TOOLS AND METHODS
for Estimating Populations at Risk
from Natural Disasters and Complex Humanitarian Crises

Committee on the Effective Use of Data, Methodologies, and Technologies to Estimate Subnational Populations at Risk

Board on Earth Sciences and Resources

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Preface

We do not live in a risk-free society, and at any moment somewhere in the world, resident populations are exposed or are responding to natural or human-induced disasters that result in humanitarian crises. The number, demographic characteristics, and locations of the populations at risk during these crises are often imprecise or unknown, complicating or impeding humanitarian relief and disaster response efforts. Population data—and the tools and the persons trained to analyze and use them—are some of the basic components of humanitarian response efforts and of development and reconstruction programs.

Resource-poor nations have the greatest difficulty in obtaining, maintaining, and making available their population databases for purposes of development and humanitarian response and are more likely to require external support in responding to natural or human-induced disasters. However, as events surrounding Hurricane Katrina demonstrated, the existence of adequate financial resources in the presence of good population databases does not always guarantee a completely effective response to assist a population in crisis. Effective use of existing population data in crisis or planning situations also requires coordinated responses by decision makers from national or international through local levels.

Improved estimation of populations at risk in resource-poor countries and better use of population data in connection with planning and executing emergency and development aid programs has garnered international attention from a wide spectrum of professionals. Descriptions relayed by emergency workers regarding their planning for and execution of disaster and complex humanitarian emergency responses have emphasized the underlying importance of data on the numbers of the affected populations, and their ages, gender, health characteristics and locations in order to execute an efficient and appropriate response level. In a world now oriented toward map applications popularized by the advent of GoogleEarth and personal global positioning systems for automobile and pedestrian navigation, developing a seamless link between digital geographic information systems and various types of population data for use in emergency and development programs has clear impetus. However, resource-poor countries with a paucity of adequate demographic data often also lack the tools and training to interpret and employ such data, thus placing them at further disadvantage to address disasters that affect their own populations. Without data, or the political and organizational will to employ them, geographic information systems-based approaches will not meet the basic needs of a country responding to a crisis within its borders.

In May 2004, the Humanitarian Information Unit of the U.S. Department of State, the U.S. Census Bureau, and the National Academy of Sciences hosted a Workshop on Systematic Population Estimation, where continued U.S. government interest in improving estimates of populations at risk was demonstrated. This workshop followed publication of a number of National Research Council (NRC) reports, including *Forced Migration and Mortality* (2001), and *Down to Earth: Geographic Information for Sustainable Development in Africa* (2002), that addressed various aspects of the lack of demographic data in many countries and the impacts on the population when data were not available or were not used. In *Down to Earth*, a recommendation was made that "USAID [United States Agency for International Development] and the Bureau of the Census should provide financial and technical support to national census offices and bureaus [in Africa] to help them complete censuses, geographically reference the data, and make the data available in disaggregated form to decision makers." The present study was conducted at the request of the U.S. Department of State, USAID, the U.S. Census Bureau, the National Aeronautics and Space Administration, and the Centers for Disease Control and Prevention in partial recognition of the information gathered at that 2004 workshop and builds on earlier and ongoing NRC work.

As a response to the request from these agencies, the NRC established the Committee on the Effective Use of Data, Methodologies, and Technologies to Estimate Subnational Populations at Risk. The committee comprises individuals with professional backgrounds in demography, geography, sociology, statistics, disasters, humanitarian aid and development, forced migration, geographic information systems, remote sensing, and epidemiology and international health. Based on the interest expressed by U.S. government agencies in having population data available in humanitarian response situations, the committee made a basic assumption that U.S. government agencies would like to see better subnational population data collection and estimation, and improvements in data accessibility in times of crisis. The committee thus established a link between the tools and methods used in making these data collections and population estimates, and the institutional requirements needed to maintain and employ the data effectively.

In addition to information derived from their own expertise, committee members called upon population researchers, demographers, geographers, and policy makers from federal agencies, nonprofit and for-profit institutions, and the private sector, and representatives of national and international humanitarian aid and development organizations to present their perspectives at one public workshop and one public meeting. These individuals provided testimony on which population data were required, collected, and/or accessible and why they were or were not used in humanitarian aid or development situations. Approximately half of the panel group at the main study workshop had some or very extensive field experience in delivery of humanitarian or development aid. However, limited time at the public meetings and limited availability of some individuals who had specific field experience in two countries named in the study's scope, Haiti and Mozambique, precluded complete discussion on some issues important to the study. The committee supplemented the information it gathered at these meetings through interviews and correspondence with individuals at humanitarian and development organizations, at government agencies, and health institutes, domestically and abroad. Relevant scientific literature and other published materials, particularly reports and framework documents from organizations such as the United Nations, the World Health Organization, Save the Children, and Oxfam, were also drawn into the committee's deliberations. Chapters 1 and 5 give further background on the committee's information-gathering efforts.

This report and its recommendations were a result of the consensus of the committee. The recommendations specifically address the statement of task and apply primarily to the U.S. government sponsors of the study, but the needs of other international organizations, agencies, and governmental and nongovernmental groups involved in disaster response and development aid were also addressed in the course of the committee's deliberations. Since effective international development and disaster relief aid represent coordinated efforts on the part of agencies, organizations and governments, the committee's recommendations underscore the need for feedback between aid donors, disaster responders, and aid recipients in the United States and abroad. While not providing a solution to the world's political and social crises or natural and technological disasters, geographically referenced population data are important components of the response to assist populations at risk in these situations; proper collection, analysis, and dissemination of such data can be a useful part of an integrated response to these crises. Importantly, development and reconstruction programs can also use population data in effective planning of educational, health, and food security initiatives outside times of crises.

Members of the committee provided key insights and took part in the drafting of the report. We were assisted in our efforts by Elizabeth Eide, study director, Caetlin Ofiesh, research associate, Nicholas Rogers and Amanda Roberts, senior program assistants, Tonya Fong Yee, project assistant, and Hedy Rossmeissl, study director until January 2006. Without the support of such a fine staff, the committee would have faltered in its task.

We would especially like to dedicate this report to Dr. William Wood, former State Department Geographer and Deputy Assistant Secretary of State for Analysis and Information Management, Bureau of Intelligence and Research. Bill requested and helped to develop this study before he died at far too young an age in July 2005. Bill, a renowned applied geographer and a strong supporter of the work of the National Research Council Board on Earth Sciences and Resources' Geographical Sciences Committee, was passionate about using geographic information to help the disadvantaged people of the earth—a passion that was galvanized by numerous field missions to countries where humanitarian crises were occurring or likely to occur. We hope the study does justice to his goal of having different government agencies more effectively work together in a collective effort to protect vulnerable populations.

Susan L. Cutter, *Chair*
March 2007

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NRC, 2002. *Down to Earth: Geographic Information for Sustainable Development in Africa*. Washington, D.C.: National Academy Press, 155 pp.

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This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their participation in the review of this report:

Patrick Ball, Benetech, Palo Alto, California
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Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations nor did they see the final draft of the report before its release. The review of this report was overseen by John Adams, University of Minnesota, Minneapolis, and Susan Hanson, Clark University, Worcester, Massachusetts. Appointed by the National Research Council, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

Contents

Summary

Recent natural disasters like the South Asian earthquake-tsunami in 2004 and the Pakistan earthquake and Hurricane Katrina in 2005 highlight the range of scales—from village to nation—at which populations can be affected by natural events and, similarly, the range of scales at which humanitarian assistance must be coordinated and delivered. In addition to sudden-onset natural disasters, which capture public attention and significantly underscore such critical outcomes as deaths and economic and livelihood losses, chronic disasters such as drought, famine or civil conflicts of a duration and severity that displace populations from their homes and livelihoods continue to demand international responses in the form of aid and reconstruction and must be addressed at local, regional, and national scales. Although specific data needs vary according to the type of disaster and regional issues, some basic necessities in responding to these events are population data and the ability of responders to use the data to deliver effective humanitarian aid. Population data allow determination of how much and what types of aid are needed and where the aid should be directed. Similarly, population data can be used in development and reconstruction efforts prior to and following a particular crisis. When population data are also geographically referenced, the versatility of combining data with maps becomes evident and generates potential for a great variety of products useful for the emergency response and development communities in planning and delivering aid.

A timely response and the delivery of disaster relief or humanitarian assistance is challenging in and of itself, yet decision makers often lack the requisite population data for the affected area, including the total number of people and their characteristics, density, and vital statistics—descriptors of the population that constitute its demographic features. Demographers study the characteristics and composition of human populations, in particular with reference to size and density, distribution, and vital statistics such as age, gender, fertility, mortality, and migration. Although location is implicit in these population analyses, the extent to which it is explicit varies tremendously. During humanitarian crises, it is not uncommon for humanitarian or emergency response teams to deploy without even rough estimates of the number and location, let alone ages and gender, of the people in the vicinity of the disaster. Even if the data are available, they are not always in a form that can be used by decision makers, and demographers are not always placed with the response teams. Once the initial emergency period has passed, accurate data on the characteristics and size of the population are also required for recovery, reconstruction, and resettlement. With the number of refugees and internally displaced populations in the world remaining close to 20 million for nearly a decade (UNHCR, 2006), the challenges in providing this type of assistance are constant and global, and inaccurate numbers and locations for populations in crisis can slow the relief effort and literally mean the difference between life and death (NRC, 2001). How do emergency response, aid, and development organizations receive, maintain, and disseminate timely information to know where and which populations are most at risk and likely to be affected by a disaster?

The National Research Council Committee on the Effective Use of Data, Methodologies, and Technologies to Estimate Subnational Populations at Risk was convened to respond to a request from the U.S. Department of State, U.S. Agency for International Development (USAID), U.S. Census Bureau, National Aeronautics and Space Administration, and Centers for Disease Control and Prevention that considers this broad question, further refined in the study's statement of task (Box 1).

This committee report responds to that charge and provides the specific framework for understanding populations at risk of disasters and the need for good population data, including demographic features; it also describes how demographic data are used before, during, and after a crisis, as well as some of the more important reasons these data are underutilized. The report also examines the current status of techniques for estimating and analyzing at-risk populations, with an overview of the direct and proxy measures for making these population estimates, and outlines the inter- and intra-institutional challenges of data sharing and information management. The committee was asked to examine some examples of responses to crises in three specific countries—Mali, Mozambique, and Haiti—each with varying population data records at the times of specific crises. The report illustrates the manner in which population data and geographical visualization tools were and were not used in these responses, and how their use

BOX 1
Statement of Task

An ad hoc committee under the auspices of the Geographical Sciences Committee will conduct a study on improving demographic data, methods, and tools and their application (1) to better identify populations at risk—groups that are susceptible to the impact of natural or human-made disasters; and (2) to improve decisions on humanitarian intervention, disaster relief, development assistance, and security for those populations at subnational scales. The study will be organized around a workshop that will address the following tasks:

1. Assess the strengths and weaknesses of existing data, methods (e.g., gaps in spatial and thematic coverage, counting individuals, proxy measures such as those derivable from Earth observations), and tools for estimating population.
2. Identify the limitations of current institutional structures in using existing demographic and other data and tools for these applications, and potential new approaches resulting from science and technology advances for collecting better data and producing more effective information and analysis tools.
3. Identify ways in which subnational demographic and geographic data and tools could be used to help decision makers in U.S. federal agencies, foreign governments, international organizations, and international partner organizations provide useful information to populations at risk of facing disasters as well as to better respond to their needs for humanitarian assistance.
4. Review the strengths and limitations of information and data analysis and visualization tools developed by government agencies for responding to conflict-, climate-, and health-related crises in Mali, Mozambique, and Haiti.
5. Informed by this three-country example, recommend ways to make information collection and data analysis and visualization tools more effective for decision makers responding to humanitarian crises.

might have been improved. While directed primarily at the U.S. government sponsors of the study, the main recommendations identify dedicated actions with respect to population data that might improve the ability of federal agencies and international organizations, national governments, institutes, and private entities to conduct timely, effective disaster response and development work.

ACCURATE, ACCESSIBLE, AND GEOSPATIALLY RESOLVED SUBNATIONAL POPULATION DATA

National census data serve as the foundation for measuring likely populations at risk from the impacts of natural or human-induced disasters. Census data include not just the number of people but also some of the characteristics of the population such as age, gender, and race or ethnicity; these categories are commonly described as demographic data. In many countries, data on economic well-being and housing stock are included as well. In this report, the broader term "population data" is used to encompass both the number of people and their demographic and other socioeconomic characteristics such as those typically collected through censuses and surveys. Improvements in the collection of and access to subnational data are vital to decisions on humanitarian intervention, disaster relief, and development assistance. However, various acute, but in many cases resolvable, limitations in geospatial data, methods, and tools for improvements in subnational demographic data estimations often preclude the use of the data under normal conditions for planning, let alone during periods of crises. In this view, the committee found that ***assessments of at-risk populations involve a linkage between population data by location (place or area), frequency and severity of a specific kind of hazard or sets of hazards acting on that location, and the resilience (coping capacity) of societal and environmental subsystems of that location. In other words, the quality and level of population data will have a direct effect on the quality of the response and the number of lives saved.***

Based on information gathered during the course of the study and on its own expertise, the committee has reached an overarching conclusion that ***the data and analytical capacity or potential capacity to address populations at risk exceeds the actual use of such data and appropriate analysis as judged by recent disasters in the United States and globally. Further, governments, emergency response organizations, and other types of responders need to be educated and trained in the importance, need, use, and contributions of such data and to be proactive in seeking and utilizing this information to enhance the distribution of disaster relief aid.*** The committee's recommendations to agencies and organizations working in relief and development capacities support this conclusion and specifically address improvement of the institutional capacity for a baseline census; improvements in the base census and the release, availability, and archiving of data; institutional and decision-making needs; research needs; and the interorganizational structure of U.S. government data providers (Box 2).

Improvement of the Institutional Capacity for a Baseline Census

Estimation of the total population at risk and definition of its characteristics (e.g., age, gender) and its subnational and spatial distributions are critical for mounting any humanitarian response. While the expense and resource commitments needed to conduct national censuses with greater than 10-year frequency may prohibit obtaining these data more often, simple algorithms could be used to update the census population data

BOX 2
Summary of Study Recommendations

Improvement of the Institutional Capacity for a Baseline Census

1. Improve the capacity of census-poor countries, through training and technical assistance programs, to undertake censuses. Such improvement is critical for the long-term availability of subnational data that can assist in humanitarian emergency and development situations. Knowing the location, number, and critical characteristics of populations is pivotal to all planning, response, and long-term understanding of disasters. These data sets should have pre-existing protocols for data format, sharing, mapping, intercensal projections, and metadata that are consistent with international standards.

2. Integrate the national statistical offices (NSOs) into the national preparedness and response teams for national emergencies. This role would involve the development of pre-disaster geospatial databases and experience in working at subnational levels relevant to hazards of all kinds. The aim is to improve the capacity of NSOs to generate and modify existing data in a timely fashion to enhance emergency response and crisis decision making.

3. National and international disaster response and humanitarian agencies and organizations should elevate the importance of demographic and specifically spatial demographic training for staff members. Further, census staff and others working in NSOs throughout the world should be encouraged to undertake such training in order to promote the analysis and use of subnational data before, during, and after emergency response situations.

