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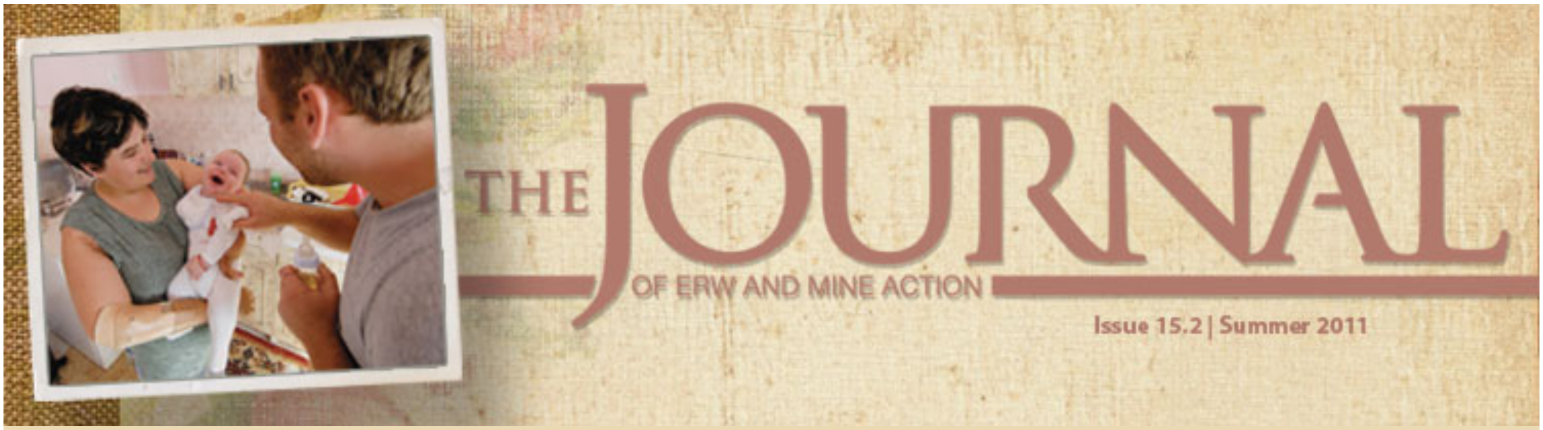
Pierre Lacroix
University of Geneva

Jonas Herzog
Geneva International Centre for Humanitarian Demining (GICHD)

Daniel Eriksson
Geneva International Centre for Humanitarian Demining (GICHD)



Mapping Populations at Risk of ERW

by Pierre Lacroix [University of Geneva] and Jonas Herzog and Daniel Eriksson [GICHD]

Having precise, available data on recorded explosive remnants of war hazards does not necessarily represent the big picture concerning the contamination distribution in a country. However, when available datasets are evaluated with population-density data, heavy concentrations of ERW hazards are more easily detectable. This article examines a few of the many tasks that can be achieved by analyzing ERW hazard data and by combining it with other information.

The Geneva International Centre for Humanitarian Demining is collaborating with the University of Geneva to explore the feasibility of creating worldwide visualizations of the density of ERW contamination, such as anti-personnel landmines and cluster munitions. Using ERW hazard data collected with the Information Management System for Mine Action and other relevant data, the Server for Explosive Remnants of War Information Systems project helps visualize large-scale contamination.

Objectives

This paper's primary objective is to explore the feasibility of visualizing at-risk populations through maps that combine ERW hazards and population data. The interpretation of the SERWIS maps can highlight the highest densities of ERW hazards in populated areas. This also allows further tests and analyses to help determine the impacts of hazards on the population. Throughout this paper, we used the following formula: *Population at risk of ERW = Presence of population x Presence of hazards*. We applied this method to data from Afghanistan provided by the Mine Action Coordination Centre of Afghanistan. However, the project is potentially open to all countries that desire to share their information with the mine-action community.

