Disaster Statistics and Censuses

Select Topics in International Censuses[1]

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INTRODUCTION

Official statistics enable measurement and understanding of populations living at risk to disasters. Providing disaggregated and timely statistics is of increasing urgency as people move to places with greater exposure to hazards, and as places where people already live become more hazard prone. This brief, part of the Select Topics in International Censuses (STIC) series, will introduce the United Nations (UN) Disaster-Related Statistics Framework (DRSF), explore how censuses play a key role in enabling national statistical offices (NSO) to provide data that can be linked to hazard reporting, and will support the formulation and monitoring of risk-informed development plans and policies.

As most NSO employees are likely unfamiliar with disaster statistics and the applicability of NSO work to disaster statistics, first we must answer a simple question—what exactly is a disaster? The United Nations Office for Disaster Risk Reduction (UNDRR) defines a disaster as "a serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability, and capacity, leading to one or more of the following: human, material, economic, and environmental losses and impacts" (United Nations Economic Commission for Europe, 2019). An emergency is simply an official declaration of a disaster. Box 1 summarizes disaster-related terminology used in this brief.

The "Sendai Framework for Disaster Risk Reduction," an intergovernmental framework adopted at a UN world

Box 1.

Disaster-Related Statistics Terminology

Emergency: The officially declared period of responsive action to protect life or property (United Nations Economic and Social Commission for Asia and the Pacific [UNESCAP], 2018).

Exposure: People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses (United Nations International Strategy for Disaster Reduction [UNISDR], 2009).

Hazard: A process, phenomenon, or human activity that may cause loss of life, injury, or other health impacts, property damage, social and economic disruption, or environmental degradation (UNISDR, 2009).

Resilience: The ability of a system, community, or society exposed to hazards to resist, absorb, accommodate to, and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions (UNISDR, 2009).

Risk: The combination of the probability of an event and its negative consequences (UNISDR, 2009).

[1] This technical note is part of a series on *Select Topics in International Censuses* (STIC), exploring matters of interest to the international statistical community. The U.S. Census Bureau helps countries improve their national statistical systems by engaging in capacity building to enhance statistical competencies in sustainable ways.

U.S. Department of Commerce
U.S. CENSUS BUREAU
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United States Agency for International Development
www.usaid.gov

Economic and Social Commission
for Asia and the Pacific
www.unescap.org

conference in 2015, calls for a reduction in mortality (goal A) and losses (goal B) due to disasters. The language for these goals is similar, "Substantially reduce (goal A: global disaster mortality) and (goal B: number of affected people globally) by 2030, aiming to lower the average global figure per 100,000 between 2020–2030 compared with 2005–2015 (UN, 2015)." Census data are, for most countries, the main input for population distribution mapping, and have clear uses for measuring Sendai Framework goals A and B. Goal C (economic loss reduction) and goal D (infrastructure loss reduction) can, in certain situations, also be linked to census data. A set of 38 indicators was identified across all goals to measure global progress in the implementation of the Sendai Framework for Disaster Risk Reduction. Refer to the "Technical Guidance for Monitoring and Reporting on Progress in Achieving the Global Targets of the Sendai Framework for Disaster Risk Reduction" (UNISDR, 2017) for detailed information on the full set of indicators.