Improvements in the Base Census and the Release, Availability, and Archiving of Data

4. Develop a template of minimum acceptable population and other geospatial data sets that are required by disaster responders. The data sets should be updated frequently (at least mid-decade if not more frequently) and include digital census enumeration units and other census maps in digital form.

5. The standard of open-access census data and sharing (as practiced, for example, by Brazil, South Africa, and the United States) should serve as a model for other agencies and for countries that currently do not operate in an open geospatial environment. This access includes spatial data such as digital boundary files of subnational units of countries of the world. Governments should release specific data sets that are vital to disaster planning and response. Furthermore, international standards should be developed for the release of subnational population data to maintain confidentiality. Countries financially unable to comply with confidentiality standards should be offered incentives to do so.

6. Establish a centralized system of access, such as distributed archives and data centers for publicly available subnational data, including data from surveys. The archives would function as such a repository for shared local data and would have the primary responsibility for re-dissemination of data to the appropriate response communities during a disaster. The archives should build upon existing data resources.

Institutional and Decision-Making Needs

7. Relief agencies should broaden their collaborative relationships with NSOs to ensure the acquisition of real- and near-real-time data that complement and are compatible with existing data used for disaster response.

Research Needs

8. Support should be given to test the accuracy of estimates of size and distribution of populations based on remotely sensed imagery, particularly in rural and urban areas of countries with spatially, demographically, and temporally inadequate census data. Current efforts to render global spatial population estimation—LandScan and Gridded Population of the World—use different methodologies. An independent study of the state of the art in spatial population estimation would highlight the strengths and weaknesses of the existing methods, and could serve as a guide for improvements in the methods and development of new ones for the purposes of understanding populations at risk.

9. Improve subnational analyses of vulnerability to natural disasters and conflict in order to delineate hazard zones or exposures where routine, periodic data collection ex ante could occur. The development of such georeferenced vulnerability analyses could help provide accountability to decision makers in preparedness and prevention and establish priorities for risk reduction investments by all stakeholders.

Interorganizational Structure of U.S. Government Data Providers

10. The U.S. Census Bureau should be given greater responsibility for understanding populations at risk and should be funded to do so. These responsibilities could include greater capacity and authority for training international demographic professionals in the tools and methods described in this report, and providing data and analytical capabilities to support the U.S. government in international disaster response and humanitarian assistance activities. The U.S. Census Bureau should also have an active research program in using and developing these tools and methods, including remotely sensed imagery and field surveys. Existing research support models that involve government-academic-private consortia could be explored to develop a framework for the U.S. Census Bureau to adopt these added responsibilities.

with information from ongoing demographic surveys conducted between censuses. These methods are rarely employed in pre-disaster preparedness or in post-disaster response situations. At the time of the October 2005 Pakistan earthquake, the census data in Pakistan were seven years old and not fully representative of the characteristics of the subnational populations affected by the event. The experience of the humanitarian aid response to the earthquake exemplified that census data, supplemented by more recent population survey updates provided in real time to responders, would have improved aid planning and allocation after the earthquake struck. Although various methodologies for conducting intercensal surveys are well established, the committee notes that surveys are not routinely used to update census information, and the smaller numbers of observations that generally comprise a typical survey are not always easily integrated into existing census databases. Thus, methods for integrating survey and census data for this purpose need to be developed and tested by teams of researchers and relief practitioners.

Good population data and their use in humanitarian situations are also predicated on the existence of staff trained in both demography and geospatial tools and technologies at national statistical offices (NSOs) in each country. The committee found that, at present, relatively few NSOs, especially in developing countries, have sufficient trained expertise in both demography and geospatial tools and technologies. Building appropriate skill sets and establishing more formalized training in countries lacking demographers and people with geospatial expertise are a fundamental part of NSO development. Such training programs could be part of overall capacity building with funding by bilateral aid programs, such as USAID, or through broader country capacity building programs, such as those supported by the World Bank or the United Nations.

Improvements in the Base Census and the Release, Availability, and Archiving of Data

The issue of determining populations at risk involves more than just data; however, every community needs accurate and place-specific population and population attribute data for improved disaster planning and response. Georeferenced total population and age-gender specific counts are thus the minimum data sets required for disaster response. Population attribute data such as race or ethnicity, socioeconomic status, and education are also important and serve to improve the effectiveness of the response.

Examination of existing data and methods for estimating subnational populations led the committee to understand that the methods themselves are likely less problematic than the data to which estimation techniques are applied, especially in those countries that are data poor. Censuses, surveys, and remotely sensed imagery, as well as modeling techniques, can be applied to overcome deficiencies in the data sources. While it may be impractical (and potentially problematic from the standpoint of privacy) to obtain individual household data, aggregate counts by census tract or small enumeration area are key to effective disaster management. Equally important is the ability to aggregate these enumeration areas into other geographies or spatial units, such as physical zones (e.g., coastal areas, steep slopes, floodplains) or social zones (e.g., urban areas). The enumeration unit ought to be georeferenced and provided in digital form with hard-copy maps available for field responders.

A persistent limitation on the effective use of subnational population data is the low level of access to sensitive data and of data sharing among agencies and organizations. A practical issue that may hinder data sharing, for example, is that governments may charge for access to data as part of their cost recovery plans for the initial expense of data collection, analysis, and management. A direct result of cost recovery programs is that data are not freely available to those requesting them for the purpose of humanitarian assistance. Some national examples of open-access census data and sharing should serve as models to make census and administrative boundary data freely accessible; the response community may also consider negotiating appropriate reimbursement costs to the government agencies that collected the data.

Decision-making communities would benefit not only from access to the required data but from maintenance of appropriate safeguards regarding data confidentiality. One such mechanism is a centralized repository—an "Archive and Data Center"—for subnational population data worldwide. To be successful, countries contributing subnational data must be assured of confidentiality protections. Equally important are consistent protocols for inclusion, standardization, georeferencing, and analysis of the population data in such an archive.

Institutional and Decision-Making Needs

Although agencies commonly anticipate data and information needs in advance (the preparedness phase), oftentimes other critical informational needs arise during and after the event (response phase)—such as which road networks are destroyed, how many people were displaced and where they went, and designated shelters or camps. It is beyond the capability of many NSOs to conduct field surveys of affected populations living outside of officially designated camps or to obtain ancillary data (e.g., fixed-wing airborne imagery, or satellite imagery) to assist in determining the number and characteristics of the affected populations. Relief agencies, in contrast, typically have this capacity and should work closely with local NSOs to ensure that such data complement, and do not duplicate, existing data sets for disaster and humanitarian relief.

Research Needs

The committee identified various approaches both to population size estimation as well and to understanding the vulnerability of subnational groups. At present, a number of differing approaches exist for spatial population estimation, but little guidance is provided as to which are most useful to local responders and in what circumstances. In addition to research on spatial population estimation methods, more analytical work is needed on subnational vulnerability analyses, an area that is now demanding more attention with the adoption of the Hyogo Framework of Action 2005-2015 by the international community at the 2005 United Nations World Conference on Disaster Reduction.

Interorganizational Structure of U.S. Government Data Providers

Prioritizing resources for preparedness and response is one of the most vexing aspects of disaster and humanitarian crisis management. Objective data on hazard vulnerability and population are often lacking, as are subnational population data. Tensions and impediments exist between federal agencies with respect to spatial and demographic data for disasters and humanitarian crises. From an operational and policy standpoint, these issues lead to inefficiencies and are often duplicative of human and financial resources.

The exact compositions of the populations at risk including total numbers, characteristics, and location are often imprecise or unknown, which complicate humanitarian relief and disaster response efforts, even if local governments and agencies are willing to make existing population numbers available to responders. Lack of data access or absence of coordinated data analysis and response in the presence of population data poses problems not only for the world's poorest nations, but also for the wealthiest. The recommendations resulting from this study provide a potential pathway for U.S. government agencies to improve population data estimates and their application to the identification of at-risk populations. Other international organizations, agencies, and governmental and nongovernmental groups involved in disaster response and development aid may also find implementation of some of these recommendations useful. These recommendations can help improve decision making on disaster relief and humanitarian intervention during a given crisis event and, importantly, recovery and development assistance efforts outside the crisis period.

The committee understands that these recommendations involve allocation of additional financial resources in an environment of intense domestic and international competition for funds to support a host of worthy and practical programs and causes. The information in this report is intended to inform governments and donors about the longer-term benefit of investment in establishing and maintaining regularly updated georeferenced population data sets in all countries, with flexibility for disaggregation of the data to subnational levels. Governments and donors must determine themselves if and to what degree additional investment in these efforts is justified in the context of national spending priorities.

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1

Populations at Risk: Local to Global Concerns

NATURE OF THE PROBLEM

The South Asian earthquake and tsunami of December 2004, the Pakistan earthquake and Hurricane Katrina in the latter part of 2005, and the ongoing humanitarian crisis in Darfur graphically illustrate the human toll of natural and human-induced disasters and the ongoing need for understanding the populations at risk from such events. Each year, millions of persons are affected. The global disaster death toll in 2004 and 2005 was higher than for any two-year period in the last decade, largely attributed to two singular, regionally significant events—the Indian Ocean earthquake-tsunami and the Pakistan earthquake.

Less frequent, sudden-onset natural events that trigger humanitarian disasters capture public attention and significantly underscore such critical outcomes as deaths and economic and livelihood losses. These events also involve the mass movement of groups of people away from their homes either as refugees to other countries or within their own borders, as internally displaced persons (IDPs). However, these types of disasters may mask the equally important consequences of more frequent or chronic events, such as flooding, tropical storms, drought, famine, and civil strife. Indeed, while the total number of refugees under the mandate of the United Nations High Commissioner for Refugees (UNHCR) continues to fall, the total population "of concern" to UNHCR, including refugees, IDPs, returnees, and stateless persons, has remained fairly constant during the past 10 years (UNHCR, 2006).

With both sudden-onset and chronic events, the populations under consideration require humanitarian relief at the time of, or immediately following, the crisis, as well as in the post-disaster, recovery phase of the event. Development aid ideally serves as a preventive measure to increase the resistance of a particular group of people to the effects of a natural or human-induced event, thereby decreasing their vulnerability. Development aid is also an important element of the disaster cycle with a role in generating a sustainable foundation for a population to support itself. Considerations of populations at risk, therefore, ought to address chronic and sudden-onset events at local, regional, and national scales and in the disaster relief and recovery and the development phases.

CHARGE TO THE COMMITTEE

In May 2004, the Humanitarian Information Unit of the U.S. Department of State hosted a Workshop on Systematic Population Estimation together with the U.S. Census Bureau and the National Academy of Sciences. The workshop facilitated discussion of approaches to population estimation in regions of the world generally lacking in data and prone to experiencing human-induced or natural humanitarian crises. The workshop resulted in recognition of the need for a more systematic U.S. government approach to subnational population estimation.

This study was an outgrowth of the information gathered at that workshop and was conducted at the request of the U.S. Department of State, U.S. Agency for International Development (USAID), U.S. Census Bureau, National Aeronautics and Space Administration, and Centers for Disease Control and Prevention. As a response to this request, the National Research Council (NRC) established the Committee on the Effective Use of Data, Methodologies, and Technologies to Estimate Subnational Populations at Risk to address the issues outlined in the study's statement of task (Box 1.1). The committee consisted of 12 experts from academia; international organizations; and national bureaus with expertise in geography, demography, geographic information science and remote sensing, public health, natural disasters, environment and climate, sociology, humanitarian affairs, and economics; and individuals with experience in planning and delivering humanitarian assistance following natural and human-induced disasters (Appendix A).

COMPLEXITY OF THE SITUATION

A timely response and the delivery of humanitarian assistance in a disaster situation is challenging in and of itself (IFRC, 2005, 2006). Efficient coordination of various actors involved in disaster relief requires a well-

BOX 1.1
Statement of Task

An ad hoc committee under the auspices of the Geographical Sciences Committee will conduct a study on improving demographic data, methods, and tools and their application (1) to better identify populations at risk—groups that are susceptible to the impact of natural or human-made disasters; and (2) to improve decisions on humanitarian intervention, disaster relief, development assistance, and security for those populations at subnational scales. The study will be organized around a workshop that will address the following tasks:

1. Assess the strengths and weaknesses of existing data, methods (e.g., gaps in spatial and thematic coverage, counting individuals, proxy measures such as those derivable from Earth observations), and tools for estimating population.
2. Identify the limitations of current institutional structures in using existing demographic and other data and tools for these applications, and potential new approaches resulting from science and technology advances for collecting better data and producing more effective information and analysis tools.
3. Identify ways in which subnational demographic and geographic data and tools could be used to help decision makers in U.S. federal agencies, foreign governments, international organizations, and international partner organizations provide useful information to populations at risk of facing disasters as well as to better respond to their needs for humanitarian assistance.
4. Review the strengths and limitations of information and data analysis and visualization tools developed by government agencies for responding to conflict-, climate-, and health-related crises in Mali, Mozambique, and Haiti.
5. Informed by this three-country example, recommend ways to make information collection and data analysis and visualization tools more effective for decision makers responding to humanitarian crises.

organized, cross-institutional, inter- and intragovernmental structure that transcends the international public and private sectors. These actors include local and national governments in the affected countries, international and national nongovernmental organizations (NGOs) that offer relief, and governments that donate aid directly or through third parties. Coordination involves communication between these different actors in order to donate, receive, and distribute the appropriate aid to those most in need in a timely fashion. Recognizing that coordination is a critical factor in the successful response to disasters and emergencies, much attention has been given to the coordination of international relief efforts in recent years. At the international level, the role of the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) has been expanded significantly, whereas UNHCR continues to be the lead agency for refugee situations.

Relief efforts may be particularly challenging if the transportation and electrical infrastructure are not functioning as a result of the disaster or are not of a reliable standard due to the relative poverty of the country in question; similarly, the conditions for relief workers to operate safely and effectively may also be compromised. Regardless of the conditions that relief workers and agencies encounter in disaster response situations, the underlying theme of relief efforts is to give aid to affected populations and to assist these populations in their recovery following a disaster. Data considered fundamental to relief efforts include the total number of people affected by the disaster in any specific, affected (subnational) area and the characteristics, density, and vital statistics of that population subset. Often, however, decision makers lack the requisite population or demographic data for the affected area, and the deployment of emergency response teams without even rough estimates of the number and location of the people in the vicinity of a disaster is not uncommon. Even if data on the population at risk are available, their usefulness may be hampered by the impact of the disaster or conflict or by impediments engendered by inefficient coordination among responding agencies, government(s) of the affected nations, and organizational structures in place to provide relief to the people in crisis.

Increasingly, humanitarian relief for disasters has become international in scope, involving both international organizations and programs and country-to-country assistance. For example, the 2004 Indian Ocean tsunami disaster saw assistance from dozens of NGOs and more than 50 countries not directly affected by the event (Figure 1.1). Thus, risk, vulnerability, and disaster planning and response transcend individual states and countries and point to a need for data that are global in reach in order for governments and intergovernmental programs to prepare and respond accordingly.

Decision makers need interpreted data in real time that can be visualized easily, such as those packaged in geographic information systems (GIS). Once the initial emergency period has passed, accurate data on the characteristics and size of the population are required for recovery, reconstruction, and resettlement of the displaced persons. For this succession of events to take place, information on the affected population ought to be collected and shared as soon as possible and provided to update existing national databases.

