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LAUNCH OF THE WHO/EMRO ATLAS OF DISASTER RISK: VOLUME 1 – EXPOSURE TO NATURAL HAZARDS

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Launch of the WHO/EMRO Atlas of Disaster Risk: Volume 1 – Exposure to Natural Hazards

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Abstract

It is extremely difficult if not impossible to predict the occurrence of most natural hazards; in particular their location, magnitude, and potential impact. Because of the potential large scale loss of life, large numbers of casualties and/or widespread displacement of populations that might result from such events, individual, community and government responses to these hazards require resources in excess of those that may be locally available.

While emergencies and disasters remain unpredictable and resources will always be limited, it is possible to take action before an event happens, to plan for its occurrence, and to mitigate its potential effects. In this context, geography, through the use of Geographic Information Systems (GIS), can be used to model the disaster risk for a region and its resident populations and therefore provide appropriate information and maps for decision makers to strengthen their disaster management capacity by:

- advocating for resources to improve emergency preparedness and mitigation,
- aiding in emergency response,
- helping identify, plan and prioritize areas for mitigation activities to minimize the effects of natural hazards, and;
- providing a springboard for additional disaster management and recovery activities.

These capacities are the basis for the development of an Atlas of Disaster Risk that would provide disaster risk estimates for the 22 Member States that constitute the WHO Eastern Mediterranean Region (WHO EMRO). The Atlas will be partitioned into three volumes, each volume presenting a different component of the risk equation. This paper presents the purpose and content of the first volume of the Atlas, entitled Exposure to Natural Hazards, to be launched during the 17th UNRCC-AP Conference. It describes the future development of this work as well as the potential links that could be established with other initiatives or institutions also working on risk reduction initiatives.

Keywords: Natural disaster, WHO/EMRO, Geographic Information System (GIS), Natural hazard, Disaster management

1. Introduction

According to the data gathered by the World Bank (2006), frequency as well as impact of natural disasters in terms of human and economic costs has increased at an alarming rate globally over the past two decades and developing countries have been affected much more than developed countries. From 1984-2003, more than 4.1 billion people were affected by natural disasters. Of this total, 1.6 billion people were affected by natural hazards between 1984–1993 and almost 2.6 billion people between 1994 – 2003, with yearly estimates of up to 200 million peoples. In constant dollars, disasters between the period of 1990-1999 contributed to material losses of US$ 652 billion. In the recent two year period of 2004-2005, over 160 countries were affected by natural and technological disasters resulting in over 350,000 deaths and contributing to losses in excess of US$ 254 billion.

The region defined by WHO as the Eastern Mediterranean Region, which includes three countries in common with the PCGIAP Region (Afghanistan, Iran and Pakistan), has experienced a large proportion of both natural and man-made disasters. War, internal conflict and sparks of violence throughout the region increase the vulnerability of populations. Countries like Afghanistan, Iraq, Sudan, Palestine, and Somalia have previously or are currently experiencing complex humanitarian emergencies (CHEs) (Zwi & Uglade, 1991) described as complex political disasters where the capacity to sustain livelihood and life is threatened primarily by political factors and in particular, by high levels of violence. CHEs are often associated with natural disasters such as the recent drought in the Horn of Africa.

With respect to natural hazards, Yemen, Syrian Arab Republic, Egypt, Lebanon, Somalia, Iran and Pakistan have experienced floods, droughts, earthquakes, and landslides. The recent earthquakes in Iran and Pakistan affected large numbers of people and caused significant material losses. The 2005 earthquake (magnitude 7.6 on the Richter scale) struck parts of northern Pakistan, India and Afghanistan, affecting an area of more than 28'000 square kilometers. The impact of the quake according to federal government of Pakistan reports indicated more than 73'000 dead, about 70'000 seriously injured and another 59'000 with minor injuries. An estimated three million people were also rendered homeless, most of who already lived in remote, difficult-to-access areas. Reports also indicated significant damage to the health infrastructure, with some locations reporting that 80% of the health facilities were not functional. A detailed assessment of the health situation, including a review of structural damage to health facilities, has shown that some 320 health institutions were destroyed, 44 were partially damaged and 171 remained functional.

