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The intelligence of geospatial data to foster water resilient urban ecosystems

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ABSTRACT

Data science is transforming digital maps into integrated intelligence systems that provide meaningful data-driven solutions to complex problems by recognizing underlying patterns, relationships and trends in a geographic context. Hence, GIS technologies are crucial to understand the human impact on the Earth and its contribution to climate change, considering that the likely increase of extreme weather events such as droughts and floods could trigger major global water–related disasters in urban agglomerations. The complexity of the planet's most pressing water related-issues is not easy to identify; nevertheless, we can answer some questions through the relationship of water resources and society over the years with the use of ESRI technology to improve decision-making and urban planning.

This work presents the existing risks of urbanization and megacities at the global scale from reliable open data repositories, satellite imagery and geospatial tools to find solutions that can pave the way towards sustainable development and build resilient cities.

KEYWORDS

#opendata #bigdata #geospatialintelligence #water #risks #urbanresiliency

PROJECT

1. Introduction

By 2050, almost three quarters of the world's population will live in urban areas (UNECE, 2015). In general, cities are perceived as attractive destinations for inhabitants because of better opportunities, higher salaries, better services, and better lifestyles (Bhatta, 2010). However, managing urban growth has become one of the most important challenges of the 21st century (Cohen, 2006).

The uncontrolled and accelerated urban sprawl associated with the high population density have triggered ecological, economic, social and infrastructural risks, particularly in megacities, making them prone to natural and man-made disasters (Theo Kotter & Frank Friesecke, 2008).

Floods account for 43% of all natural disasters. Between 1995 and 2015, floods affected 2.3 billion people globally and killed 157,000 (Wahlstrom & Guha-Sapir, 2015). Scientific evidence indicates that climate change will create stronger storms (Knutson, et al., 2010), therefore a comprehensive analysis of the morphing city systems is needed to understand how cities can become more resilient in the face of water-related disasters.

The power, versatility, and accessibility of Open Data can be used to help countries around the world address a wide range of development goals, including food security, sustainable cities, the environment and climate action (World Bank, 2015). Despite the abundance of data, it has had little impact on furthering our understanding of our planet, in contrast to other fields such as marketing or business (Faghmous, 2014). Considering that data is useless unless it is applied, in this research we demonstrate how Web AppBuilder for ArcGIS adds value to the integration of demographic, risk and hurricane open data. The production of 2D and 3D digital maps offer a range of options for effective data visualization to locate areas in risk and to promote water resilient urban cities for global awareness.

2. Data and Methods

The type of methodology used in this research consist of global quantitative data of countries and cities, based on the level of urbanization and risk, structured in four phases:

I. Data collection
II. Data homogenization
III. Mapping and data visualization
IV. WebApps

2.1. Data collection

The collection of qualitative data is mandatory to perform data analytics. A dataset is characterized by the representation of numerical values known as datum in a matrix corresponding to a particular event. Data can be available to the public through open data repositories or obtained from private sources. Official international organizations as well as national and regional entities are recognized as reliable sources of information, collecting and producing official datasets and statistics from a wide range of sectors, including urban development, health, economy, environment and education.

Layer	Source
Urban agglomeration by country (%)	2014 World Urbanization Prospects
Annual population of urban agglomerations (thousands)	2014 World Urbanization Prospects
Country boundaries	Google Fusion Tables
World Risk Index	World Risk Report 2016
Hurricane Archive	Weather Underground

Table 1 – Open data sources

2.2. Data homogenization

After completing the data collection process, the homogenization phase consisted on selecting one reference column of two datasets to provide data visualization with an area-value map instead of a point. In this case, we associate the data from the 2014 World Urbanization Prospects and World Risk Report 2016 integrated with the geographic data from Google Fusion Tables for visualization purposes.

To successfully merge the files, we used the “country code” as reference column because of orthography differences in the country names from both datasets. Manual data filtering may be required when columns cannot be associated automatically due to misspelling when constructing data from multiple languages or the existence of additional accents, commas and/or spaces.