POPULATION DATA AND VULNERABILITY IN THE DISASTER AND DEVELOPMENT CONTEXT

Natural and human-induced disasters occur throughout the world but are often most felt by individuals living in impoverished communities or countries. Delivering effective emergency response and humanitarian and development aid to these populations at risk is part of the mandate for a variety of U.S. federal agencies (for example, Department of State, USAID), in-

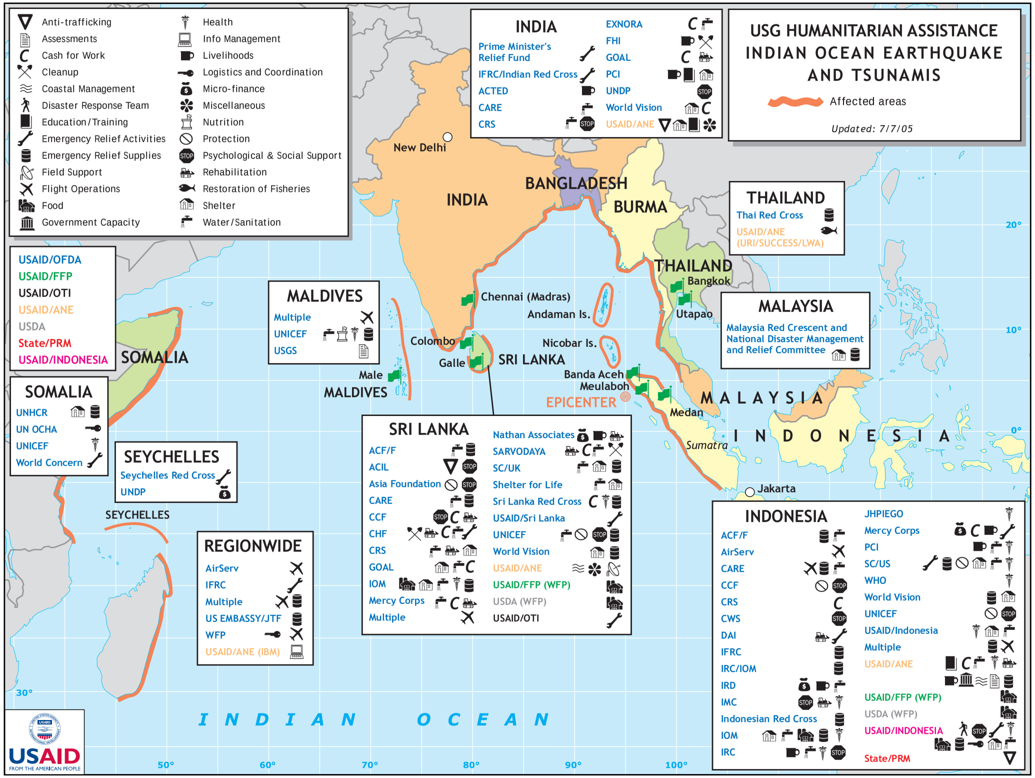

FIGURE 1.1 The number of organizations and countries involved in disaster relief efforts after the Indian Ocean tsunami illustrates the complexity of disaster relief coordination. SOURCE: USAID.

ternational organizations (for example, World Health Organization, United Nations, World Bank, International Federation of the Red Cross and Red Crescent Societies), and nongovernmental organizations (for example, Veterans America [formerly Vietnam Veterans of America Foundation], CARE, Oxfam, Church World Service, and Médecins Sans Frontières). How many people, their characteristics, and where they are constitute critical information needed by agencies and organizations charged with disaster response. Inaccurate numbers and locations for populations can slow the relief effort and literally mean the difference between life and death. This report examines how these organizations might generate and receive information on where and which populations are most at risk and may be most affected by the disaster. Critical to the discussion is the ability to generate and use reliable georeferenced population data sets that allow population data to be linked directly with maps; this was a recurring theme expressed to the committee throughout this study process from a variety of crisis responders and development aid providers. Some of the basic terminology used in these discussions and applied in this report is reviewed below. Appendixes B and C contain a list of acronyms and a glossary of definitions.

This study focuses on the use of data, methodologies, and technologies to estimate populations at risk from or subjected to natural or human-induced disasters. A disaster is commonly defined as a singular, large, nonroutine event that overwhelms the local capacity to respond adequately (NRC, 2006). Natural or human-induced disasters often lead to massive displacement, creating a humanitarian crisis and triggering the need for material assistance, legal protection, and a search for durable solutions. Humanitarian response is generally organized according to sectors, such as health, shelter, sanitation, community services, and protection. Today, most population displacement occurs within national borders, creating so-called internal displacement (internally displaced persons). Refugees are victims of conflict, civil or ethnic strife, or persecution who flee across international borders and who are protected under international law.

Often, natural disasters are triggered by relatively short-lived events, but their impacts may necessitate longer periods of recovery and reconstruction (months to years) for communities to reestablish their livelihoods and to return displaced persons to their homes (Kates et al., 2006). Human-induced disasters, such as civil conflicts, are more likely to create protracted situations requiring long-term (years to decades) intervention and support before people can return. These protracted situations may constitute a complex emergency—"a humanitarian crisis in a country, region, or society where there is a total or considerable breakdown of authority resulting from internal or external conflict . . . which requires an international response that goes beyond the mandate or capacity of any single agency and/or the ongoing United Nations country program" (IASC, 2004). Response to complex emergencies is often more difficult than response to natural disasters, given the potential for ongoing violence in the area, extensive loss of life, massive displacement of people, and widespread damage to livelihoods. Security risks for relief workers may slow the response further (Figure 1.2). Actors involved in all disaster relief efforts include national and local authorities, international agencies, and nongovernmental organizations. The degree of international assistance generally depends on the national capacity of the country to cope with the disaster.

A wide range of terminology is employed to describe these different types of risks, disasters, and responses. In this report, the term "disaster" is generally used to describe these different situations. Depending on the scenario, more specific terminology is used, such as natural disaster or humanitarian crisis.

The mere exposure of a population to a hazard does not create a disaster. Disasters follow from the severity or intensity of the hazard and the sensitivity and resilience of the system (population-place) exposed. This point led the expert community to enlarge the risk-hazard model to a vulnerability model (Wisner and Blaikie, 2004; Cutter, 1996), ultimately adding the environment itself to population and place in order to determine resilience (Adger et al., 2005; Turner et al., 2003) (Box 1.2).

With risk embedded in the vulnerability concept, a more vulnerable population is one that is frequently exposed to, is easily harmed by, and has low levels of recovery, buffering, and adaptation to a hazard. In this view, ***assessments of at-risk populations involve a linkage between population data by location (place or area), the frequency and severity of a specific kind of hazard or set of hazards acting on that location, and the resilience (coping capacity) of societal and environmental subsystems of that location.***

NEEDS FOR DISASTER RESPONSE AND PREVENTION

Data

Two fundamental data needs in responding to population crises—whether disasters or complex emergencies—are where the event is occurring and how many people are likely to be affected. Inadequate spatial and temporal data of this kind during crises and emergencies significantly impair effective humanitarian response. This impediment is amplified for those countries that have poor and outdated censuses and incomplete demographic characteristics data at the local (subnational) level. While the focus on crisis response is time sensitive, data for longer-term disaster recovery, mitigation, and prevention are also important.

FIGURE 1.2 Internally displaced persons in Darfur, Birjaffa, exemplify the difficulties of responding to complex emergencies like the crisis in Darfur. Internal civil conflict and violence have led to forced movements of large numbers of the population to other areas of the country and outside the country as refugees. The mass, forced migrations of people disrupt normal agricultural growing practices, herding, and access to proper housing, clean water, sanitation, and food. Malnutrition and disease spread easily in these circumstances, and efficient supply of aid can be hampered by continuing civil conflict, heavy rainfall or drought, and continuous change in the number of people requiring assistance in a given area. Accurate counts of people and knowledge of some of their vital characteristics are important for effective and efficient delivery of needed aid. SOURCE: © Pierre Abensur, 06/04ref. sd-n-00220-19.

BOX 1.2
Populations at Risk and Vulnerable Populations

A rich, inter- and multi-disciplinary tradition focuses on risk, hazards, and disasters (NRC, 2006; McDaniels and Small, 2004). Hazards arise from the interaction between society and natural systems (e.g., earthquakes, tsunamis, tropical storms), between society and technology (e.g., chemical accidents, nuclear power plant accidents), or within society itself (e.g., war, civil and ethnic strife, persecution, human rights violations). Hazards have the potential to harm people and places, including ecosystems. Risk, another widely used concept, is the likelihood of incurring harm—that is, the chance of injury or loss, in this case, from the hazard event.

Over the last decade, the risk-hazards concept has given way to a more inclusive view of hazard and impact captured in the term "vulnerability." Although there are numerous definitions of this concept (Wisner and Blaikie, 2004; Kasperson et al., 2005; Adger, 2006; Janssen et al., 2006), they tend to speak to the degree to which a system or unit (such as a population or a place) is likely to experience harm due to exposure to perturbations, stresses, or disturbances from natural, technological, or human-induced sources. In this case, risk is embedded in the three characteristics that comprise vulnerability:

- exposure to the hazard,
- sensitivity to the exposure, or the degree to which social groups or places are initially harmed by the hazard, and
- resilience to the harm, or the ability of the social groups or places to recover from the hazard, and to buffer themselves and adapt to future ones.

This systemic view opens the possibility that the hazard may reside within or be strongly affected by the existing context of the exposure. The view also recognizes that both social and environmental conditions and their interactions strongly affect each of the essential elements: exposure, sensitivity, and resilience (Adger et al., 2005; Turner et al., 2003; Cutter et al., 2000).

Two basic types of hazards are recognized—sudden-onset and chronic events—both of which can challenge the resilience of an exposed population. Sudden hazards tend to be "big-bang" events—earthquakes, industrial accidents, or surprise attacks—whose surprise and sheer magnitude over a very brief period overwhelm the exposed population. Persistent (or chronic) hazards, in contrast, affect the exposed population incrementally, perhaps imperceptibly at first, but they may ultimately push the resilience of the system to a tipping point and into a disaster phase. In many cases, society fails to respond to the incremental problem and thus becomes a factor in generating and accelerating the disaster. The 1930s Dust Bowl in the United States is exemplary of a chronic hazard event (Worster, 1979). An extended dry climate cycle developed over cultivation practices that were not suited for that type of climate and among a population that had minimal fiscal capacity to shift agricultural practices. Soil productivity declined, soil erosion increased, and farmers were no longer able to earn a living off the land. Ultimately, the southern Great Plains witnessed the largest out-migration of any region in U.S. history.

Demographic Data

All disasters affect local places; and thus, the first responders to any crisis situation are the affected residents themselves. To prepare for and respond to crises adequately, subnational data on the population and its characteristics are required. Given the spatial variability in hazards, a need for spatially explicit demographic data is also evident. Typically, finer spatial resolution of data is better. For many countries, disaggregating national census data at subnational levels is difficult or impossible, even if the provision of national population censuses is possible. Haiti is a good example (see Chapter 5). Despite experiencing continuous civil strife and countless natural disasters, the first formal population census data since 1982 were released by the Haitian Institute of Statistics in May 2006 based on a national census conducted in 2003, with the support of the United Nations. In 2005, the Haitian government prepared an Emergency National Plan into which the new census data are being incorporated (H. Clavijo, personal communication, May 2006). These data, however, were not available to local or international responders during the crisis that followed the passage of Tropical Storm Jeanne over Haiti in September 2004 and added to the challenges experienced by relief workers in responding to the disaster (see also Chapter 5).

The population data needs are not only about the total number of people at risk, but also about their characteristics and the related vulnerability measures of their location. Yet, according to the UNHCR, data by gender are available for only half of the population under its mandate (11 million), while age breakdown is available for only a quarter of that population (UNHCR, 2006). UNHCR estimates that half of the population under its mandate is female, and 44 percent are under 18, yet these figures are not truly representative of the total population of concern to the organization. Ideally, finer-resolution, spatially explicit demographic data would be readily available to the disaster and relief communities. Because in many places, they are not, this committee explores alternatives.

Through extensive case studies, the vulnerability research literature has identified those factors that contribute to the vulnerability of people and the places in which they live (Bankoff et al., 2004; Birkman, 2006; Wisner and Blaikie, 2004; Pelling, 2003; Cutter et al., 2000, 2003; Heinz Center, 2002). Among these factors are health status; beliefs, customs, and social integration; racial, ethnic, and gender inequalities; wealth and poverty; access to information, knowledge, and resources; institutions; respect for human rights; good governance; and level of urbanization. Specific demographic and related variables have been identified as well, and these provide the baseline for understanding population vulnerability in both pre- and post-disaster contexts (see Box 1.3).

BOX 1.3
What Variables Measure Vulnerability?

There are rich debates both nationally and internationally about the conceptual basis for measuring vulnerability and at what geographic scale (UNISDR, 2004). As part of the World Conference on Disaster Reduction, the Hyogo Framework of Action produced a blueprint for global disaster reduction from the local to the global (UNISDR, 2006). Despite this effort, consistent vulnerability metrics still do not exist. The United Nations Development Programme's disaster risk index (DRI) (UNDP, 2004) and the Inter-American Development Bank's Prevalent Vulnerability Index (PVI) (Inter-American Development Bank, 2005) have subindices that measure exposure in hazard-prone areas, socioeconomic fragility, and lack of social resilience. However, these are country-level assessments and, in the case of the DRI, focus on only a small number of hazards (earthquakes, tropical cyclones, and floods).

Post-disaster field studies at the subnational level reveal that certain social, economic, and demographic characteristics influence the degree of harm to individuals or communities and their ability to recover from a hazard event or disaster. The Community Risk Assessment Toolkit developed by the ProVention Consortium (ProVention Consortium, 2006) uses a case study, mostly narrative in approach, in its community-based vulnerability assessments. However, to measure these concepts consistently across communities or at subnational levels, a set of specific variables is required. Those variables most often used are socioeconomic status (income, poverty); gender (male, female); race or ethnicity; age (number under 5, over 65); occupation and livelihood; households (size and composition); educational attainment; access to roads, rivers, airstrips; housing characteristics (owner or renter, building types); population growth; health status (mortality rates, infant mortality rates, HIV infection rates); access to medical services; social dependence (social security, welfare); and special needs populations (transients, infirmed, refugees) (Birkmann, 2006; Cutter et al., 2003; Heinz Center, 2002; Tierney et al., 2001).

Geographic Data

Demographic data are inherently spatial; geographic data, however, are not inherently demographic. The geographic data needs in times of crises are just as important as demographic data (NRC, 2007). Disasters affect the totality of local places, so it is vital that geographic data have the requisite scale and resolution to facilitate a response. These requirements include political or administrative boundary delineations, adequate subnational maps with topographic features (rivers, lakes, mountains, coasts), land use/or land cover data, and spatial measures of existing environmental conditions. Such data could be complemented by infrastructural information (roads, waterways, airstrips, etc.) in order to deliver humanitarian assistance to the affected population. Most importantly, georeferenced data on demographic characteristics are needed and preferably provided as anonymous individual census records so that data can be aggregated to any spatial scale. Geospatial data in emergencies can save lives by directing assistance immediately to those most in need (NRC, 2002, 2007).