In addition to the direct impact on health, disasters indirectly affect the health status of a population through increased vulnerability to adverse health effects caused by the destruction of livelihoods, homes, businesses and infrastructure. Recovery from a disaster (for an individual, family, community, business or government) often requires the use of resources originally intended for health-related activities, further increasing the vulnerability of a population.

Among the different actions that can be taken in order to reduce the health impact of disasters, it is recognized that mitigation and preparedness activities coupled with effective disaster management practices and planning are the most effective. Activities essential for effective disaster mitigation and planning include (Noji, 1997):

- Mapping specific potential disaster locations,
- Pinpointing potential disaster-associated risks,
- Conducting a vulnerability analysis,
- Developing an inventory of existing disaster response capacities and resources,
- Planning and implementing appropriate preventive, preparedness, and mitigation measures, and;
- Conducting education, awareness raising and training of health personnel and the community to better respond to disasters if and when they occur.

All of these activities require the capability to integrate large amounts of data and information from disparate sources and the capacity to perform complex spatial analysis. In this context, geography and Geographic Information Systems (GIS) can provide the necessary platform for the integration of these different data, their analysis and the development of models aiming at assessing the impact of some natural disaster events on the health of vulnerable populations.

Globally, there are two projects that have already used GIS and associated mapping techniques to assess natural hazard risks:

- The work conducted by the UN Development Programme (UNDP) in partnership with UNEP-GRID (UNDP, 2004 and Pelling, 2004) that looked at quantifying disaster risk through the development of a Disaster Risk Index (DRI). This project provides country level information regarding physical exposure and relative vulnerability to earthquakes, tropical cyclones, flooding, volcanoes, landslides and drought risks.
- The Natural Disaster Hotspots (NDH) project implemented by Columbia University and the World Bank under the umbrella of the ProVention Consortium (The World Bank, 2005). This project assesses the risks of two disaster related outcomes: mortality and economic losses. The level of risk for six natural hazards (earthquakes, volcanoes, landslides, floods, drought, and cyclones) is mapped with a resolution of 2.5 minutes (equivalent to five kilometres at the equator) through the combination of hazard exposure with historical vulnerability for two indicators: population and the Gross Domestic Product (GDP). By using sub-national grid cells rather than country level data this work is the first attempt to globally look at risk at the sub national level.

It is also important to reference some local studies which took place within the WHO/EMRO region mainly in connection with landslide and floods (Kelarestaghi, 2003; Esmali & Ahmadi, 2003; Tangestani, 2003; Al-Rawas et al, 2001).

If the data produced through the NDH project represents a starting point for assessing natural disaster risk in the WHO/EMRO countries, some limitations have been identified regarding their potential use for prioritizing mitigation and preparedness activities. These limitations include the fact that the granularity at which the maps have been produced might not be detailed enough and that some important factors have not been taken into account when modelling the distribution of the hazard.

The Emergency Preparedness & Humanitarian Action Unit (EHA) of WHO/EMRO therefore decided to embark on a research oriented project that would allow the creation of a new set of maps presenting the distribution of the risks for five hazards (floods, heat, earthquakes, wind speed and landslides) at a resolution of one square kilometre with the objective of better understanding the health impact and vulnerabilities to such events.
In order to achieve the above objective and considering the formula developed by UNDRO (1991):

$$Risk = Hazard * Element\ at\ Risk * Vulnerability$$

it was determined that three specific components needed to be mapped for the WHO/EMRO region:

- The distribution of each hazard,
- The distribution of the population (the element at risk), and,
- The distribution of its vulnerability.

The following section describes the content of the first volume of this Atlas. Entitled "Exposure to Natural Hazards" its primary objective is to illustrate and quantify the distribution and population exposure to the five selected natural hazards.

