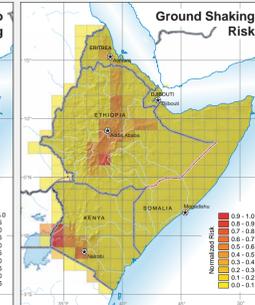
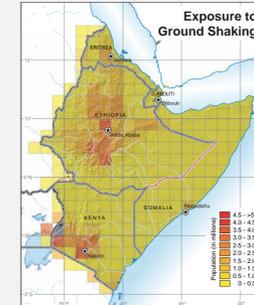
EARTHQUAKES



The Horn of Africa has significant seismic hazard associated with the East African rift system. A number of destructive earthquakes, some deadly, have been reported this century. Notable events include the 1921 earthquake that destroyed the port city of Massawa in Eritrea. In Ethiopia, the 1961 M=6.1 Kara Kore earthquake destroyed the town of Majete, the 1969 M=6.3 Serdo event resulted in four deaths, and the 1989 M=6.5 Dobi graben earthquake destroyed several bridges between Assab and Addis Ababa.



Earthquake location, magnitude, and probability data are taken from the Global Seismic Hazard Assessment Program (GSHAP), which evaluated earthquakes occurring in the period A.D. 627-1994. Shaking levels are shown as peak ground surface acceleration. Accelerations of 1 to 2 m/s² are considered strong to very strong shaking and will produce light to moderate damage. Note that a M > 7 event could produce shaking that far exceeds 2 m/s².



KEY FINDINGS:

- Drought:** Eastern and western Ethiopia and western Kenya are the areas most frequently affected by severe drought, with a greater than 40% annual probability of moderate to severe drought during the rainy seasons.
- Flooding:** On the long-term average, the Shabelle River floods once a year and the Juba, Awash, and Tana Rivers flood once every two years. The densely populated areas along these rivers in Ethiopia, Kenya and Somalia face the highest risk associated with flooding within the HOA.
- Locust Infestation:** Historical infestations are clustered in northern Eritrea and near the conjunction of Somalia, Ethiopia, and Djibouti, and the annual probability in these regions can exceed 30-40%. Over the past 15 years there have been 106 documented infestations, with 57% occurring in Eritrea, 26% in Ethiopia, and 17% in Somalia.
- Seismic Activity:** The largest earthquakes are most likely to occur along the rift regions of Djibouti, southern Eritrea and northeast Ethiopia; however, due to the relative infrequency of large damaging earthquakes in the HOA, the risk from seismic hazard is not an annual concern.
- Combined Hazard:** Calculations of joint probability of drought, flooding, and locust infestation suggest that most regions of the Horn could expect to receive a natural disaster on an annual to semi-annual basis with drought being the most probable over the most land area, followed by flooding.