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Haiti: Spatial Analysis of Vulnerability

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A COUNTRY AT THE EDGE OF DISASTERS

INTRODUCTION: The Caribbean Basin is among the most vulnerable regions to natural hazards and climate change (e.g., Manuel-Navarrete et al. 2007; Ibarrarán et al. 2009; Rossing & Rubin 2010). Haiti has the combined challenges of a severely degraded environment, extreme poverty, limited institutional and governance capacity, and repeated occurrence of natural hazards such as hurricanes, floods, landslides, and earthquakes (e.g., McAdoo & Paravisini-Gebert 2011). However, these challenges are not distributed evenly across the country. Key drivers of deforestation and land degradation in Haiti include the internal demand for charcoal and the cultivation of steep slopes (e.g., Murray 1987; Stevenson 1989). Interactions between socio-economic and natural hazard vulnerabilities need to be better understood spatially in order to support sustainable development efforts aimed at reducing poverty while managing multiple hazard-related risks.

RESEARCH HYPOTHESIS: We hypothesize that vulnerability is greatest among populations that are: living in locations most remote from Haiti's capital city, Port-au-Prince; disadvantaged by limited and difficult access to health care facilities; and living in areas where soils on steep slopes are under cultivation and/or areas that lack vegetation cover.

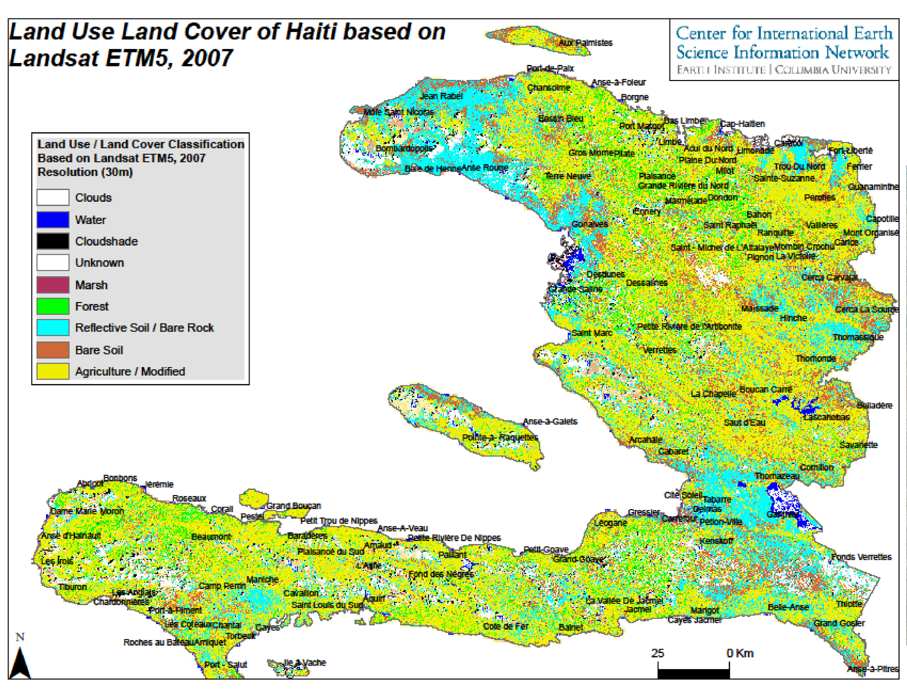

Fig.1: Land use and land cover of Haiti at 30m resolution, based on Landsat image of 2007.

Photo credit: L. Asaf, April 2010

A 2007 land use map was produced using atmospherically corrected Landsat TM images and an isomeans unsupervised classification algorithm in ENVI. Initially 30 classes were generated and combined to create the final 9 classes depicted in Figure 1. Without consistent ground data or country-wide high resolution data, reliable accuracy assessment was not possible; however, validation of the classification layer was performed via comparison with a previously produced land use map by Haiti's Geospatial Center (CNIGS) from 2002. The key classes of interest were areas classified as agriculture, bare soil and reflective soil/bare rock, which were used for proxies of local land degradation.

A centralized government: distance from Port-au-Prince correlates to limited access to formal institutional and governance capacity.