2. Content of the first volume of the Atlas

The first volume of the Atlas contains:

- the data and documents that have been compiled and/or created in order to generate the distribution of the five selected natural hazards,
- the resulting maps in pdf (country level) and GIS (regional level) format; and,
- links to other information of interest regarding natural disaster risk assessment (web sites, reports, etc).

The data set generated covers the 22 countries of WHO EM region at a scale of 1:1'000'000 for the vector layers and a resolution of one kilometre for the raster layers. Because of the redistribution rights attached to some of the data sets used in this volume of the Atlas, only the publicly available data, like the soil type distribution map (Figure 1), are included.

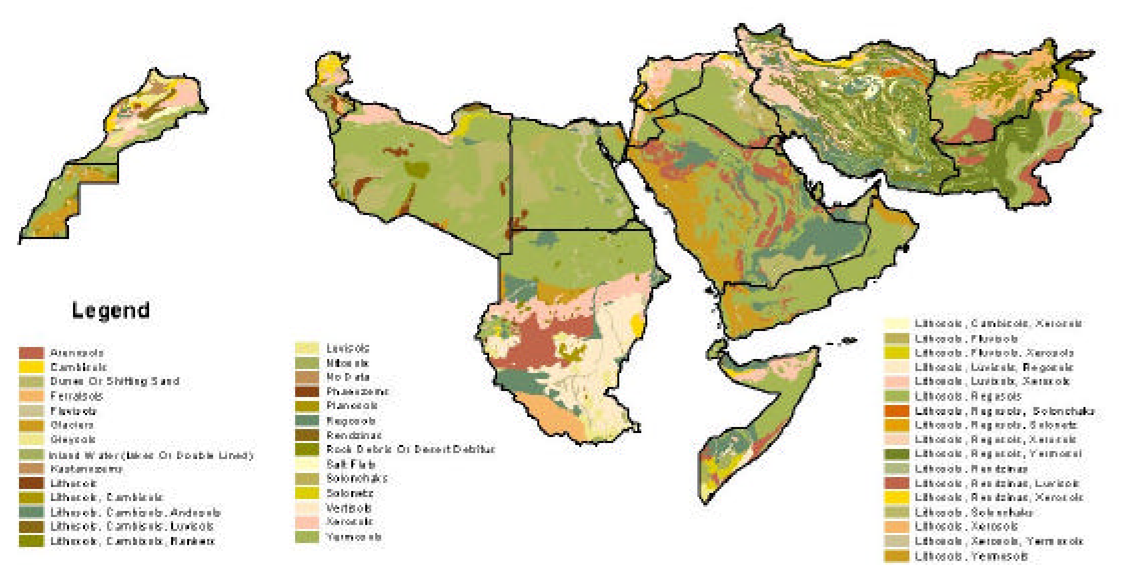

Figure 1 - Soil Types of the WHO EM region

The protocol which has been applied in order to homogenise the above mention data set is part of the documentation included in the Atlas. Additionally, a second set of protocols describing the models and their application for spatializing the distribution of the five hazards (El Morjani et al, under preparation) is also available.

As the complete description of these models as well as the result of the literature review that led to the selection of the different factors taken into account are beyond the scope of this present paper only limited information is reported here.

<u>Floods</u>

By crossing the flood frequency distribution map coming from Global Active Archive of Large Flood Events at the Dartmouth Flood Observatory with the distribution of each of the identified causal flood factor maps (land cover, elevation, soil type, geology, distance from the flow accumulation, and annual daily maximum precipitation) a weighted score for each of the factors can be calculated These scores are then combined as a Flood Hazard Index (FHI) in order to generate the flood hazard distribution maps.

Landslides

A multi-criteria analysis (MCA) is performed to classify areas by their susceptibility to landslides based on standardized, reclassified, and weighted causal factors (slope, relative elevation, annual daily maximum precipitation, land cover, distance from roads, distance from fault, distance from drainage networks and soil texture).