Weather underground is an internet-based commercial weather service that provides real-time weather information and historical data. Detailed tracking charts and information for tropical storms in the North Atlantic, East Pacific, Western Pacific and Indian Ocean is available in html format; in order to use this data, manual procedure of organizing the information into an Excel file is required to create the csv file.

2.3. Mapping and data visualization

Effective data visualization remains the main challenge for digital mappers. The complexity of summarizing data requires time and creativity to represent in an easy-friendly way the final product to the audience. ArcGIS Online enables users to tailor the map as desired, from a range of styles based on the attribute of your interest, to the ‘Living Atlas of the World’, a geographic public repository that includes maps, apps, and data layers from the ESRI community (ESRI, 2018).

2.4. WebApps

2.4.1. StoryMaps

The distribution of megacities close to main river systems and coastlines is not new. Figure 1 depicts four main urban corridors, from New York to Mexico City, London to Istanbul, Tokyo to Shanghai and New Delhi to Jakarta. The percentage of population living in urban agglomerations is depicted in a choropleth map.

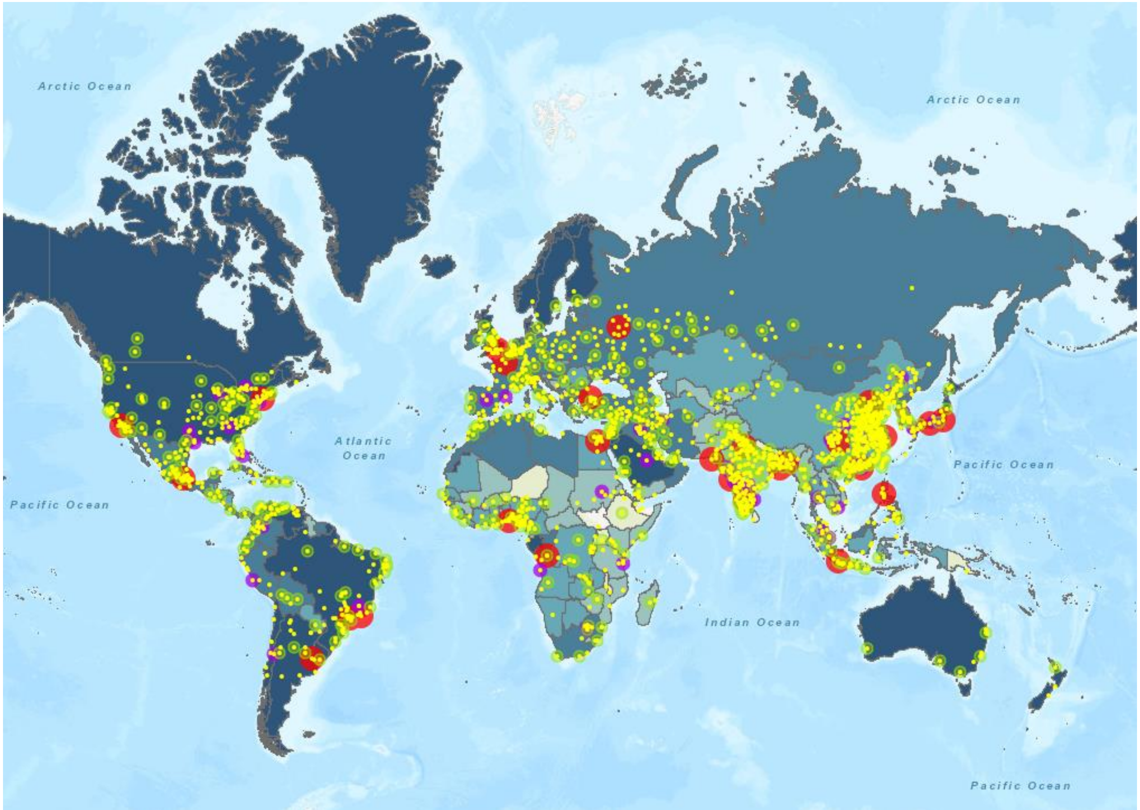

Fig. 1 - Percentage of urban and locations of urban agglomerations of >.5m inhabitants on 2015. Source: World Population Prospects