In the absence of available subnational census data or population surveys to complement existing population data, proxy data can be used to match demographic characteristics to specific locations (NRC, 1998). For example, Earth observations can be used to distribute geographically the estimated daytime population from censuses to subnational levels using areal grids (Dobson et al., 2000; Harvey, 2002a,b) or census district levels (Chen, 2002). Overall estimates of population and dwelling units from satellite imagery work well at the macro level, but in areas of high population densities (e.g., cities) they may not be as reliable (Jensen and Cowen, 1999). Further, satellite measurements of nighttime lights may be used to model the distribution of the nighttime population into settlements (Sutton, 1997; Sutton et al., 2001).

Even in the presence of high-quality, fine-resolution census data, most censuses report nighttime (i.e., place of residence) population values only. The use of Earth observations from space and GIS modeling for differentiating daytime from nighttime populations (where people live versus where they work or attend school) or between residential and nonresidential populations is more difficult and somewhat experimental, but worth consideration (Sutton et al., 2003). The details of these aspects of estimating population are discussed in Chapter 2, so the emphasis here is that information about where people are (at home, at school, at work) when a disaster strikes can be of vital importance in gauging the level and directing the delivery of aid. While baseline geographic, infrastructural, and demographic information is essential for planning purposes during the first phases of the emergency, such data ought to be verified and updated at the local level as soon as possible following the disaster, particularly because any mass displacement will have rendered much of the pre-disaster information obsolete.

Operational Needs

Collection, maintenance, and use of population data will be most effective in the presence of a coordinated operational infrastructure during all phases of humanitarian relief response, recovery, and development. In the context of assisting populations at risk, during and after crises, demographic and geographic data will be most useful if their collection is timely, relative to the particular application for the data, and involves input from those groups involved in providing the requisite assistance—whether international nongovernmental organizations (INGOs), local nongovernmental organizations, governments, or other relief and development groups. While it is challenging to quantify and analyze the degree to which individual aid and development agencies successfully function and interact either during or after the event in general, some literature has explored the factors leading to effective (or ineffective) coordination of relief, recovery, and development activities for particular disaster situations (Stephenson, 2005; Moore et al., 2003; Van Rooyen et al., 2001). Some agencies also provide public self-assessments, post-crisis, of their responses during crises (for example, UNHCR, 1998; see also Chapter 5). The challenges in providing evidence-based assessment of the "success" of an emergency response or development effort begin with defining the "success" of a relief or development operation. Perhaps more significantly, the inherent complexities of humanitarian disasters lead to difficulties in identifying one or more direct factors behind the success or lack of success of an operation. Attribution of those factors to the direct actions of one or more organizations, governments, or their operational structures proves difficult in a situation that probably involved numerous actors with various roles, interests, areas of expertise, and budgets.

The objective of this report is not to critique the actions of individual agencies or groups of agencies in responding to disasters, but rather to address the operational manner in which agencies might better collect, estimate, access, and use population data that are spatially and temporally defined and updated in the context of disaster response and recovery, as well as in development endeavors. In doing so, the committee has been guided by the premise that geographically referenced population data are a key component of relief, recovery, reconstruction, and development activities. The factors affecting the collection, analysis, and use of population data at the level of the institutions involved in responding to a crisis or its aftermath are distilled into three main categories: (1) the agency's, organization's, or government's role—either as a data provider or user or as an emergency responder or development organization; (2) the capacity of the agency or organization to collect or use the data appropriately—including personnel qualifications and access to appropriate technology to collect and update the data; and (3) the agency's or organization's inherent administrative structure, size, and mode of operation in the aid or development situation.

These operational factors imply the need for an agency or organization to understand and implement its own role in the context of other actors. Appropriate funding for modern equipment and sustained training is also implicit in this set of factors that influence the ability to collect and use population data. The factor that is most difficult to identify and implement is the need for institutional structures that enable intra- and cross-agency or organization communication and coordination to put in place an efficient work flow in situations that are often characterized by constant change, physical challenges, and disrupted infrastructure.

COMMITTEE PROCESS AND REPORT STRUCTURE

To address the statement of task and establish report recommendations, the committee reviewed relevant NRC reports; information submitted by external sources, including interviews, open meetings (see Appendix D), and technical papers submitted by some of the open meeting participants (Appendix E); other published reports and literature; and importantly, information from the committee's own experience.

The committee held three open meetings in Washington, D.C., two at the National Academies' Keck Center and one at the National Academy of Sciences Building. At its first meeting in November 2005, the committee heard from the federal sponsoring agencies and reviewed the statement of task and plans for the workshop. The second meeting consisted of a two-day workshop on the Effective Use of Data, Methodologies, and Technologies to Estimate Subnational Populations at Risk, which was held in March 2006 (Appendix D). This meeting comprised a spectrum of panelists representing practitioners, managers, and researchers in the fields of humanitarian and development aid, government, and research fields wherein demographic and geospatial information play coeval roles. Approximately half of the panel group had field experience in planning and delivering relief or development aid. Having focused some efforts to obtain access to individuals with geospatial knowledge, the committee was not surprised to hear repeatedly that access to regularly acquired, georeferenced population census and survey data was always desirable, but rarely available. Additional testimony was provided to the committee in an open session in April 2006. The final meeting of the committee was a closed session held in June 2006 at which time the recommendations were reviewed and finalized. Throughout the study process, the committee also received valuable input through informal interviews with various professionals associated with planning and delivery of humanitarian and development aid and their use and familiarity with population data to affect more efficient aid distribution.

This chapter has provided the framework and context for understanding populations at risk of disasters and humanitarian crises and the need for accurate, georeferenced data for disaster response and prevention. The chapter has emphasized the idea that population data are a fundamentally useful element of any relief or development activity, but that data alone are not enough to ensure efficient delivery of aid to those in need as the case of Hurricane Katrina shows. Chapter 2 examines the current status of techniques for estimating and analyzing at-risk populations, provides information on gaps in the coverage, and gives an overview of both contemporary methods and proxy measures for making these population estimates. Chapter 3 is a bridge between the data issues discussed in Chapter 2 and the institutions and organizations employing the data in disaster response and development situations discussed in Chapter 4; Chapter 3 explores how demographic data are used pre- and post-event and some of the more important reasons why these data may be underutilized by decision makers during disasters. In Chapter 4, the inter- and intra-institutional challenges of data sharing and information management are described. Chapter 5 presents examples of the use of population data in response to natural and human-induced disasters in three countries—Mali, Mozambique, and Haiti—and analyzes the strengths, limitations, and possibilities for population data use and the approaches employed in situations where the existing population data were of varying quality. The real-world examples throughout the report provide lessons that can be used to improve decision making and disaster response. Each of Chapters 2 through 5 concludes with report recommendations supported by material in that particular chapter. The recommendations are collected in Chapter 6, which is a synopsis of the report's main conclusions and recommendations for improving the capability of decision makers to identify populations at risk and, thereby, improve the effectiveness of humanitarian responses to aid these populations.

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2

Current Status of At-Risk Subnational Population Estimation

The principal goal of this chapter is to address the first task of the committee, which is to "assess the strengths and weaknesses of existing data, methods (e.g., gaps in spatial and thematic coverage, counting individuals, proxy measures such as those derivable from Earth observations), and tools for estimating population." Because the committee was charged with the overall task of better identifying populations at risk—groups that are susceptible to the impact of natural or human-induced disasters—we recognize that there are three critical elements of the data, each of which is a scale issue: (1) spatial scale (how far below the national level can estimates be derived?); (2) temporal scale (for how recent a time period can estimates be made?); and (3) social "scale" (how detailed are the available population characteristics?).

A close corollary of the scale issues is the question of accessibility of the data. Data might be "available" in the sense that they have been collected, but access to them may be highly restricted and this will limit their usefulness to the humanitarian relief community. Each of these scale issues, along with the availability of existing data, is influenced by the trade-off between costs and "errors." The finer the scale at which data are collected, the costlier the information will be, and making these more detailed data available to users will be proportionally more expensive.

As a preface to assessment of the current state of the art, the committee notes that input was sought from a range of individuals, familiar with planning and delivery of humanitarian relief, regarding the kinds of data that would be most useful to them. These individuals expressed complete agreement that very recent local data are extremely useful (without agreement, however, on a strict definition of "recent" nor on the spatial scale at which data become "local"), whereas less agreement was evident about the kinds of population characteristics that data users routinely employ. Distributions of the population by age and gender were most often mentioned because women, children, and the elderly tend to have higher levels of vulnerability in almost any emergency situation. In some parts of the world, relief agencies are clearly aided by knowing the distribution of the population by characteristics such as income levels, housing, religion, race or ethnicity, and language. In culturally homogeneous areas, especially rural regions, some of these characteristics may be common knowledge and sophisticated data collection schemes are not necessary, but in urban areas and other places experiencing in-migration, it may be important to know the relative distribution of various cultural groups. In its discussion of the social scale of available data, the committee includes age, gender, and socioeconomic and cultural characteristics, with the caveat that not every emergency may demand these characteristics and not every relief agency may use them.

This input to the committee's report is consistent in all respects with the Hyogo Framework of Action for 2005-2015, which was adopted by the international community at the United Nations World Conference on Disaster Reduction held in Hyogo, Japan, in January 2005, shortly before this committee began its work. Particularly noteworthy are the following elements, which the Hyogo Framework (UNISDR, 2005) suggests should be incorporated into all disaster reduction planning: (1) A gender perspective should be integrated into all disaster risk management policies, plans, and decision-making processes, including those related to risk assessment, warning, information management, and education and training. (2) Cultural diversity, age, and vulnerable groups should be taken into account when planning for disaster risk reduction, as appropriate. (3) Systems of indicators of disaster risk and vulnerability at national and subnational scales should be developed that will enable decision makers to assess the impact of disasters on social, economic, and environmental conditions and disseminate the results to decision makers, the public, and populations at risk.

Although tasked with evaluating both data and methods, the committee's view is that methods themselves are likely less problematic than the data to which estimation techniques are applied, especially in those countries that are data-poor. The committee discusses the use of censuses, field and weighted population sample surveys, and remotely sensed imagery, as well as spatial modeling techniques designed to overcome deficiencies in the extant data sources. A key element in modeling and estimation techniques is the emphasis on spatially explicit demographic data—combining demographic characteristics of the population with the georeferenced location of people according to those characteristics. "Georeferenced" means a location in terms of an address or latitude-longitude, not just a place or regional name. The committee emphasizes that its focus is on pre-event population estimation—having knowledge about who is likely to be at risk when an emergency strikes, so that the size and scope of the response can be estimated properly and mobilized. However, the collection of data in the post-event environment is also discussed, especially in terms of its reliance on pre-event estimations of the population at risk.

GAPS IN SPATIAL AND TEMPORAL COVERAGE

The Ideal Census Database for Estimating Populations at Risk

The ideal population database at the subnational level would probably be a population register, with data recorded for every person with respect to residence, place of employment, age, gender, and other relevant sociocultural characteristics, with the requirement that every person has to report each change in status and location. However, the cost and intrusiveness of such a scheme means that it is presently impracticable in all but a few countries. Data from the United Nations Statistics Division (UNSD) show that scarcely more than 70 million people worldwide (about 1 percent of the world's population) live in a country with a population register, and all of them are in Europe (UNSD, 2005). The closest database that most countries come to this kind of register would be administrative sources for the purpose of voting, taxes, or driver's licenses, which record age, gender, and residence and are updated routinely. However, such registers generally exclude children and may also exclude the most vulnerable individuals in a population because they do not drive, pay taxes, vote, or otherwise have need of a formal identification card.

Population registers are maintained at the local level, with events being registered by the municipal authorities. From this point the data may be relayed up to regional and national levels, creating a central population register. Data could, of course, remain at the local level and be shared at higher administrative levels only as needed. This would be one of the "bottom-up" approaches that international organizations such as the Asian Disaster Preparedness Center (ADPC) suggest be combined with the more traditional "top-down" approaches to data collection and analysis (ADPC, 2006). The usefulness of local data depends, however, on the ability of relief organizations to access and integrate those data into standard methods of analysis. Thus, an integration of top-down standards and bottom-up data collection would probably yield the most reliable and useful type of population register.

Until resources become available to generate ideal population databases in all countries, the best working set of data by which to estimate populations at risk almost certainly comes close to what is available for countries such as Mexico, the United Kingdom, Canada, South Africa, and the United States—census data for two or more time periods at the equivalent of the subcounty level (e.g., census tract, or preferably census block, in the United States and Canada; area geográfica estadística basica (AGEB) in Mexico; enumeration area in the United Kingdom), along with digital boundary files (e.g., Shapefiles) that cover that level of geography and to which the data can then be georeferenced. Preferable in almost every situation is to have data at the finest possible spatial resolution, especially when dealing with emergency situations. In general, it is easier to aggregate detailed data to coarser spatial resolution than it is to parse aggregated data into finer units. In an emergency situation, in particular, detailed data may help identify populations that are especially vulnerable and are thus likely to be in the greatest need of assistance.

Censuses measure people at their place of residence (the "nighttime" population), not where they work or attend school. If emergencies occur during a time period when people are not at or near home (typically the daylight hours), then estimates of residential population are apt to overestimate the population at risk in some places (by inferring that people are at home when they are really at work) and underestimate it elsewhere (where people work, but do not live). Partial compensation for these daytime and nighttime differences is possible in countries such as the United States where an economic census (a census of businesses, rather than households) or the Place of Work data set produced by the Population Division of the U.S. Census Bureau is available. These data can be used to create at least rough estimates of daytime populations at the local level.

In theory, every census has the potential to become this kind of versatile resource because each interviewed household should have an address associated with it, and thus the data can be aggregated (anonymously) to local administrative boundaries, although the committee notes that sample size issues can make this exercise challenging. The existence of paper maps for such boundaries means that digital maps can be produced, as long as the paper maps (or other legal description of boundaries that can be produced in a map) are made available to someone with the software and expertise to create digital maps. The committee notes that the spatial precision of maps rendered from imprecise paper maps will retain those aspects of impression in their digital forms. Producing digital maps is not an insurmountable issue for any place just as long as some type of hard-copy enumeration unit map exists. Once a digital map is made, it does not need to be remade, only updated as boundaries change.