Heat Index and Windstorm

The methodology used to spatialise these hazards is based on the Gumbel frequency analysis technique. This technique estimates the maximum heat index and the wind speed for different return periods for each weather station. Once the estimates are calculated, they are amalgamated using multiple regression modelling to produce an interpolation for the entire WHO EM region. Three maps are created in order to assess potential hazards over a two, five, and ten year return period.

Earthquake

The hazard distribution maps for earthquakes are developed using the same methodology as the Hotspots project. Data on earthquake probability of occurrence is accessed from the Global Seismic Hazard Program (GSHAP). The resulting Global Seismic Hazard Map is compiled by joining the regional maps produced for different GSHAP regions and test areas. The map depicts the global seismic hazard as peak ground acceleration (PGA) with a ten percent chance of exceedance in 50 years, corresponding to a return period of 475 years.

In a final phase, the reclassified hazard distribution maps are combined in order to create multi hazard distribution maps allowing the identification of specific hotspots within the region.

The GIS data set resulting from the application of these models as well as country specific maps in pdf format form the next element of the Atlas. The following figures present two examples of this data set for Iran, the reclassified distribution of the landslide hazard (Figure 2) and the heat index for a return period of five years (Figure 3).

To make the information presented in the hazard exposure maps more actionable, links to supplemental material linked to other disaster management activities are provided to the users. This is for example the case of the publications made organization working in this field such as the International Strategy for Disaster Reduction (ISDR).
Besides providing users with additional disaster management information, these supplemental materials also help connect the Atlas to the larger body of disaster management knowledge that has been developed.