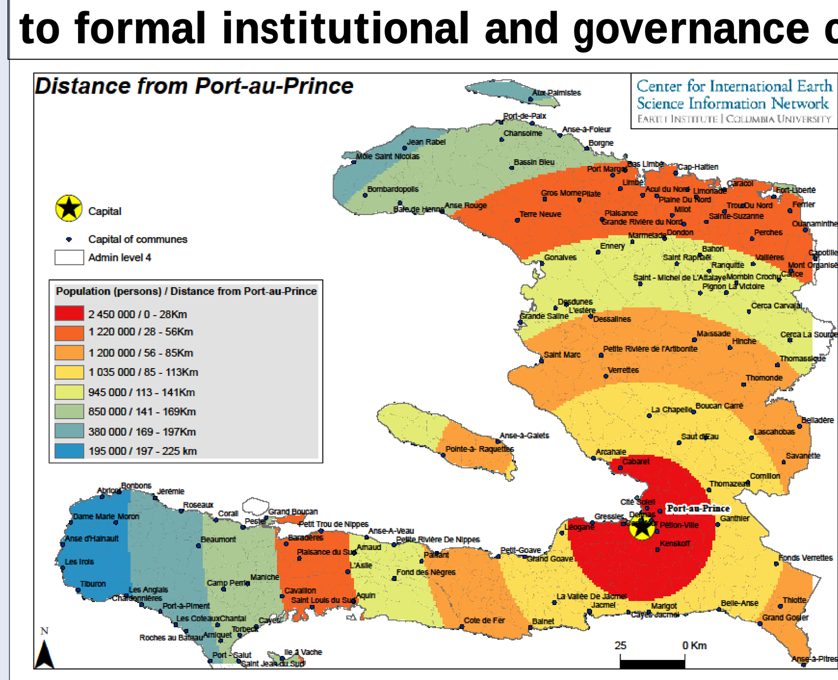

Fig. 2: Euclidian distance from Port-au-Prince and the total population in each buffer. Population data are based on the 2003 Census before the Jan 2010 earthquake. To reflect more the field condition, this map has to be adjusted with the road networks.

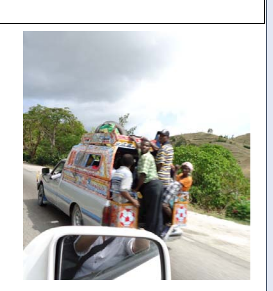

Photo credit: P. Kim-Blanko, Jan 2011

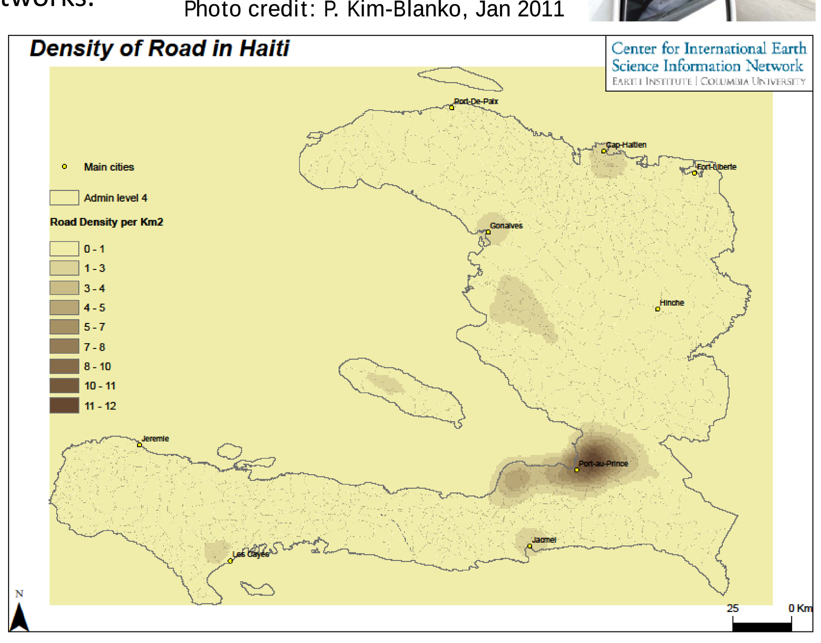

Fig. 3: Density of roads in Haiti based on road network lines. Data is rendered in square km. The differential between the main cities and the rest of country is captivating.