The utility of existing census data can be seen in Figure 2.1, which summarizes and updates UN data on the recency of national censuses throughout the world. Since 2000, 85 percent of the world's population has been enumerated in a census or population register. To be sure, this

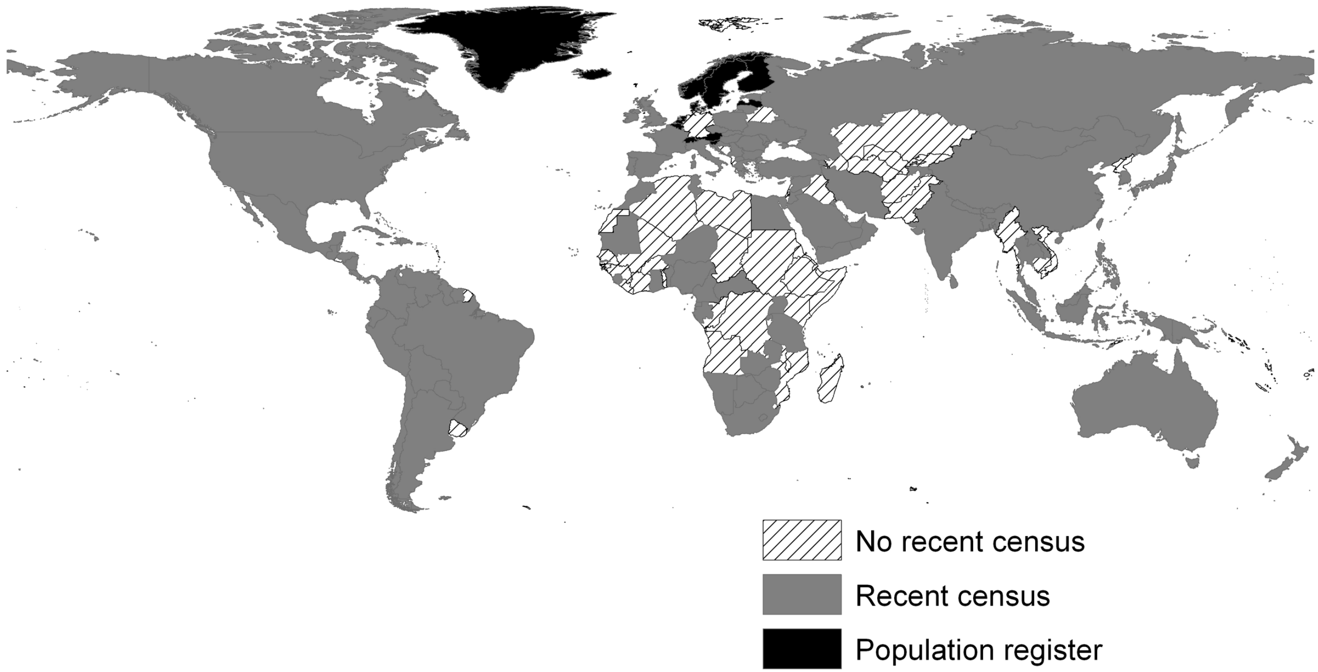

FIGURE 2.1 Censuses by country as of the year 2005 based on data back to the year 2000. Most countries have taken a census in 2000 or more recently. Mozambique, shown in this figure as lacking a recent census, had conducted a full census in 1997 and has made these georeferenced data available digitally. Mozambique will conduct its decennial census in 2007 (see also Chapter 5). Thus, "recent" as a qualifier to the existence of reliable census data in a country must be evaluated on a country-by-country basis. SOURCE: Courtesy of and adapted and updated from United Nations Statistics Division (2005).

still excludes nearly 1 billion people, about half of whom are in Asia and half in Africa. The latter region is particularly underrepresented in census counts, with scarcely half of the population having been enumerated in a recent census.

A positive development in terms of maintaining current data is the increasing (albeit still relatively limited) use of continuous measurement programs, such as the American Community Survey in the United States, to supplement the regular (typically decennial) censuses. Peru is among the first developing countries to begin the implementation of such a program (Peru Instituto Nacional de Estadistica e Informatica, 2005).

For the best-case scenario, the assumption is made that the information obtained in the census includes those attributes of people, households, and housing units that will be most useful for planning purposes. Such censuses would have followed the recommendations and guidelines on census content set forth by the United Nations and available at *http://unstats.un.org/unsd/publication/SeriesM/SeriesM_67rev1E.pdf*. At present, these guidelines are silent on overall principles of census taking, and the recommendations on subnational data collection are weak. Furthermore, there are no guidelines whatsoever for spatial data collection and dissemination. What would an ideal set of guidelines include?

The population characteristics or attributes that may be especially useful in humanitarian relief situations include age and gender, household structure, religion and/or race or ethnicity (in diverse populations), levels of education, categories of economic activity, health status and skills, and characteristics of the housing unit (Box 2.1). However, in addition to the importance of the categories of each variable, the cross-tabulation of different variables is also significant. What is the age structure of the population by race or ethnicity? What is the household structure by religion or by educational attainment? These kinds of details help planners evaluate levels of vulnerability. Detailed tables could be assembled at a fine resolution in advance by statistical agencies, but this rarely occurs. Instead, such detailed tables are normally requested based on specific planning or research needs for particular projects or in response to some disaster situation. To develop such detailed cross-tabulations requires access to individual census records, or census microdata, as these resources are called.

The principal drawback to micro-level data is the potential for violations of confidentiality. Privacy is a major concern with the use of any data. In the United States, aggregated census data are sometimes altered or even suppressed in order to maintain confidentiality (Abowd and Lane, 2004). One common way in which confidentiality is preserved when microdata are made available to the public is to strip each record of its specific address and assign it instead to an administrative unit that includes enough people so that no single individual can be identified on the basis of the

BOX 2.1
The Gold Standard for Census Data That Permit an Assessment of Subnational Populations at Risk

1. Regular censuses of population and housing with data aggregated at subnational geographic units at a geographic scale equivalent to the census tract/ or enumeration area or even block level
2. Current and accurate digital boundary maps of the subnational units for which data are aggregated and georeferenced
3. Detailed content of census questions, including age, gender, race or ethnicity, religion, education, economic attributes, household structure, health status, skills, and housing characteristics
4. Availability of census microdata for special analyses at local geographies on an as-needed basis

data included in the census. In the United States these are called Public Use Microdata Areas (PUMA), and depending on population size, they encompass several census tracts or several counties in less-populated areas of the country. Further complicating the situation is that PUMA boundaries do not coincide with the administrative units for which other information is collected, thus making it difficult to provide an integrated database of information that would be most useful in an emergency situation.

Planning for emergencies, however, does not necessarily require that geographically precise microdata be publicly available, only that someone at the national statistical agency has the background, training, and authority to conduct analyses when requested. Of particular importance is that maps are available, and that population data are integrated into the maps. To date, most census bureaus or national statistical offices in which these confidential data reside are ill-equipped to produce on-demand estimates of census variables by hazard-specific geographic boundaries.

Reality Compared with the Gold Standard

Every country can be evaluated against the gold standard for census data (Box 2.1), and the results of that global comparison provide an estimate of the overall gap that needs to be bridged with regard to estimating subnational populations at risk. These gaps are roughly categorized into (1) lack of recent census or population data, (2) deficiencies in the existing census data, and (3) lack of or deficiencies in maps.

Lack of Census or Population Data

Conducting a census is, of course, an extremely expensive operation, and for this reason the availability of censuses at the appropriate level of detail is difficult in less-developed countries, especially Africa and Asia as noted above. However, an equally important issue is that in many less-rich countries, census data are collected but are not processed quickly or not made available for use. For the billion people not enumerated in a recent census, estimates of their number and location must be made by some modeling technique. These estimates require at least one reasonable source of information to fill in the gap left by the lack of a census. Two basic sources of such data exist—surveys and administrative data—as well as one important ancillary source, remotely sensed imagery.

Survey Data. In addition to administrative registers and population censuses, surveys are an essential, but often underestimated, source of information for vulnerability assessment and disaster response. Given the absence of recent censuses and the rudimentary status of administrative data in many developing countries, survey data are generally the most important source of information. The wide range of local, national, and international actors involved in development and humanitarian activities carry out surveys on a regular basis to scope interventions for health, nutrition, access to water, housing, eradication of poverty, and so forth. These surveys all produce baseline population data and indicators relevant for the risk and vulnerability assessment. Such surveys are relevant even in countries where regular censuses are carried out, given the inherent aspects of census data, including their decennial frequency, potential difficulties of access, slowness in processing, and weighty administrative procedures. Publishing and centrally archiving population surveys and their indicators are essential steps in ensuring their quick availability in periods of looming or actual disaster.

Sample survey data are important sources of information, especially with respect to detailed population characteristics, even in places where censuses are undertaken. The obvious advantage of the sample survey is that it is less costly to undertake a sample that includes only a small fraction of the total population. The disadvantage, of course, is the loss of geographic detail. However, it may be possible to use a variety of spatial modeling techniques to make estimates for places that were not surveyed based on the patterns found in those places that were surveyed. This estimation is made more or less difficult by the type of sampling strategy employed. The most common survey design is a multistage cluster probability sample, often stratified by urban and rural residence, which is based on sampling from defined administrative units using estimates of the enumerated population in each area. Typically, sample sizes within administrative units are based on probabilities proportional to the number of people (a self-weighting sample within each stratum), so the more populated areas are overrepresented. This approach is appropriate for obtaining national-level data but may lead to large geographic areas, especially sparsely populated rural areas, that are excluded from the sample.

Another concern with sample surveys is the size of the sample itself. The sample size must be large enough within the subnational levels sampled for estimates of subnational populations to be made with a reasonably small margin of error (with the caveat that "small" has been left undefined). Furthermore, urban areas, often oversampled already (see above), may require even greater oversampling to obtain good estimates of at-risk populations living in marginal locations such as informal settlements and unofficial housing.

The value of sample surveys is enhanced if the survey data can be combined with census data in those places where the survey was conducted. In developing nations where higher fractions of the population at risk of natural or human-induced disasters are especially vulnerable to the long-term disruption from such events, the scientific sample surveys most likely to be available are either the Demographic and Health Surveys (DHSs) conducted by Macro International Inc., an Opinion Research Corporation company (ORC Macro), with funding from the U.S. Agency for International Development (USAID), or the United Nations Children's Fund (UNICEF) Multiple Indicator Cluster Surveys (MICS). These surveys almost always include at least one subnational administrative level and thus provide an important basis for modeling subnational populations. The list of currently available and planned surveys can be found at *http://www.measuredhs.com* and *http://www.childinfo.org/MICS2/natlMICSrepz/MICSnatrep.htm*, respectively.

Household surveys have also been conducted over the past several years by the World Health Organization (WHO). These surveys are undertaken primarily in developing countries and may overlap coverage with the DHS. Information about the World Health Surveys can be found at *http://www.who.int/healthinfo/survey/whsresults/en/index.html*.

The World Bank, in conjunction with the United Nations Development Programme, has sponsored a series of household surveys aimed at evaluating levels of poverty in developing countries. The Living Standards Measurement Surveys were conducted especially during the 1990s, but some others are more recent. A complete listing is available at *http://www.worldbank.org/LSMS/guide/select.html*.

The World Bank has supported the creation of metadata for these and other household surveys (including the DHS, MICS, and WHO surveys), and this information has now been compiled by the International Household Survey Network and can be accessed at *http://www.international* *surveynetwork.org/home/?lvl1=activities&lvl2=catalog&lvl3=surveys/*. The metadata include contact information for obtaining access to the micro-level data with identifiers removed.

Rapid-assessment surveys conducted just after an emergency also fill in some of the data gaps by obtaining expert judgment estimates from well-informed local leaders—community leaders and planners or local nongovernmental organization (NGO) or national statistical office (NSO) heads. While the quality of these data is typically unknown Noji (2005) suggests that such data are preferable to no data at all. The committee would qualify this statement by indicating that consistent collection and updating of census and survey data would reduce reliance on data that may be of questionable or unknown reliability.

Administrative Data. Administrative data refer to data collected by the government or other large entity for purposes other than demographic uses. These data might be land parcel data used for taxation and land tenure purposes or utility data collected for billing purposes. Committee members recognize, however, that areas lacking censuses are equally likely to lack these sources of information. When available, administrative records typically provide data on the number of households in a given region, and in combination with other estimates of household size, this information can be used to generate total population estimates for subnational areas. However, these sources of population estimates rarely provide data on the characteristics of the population or households. Quite often, administrative data in developing countries are not automated and thus not very practical for creating and updating statistical profiles.

Remotely Sensed Data. Remotely sensed imagery includes data acquired from sensors positioned on satellites and other airborne vehicles and has generally been collected for the purpose of Earth science observation and monitoring. The total costs of undertaking a mission to acquire satellite data would far exceed the expenditures of undertaking frequent national censuses; in contrast, the marginal cost of acquiring already-collected imagery is fairly inexpensive at moderate resolution. The image itself is composed of a two-dimensional array of pixels from which radiant energy has been captured for an area on the ground that is equal to the spatial resolution of the image. The information recorded for each image depends on the particular sensor, but the brightness within a given band is assigned a digital number. The combination of digital numbers representing relative reflectance across the different bands of light yields the spectral signature of that pixel. Particular types of land cover (e.g., vegetation, soil, water, impervious surface) tend to have unique spectral signatures. The more bands that a sensor has, the more detailed is the land cover classification.

Determining any personal information about individuals directly from remotely sensed imagery is nearly impossible, although we may indirectly infer the social status of residents in an area by interpreting characteristics such as building size and shape and amenities such as swimming pools and vegetation. These inferences build on the fact that humans generally transform their physical environment in ways that provide clues about their numbers, location, and overall well-being. In rural areas, people clear forests and plow fields to plant crops; they dam rivers to create reservoirs of water, build roads, and alter the environment in numerous other ways. These activities yield clear, aerially extensive signs of the human alteration of the physical environment. This transformation is even more intense in urban areas where people put infrastructure underground and then cover the surface with an almost endless variety of buildings and transportation networks, interspersed with bits of nature (parks) in the midst of vast areas of human-built impervious surfaces (de Sherbinin et al., 2002). In all cases, people build dwellings that can be counted and identified from satellite imagery pre- and post-disaster.

Because of the direct and deliberate impact that humans have on the environment, the transformed environment may be used as an index to the population living there. Depending on the spatial, spectral, and temporal resolution of the data, it is possible to estimate the extent of human activity in an area. For example, nighttime light imagery has been used extensively to estimate the size and extent of urban populations (Balk et al., 2005a), and these images are probably among the more widely recognizable of all satellite images (Figure 2.2). These data are discussed later in the chapter, but it is useful at this point to note that in spite of the imagery's popularity, a number of limitations to the use of these data exist (Elvidge, 2006). In highly developed areas, the lights tend to splash into unpopulated areas leading to an overestimation of population, whereas in less developed areas the lack of electricity leads to an underestimation of the population. Further, no intra-urban distinctions are possible, limiting the use of these data to the detection of entire settlements. Nonetheless, the usefulness of nighttime lights for social science purposes has led to proposals for launching satellites with more sophisticated light sensors that would at least diminish some of these problems and make the data even more useful for subnational population estimation purposes (Elvidge et al., 2007).