Estimating the Population Density

Population data can be found in the form of global datasets, such as the LandScan™ global population database and the Gridded Population of the World.[1,2]

LandScan Global Population Database. The LandScan global population data is a common dataset used by numerous governmental and nongovernmental organizations. Based on remote-sensing data, it is regarded as the most accurate and reliable population-distribution model. Various other data are included to estimate the population density, such as information about population movement, census counts, land cover, infrastructure, terrain, etc. LandScan population data is available for the entire world as a grid with a resolution of 1 kilometer, where each pixel represents one kilometer and every cell has a value for the estimated population.

The Gridded Population of the World. The GPW dataset is based on census data and provides population data on a

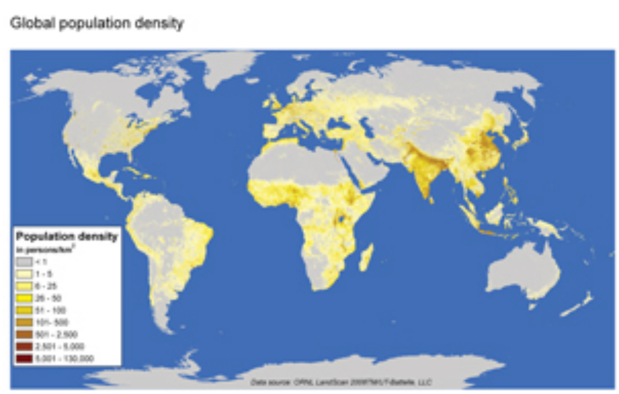


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Figure 1. The LandScan global population dataset.
All graphics courtesy of the authors.

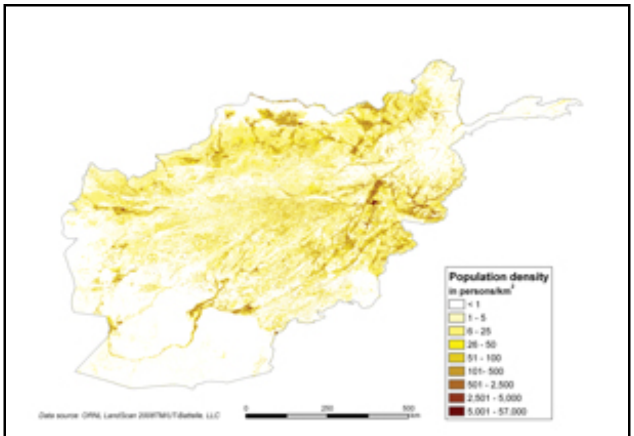

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Figure 2. LandScan population dataset for Afghanistan.

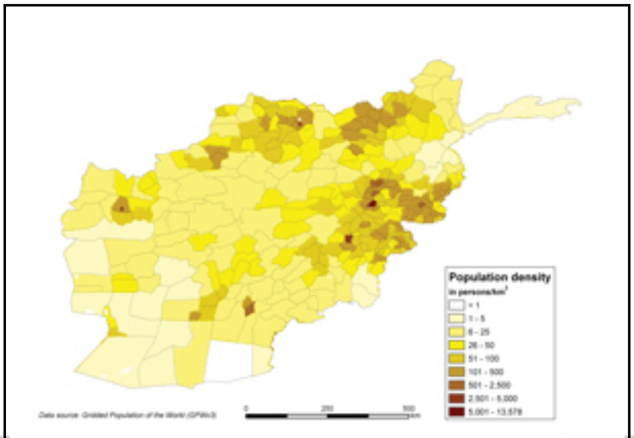

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Figure 3. GPW population density in Afghanistan

global level. It is calculated based on two inputs: administrative boundary data and population estimates associated with those administrative units. Grid cells are assigned a portion of the total population for the administrative unit they fall within, dependent on the proportion of the area of the administrative unit that the grid cell takes up. This allows transforming administrative boundary data from their native units into raster cells, the smallest unit of measurement within raster data, which is a means of representing spatial data. As a consequence of this, the precision of the dataset depends heavily on the availability of data at a high level of precision. This means that countries with many small administrative units (such as municipalities) have more accurate data than those with few high level units (such as regions).