Photo credit: L. Razafindrazay, June 2009

INNOVATIVE APPROACH: SPATIAL ANALYSIS AND REMOTE SENSING

Spatial Analysis involves the combination of overlaying and weighting GIS and remote sensing layers for meaningful analysis of both physical and social variables.

RESEARCH METHODOLOGY: To initiate the development of a spatial database for the integrated analysis of natural hazard and social vulnerability in Haiti, we mapped the following data sets utilizing a combination of remote sensing and geographic information system (GIS) techniques: (1) high-resolution population data from Haiti's 2003 nationwide census to derive population density (people per km^2); (2) the distance of populations from Port-au-Prince, using road network data, as a measure of accessibility to the country's capital city (this measure serves as a proxy for formal institutional and governance capacity); (3) the distance of populations to health care facilities, which serves as a proxy for access to health and emergency services; (4) Landsat TM satellite images for 2007 used to produce a land-use classification map to identify areas most likely to have undergone or to be in the process of land degradation as a result of the cultivation of soils on steep slopes and soil erosion; and (5) a 90-meter Shuttle Radar Topography Mission (SRTM) digital elevation model (DEM) to identify these three land covers on steep slopes of 30% or greater.

Fig. 4: Methodology concept

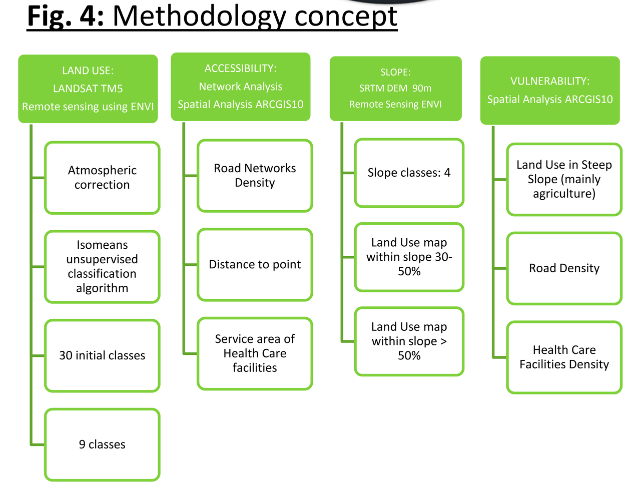

Fig. 5: Detailed steps of data analysis

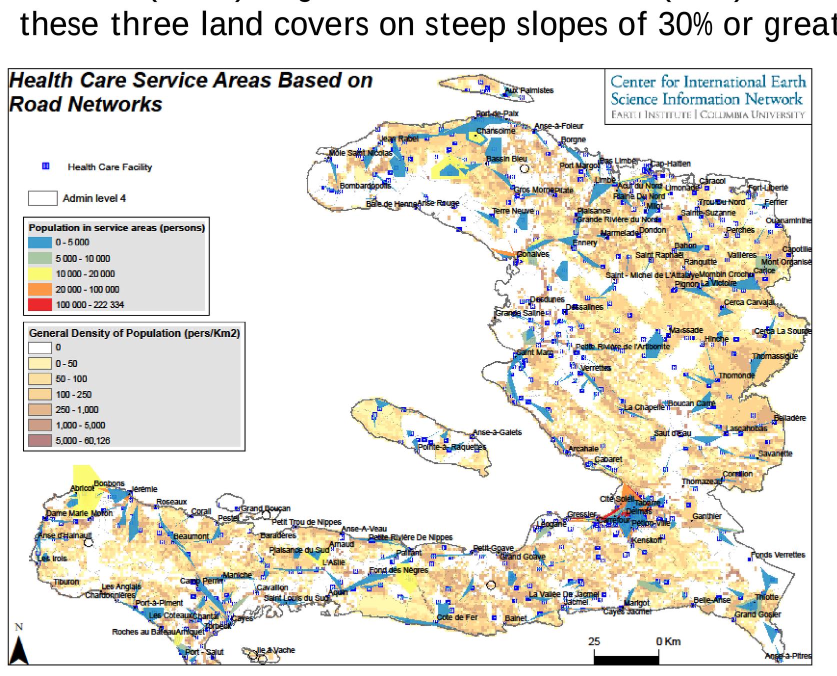

Fig. 6: The area of influence for each health care facility located in Haiti, within a 10km radius. The area is adjusted by the road networks density.