Urban agglomerations	Legend
Cities of 500,000 to 1 million	🟡
Medium-sized cities of 1 to 5 million	🟢
Large cities of 5 to 10 million	🟣
Megacities of 10 million or more	🔴

Table 2 – Level of urban agglomerations

2.4.2. Global weather risk outlook

The pace of urbanization is on the rise, as well as the increasing level of exposure and vulnerability of megacities. Hurricanes are responsible of flooding, storm surges and strong winds, leaving a trail of mass damage and destruction in its path. Some global populations, particularly in the Atlantic and Pacific Ocean suffer from hurricanes and typhoons every year. Figure 2 shows a 3D map of the costliest Atlantic hurricane paths and intensities. The rise of global sea surface temperatures is consistent with a change in intensity to more intense storms. This new pattern may explain that three of the top five most costly hurricanes took place on 2017.

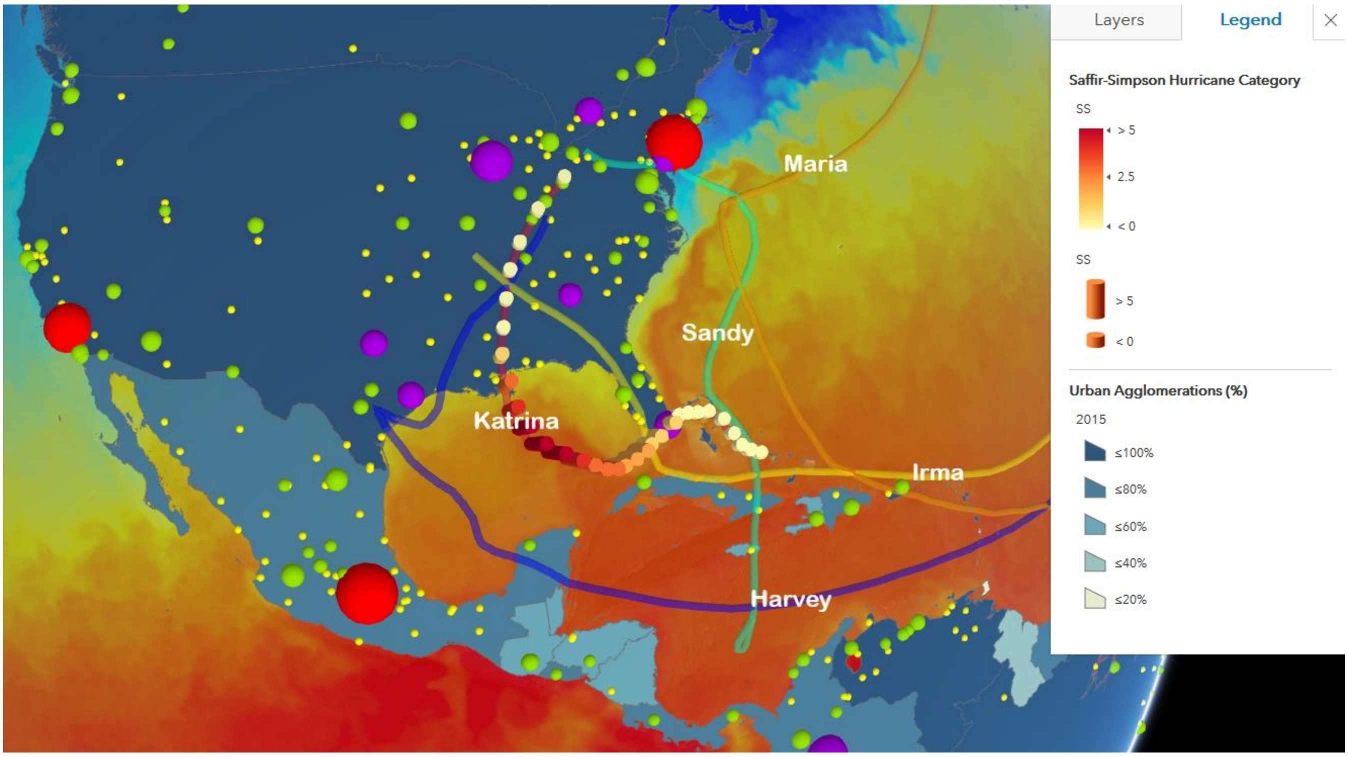

Fig. 2 – Urban agglomerations of >.5m inhabitants, intensity and tracks of the most costly hurricanes in the Atlantic: Katrina (2005), Harvey (2017), Maria (2017), Sandy (2012) and Irma (2017). Source: NOAA