Deficiencies in Existing Census Data

Census information, such as tables on population and housing characteristics, is increasingly georeferenced using twenty-first century geospatial technologies, but it is still the case that census tables are often not released with census geographic boundaries. Even where a census has recently been

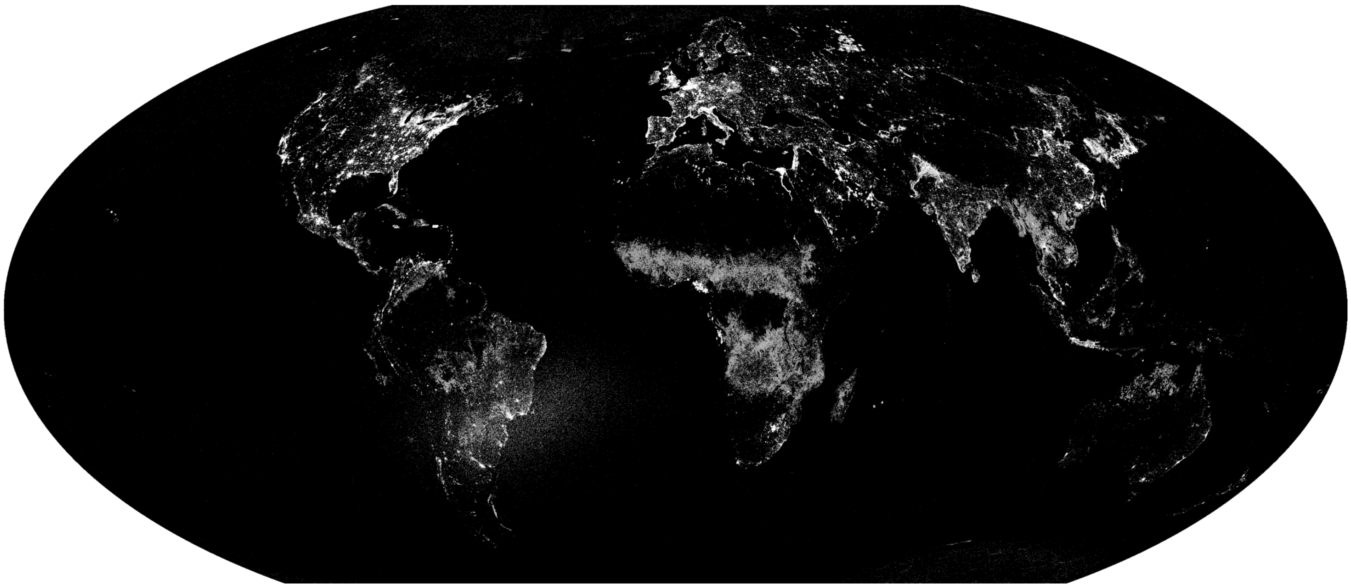

FIGURE 2.2 An example of global, stable nighttime lights (average visible band digital number) including city lights and fires. Equal-area grid. Image courtesy of Chris Elvidge (National Oceanic and Atmospheric Administration).

conducted, resource limitations may mean that data have not been aggregated or disaggregated to the local levels where they are most useful for disaster planning and response. Furthermore, even if data are available at a subnational level there may be a requirement that they be purchased and, more importantly, the purchase price may include restrictions on their reuse by others. Both requirements can prevent these data from being employed in the support of humanitarian relief operations. Although tabular data are often made available freely by NSOs—even at a fairly high level of spatial disaggregation—the corresponding census boundaries are much less likely to be made available without fees.

Another potential deficiency of existing census data is that important population characteristics may be missing. In particular, ethnic and religious differences have historically been triggers for internal violence, yet these characteristics are not always available in a census. For example, censuses in the United States historically asked about race and, since the 1980s, about Hispanic ethnicity, when the United States recognized the importance of the increasing Hispanic population. The 1980 Census question sought to obtain a count of the population of Hispanic descent. Those who selected the "Hispanic" category were asked to identify their ethnic background (e.g., Mexican American, Puerto Rican, Cuban, or "other" [Spanish, Hispanic, Latino]) (Rodríguez et al., 2007). While sensitive to some, these questions have been retained in the census, despite criticism, on the grounds that only by collecting such information could inequalities be addressed. The French, in contrast, deliberately have not asked such questions about race or ethnicity because of the social philosophy that all citizens of France should be thought of as French, regardless of their racial/ or ethnic origins. Sometimes questions about certain population characteristics, especially ethnic group identity or religion, deliberately may not be asked for fear that the information will be used by one group against another (Box 2.2). To compensate for the lack of such information, modeling techniques can be employed using sources other than census data to fill in gaps, as discussed below.

Data on health and the overall standard of living of a population are important in the evaluation of levels of vulnerability (see Chapter 1). It is assumed that persons with lower levels of health and of economic well-being will be more vulnerable than others in a population, because they tend to be more sensitive to the hazard and have less coping capacity. The source of vital statistics is a system of vital registration (e.g., birth and death registers) or a population register in combination with surveys. The source of standard-of-living data is also a census in richer countries (and sometimes in less-rich countries) and surveys in less-rich countries. In the absence of such data, it is possible to model mortality levels (which are important indicators of overall health) if reasonably accurate age and gender data are

BOX 2.2
Dangers of Census Taking in Nigeria

In March 2006, Nigeria (the world's ninth most populous nation) completed its first census in 15 years, but not without protests, boycotts, rows over payments to officials, and at least 15 deaths (Lalasz, 2006). Notably missing from the questions asked on the census were those relating to religion and ethnicity. Nigeria's population is divided among three broad ethnic groups: the Hausa-Fulani in the north, who are predominately Muslim; the Yorubas in the southwest (of various religious faiths); and the largely Christian Ibos in the southeast. The 1952 census of Nigeria indicated that the Hausa-Fulani had the largest share of the population, so they dominated the first post-colonial government set up after independence in 1960. The newly independent nation ordered a census to be taken in 1962, but the results showed that northerners accounted for only 30 percent of the population. A "recount" in 1963 led somewhat suspiciously to the north accounting for 67 percent of the population. This exacerbated the underlying ethnic tensions, culminating in the Ibos declaring independence. The resulting Biafran war (1967–1970) saw at least 3 million people lose their lives before the Ibo rejoined the rest of Nigeria. A census in 1973 was never accepted by the government, and it was not until 1991 that the nation felt stable enough to try its hand again at an enumeration, after agreeing that there would be no questions about ethnic group, language, or religion, and that population numbers would not be used as a basis for distributing government expenditures. The official census count was 88.5 million people, well below the 110 million that many population experts had been guessing in the absence of any real data (Okolo, 1999; Weeks, 2005). If the final count from the 2006 census conforms to demographic estimates, it should be about 130 million. The 2003 Nigeria Demographic and Health Survey suggests that 51 percent of these people are Muslim, while about 48 percent are Christian, and 1 percent practice some other religion (Nigeria National Population Commission and ORC Macro, 2004).

available at the subnational level (NRC, 2003). Some assumptions about the standard of living can be made from ancillary data or even inferred from the absence of data. The World Bank has pioneered methods of inferring levels of consumption, poverty, and inequity from indirect estimation techniques that couple limited census information with more expansive but more geographically confined survey information for small administrative areas (Elbers et al., 2003; Henschtel et al., 1998).

Insufficient or Deficient Maps

The easiest of the gaps to fill is with respect to maps, at least in theory. In the United States, the Census Bureau has been at the forefront in the creation and distribution of digital boundary files that provide the spatial locations referred to in census and government survey data (for the United States and Puerto Rico). The boundary files are a product of the Topologically Integrated Geographic Encoding and Referencing (TIGER) system and are available for free download from the Census Bureau at *http://www.census.gov/geo/www/cob/index.html*. Canada and Mexico have produced similar digital boundary files, but require that most users purchase them from the national statistical agency (Statistics Canada and Instituto Nacional de Estadística e Informática [INEGI], respectively). An increasing number of countries are following this lead, and private companies also buy these data sets and repackage them for consumers. The Environmental Systems Research Institute (ESRI), one of the largest producers in the world of geographic information system (GIS) software, includes a set of boundary files in its basic desktop mapping software, and it maintains a web site that has a search engine for existing digital maps from anywhere in the world, albeit without any assurances of the quality of the data found at each link available at (*http://www.geographynetwork.com*). ESRI's VMap (Vector Smart Map) data files were produced in conjunction with the U.S. National Imagery and Mapping Agency (NIMA; now the National Geospatial-Intelligence Agency [NGA]).

At first glance, the necessary maps appear to exist so there should be no problem in linking maps with demographic data. The reality is that the existing maps tend to be of uncertain or unknown quality, in terms of both accuracy and age. Furthermore, the extant maps are not necessarily available at the same level of geography (e.g., enumeration areas) as the available census data. Researchers must anticipate that for most nations a great deal of time and effort will be required to obtain digital maps that correspond to the subnational boundaries referred to in census or survey data.

Considerably more effort has been given to obtaining place-name and location data than has been devoted to building a global database of political and administrative boundaries (Lauber, 2007; see also Appendix E). While the place-name data are extremely useful for a variety of purposes, knowledge of the geographic distribution of a population within a place is crucial for estimating the size and characteristics of at-risk populations. Since census data are collected with administrative boundaries in mind, appropriate maps of those boundaries are required in order to locate people spatially. A recent Working Group of the International Union for the Scientific Study of Population (IUSSP) argues for making as many of the spatial building blocks available so that it is possible to determine the location of particular places within their administrative units and with respect to all other neighboring units (Champion and Hugo, 2004).

The United Nations Geospatial Information Working Group (UNGIWG) was created in 2000 to address these and related issues and in 2001 began work on a Second Administrative Level Boundary (SALB) project to map all countries of the world at the second administrative level, which is equivalent to the county level in the United States. This project is described in more detail on its web site (*http://www3.who.int/ whosis/gis/salb/salb_PO.htm*).

One of the limitations of the work being done by UNGIWG is that mapping is done at the scale of 1:1,000,000, which might compromise the positional accuracy of the data. As Lauber (2007; see also Appendix E) indicated, maps that were produced at the equivalent of a 1:50,000 scale would be preferable. As of 2006, maps at this scale were available for only a relatively small number of countries. An important reason for this restricted availability may be that countries are less willing to share boundary information than they are to provide place names (Lauber, 2007; see also Appendix E).

The NGA is currently in the process of digitizing the known subnational boundaries for all countries of the world (Lauber, 2007; see also Appendix E), based on descriptions of those boundaries provided to it by the U.S. Department of State. These data are an important resource with even greater value if made available publicly and accompanied by full metadata consistent with Federal Geographic Data Committee (FGDC) standards. To date, public use data files produced by NIMA (NGA's predecessor), although widely used, are considered to be poorly documented according to most university and agency standards.

With the exception of Africa, most regions of the world have a high level of coverage of the population from a recent census (Figure 2.1). Most countries that have not taken a census recently have had one or more household surveys conducted that have the potential to provide population estimates. Administrative data and remotely sensed imagery can also be used to fill in gaps in population coverage from other sources. Because all census and survey data are collected initially at the household level, the locations were known at that time. Coming close to the gold standard for census data availability requires recognition on the part of people everywhere that georeferencing the data collected is the key to success in all subsequent efforts to create subnational population estimates. Once the link is lost between the data and their location, the task of creating subnational population estimates becomes tremendously more complicated.

Added to these complications are the problems associated with trying to overlay population data with maps representing areas hit by a hazard, such as a flood, fire, or conflict. Overlaying maps is a relatively straightforward process with GIS computer software, but the computer requires a set of digital maps and many statistical agencies throughout the world are only now beginning to undertake the task of creating the maps that coincide with the boundaries of places for which statistical data are aggregated.

Because so few countries have the combination of fine-scale demographic data and accurate maps of the places represented by those data, a variety of other techniques to estimate subnational populations have been developed on an ad hoc basis. The next several sections review these techniques in order to assess their strengths and weaknesses.

Post-event Population Data

Once an event has occurred, the demographic structure and dynamics and the condition of the population in the affected region may change as a result of deaths and/or mass displacement. The issues and methods involved were reviewed in a previous report (NRC, 2001), and this section largely updates information contained in that report.

The difference between the estimate of the baseline (pre-event) population and the estimate of the post-event population provides an estimate of overall impact, and of course, the baseline data provide denominators so that death rates (and thus excess mortality) can be calculated. While baseline population counts are necessary, these counts should be sufficiently spatially disaggregated for event-specific denominators to be constructed. For example, the high-resolution census data for Indonesia (i.e., at the fourth administrative level, representing 60,000 units nationally and more than 2,000 within Aceh Province alone) permitted the estimation of the population within a narrow band of the coast—at risk from the tsunami. Data for other countries affected by the December 2004 Indian Ocean tsunami were not available at this fine a scale, adding greater uncertainty to the denominators (Balk et al., 2005b) and thus to the overall estimations of deaths and injuries.

Age and gender, which represent key demographic variables differentiating death rates and coping capacities, are the population characteristics most sought after (Doocy, 2007; see also Appendix E). Two additional characteristics, race or ethnicity and social class, were also identified as essential to understanding pre- and post-disaster vulnerability among populations affected by Hurricane Katrina in 2005 (Cutter, 2005; Cutter and Emrich, 2006; Cutter et al., 2006; Pastor et al., 2006).

Estimates of post-disaster event demographics are generally made by members of the emergency relief team or other relief agencies or, in some cases, by researchers from academic institutions or NGOs (Noji, 2005). The methods used appear to vary by organization, and often the results are not shared and compared with those of other organizations, as discussed in Chapter 4. Estimates of populations residing in refugee camps, such as those maintained in the Complex Emergency Database (CE-DAT) by the Centre for Research on the Epidemiology of Disasters (CRED) at the University of Louvain School of Public Health, have an unknown level of accuracy since there are seldom methods of validation, but the expectation is that proper scientific sampling techniques will yield reliable results (Brown et al., 2001). The office of the United Nations High Commissioner for Refugees collects and posts data on hundreds of refugee camps and other locations by gender and age on its web site (*http://www.unhcr.org/statistics/STATISTICS/4486ceb12.pdf*). Often, the refugee population is residentially intermingled with the existing population, making it impossible to assess the refugees within the community without a separate population survey (Bilsborrow, 2006). For this reason, the demographic impact on areas outside of the immediate event area remains largely unknown.

METHODS AND TOOLS FOR POPULATION ESTIMATION

Substantial investment has gone into the collection of data and the estimation and forecasting of national-level populations (Lutz et al., 2004; UNPD, 2005). Although subnational data are, by definition, collected in the process of constructing national-level estimates, analysis of subnational population data currently is not seen as the responsibility of the United Nations or any other international organization.

Organizations that regularly provide estimates and projections of subnational populations for different countries of the world include the United Nations Population Division (UNPD) and the Population Division of the U.S. Census Bureau. For the U.S. Census Bureau, this type of international work is entirely client based, and the subnational estimates and projections are not routinely made publicly available. In practice, the data may be made available to another U.S. federal agency but may not necessarily be openly accessible to the public. One of the Census Bureau's clients is Oak Ridge National Laboratory (ORNL), which uses the data as input to LandScan (see section on global population data below).

If census or survey data exist for subnational units, those data can be updated to create estimates of current population or can be projected forward in time. Population projection methods—including the well-used cohort-component method and newer probabilistic forecasts—were not the focus of this committee. Within the field of demography, established techniques for estimating and projecting local populations exist, but these methods rely on the prior existence of subnational population data, typically down to or below the fourth administrative level, such as census block groups in the United States. (Smith et al., 2001; Plane and Rogerson, 1994; Kintner et al., 1994).

However, the committee realizes that many countries with vulnerable populations have out-of-date censuses or existing censuses that have not been processed to the local level, and thus may be in need of projection or forecasting methods simply to estimate their current populations. Such methods require either good vital statistics data, indirect estimates of mortality that may be derived from the model life tables created by Coale and

Demeny (1983), or for countries of sub-Saharan Africa where deaths due to AIDS have altered previous mortality patterns and gains in life expectancy, the new life tables created by the INDEPTH Network (2004). Additional information (e.g., age-specific birth rates) may be drawn from DHS or similar reproductive surveys. Age- and gender-specific migration rates can also be incorporated into the cohort-component method, although data on migration rates are more difficult to model than are mortality and fertility.