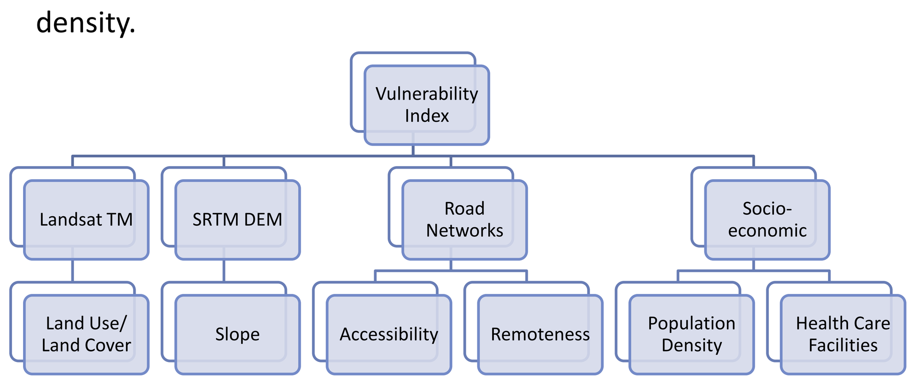

Fig. 7: Analysis workflow

UNEQUAL DISTRIBUTION OF VULNERABILITY

Highly degraded biophysical environment combined with low institutional capacity including health care facilities and roads.

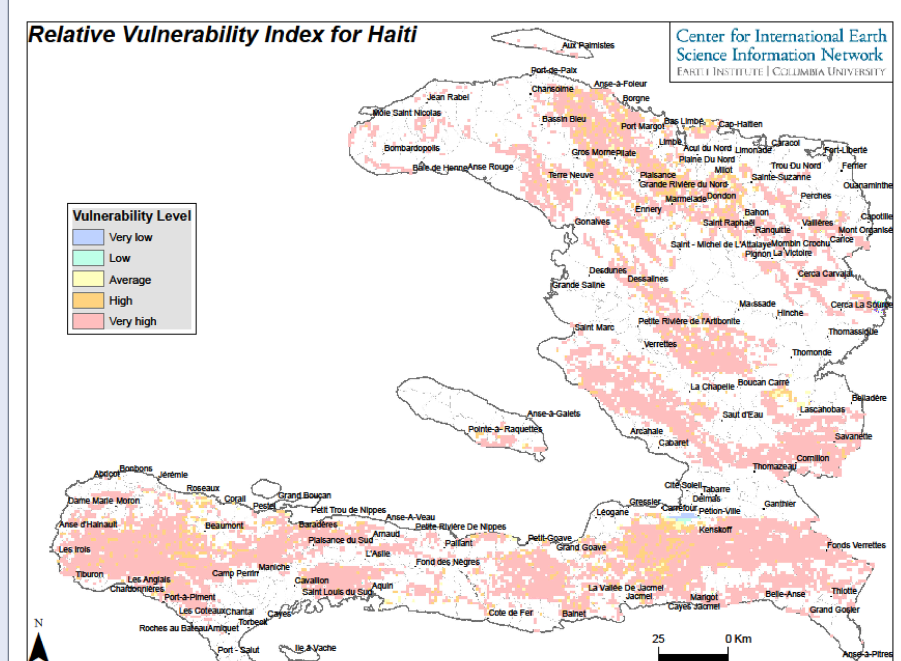

Fig. 8: The "relative" vulnerability here is defined as the result of the combination of agriculture and bare soil on steep slopes (>50%), low density of road network and low density of health care facilities.