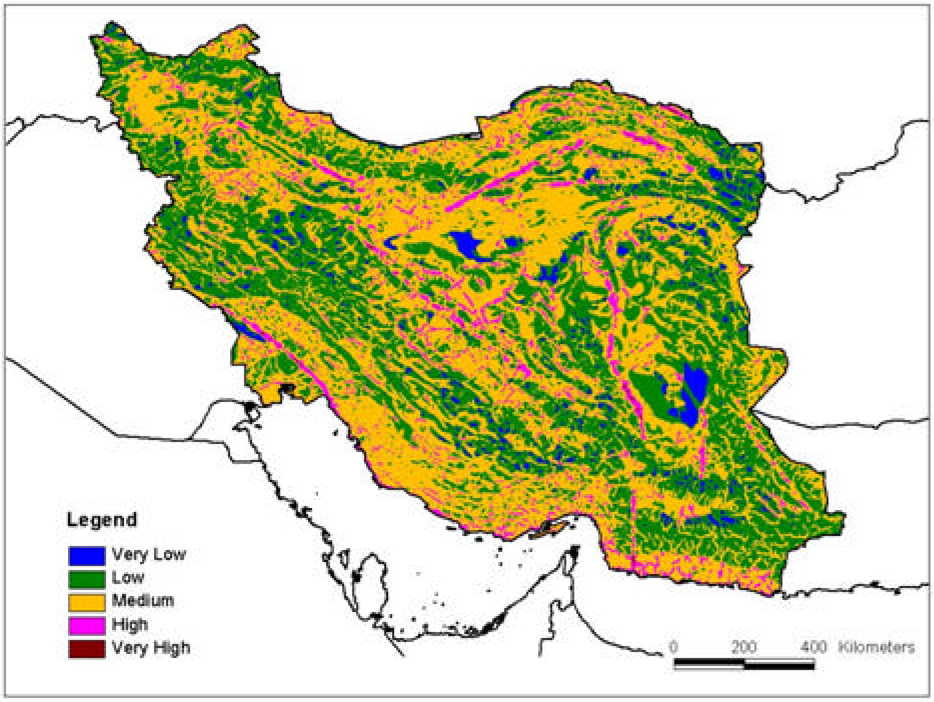

Figure 2 - reclassified distribution of the landslide hazard for Iran

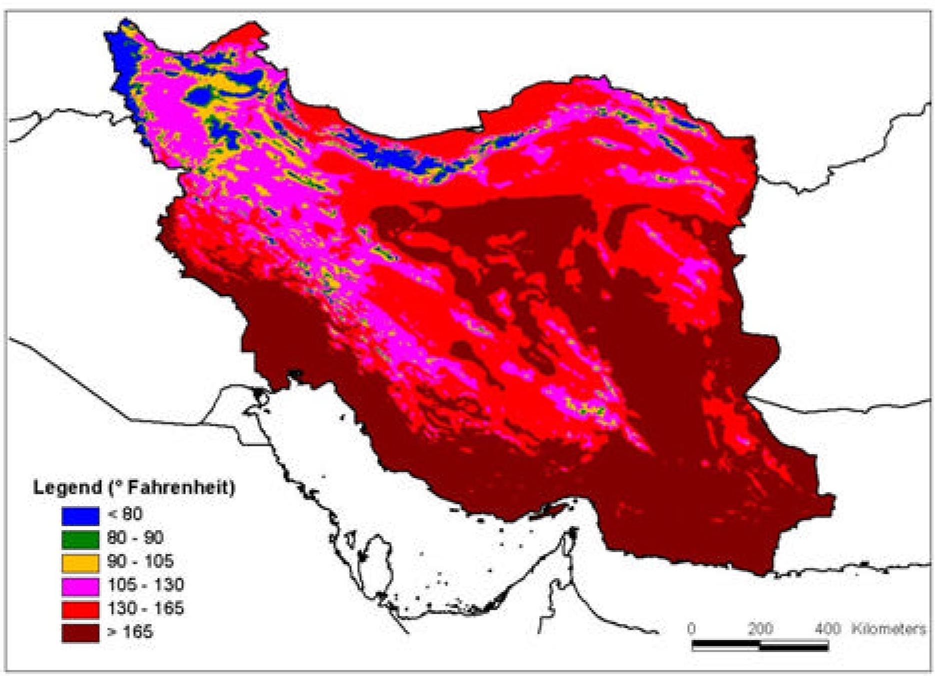

Figure 3 - reclassified distribution of the heat index for Iran (5 year return period)

3. Future steps

This volume of the Atlas represents the first piece of a process which will lead to the spatialization of risk factors for the WHO EM region. In order to reach this stage it is also necessary to have access to the spatial distribution of the two other elements reported in the UNDO (1991) formula: population and vulnerability.

Although the distribution of the population may already exist, for example the Landscan [1] and the Gridded Population of the World (GPW) [2] initiatives, this does not result in the understanding of its vulnerability.

Vulnerability can be defined in terms of location, socioeconomic status, and demography. The socio-cultural aspects of the population which include social networks and political environment are considered equally important determinants when defining true vulnerability [3].

In order to decide how vulnerability will be mapped, a review will have to take place. Some indicators to be considered include:

- the various socio-economic factors that affect the vulnerability of a population's health status to natural hazards (this could include wealth, baseline health status, education, etc.);
- accessibility to the different infrastructures which can help decrease a population's vulnerability to hazards (health facilities, schools, etc.); and,
- proximity to infrastructures that can make them more vulnerable to hazards (chemical plants, nuclear power plants, pipelines, etc.).

This review as well as the maps that will result from the selection of the indicators will form the content of the second volume of the Atlas.

Having obtained the spatial distribution of both the hazards and the population's vulnerability in the first two volumes, the third volume of the Atlas will focus on population risks. Using the new set of maps, it will be possible to map the health-related effects (mortality, morbidity, and displacement) of these risks to the various hazards. This third and final volume of the Atlas will also include a discussion on the notion of risk and how it can be calculated. A review of risk reduction strategies at different stages across the disaster management continuum will complete its content.

In order for the results of this work to be useful for decision making at the sub national level it is important that different figures (e.g. percentage of population at risk, population coverage, etc.) can be aggregated according to the administrative structures of each country. Unfortunately the availability of validated GIS format administrative boundaries is currently limited for the WHO/EM region. However, resources have provided under the Second Administrative Level Boundaries data set project (SALB) [4] in order to complete and/or update the data set for this region.