2.4.3. Indexing and comparative analysis for hydro-extreme hazards

Disaster risk is a function of hazard, exposure, vulnerability and capacity (UNISDR, 2015) . A compared analysis of the World Risk Index report is presented in Figure 3. Over the past years The Netherlands, Greece, Romania, Serbia and Hungary have been regularly hit by floods, therefore is not surprise to observe that are classified as most exposed countries in Europe, influencing their rating on the world risk index.

Concept	Definition
Disaster risk	The potential loss of life, injury, or destroyed or damaged assets, which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity
World Risk Index	Result of exposure and vulnerability
Vulnerability	Vulnerability of society as the sum of susceptibility, lack of coping capacities and lack of adaptive capacities
Exposure	The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas, such as earthquakes, storms, floods, droughts and sea level rise
Susceptibility	Dependent on public infrastructure, nutrition, income and the general economic framework

Table 3 – Terminology on disaster risk. Source: UNISDR & World Risk Index Report

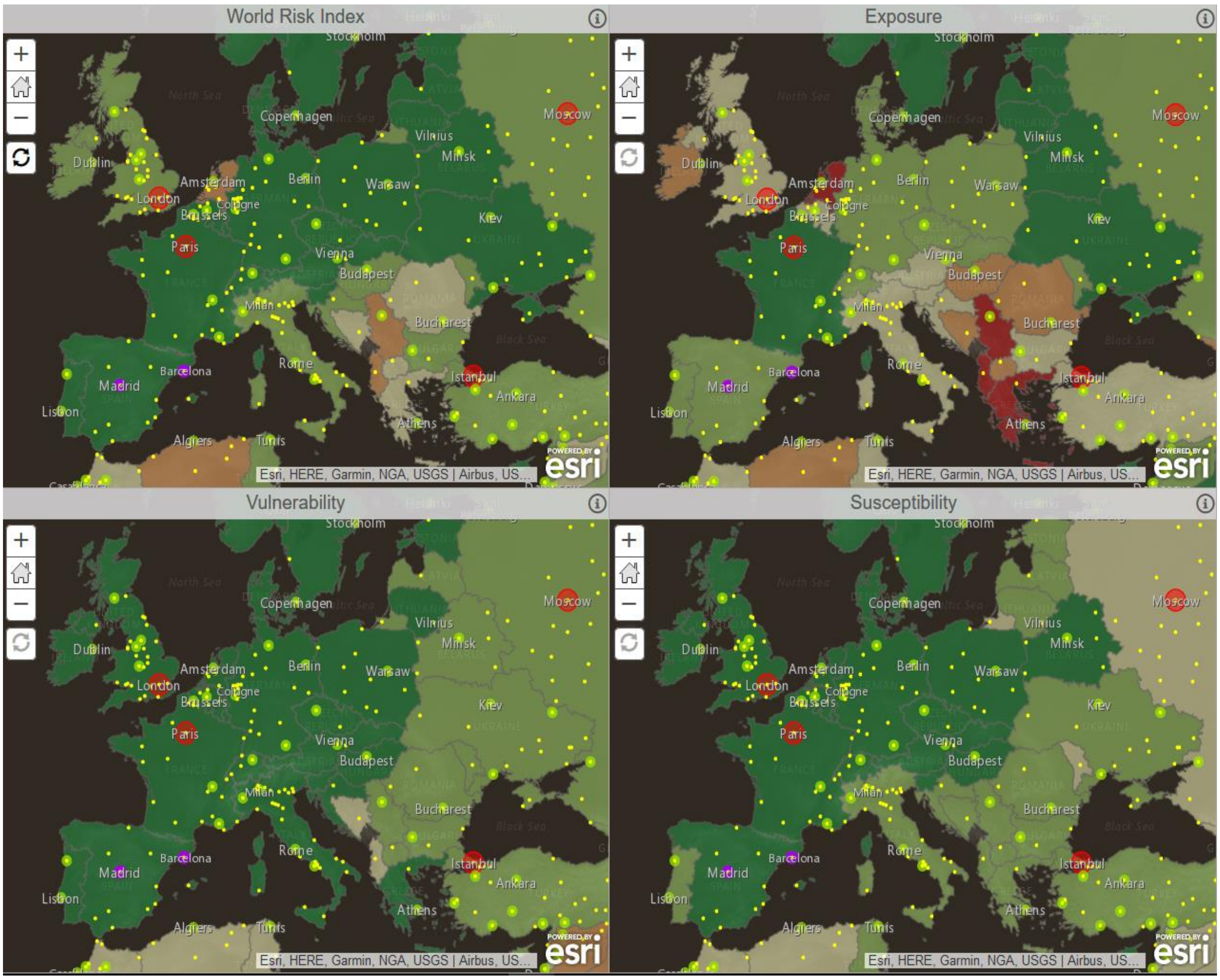

Figure 3 – Compared analysis of urban agglomerations of >.5m inhabitants and the World Risk Index. Source: World Risk Index Report

3. Results

The three maps provide a range of options to put in perspective the existing risks based on the distribution of megacities around the world. ArcGIS Online offers a number of possibilities to display data, going from StoryMaps and WebApps to ArcGIS Operations Dashboard. The final products encourage discussion and further analysis to evaluate the level of vulnerability of regions in regard of the number and concentration of megacities, risk index and hurricanes path. The advantage of interactive 3D maps (Figure 2) is that users can recognize immediately the changes in magnitude of each hurricane by the changes of height and color. The possibility to add big hurricane data and sea global temperatures over time, including the urban population growth of megacities could provide hints of new hurricane patterns and potential landing areas. This information is vital for government officials and decision makers for disaster risk preparedness and mitigation purposes.