Because the data tend to be more available and reliable at the national than at the subnational level, the estimation/or projection methods tend to be top-down ratio methods—extrapolation or ratio regression methods, controlled to national totals (see, for example, Smith et al., 2001). If the data permit, the preference is to use cohort component at the subnational level and then control those totals to the cohort-component model created at the national level. An alternative approach is to estimate all but the largest subnational areas and then assume that the largest area is equal to the total minus the sum of the subnational level.

The availability of such data obviously varies from place to place, but the methods themselves are standard techniques and are well known to demographers. Although the methods can be implemented by trained demographers, the committee was reminded that few such experts are currently employed in sub-Saharan Africa (Landau, 2007; see also Appendix E). As a result of this human resource deficit, these kinds of demographic estimates and projections are unlikely to be undertaken by national statistical agencies.

In the past several decades, numerous models for facilitating training for census officials, ranging from bilateral assistance from the U.S. Census Bureau (and other NSOs) to specialized training programs at Demographic Training Centers were established by the UNPD. Unfortunately, these basic demographic training programs have diminished over time (Landau, 2007; see also Appendix E; Menken et al., 2002). Technical assistance is still given, but it is presently at much lower levels than in the past. Further, the technical assistance has focused largely on demography with some minor training in spatial techniques, but the spatial and demographic components have not been well integrated.

Since population research tends to be allied with social problems and the search for solutions to those problems, donor priorities have an important influence on the field. Over time, new donors have entered the population field and the substantive priorities of established donors have shifted. Moreover, a critical change in the population field occurred in the mid-1990s when United Nations Population Fund (UNFPA) and USAID decreased or eliminated funding for doctoral and master's training. New donors in the field have not provided substitute funding for the diminished contributions of the established donors in the training arena, and those interested in capacity building generally confine themselves to short-term training. Opportunities for graduate training for promising developing country scholars are now largely dependent on a diminishing number of private foundations and some national governments (Menken et al., 2002). While the most desirable situation is one in which population experts are trained primarily in high-quality institutions located in their own countries or regions, this is not likely to be achieved in the near future.

Issues of Uncertainty Regarding Population Counts and Characteristics

All methods of population estimation have a level of uncertainty associated with them. Some of the uncertainty is a consequence of nonsampling error (such as poor data quality) and is not readily measurable. Some of the error is associated with sampling (which occurs within censuses, as well as within purpose-driven surveys such as the DHS), and some of the error is associated with the estimation or projection techniques. With the exception of the sampling error associated with censuses and purpose-driven surveys, the other errors are nonparametric in nature and require bootstrapping and Monte Carlo methods in order to create a confidence envelope around the estimates or projections (Mooney, 1997; Lunneborg, 2000). These techniques employ resampling of a researcher's observed data to evaluate the variability in those data as a way of estimating the likely confidence interval around a population value. Thus, instead of taking repeated samples from a population (the classical statistical approach), one takes repeated samples from a single sample drawn from the population. These simulation methods are possible only with computers that can handle the enormous number of computations involved.

The committee did not discuss this issue in detail, but notes that all users of population estimates and projections should be familiar with literature such as Smith et al. (2001) and Siegel and Swanson (2004) and should be aware of methods that are still evolving to provide measures of uncertainty with respect to demographic estimation. The committee also notes that to the extent that rates are estimated over a geographical surface, the statistical significance of differences between contiguous areas can be estimated using Bayesian procedures such as those developed by Christakos and associates (Christakos et al., 2005).

Spatial Demography

As noted above, subnational population characteristics may be estimated by modeling data from georeferenced surveys, such as the DHS and the MICS, and similar household surveys. These surveys do not cover all countries, but they do cover places in the world that are the most data-poor, by census standards, and are likely to have disproportionate shares of vulnerable populations. Livia Montana, of ORC Macro, provided the committee with examples of how this modeling might proceed (Montana, 2006). Survey data are georeferenced to the centroids (geographic centers) of the administrative boundaries representing the clusters from which households are sampled for the DHS. Data summarized for these areas can then be interpolated between clusters to produce estimates for those places not included in the sample. Montana (2006) illustrated this method using inverse distance-weighted interpolation to model HIV prevalence in Kenya and Tanzania, but a variety of other spatial interpolation techniques (e.g., kernel density estimation, kriging) exist to accomplish this task, and the choice of modeling technique depends on the nature of the data being used and the assumptions being made about the spatial distribution. The state of the art is still quite nascent in this regard, and considerable additional research will be required to help researchers make decisions about the appropriate modeling strategies to employ in this situation. At present, not enough validation studies have been conducted to guide researchers definitively to a method of choice.

As Weeks et al. (2000) and Openshaw and Rao (1995) suggested, the use of point data in statistical modeling to represent information aggregated for an area around that point can be improved if the point refers more accurately to where the population actually resides, rather than relying generically on the geographic center of the administrative region to which the data refer. The use of remotely sensed imagery provides a way of locating populations within an area, because humans almost always make modifications to the natural environment that can be detected remotely and then mapped on that basis. This referencing technique is called dasymetric mapping (Mennis, 2002, 2003) and is an example of what is often referred to as the modifiable areal unit problem (MAUP), keeping in context the fact that the MAUP shows that the results of statistical analyses almost always depend on the spatial scale of the analysis (Plane and Rogerson, 1994).

Global Population Data

All of the data and methods discussed to this point are place specific, in the sense that we are asking what kinds of demographic data and digital geospatial data exist for a particular country for the most recent date possible. However, important initiatives have been made to create global spatial databases of population that can be used to identify populations at risk. Tobler (1992) summarized a model for allocating national-level population data to a global grid of 5-arc-minute by 5-arc-minute quadrilaterals. The model was refined and summarized in subsequent publications (Tobler et al., 1995, 1997). The database was made available on the Internet site of the Center for International Earth Science Information Network (CIESIN) and was the basis for the current Gridded Population of the World (GPW), housed and now produced with refinements at CIESIN at Columbia University (CIESIN et al., 2004). This model inspired the development of a similar database, but with higher resolution, designed specifically to help globally identify populations at risk of disasters. That database, known as LandScan, is a project of ORNL (see summary in Dobson et al., 2003). Both GPW and LandScan have largely concentrated on population "surfaces"—arbitrarily defined areal grids—rather than on the specific identification of populated places or settlement networks. Thus, GPW and LandScan are grids, not geographic features, and have to be used with this understanding when dealing with specific locations in space such as a village or town. Further, the only aspect of population captured by these approaches is total population size. No other demographic information that could identify risk (beyond being in the path of a disaster), such as age, gender, or race or ethnicity, is currently available in these data collections. Nonetheless, both models have considerable utility and are used for a variety of purposes including emergency planning; so they are reviewed here with the caveat that if either or both of them met all of the needs of humanitarian relief and development organizations, this committee's work would not have been requested.

Gridded Population of the World

A gridded population surface of the world was developed for studying the human dimensions of global change rather than for identifying populations at risk. The initial GPW data set, GPW version 1, was a direct outgrowth of a Global Demography Workshop held at CIESIN in 1994 (Tobler et al., 1997). The data set was produced by Tobler and colleagues at the National Center for Geographic Information and Analysis (NCGIA), at the University of California, Santa Barbara, with partial support from a CIESIN National Aeronautics and Space Administration (NASA) contract so that population data could be integrated with Earth science data. GPW is now in its third version and includes a major update of the underlying population and spatial data. The first version had fewer the 20,000 input polygons (or administrative units), whereas the third version has almost 400,000 such units (see *http://sedac.ciesin.columbia.edu/gpw/*). The GPW data include only total population numbers (denominator data) and must be overlaid with other data layers (numerator data) to create measures of risk or vulnerability. Although used in applications for assisting at-risk populations, most uses are still moderate in scale and concern health applications (Balk et al., 2006) or global environmental change assessments.

LandScan

LandScan was developed in 1997 at ORNL, with the explicit intention of modeling populations at risk (Dobson, 2007; see also Appendix E). LandScan starts with subnational population estimates provided by the Population Division of the U.S. Census Bureau and then uses ancillary data sources—elevation, slope, land cover, and road networks—to reallocate persons within administrative areas (Dobson et al., 2003). LandScan is an explicit model to measure population across times of day, seasons, and likely localities (e.g., implicitly at work rather than at home), that is, at an individual's "average" or ambient location. Such a model has considerable appeal because it does not assume that individuals remain stationary and near their homes at all times. At present, however, the more detailed data have been completed only for the United States and Puerto Rico. These data rely not on population estimates but on actual census counts at a fine geographic scale for the United States and its territories.

LandScan has utility in helping estimate populations at risk, and improvements in the program could enhance this utility further. For example, in addition to producing a single ambient measure, estimates that represent the most common flows of individuals—daytime verses nighttime movements—could be very useful. In particular countries or portions of countries including hazard zones (e.g., near coasts), a set of seasonally specific population estimates would also enhance LandScan's utility. LandScan staff are presently working on such refinements to their product, but the work thus far has been limited to a few geographic areas within the United States (Shankar et al., 2005). Another limitation of the LandScan global product is that, as is true with GPW, it is based solely on total population counts and does not incorporate any other population characteristics.

Comparative Assessment

While both approaches rely on population counts that come from individual countries' statistical agencies or NSOs, GPW and LandScan differ in the types of inputs they use and the intent of the output. The GPW data collection uses a heuristic approach to population distribution, and the basic data include only spatial boundaries and population counts as inputs. The intent is to represent the "usual residence" (the measure used by most censuses to determine where census respondents usually reside) of the global population. The LandScan collection uses population data along with ancillary inputs (e.g., roads, land cover) to indicate an ambient distribution of population (i.e., an individual's location averaged across all times of day, seasons of the year, and so forth). LandScan models each nation (and, in many cases, separate regions within nations) individually due to the spatial disparities of input data quality, scale, and availability. Further, the population distribution for each administrative area is calculated separately within each nation to account for differences in the spatial data inputs and settlement patterns.

Testimony to the committee during the study presented a number of the key issues and a historical context for constructing population surfaces (Dobson, 2007; see also Appendix E) or what we consider baseline data. These population data can be used as denominators for rates or to determine the total population exposed to risk. However, because of the lack of information about population characteristics, neither LandScan nor GPW can be used for a rapid assessment of exactly who was or will be affected by a specific event.

Table 2.1 reviews basic similarities and differences in the databases. The committee notes that these two data collections were developed largely independently of one another. Although efforts to share data have worked in the past, it is not the current practice. The underlying data, including the spatial and population estimates may be proprietary, making it challenging to share the full suite of data products across institutions.

These data products are intended as complements rather than substitutes for one another, although most data users select one over the other for a given purpose. Hay et al. (2005) published one of the few studies that compare these and other data sets in their study of malaria in Africa.

Each of these data products has strengths and weaknesses. In general, GPW most resembles the underlying census inputs. To the extent that both GPW and the census inputs are spatially precise, of reasonably high spatial resolution, and recent, they are very likely to approximate the distribution of usual residence. LandScan, in contrast, represents an ambient population, and estimates of population distribution from this data set will tend to be better than GPW in places where the census data are spatially coarse and not recent (as long as the ancillary data are more current). It is unclear which data set would be objectively superior for places where the data quality and spatial and temporal resolution of the underlying census data were high (Figure 2.3).

Both GPW (and related data products) and LandScan would need new methods to construct surfaces of population characteristics such as age distribution, gender, or race or ethnicity. Even in GPW, where the only assumption made is one of proportional allocation, population counts are often available at the finest spatial resolution, whereas other demographic or housing information is available at a coarser level. Similarly, LandScan's ancillary data inputs assume equal patterns across ages; this type of assumption would not, for example, allow differentiation of the ambient populations of children from those of people in the paid labor force.

Lastly, although the population surfaces from all of these databases are publicly available, the underlying data are not, even though in many

TABLE 2.1 Comparison of LandScan and GPW

Overview	LandScan 2004	GPW Version 3
Number of administrative units	239,178	399,000
Output resolution (grid cell area at equator)	0.5 ft. (1 km)	2.5 ft. (5 km)
Model input variables		
Census data (population)	YES	YES
Land cover	YES	NO
Roads	YES	NO
Digital Elevation Model inputs (elevation and slope)	YES	NO
Nighttime lights	NO (but was included up to LandScan 2003)	NO
Other imagery	Shuttle Radar Topography Mission (SRTM) for elevation data; Controlled Image Base (CIB) data for urban boundaries and settlement identification; MODIS for land cover data; Landsat Thematic Mapper Derived Land Cover Data; Digital urban boundaries updated and modified with IKONOS/Quickbrid high-resolution imagery	
Population data source	U.S. Census Bureau	Variable data sources (mostly NSOs)
Years of estimate	2004	1990, 1995, 2000, 2005, 2010, 2015
Export Data Type	ArcInfo Grid/ArcInfo BIL/ HPAC Binary	ArcInfo export files
Minimum downloadable unit	Continent	Country
Institutional		
Producer	ORNL	CIESIN and CIAT
Sponsors	Department of Defense	NASA
URL	*http://www.ornl.gov/sci/landscan/*	*http://sedac.ciesin.columbia.edu/gpw*

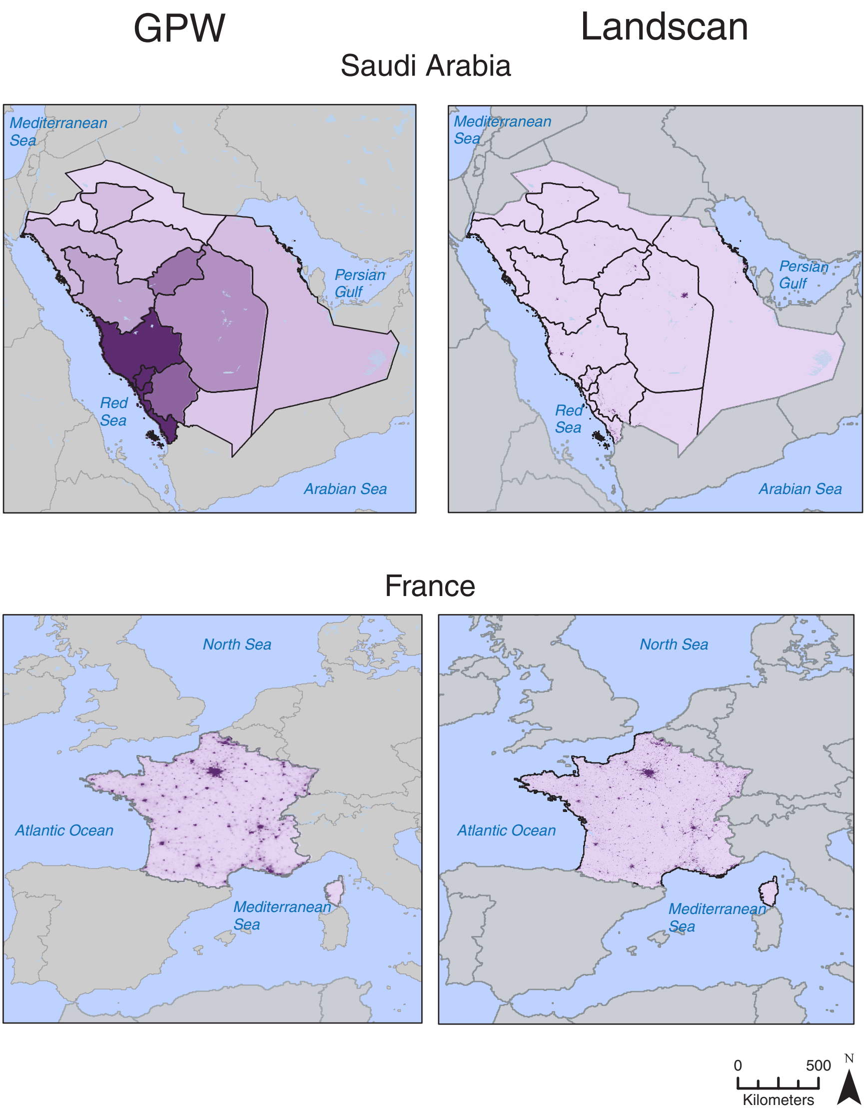

FIGURE 2.3 Comparison of GPW version 3 and LandScan 2003 for an example of a high- and low-input-resolution country. All data shown are gridded with first-order administrative boundaries overlaid for the low-resolution country, Saudi Arabia. The LandScan model reallocates population in Saudi Arabia from large administrative regions to likely places of work or residence and produces a much more finely resolved population distribution map. Where underlying population inputs are high per unit area, as in the case of France, the output grids of population distribution appear quite similar.

instances the underlying data would be preferable to the gridded surfaces. The restrictions on the underlying data are due largely to the fact that some data layers are derived from proprietary sources. In other instances the underlying data are not available publicly because they have not been prepared to the same standards (e.g., the data lack full metadata records, cross-national boundary rules, or place names) and the sponsors for these global data products do not require or supply sufficient resources to make the data inputs available as well. A reasonable conclusion is that the same problems that prevent existing census data from being directly usable by humanitarian relief agencies also prevent the data from being made available through GPW or LandScan.