The challenge to create a clear and composite illustration of vulnerability at local and national levels for the purposes of planning and response is to bring together available data generated from different sectors. Although mapping the distribution of natural hazards is not directly part of WHO's mandate, efforts will be made to link this work with the initiatives already developed or under development by other UN Agencies in order to ensure a continued focus on the health layer and to avoid duplication of work.

In follow-up to the roundtable organized last year with the UN Environmental Programme (UNEP) and the International Strategy for Disaster Reduction (ISDR), the priority is to link with other institutions that have already embarked on the process of vulnerability mapping, such as the World Food Program (WFP) and the Food and Agriculture Organization (FAO). The first volume of the Atlas will therefore be shared with these potential partners to see if a collaborative process bringing the different initiatives under a unique umbrella is feasible. This discussion should also look at the provision of capacity building resources to interested countries in order for the countries to continue the development of these initiatives from a local perspective, which could ultimately influence national policy and planning through the establishment of national databases to be run by experts.

Within WHO, it is expected that the work performed for the WHO/EM region may also interest other regions where natural disaster hazards have also had significant impacts on the population.

4. Discussion and Conclusion

Although the Atlas provides access to maps containing the distribution for five natural hazards over a surface as large as the WHO/EM region at a resolution that has never been reached before, it remains important to remember that the maps were established using modelling techniques and that the results must be verified locally.

In developing the different layers necessary for the creation of the first volume of the Atlas and through the homogenisation process, the following observations were made:

- using satellite images as a ground reference confirmed that both the river and road network data available at the time of this work included some significant gaps and imprecision;
- some of the global datasets used did not cover some of the small islands that exist within the WHO/EM region;
- the data sets that have been used originate from different sources which creates some interoperability problems between the layers under the form of shifts;
- historical meteorological data were not available for several countries (Afghanistan, Iraq and Somalia) which reduces the reliability of the resulting distribution maps which were developed using interpolation methods;
- one kilometre resolution elevation data could mask very crucial elevation changes in the topography of an area. This is especially true when trying to delineate landslide and flood hazards. For landslide, slopes calculated at one kilometre resolution can mask very steep (extremely hazardous) areas. For floods, an elevation difference of a few meters can greatly influence the magnitude of inundation;
- to accurately model the distribution of flood hazard it would have been necessary to use stream flow data coupled with elevation, channel profiles, lithology properties and detailed precipitation.

All of these issues could potentially be solved through the use of other datasets that are publicly available such as the SRTM90 dataset [5] which would give access to a 90 meters resolution Digital Elevation Model (DEM) or through data available at the country-level.

Access to more complete and more accurate data would definitively increase the level of confidence that we could have on the results but no evidence is available regarding the pertinence of generating hazard distribution maps at a resolution below 1one kilometre. This reflexion can also be applied to the population distribution grids that might not make much sense below this resolution.

Despite these limitations, the first volume of this Atlas already provides a tool for GIS practitioners to refine their analytical capabilities while at the same time allowing users to create more specific, meaningful local analyses by using their own data. It also provides a new source of information for decision makers that are working on emergency preparedness and mitigation. In this regard, and in order to be effective, the development of the future volumes of the Atlas must continue to provide actionable information to personnel at the national level and below.

In addition, by launching this Atlas publicly and by sharing the sources of publicly available data as well as the description of the model used, WHO clearly demonstrates its willingness to contribute and collaborate with the other existing efforts aimed at helping countries to be better prepared for natural disasters and to ultimately reduce the number of lives lost and damage to the health infrastructure.

The task of reducing hazard risks remains substantial and it is hoped that this Atlas will help in establishing an active network of collaborators to facilitate knowledge and data sharing between international organisations, UN agencies, national authorities, nongovernmental organizations, and other stakeholders in order to improve the already existing methods and datasets and to develop an integrated approach to planning and implementing future disaster mitigation and preparedness activities including improved resource mobilization processes.

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