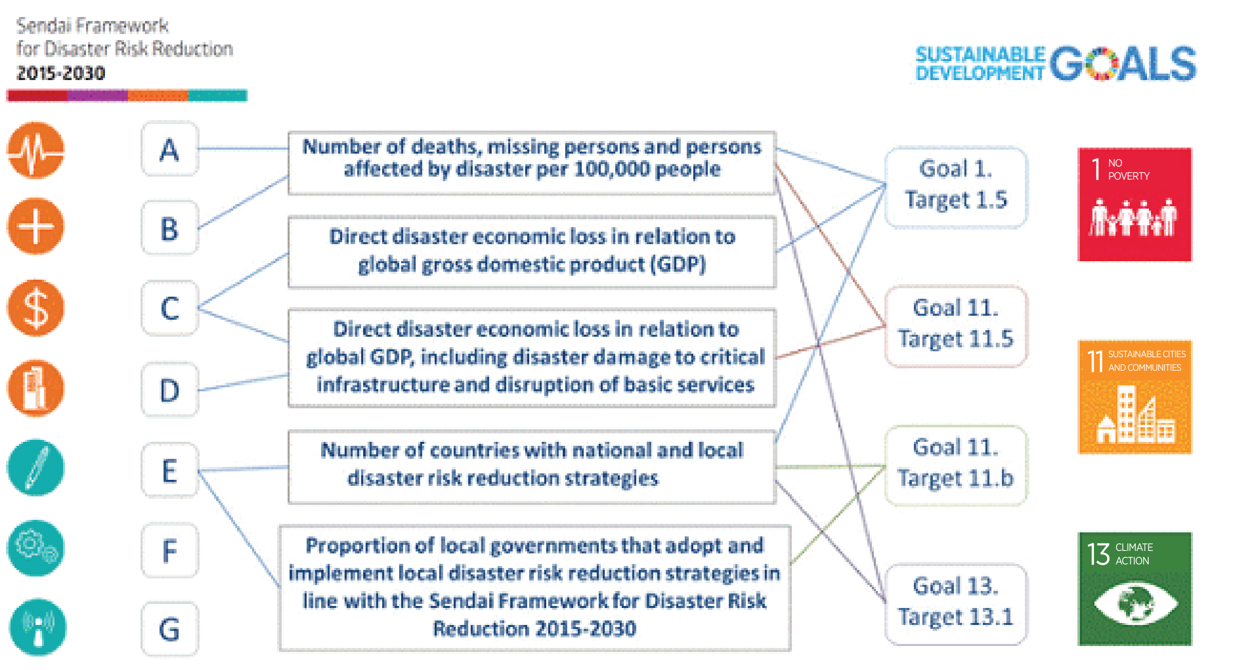
The Sendai commitment is situated within the context of the 2030 Sustainable Development Goals (SDG) Agenda. SDGs 4 (sustainable development), 11 (cities), and 6 (resilient infrastructure) have disaster reduction dimensions. Figure 1 shows the relationship between Sendai and the SDGs. Data collected to measure the SDG indicators support progress in achieving the Sendai global targets and help measure global trends in the reduction of risk and losses due to disasters. This brief will examine how census data are used as part of the disaster risk management cycle and how these uses fit into the DRSF.

Box 1.—Con.

Vulnerability: The conditions determined by physical, social, economic, and environmental factors or processes that increase the susceptibility of an individual, a community, assets, or systems to the impacts of hazards (UNISDR, 2009).

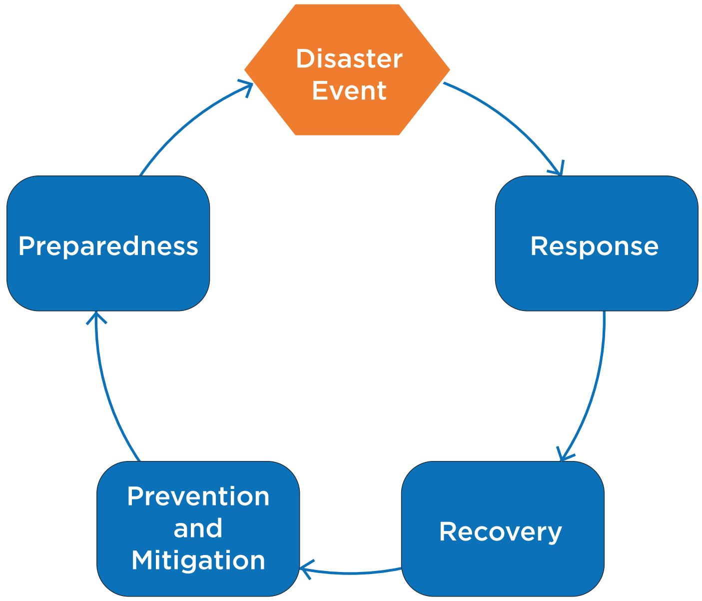
Coping Capacity: Coping capacity is the sum of factors regarding the resiliency of households, businesses, communities, regions, and entire countries against external shocks in the form of a disaster. This is the ability of households, businesses, or infrastructure to respond to external shocks without sustaining major, permanent negative impacts, and simultaneously track towards opportunities for future improvements (e.g., "building back better") (UNESCAP, 2018).

Figure 1.
Relationship Between Sendai and Sustainable Development Goals (SDG)



Source: The Sendai Framework and the SDGs (United Nations Office for Disaster Risk Reduction, 2021).

Figure 2.
The Disaster Risk Management Cycle



Source: Adapted from Disaster-Related Statistics Framework (United Nations Economic and Social Commission for Asia and the Pacific, 2018).