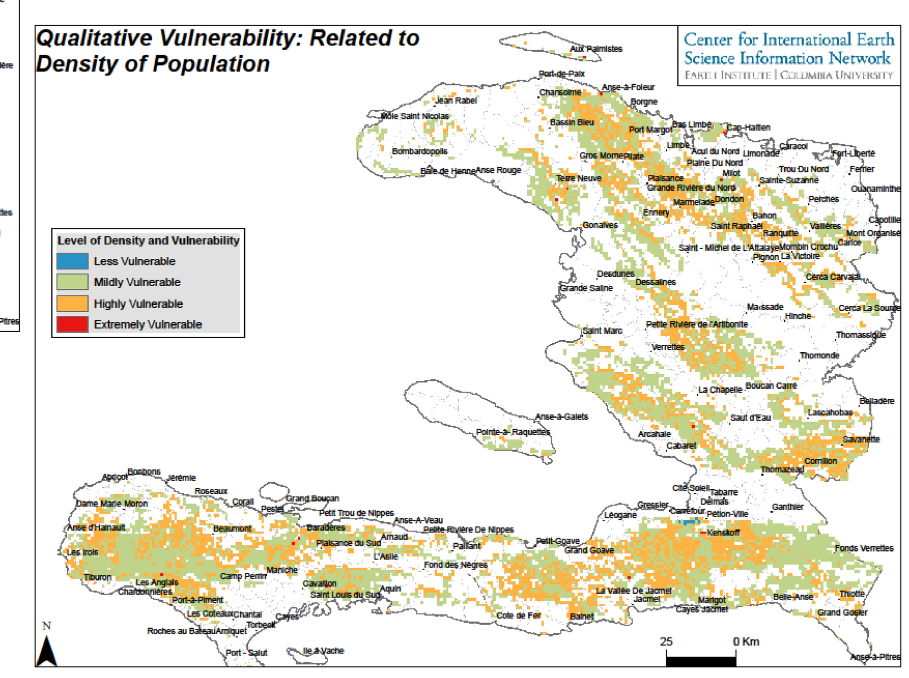

Fig. 9: The "qualitative" vulnerability is a simple combination of the previously presented layers. However, these vulnerability measures are exacerbated by high population density or lessened by low populations.

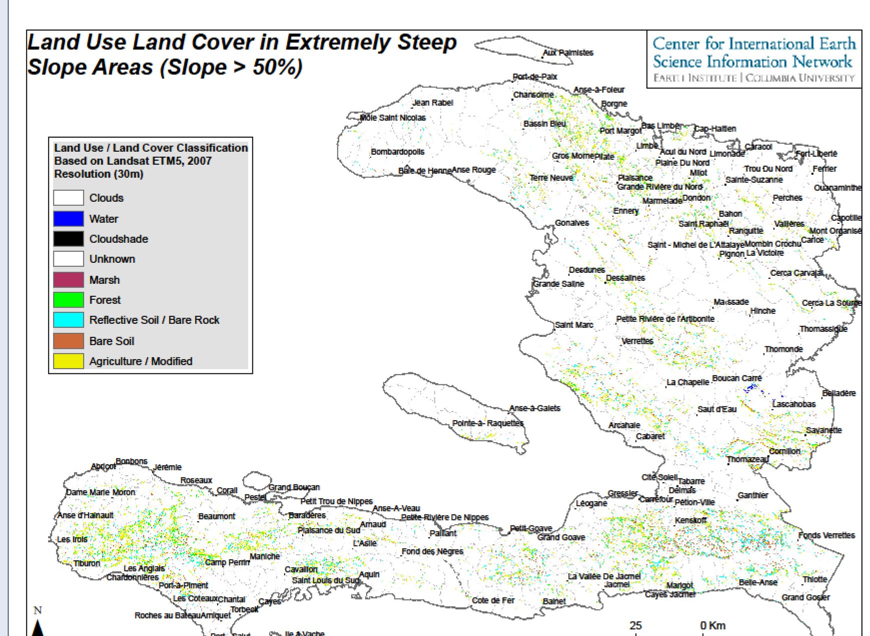

Fig. 10: Land Use on Steep Slopes. One of the central problems in Haiti is land degradation, particularly on steep slopes. For this initial assessment we are assuming that the use of non-sustainable sources of energy such as charcoal accelerates this process, leading to a vicious circle of land degradation and poverty.
The classification map was combined with a 90 meter SRTM DEM in order to highlight these three land covers on steep slopes of 30% or greater.