As an example, Afghanistan has an area of more than 600,000 square kilometers (231,661 square miles) and is divided into 328 administrative units at the second level (called districts). These districts have an average area of almost 2,000 sq. km. (772 sq. mi.) and an estimated 65,000 inhabitants. The population density is shown in Figure 3.

Where there is no data available for a given year, the values are estimated by alternate known values from previous years. Using these inputs, estimates for years between 1990 and 2015 were made for all countries. The last edition (v3) of GPW was developed between 2003 and 2005. For each country, the population estimates for the available years were produced based on the 2000 census.

Unlike LandScan, GPW does not aim at modeling time-of-day distribution by analyzing various factors (e.g., land cover, elevation and satellite imagery), but it indicates a residential picture of the population over a five- to 10-year period.

LandScan and GPW Compared. The LandScan and GPWv3 datasets are among the most widely used datasets for representing population data worldwide. Both have their advantages and disadvantages as illustrated in Table 1.

Both datasets are complementary: In GPW, each administrative unit is assigned the same value of population, while LandScan will help at a higher resolution (down to 1 km.). Moreover, LandScan represents a daily average population count while GPW indicates a residential picture of population over a five- to 10-year period.

Estimating the ERW Hazard Density

With large amounts of information on recorded AP landmines and other ERW, a way to visualize the respective densities was needed.

In Figure 4, the map becomes unreadable with an increasing amount of data. In some areas, an excess of records renders the map unreadable due to record overlap.

Using spatial statistics, estimating contamination densities by conducting a Kernel Density Estimation in ArcGIS™ is possible.[3] The principle of this tool is that for each cell, a density value is calculated that depends on the number of points and their proximity to one another. The closer the points are to one another, the higher the values. Additionally, each point is weighted with a value according to the hazard area. If they are more distant than a pre-defined radius (also called Kernel size or bandwidth), they are not taken into account at all. The values are then colored from yellow

Characteristics	LandScan	GPW
Version	Very recent data available (from 2008)	Data from 1990 to 2015, a new update will be available in early 2012
Update frequency	Data is updated annually	Datasets for every 5 years
Availability	Available online for free for educational purpose and United Nations Humanitarian efforts	Available online for free
Format	Available as ESRI GRID	Available in three different formats (ASCII, BIL and ESRI GRID)
Source	The data are aggregated from many different sources and information	The precision and the reliability of the data depends on the administrative units and on the authorities that make the census
Resolution	High (30 arc seconds, approximately 1 km)	Depending on the administrative units, but generally lower (2.5 arc minutes, approximately 5 km)
Extent	All contaminated countries are covered	All contaminated countries are covered

Table 1: Comparison of LandScan and GPW.

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Figure 4. Point data for Afghanistan. Every marker represents a hazard (point or center of a polygon).

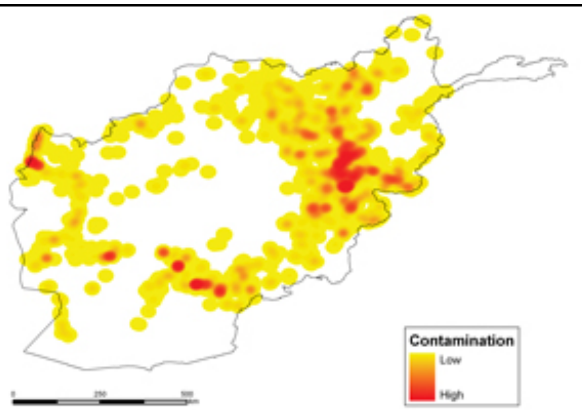

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Figure 5. Density map showing contamination in Afghanistan calculated using the ArcGIS Kernel density tool.