THE DISASTER RISK MANAGEMENT (DRM) CYCLE AND CENSUS DATA

The DRM cycle is used by emergency planners and managers to organize activities that reduce loss and suffering due to disasters. Figure 2 shows the phases of the DRM cycle. Moving clockwise after a disaster event, the **response** phase takes place immediately after a disaster and is focused on saving lives and preventing suffering. The **recovery** phase begins as the emergency ends, and includes short- and long-term actions, such as clearing rubble and rebuilding, respectively. Recovery transitions toward **prevention and mitigation** efforts, which seek to avoid or reduce exposure while increasing resilience. **Preparedness** involves increasing knowledge and capacity to navigate the disaster response cycle and is inherently data driven.

Table 1 gives examples of how census data can be used during the DRM cycle and lists the corresponding census topics (both core and optional) from "Principles and Recommendations for Population and Housing Censuses" (United Nations Statistics Division [UNSD], 2017). During the response phase, census data provide population and building counts with associated demographics relevant during response—age, sex, disability status—down to the lowest levels of geography. For catastrophic impact disasters, two or more censuses can measure long-term trends in recovery, such as changes to population distribution or economic activities found in affected areas (Zaninetti and Colten, 2012).

Vulnerability analysis, part of the prevention and mitigation phase, uses a full range of data from both the population and housing census sections and is discussed in more detail in the next section. Data from the housing section of the census can be used to track adoption of resiliency-supportive building materials and household assets. During the preparedness stage, NSOs can promote the uses of census data for emergency management through training and outreach materials (U.S. Census Bureau, 2019). Stewards of official statistics should also ensure that the data required for responding to the next disaster are available for immediate extraction during the preparedness stage. If any data relevant to emergency response are available, but not readily accessible because access is controlled (e.g., block-level population data), the procedures to share those data with the national disaster management agency should be devised as part of preparedness activities.

Census Contributions Across the DRM Cycle

The uses of census data through the DRM cycle overlap and involve repurposing the same data for different analyses. Regardless of the analysis, uses of census data in the DRM cycle require that everyone be counted and in the right place, with the best possible level of precision

Table 1.
Uses of Census Data During the Disaster Risk Management Cycle

Phase	Potential decision/planning objective	Uses of census or census-based data	Principles and recommendations sections
Response	Scope of disaster in terms of people/building affected; relief logistics (where, what, how much?).	Estimation of population affected.	Population: A1, C1, C2, D1, and D2.
		Estimation of number and type of buildings affected.	Housing: 23.
Recovery	Monitor return to baseline population and economic activity.	Measure medium- and long-term changes to population distribution.	Population: A1, D1, D2, and D9.
		Measure medium- and long-term changes to employment.	Population: G3, G5, and G6.
		Measure medium- and long-term changes to agriculture.	Population: H2 and H3 (if present).
		Measure medium- and long-term displacement.	Population: A3, A4, A5, and A6.
Prevention and mitigation	Where is exposure to hazard greatest; where are the most vulnerable?	Identifying factors that cause and or exacerbate disaster risks: e.g., migrant status, disability, health outcomes, illiteracy, and extreme poverty.	Population: All B, D, E, F, and G topics.
		Identifying vulnerable housing and infrastructure.	Housing: 1, 8–17, 21–24, 28–32, 34, and 37–39.
Preparedness	Which data sources are useful in an emergency; where should shelters be located?	Population distribution and household characteristics.	Population: A1, C1, D1, and D2.
		Preparedness and investment against disasters by households, businesses, and communities.	Housing: 8, 9, 23, 28, 29, and 32.

Source: Adapted from Disaster-Related Statistics Framework (United Nations Economic and Social Commission for Asia and the Pacific, 2018); Principles and recommendations sections column references Table 3 (p. 188) and Table 4 (p. 270) from Principles and Recommendations for Population and Housing Censuses (United Nations Statistics Division, 2017).

that still protects privacy. Geolocation of census data is particularly important for disaster-related statistics because hazards are inherently place-based (United Nations Economic Commission for Europe, 2019). That is to say that disasters happen somewhere, and even large-scale disasters can vary meaningfully on small scales. For example, elevation above sea level during cyclone-induced storm surges or distance from an aid distribution point during a drought can affect outcomes during a disaster, and whether or how households recover afterward.