January 12th, 2010: the deadliest earthquake reinforced Haiti's vulnerability.

In next steps of our research, we would like to combine those layers of vulnerabilities (Fig. 8 and Fig. 9) with where the populations moved after the earthquake (Fig. 11), in order to identify "actual" vulnerability.

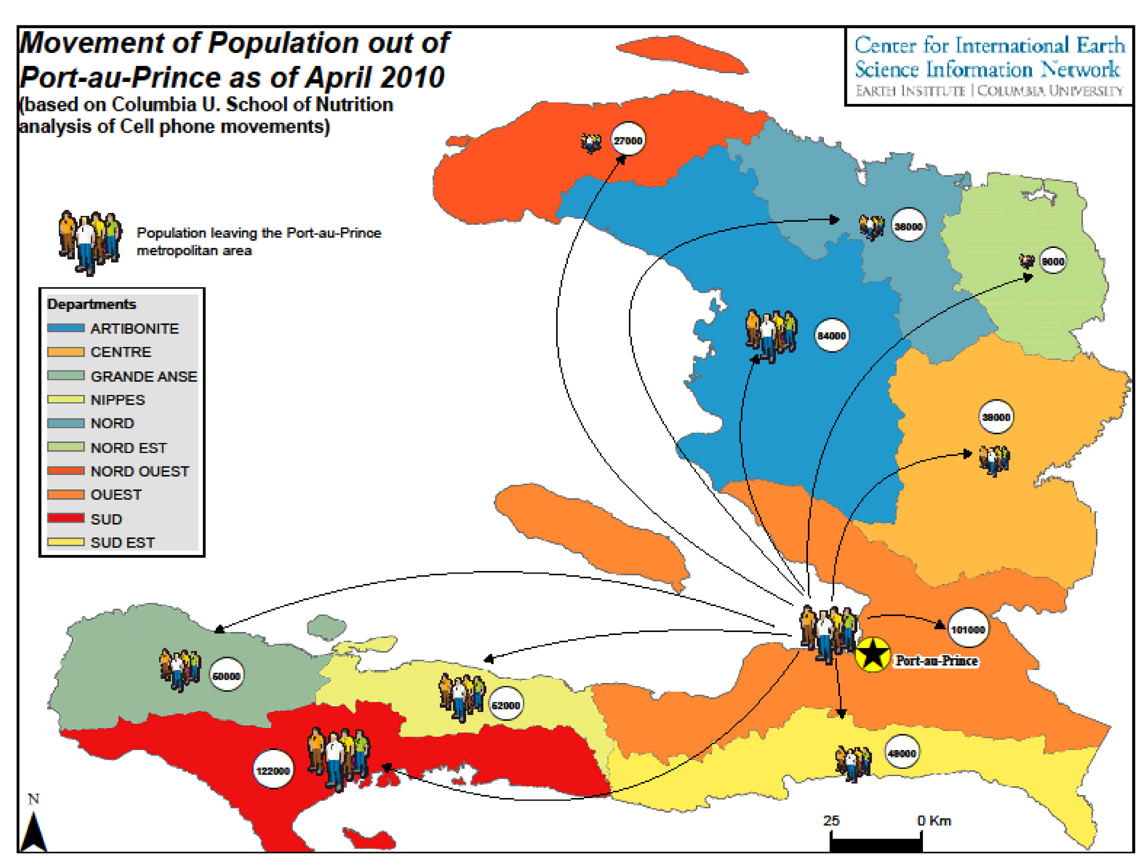

Fig. 11: The Columbia University School of Nutrition (2010) adapted an innovative approach for counting population displacement. Analysis is based on the movement of cell phones right after the earthquake until March 2010.

To attain these objectives, we will build a more detailed database of population displacement after the earthquake at finer resolution, and we will also refine our concept of vulnerability.

Finally, we would like to make recommendations on identifying first the most vulnerable populations and where they are relocated to help decision-makers in the design of any development projects.

DATA SOURCES

Centre National De l'Information Geo-Spatiale (CNIGS), UN OCHA, UN MINUSTAH, Open Street Map (OSM), UNEP, CIESIN, IOM, Columbia University School of Nutrition, DIGICEL

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