(low values) to red (high values). White areas have no known hazards.

The result is a map showing the densities of the input points (See Figure 5). While large areas have a greater impact than small ones, these are either hazards or, if they are polygons, their centers.

Looking at Figure 5, it is easy to distinguish the high concentrations of observed records and other regularities. The KDE approach is used in many other domains, such as crime mapping, estimating the home range of animals, etc. Another advantage of this method is that the resulting density maps are smoothed. This means that geometric shapes (the neighboring cells within the bandwidth) with estimated contamination values replace the original hazards and their area. Thus, this does not allow for the drawing of conclusions about the exact locations of hazards records, which can be sensitive information.

This map's output helps to visualize the problem and can also be used for further analyses. This representation gives an overview of the overall hazard distribution, but is unable to identify the exact locations.

Combining Hazard-density Maps with Population Data

GIS now provides various tool sets and innovative methods to combine different datasets into a new dataset. The methodology described below was used to combine the hazard probability with each of the population datasets.

Combination with LandScan Population Data. In order to make the two datasets comparable, the LandScan data (with an original resolution of 1 km.) was processed into a lower resolution. For the estimation measurement of at-risk people, the density map was multiplied by the LandScan population values, cell by cell.

Combination with GPW Data. As with the LandScan population data, the two input datasets had to be harmonized. In this case, the original hazards were added by district, while including their areas. Having population data on the same level of detail, namely on district-level, made it possible to multiply the values district by district and come up with a reasonable result. With this methodology, creating density maps was not necessary—only vector data (points and polygons) were processed.

Results and Discussion

Using data from the two different sources, the maps (Fig. 6 and 7) presented here suggest where most people are at risk:

Figure 6 shows detailed information about populations at risk, at national level and with a resolution of several square kilometers. It is possible to have a rapid overview of regions presenting high, densely populated areas coupled with important hazard probability, such as in the Kabul province.

Further investigations regarding ways to represent population and ERW density in the same map should be targeted.

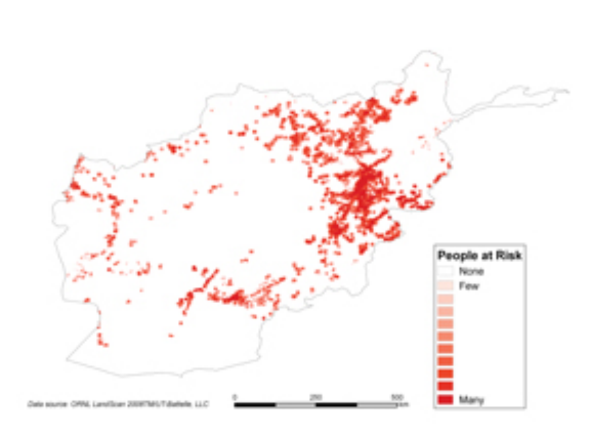

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Figure 6. Populations at risk of ERW hazards in Afghanistan, calculated with the LandScan dataset.

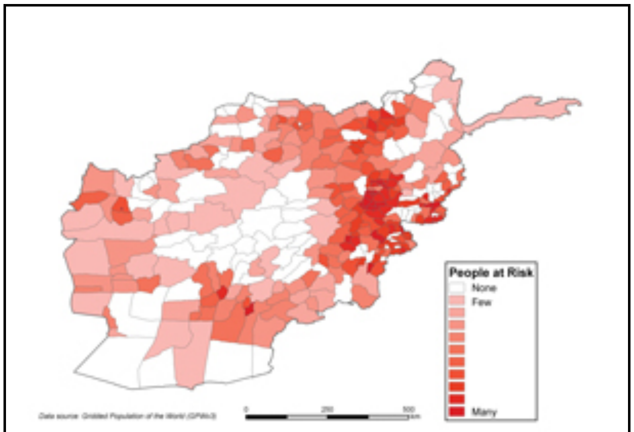

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Figure 7.Populations at risk of mines in Afghanistan, calculated with the Gridded Population of the World dataset at second administrative unit level.