Censuses take place with relative infrequency, so for most hazards they provide baseline data, either directly or as the reference for estimates produced later during the intercensal period. For ongoing or long-term environmental stressors, such as sea-level rise or desertification, changes to population distribution and economic activities can be analyzed; similar to analysis for catastrophic impact disasters with long-term consequences (Dallmann and Millock, 2017). Though infrequent, censuses may be the only observed (i.e., unmodeled) data source for analysis of small areas. Ancillary datasets produced during the census-taking process may also find use in emergency response. For example, inventories of government service locations and potential shelter locations, such as community health centers and schools, may be collected during the listing phase of a census.

THE DRSF AND CENSUS DATA

The DRSF gives guidance on how to localize and measure disaster exposure and occurrences so that they can be analyzed alongside other relevant datasets, including censuses. It is a comprehensive resource for NSO staff to learn more about the role of official statistics in disaster risk management. The statistics described in the DRSF are separated into disaster impact statistics and disaster risk statistics. Impact statistics are concerned with the response phase as a disaster occurs and the short-term component of the recovery phase. Generation and analysis of risk statistics takes place during the prevention and mitigation and preparedness phases of the DRM cycle.

Data for both impact and risk assessment statistics are generated from a common set of cross domain official statistics, shown in Table 2. The DRSF identifies several census topics useful for risk assessment (Table 2). These uses of census data primarily fall under Category B in the DRSF, in line with the role of censuses as sources of baseline data. Censuses provide a foundational dataset that also enables downstream operations (including modeling and survey sample weighting) in a national data

Table 2.
Disaster-Related Statistics Framework (DSRF) Inventory

Category	Category content
A	Summary tables of disaster cccurences.
B	Selected background statistics and exposure to hazards.
C	Summary tables of human impacts.
D	Summary tables of direct material impacts in physical terms.
E	Summary tables of direct material impacts in monetary terms.
F	Summary of material impacts to agriculture.
G	Summary table of direct environmental impacts.
DRRE	Disaster risk reduction expenditure (DRRE) accounting.

Source: DSRF (United Nations Economic and Social Commission for Asia and the Pacific, 2018).

ecosystem; these are the dynamic components required for a fully implemented DSRF.

Category B uses include exposure analysis/mapping using population density and vulnerability analysis using age structure, poverty, disability status, gender, slums, and median income. Note that poverty, residence in informal housing (slums), and median income require analysis of specialized data that may not be collected in every census. Furthermore, collection of income data on the census can be sensitive and is methodologically challenging. Sections 4.382–4.386 in “Principles and Recommendations” (UNSD, 2017) offer a full discussion of income data in a census. These challenges make spatially disaggregated official statistics on poverty and informal settlements statistics rare. Remote sensing data derived from satellite imagery show promise in allowing for more frequent, high-resolution mapping of informal settlements and poverty estimates when combined with census and household welfare survey data (Engstrom et al., 2017). Analyses that combine remote sensing and data from many censuses allow for global analysis of exposure and vulnerability to multiple hazard types expanding on the usefulness of census data in risk mapping (Ehrlich et al., 2018).

The disaggregated data called for in the Sendai Framework approach to disaster risk reduction and the 2030 Agenda for Sustainable Development are frequently only available through censuses in resource constrained countries. Gridded geospatial datasets, such as WorldPop <www.worldpop.org/methods/populations> and the Demographic Health Surveys Modeled Surface <https://spatialdata.dhsprogram.com/modeled-surfaces>, are well suited to disaster risk reduction applications and can supplement census data, especially in countries where the most recent census data are dated. However, it should be noted that these geospatial data products are ultimately dependent on censuses for model calibration or sample weighting of the underlying survey data.

Box 2.

Geospatial Tool and Workflows

Data on the geographical expanse of the location and density of the population can be used during several phases of the Disaster Risk Management Cycle. The United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) has developed a methodology to map a population’s exposure to hazards, including flood hazards. The methodology makes use of administrative boundary data and subnational-level population data from Humanitarian Data Exchange, geospatial land cover data from Copernicus Land Monitoring Service, and global flood hazard dataset from United Nations Environment Programme Global Resource Information Database, also called UNEP GRID.

These open-source data are then processed and layered using various geospatial techniques through QGIS to produce a map that shows the percentage of population exposed to flood hazard. The methodology to map the population’s exposure builds on methodology used in the operation manual “Exposure to Hazards Assessment based on ‘POP-to-GUF’ Methodology” (UNESCAP, 2018).