4. Work context

Water, disaster risk reduction, open data and digital mapping are part of the multidisciplinary research activities of the Water Resources Research and Documentation Center (WARREDOC) based at the University for Foreigners of Perugia. Geo-literacy and geo-education are fundamental to unleash the power of data science with maps, in the search of sustainable development and global awareness. The production of this work was possible by the use of the ESRI platform, including ArcGIS PRO, ArcGIS Online and StoryMaps.

5. Bibliography

Bhatta, B. (2010). *Analysis of urban growth and sprawl from remote sensing data* (1 ed.). Springer. doi:10.1007/978-3-642-05299-6

Cohen. (2006). Urbanization in Developing Countries. Current Trends, Future Projects and Key Challenges for Sustainability. Technology in Society.

ESRI. (2018). *https://livingatlas.arcgis.com/en/*.

Faghmous, J. &. (2014). A big data guide to understanding climate change: The case for theory-guided data science. *Big Data*, 155 - 163. doi:10.1089/big.2014.0026

Knutson, R., Mcbride, T. &., Chan, J. &., Emanuel, J. &., Holland, K. &., Landsea, G. &., . . . Masato. (2010). Tropical Cyclones and Climate Change. *Nature Geoscience, 3*. doi:10.1038/ngeo779

Theo Kotter & Frank Friesecke. (2008). Developing urban Indicators for Managing Mega Cities.

UNECE. (2015). *HABITAT III Regional report on housing and urban development for the UNECE Region.*

UNISDR. (2015). *https://www.unisdr.org/we/inform/terminology*.

Wahlstrom, & Guha-Sapir, D. (2015). *The Human Cost of Weather-Related Disasters 1995-2016.* Geneva, Switzerland: International Strategy for Disaster Reduction (UNISDR).

World Bank. (2015). *Open Data for Sustainable Development.* World Bank Group.