While this did not fall within the scope of this study, there needs to be a way to easily distinguish the contribution of each one of them, with elements such as two-dimensional color ramps.[4]

Figure 7 shows the result of the combination with GPW data. For every district, one value is estimated to represent the overall situation in the district. The information is reduced to the district level (there are 328 Afghan districts), which produces the effect of biasing the interpretation of the results: People in entire districts seem to be at no risk, despite the reality that they might be. The symbology applied to the output data may largely influence the map interpretation.

The choice to multiply the input datasets to model the exposure leads to a high percentage of zero values. Zero values occur if there is either no population or no contamination, thus it is easily readable and interpretable. Moreover, both maps give a first overview of the risk situation at a national level. In addition to harmonizing the data resolution to be combined, the methods chosen can be applied to any contaminated country in the world and simply automated with standard ArcGIS desktop tools. Furthermore, computing performances proved effective: Interpolating the 6,000 test hazards on the entire Afghan area took only minutes.

The comparison of the two resulting maps suggests that both input population datasets can be used depending on the scale at which the population exposure is displayed. Moreover, they could be combined with other layers, such as infrastructure, land use, resources, etc.

Conclusion

This work is a first approach for modeling and estimating people at risk of ERW hazards. It proposes a new research approach including spatial analysis, applicable to entire countries, with results at the district level or lower. It is possible to indicate in which districts or in which populated areas ERW hazards are present and are threatening people, and therefore probably affecting their daily lives. Also, the model will be influenced by the assumption that more hazards are recorded where population density is higher.

A further step will aim to incorporate the confidence of each recorded ERW area, in order to more accurately reflect the reality on the ground. For instance, minefields are usually associated with a higher confidence than dangerous areas. Hence, this should be included in the hazard-density estimation by readjusting the methodology: The Kernel radius should be smaller for the former than for the latter.

Future project steps will evaluate the risk on populations (taking into account the population vulnerability), the impact on populations (with socioeconomical considerations) and the impact on infrastructures. Datasets other than LandScan and GPW, and other GIS and statistical methods could be used and should be investigated.

Acknowledgments to Gissela Girón (University of Geneva) for her literature review on the population datasets.

Biography

Pierre Lacroix works as a scientific collaborator at the University of Geneva. He is also pursuing doctorate research on the contribution of geographical information systems to mine action. Since 2010, he has worked with the GICHD as a GIS project consultant.

Jonas Herzog works as a research fellow at the University of Geneva and the GICHD. He finished his master's degree in 2010 at the University of Zürich in geographic information science with a thesis on ERW-contamination density maps.

Daniel Eriksson, Ph.D., is the head of the Information Management section at the GICHD. He was introduced to mine action during his Swedish military service as an explosive ordnance disposal specialist. Since completing his mandatory service in 1997, he has been involved in research and implementation of information management and decision-support systems in Afghanistan, Iraq and Sudan. His past employers include the Swedish Rescue Services Agency, the European Commission, United Nations Office for Project Services and Vietnam Veterans of America Foundation / Information Management and Mine Action Programs.

Pierre Lacroix
University of Geneva
Route de Drize, 7
CH 1227, Carouge / Switzerland
E-mail: pierre.lacroix(at)unige.ch

Jonas Herzog
Geneva Centre for Humanitarian Demining
Avenue de la Paix, 7 bis
P.O. Box 1300
CH 1211, Geneva 1 / Switzerland
E-mail: j.herzog(at)gichd.org

Daniel Eriksson, Ph.D.
Geneva Centre for Humanitarian Demining
Tel: +41 (0) 22 906 16 84 | m. +41 (0) 79 477 31 91
E-mail: d.eriksson(at)gichd.org

Endnotes

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4. A color ramp is a set of colors used to depict a continuous range of values. For instance, on a pH scale, the difference in color determines how acidic something is.

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