The tool will be released shortly and provides step-by-step guidance to national agencies wishing to apply the methodology for creating national population exposure maps using open-source software and programs. The tool adds to UNESCAP’s growing suite of step-by-step guides on the use of QGIS and RStudio to integrate statistical and geospatial information (UNESCAP; 2019, 2021a, and 2021b).

Exposure Mapping and Vulnerability Analysis

The strategic vision of the UNDRR 2022–2025 (UNDRR, 2021) lays out a goal of using vulnerability analysis to break the cycle of disaster response to prevent and mitigate exposure so that disasters, when they do occur, may stress but do not devastate affected communities.[2] Exposure mapping is a relatively simple analysis to gain insight about where the greatest number of people are exposed to hazard given various intensity levels. An example of exposure analysis is using geographic information systems (GIS) to determine the number of people who would be affected by flooding given different surges

[2] The United Nations International Strategy for Disaster Reduction (UNISDR) changed its name to United Nations Office for Disaster Risk Reduction (UNDRR).

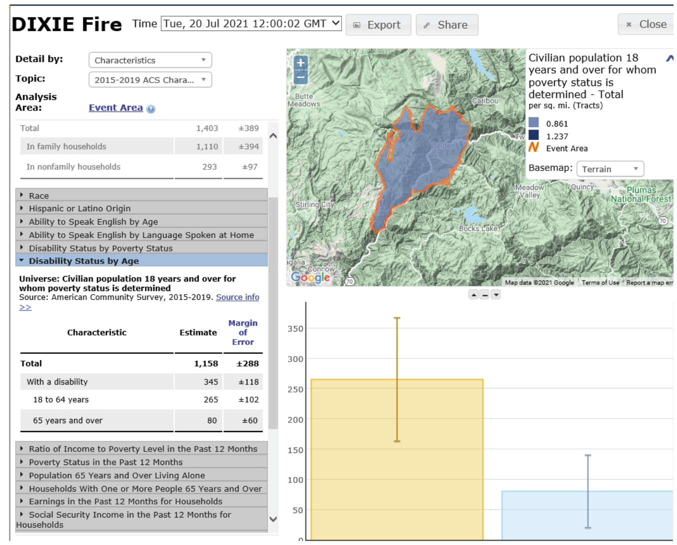
above mean sea level. The National Storm Surge Hazard Maps (National Hurricane Center and Central Pacific Hurricane Center, 2018) combines modeled flooding data and 2010 Census data to perform exposure analysis.

Disaster risk reduction requires more than simply mapping exposure, since avoidance or relocation are not always feasible or desirable options. The DRSF briefly notes the Pressure and Release (PAR) Model that expresses risk as a function of exposure, vulnerability, and coping capacity. The Access Model that was introduced in Wisner et al. (2003) expands on the PAR concept by providing a comprehensive—combining quantitative and qualitative methods—framework for the analysis of vulnerability. In the PAR and Access models, social/power relationships mediate the pressure that a disaster event places on a household or on an individual. Some households go into crisis when the stress of a disaster occurs, others do not. Whether or not a crisis occurs is not solely determined by the proximity to, or intensity of, a hazardous event. Vulnerability analysis expands on exposure by considering resilience and coping capacity to avoid and recover from disaster crises. In other words, there is no such thing as a fully "natural" disaster. Disaster, defined by the impacts on societies of hazardous events, are a function of the way societies are organized in addition to the magnitude of the event.

In a simple example, two households are located side by side along a coast. One household dwells in a wooden house at ground level, built before or despite regulations meant to improve structural survivability during a hurricane. The neighboring house is concrete and elevated to withstand wind and flooding. Clearly the construction of the houses affects the probability of a crisis (structural damage or loss). Yet it cannot be assumed that all households have the autonomy to choose the circumstances of their habitation in a vacuum. Why would these households live in such different structures when they are exposed to the same hazard? Which household has the wider social network to draw upon should they require assistance? Which can better access government services? Questions such as these are necessary to develop actions that can reduce vulnerability and improve coping capacity, for which the PAR and Access models provide a framework.

While censuses cannot provide data for this deepest level of vulnerability analysis, they do provide proxy variables that have the benefit of enabling relatively fast analysis of large areas. Data on educational attainment, maternal mortality, occupation, and housing characteristics are collected in many censuses. These indicators frequently display collinearity, indicating a shared relationship to underlying causes of vulnerability. The Social Vulnerability Index offers a method to process collinear demographic and economic indicators collected in a census (Cutter et al., 2003).

Figure 3.
Online Dissemination Example: OnTheMap for Emergency Management



Source: U.S. Census Bureau, Center for Economic Studies, 2021.

The results of quantitative analysis of census data can offer a starting point for deeper understanding required by the PAR and Access models.

Dissemination of Disaster-Related Statistics

Official statistics with disaster management applications must be accessible and organized to support disaster risk reduction analysis to be useful. Two examples from NSOs demonstrate dissemination focused on different audiences and were designed accordingly: (1) "OnTheMap for Emergency Management," from the U.S. Census Bureau, uses an intuitive Web interface designed for emergency managers and the general public; and (2) "BATER[3] (Territorial Statistical Database of Risk Areas)," from the Brazilian Institute of Geography and Statistics (IBGE)[4], is a packaged set of official statistics linked to preprocessed risk areas represented as polygons in a GIS dataset. This product is geared toward a technical audience and requires some experience with GIS to use.

The "OnTheMap For Emergency Management" <https://onthemap.ces.census.gov/em/> Web site, a screenshot from which is shown in Figure 3, combines official statistics with disaster information from several U.S. federal agencies. Users can select between demographic and economic statistics sourced from the decennial census and two additional household surveys. The unit of analysis can be set to the intersection with the disaster extent, all administrative units touched by the disaster,

[3] Base Territorial Estatística de Áreas de Risco.
[4] Instituto Brasileiro de Geografia e Estatística.

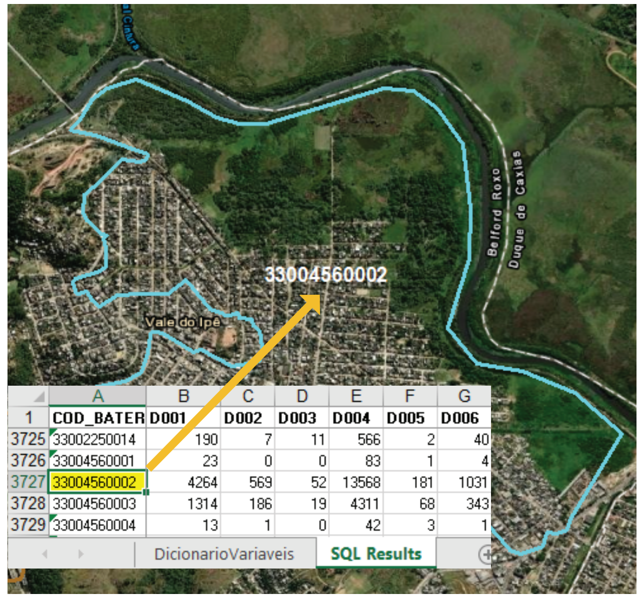
or any other user-defined set of U.S. second-level administrative areas.[5] The disaster localizations and descriptions of the disasters come from the Federal Emergency Management Agency (the U.S. national disaster management agency) and from the Departments of Interior and Agriculture, which share responsibility for reporting on active fires.

The BATER product has a limited public-facing Web dissemination footprint, with maps showing the total population living in risk areas by municipality. Full use of the product requires visitors to download the geographic and tabular data and link the two in a GIS to perform their own analysis. However, a wide range of analyses is possible with simple GIS skills. Figure 4 provides a representation of the BATER product. The highlighted area represents a single risk area near Rio de Janeiro with an ID number of 33004560002. The ID for the risk area is also present in a table of statistics from the 2010 Brazilian Census relevant to disaster management that is used to link the demographic and spatial data. IBGE notes that this product will soon be updated with 2020 Brazilian Census data. Note that only the first six out of 135 available variables in the BATER database are shown.

CONCLUSION

Disaster statistics is an emerging concept that is not fully integrated into the official statistical system in many countries. Censuses are a key component of the statistical data required to understand the dynamics of exposure, vulnerability, and coping capacity. They provide depth and coverage that might not be available from any other demographic data sources, especially in the most vulnerable countries. Collaboration between NSOs and other agencies, especially those responsible for disaster risk management and the geosciences, will allow each to take full advantage of the census as well as other sources of data and data collection infrastructure.

Figure 4.
BATER Dataset



Source: Instituto Brasileiro de Geografia e Estatistica, 2018.

[5] Counties.

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