Other Database Developments

The GPW and LandScan concepts have encouraged construction and development of additional databases. For example, in collaboration with the UN Food and Agriculture Organization (FAO), CIESIN and the Centro Internacional de Agricultura Tropical (CIAT) constructed a set of gridded population projections out to the year 2015. This effort uses the same 400,000 inputs as does GPW version 3, but estimates the population in 2005, 2010, and 2015. Where the input units are extremely local (e.g., South Africa, which has 80,000 enumerator areas), a coarser administrative level is used as the basis of the estimation. Note that these projections are extrapolations from the last two observed census estimates and are not based on the more demographically sophisticated cohort-component method.

The newly modeled data sets include the Global Rural Urban Mapping Project (GRUMP) (*http://beta.sedac.ciesin.columbia.edu/gpw/*) and those of the Accessibility Model surface for Africa and Latin America (Nelson and Deichmann, 2004). GRUMP is designed to identify urban areas by coupling satellite data (from the nighttime lights data set; see below) with point settlement information (both population counts and geographic names and location) within administrative area boundaries. These urban area populations are themselves a key data product, providing a new method of dasymetric mapping. The Accessibility Models of population distribution also use GRUMP urban areas and roads to reallocate population within administrative areas. If these data are to be of use as baselines for the disaster response community, considerable investments—in detecting urban footprints, settlement points with associated populations, and road networks—will be required. Road networks, in particular, are known to be correlated with population density (Silva and Clarke, 2002), so the mapping of road networks can be an important, even if indirect, part of population estimation. Point data, road networks, dasymetric models, and remote sensing/or high-resolution imagery analysis have also been incorporated into the LandScan program. Developments such as these based on both GPW and LandScan concepts lead to further improvements in the ability to improve subnational population estimates.

PROXY MEASURES OF POPULATION SIZE AND DISTRIBUTION

The increasing availability of remotely sensed imagery has led to investigations of the use of these data as proxy sources of population size and distribution, with the aim of improving population estimates and locations, especially for areas where little reliable information exists or at least is not available from other sources. Remotely sensed imagery has the advantage that it can be collected even for places where people otherwise cannot or will not venture on the ground. The promise of these data sources and analytical modes was recognized as early as the 1960s by Waldo Tobler, who used photographs from a Gemini NASA space mission as data from which to construct spatial models, eventually leading to the Global Demography Project, which in turn served as the inspiration for the GPW project, as noted above. Such proxy methods have proven useful for the macro spatial scale in which they are undertaken. They have proven less robust for meso- and micro-spatial scale assessments—the scale required for risk and vulnerability concerns—owing to questions of imagery resolution, costs, and the detail of ancillary information required to inform imagery analysis. Imagery-based methods can directly estimate population size reasonably well in a few (ideal) circumstances: high-resolution imagery can be used to identify housing units in an environment where reasonable housing density coefficients are known. However, imagery analysis is much more effective in identifying and monitoring the distribution of land occupation and use, which can then be used to make indirect estimates of population (Lo, 2006).

Fine to Coarse Scale

Fine-Tuned Resolution and Population Size

The basic principles of using airborne imagery to derive proxy estimates of population are straightforward and generally take one of two approaches: (1) obtain aerial photographs of a region, count the number of dwelling units, and multiply the number of households by an estimated number of people per household; and/or (2) determine the physical extent of human settlements and apply a coefficient that relates the size of the transformed environment to the number of people living there.

Fine-tuned spatial resolution and ancillary information are pivotal for such approaches as summarized by Jensen and Cowen (1999): selected characteristics of populations may be extracted from remotely sensed data based on (1) counts of individual dwelling units, (2) measurement of urbanized land areas (settlement size), and (3) estimates of land cover/or land use as proxies for the existence and type of residential units as a proxy for population density. Accuracy increases with in situ data (typically census data) used to calibrate the average number of persons per dwelling and the number of homeless, seasonal, or migratory people, and with spatial resolution sufficient to identify individual structures and their uses (e.g., house, commercial building) despite tree cover. Jensen and Cowen (1999) report good results with U.S. data, but they suggest that the methods are too time-consuming and costly for a countrywide analysis. The use of remotely sensed and GIS data to reallocate population has not yet been widely validated by the demographic community and will eventually be required for successful streamlining of these types of modeled data.

Airborne imagery from fixed-wing aircraft is typically produced on an ad hoc basis by different parties for different purposes; these images do not provide a consistent or regular source of data with global coverage as do Earth observations. Much of the public access imagery is of relatively low resolution (large pixel size) such that it cannot fulfill the attributes identified by Jensen and Cowen (1999). Those space-based products that do possess sufficient resolution (1 meter and sub-1 meter), such as Ikonos and Quickbird, are relatively new (1999 and 2001, respectively) and expensive. These costs are amplified by the relatively small footprint (area observed), which requires multiple images to address even small regions such as a city. The multiple images also lead to processing and storage problems. One-meter panchromatic Controlled Image Base (CIB) imagery is used by ORNL as input to its LandScan product, and this provides the requisite resolution for population estimation but is not widely available to civilian agencies for population analysis. The CIB-controlled image base is a federal government resource that is derived from commercial imagery. It is geometrically corrected and in panchromatic (black and white) format, available in 1-, 5-, and 10-meter spatial resolution (sourcing may vary depending on resolution). It is for government use only, and although not classified, it is considered sensitive and cannot, for example, be taken out of the United States.

Attempts to simplify population estimates with Ikonos data by linking them to imagery texture have not yet proven fruitful (Liu et al., 2006), but the high-resolution satellite imagery has the same capability as a high-resolution aerial photograph to be used to count buildings and thus make estimates of total population size. This process may be capable of automation using sophisticated imagery classification software such as IDRISI from Clark Labs (Marsh Institute) at Clark University, ERDAS Imagine, and Definiens Professional (formerly known as eCognition).

Medium-Scale Resolution and Population Size

The imagery data workhorse for much of the science and social science communities has been Landsat TM and ETM+ or SPOT 2 or 4, providing medium-scale resolution data (30 meter and 10 meter, respectively, for Landsat TM and ETM+). This scale of resolution proves problematic for estimating population size by the methods noted above because many, if not most, individual structures are missed (hidden in the pixel). However, the imagery can be used to define the urban extent of settlements and, through links to allometric growth principles, to estimate population size (Box 2.3).

Allometric growth and other models have been tested for cities in China (Lo, 1995) and the United States (Holt et al., 2004). The results suggest that the methods have quite a high level of accuracy in suburban areas, whereas the error increases in very dense high-rise cities. Allometric growth has not been tested for largely rural populations or for the dense occupation of cities in the developing world.

Alternatively, Landsat and SPOT imagery can be combined with other data to estimate population size. Various studies (Rashed et al., 2001, 2005; Weeks, 2004; Weeks et al., 2004, 2005) found that good results could be obtained in Egypt using imagery that combined higher-resolution (in this case 5-meter panchromatic Indian Remote Sensing imagery) with medium-resolution 24-meter Indian Remote Sensing multispectral imagery. From this merged data set the studies were able to distinguish detailed differences among neighborhoods throughout the greater Cairo area. More detailed data within the dense core of Cairo were obtained by merging a 0.6-meter panchromatic and a 2.4-meter multispectral Quickbird images. Examples of the difference in spatial resolution in Cairo are provided in Figure 2.4.

BOX 2.3
Allometric Growth

The "law of allometric growth" (Nordbeck, 1965) is an empirical relationship between simple urbanized built-up area classified from remotely sensed imagery and settlement population, posited as

$$r = a \times p^b$$

where r = radius of built-up area, a is constant of proportionality, p is population, and b is an empirically derived exponent. If a and b can be estimated, then p can be found by rearranging the formula:

$$p = \sqrt[b]{r/a}$$

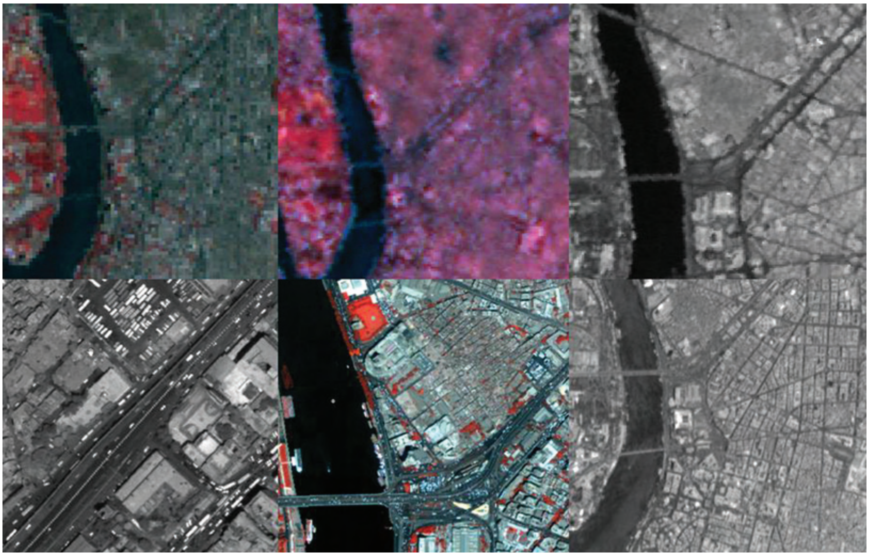

FIGURE 2.4 This series illustrates what can be observed from satellite imagery of different spatial and spectral resolutions. The images are centered on the bus station in Tahrir Square in central Cairo, Egypt. Clockwise from the upper left the imagery represents (a) Thematic Mapper 30-meter multispectral, (b) Indian Remote Sensing 24-meter multispectral, (c) SPOT 10-meter panchromatic, (d) Indian Remote Sensing 5-meter panchromatic, (e) Quickbird 2.4-meter multispectral, and (f) Quickbird 0.6-meter panchromatic. Map courtesy of John R. Weeks (San Diego State University).

Shifting to the United States, a comparative study in Dallas indicates that the U.S. Census Bureau's TIGER system GIS road data proved better at estimating populations than land change data derived from Landsat imagery (Qui et al., 2003). In contrast, by adding texture, temperature, and spectral responses to Landsat ETM+ data, imagery analysis yielded a nearly 97 percent accurate estimate of Indianapolis (Li and Weng, 2005).

Note that most urban-related work using these sensors focuses on urban land cover as an estimate of the human settlement footprint. Indeed, the low spatial resolution of Landsat means that it is a poor choice even for deriving the outlines of population settlements. Although widely used, there are significant weaknesses in Landsat-derived "urban land cover" layers such as those provided by MDA Federal Inc. (formerly EarthSat) in its GeoCover-LC products. The areas within each classification tend to be underbounded, they are not verified on the ground, and they have high incidences of both false positives and false negatives. In essence, the relatively inexpensive—and thus widely available—moderate- and low-resolution imagery has not proven very successful in population estimation. This task generally requires higher resolution imagery, either sensors mounted on low-altitude fixed-wing aircraft or satellites with high-resolution sensors. Both platforms are expensive and thus limit the ability to analyze wide swaths of land.

A new problem that has emerged with Landsat imagery is that new imagery is not apt to be available until at least 2012. Although the Landsat 5 satellite lasted far longer than NASA ever expected, Landsat 6 never flew, and Landsat 7 has been beset by sensor difficulties. Without additional support from federal funds, these national satellite programs will not meet the anticipated demands by the public; private satellite companies can offer good imagery, but this shifts the burden of cost from the federal government to the end user and thereby limits the availability of affordable imagery. In order to fill this gap, the University of California, Santa Barbara (UCSB) has created a new program in conjunction with Terra Image, Inc., which is a reseller of the French-based SPOT satellite imagery. The SPOT at UCSB program aims to offer SPOT imagery (which is similar to Landsat imagery) at a deep discount to academic researchers.

Imagery and Population Distribution

Despite the limitations noted above, imagery both at fine- and coarse-scale resolutions has been used successfully to identify and monitor the distribution of occupied landscapes. Major advances have been made in this domain, largely registered in land use and land cover change science as observed by Landsat and SPOT satellites and more recently by Moderate Resolution Imaging Spectroradiometer (MODIS) (Gutman et al., 2004; Lambin and Geist, 2006). This work does not focus on population distributions per se, as provided in nighttime light analysis, but rather on which lands and ecosystems have been modified and transformed by human occupancy and, to some extent, the kinds and intensity of that observed use. For example, "cryptic" deforestation from selective logging and forest regrowth from slash-and-burn cultivation and moving settlement frontiers can now be detected and added to the occupational uses of forests that also include clear cutting for agriculture, timber, or human settlement (Lambin and Ehrlich, 1997; Nepstad et al., 1999; Turner et al., 2004). Likewise, burning and grazing patterns in savanna and open woodlands can be used to determine not only where people are located, but changes in the intensity of livestock and cultivation activities, indicative of changing land pressures (Archer, 2004; Laris, 2002; Turner, 2003). Since these kinds of observations focus on rural lands at some distance from major urban settlement, imagery analysis offers a convenient means to "fill in" and track the presence of people and their activities in areas that often receive less attention from those sources that derive population information by other means. A major caution is the need to discern land use and land cover changes by extractive industries, such as the international timber trade, which rely on itinerant and often small pools of labor, even though the observed footprint may be exceptionally large (Curran et al., 2004).

DMSP-OLS (Nighttime Lights)

As mentioned earlier in the chapter, nighttime lights, detected by the DMSP-OLS (Defense Meteorological Satellite Program-Operational Linescan System), represent the only system currently collecting low-light imaging data globally. The U.S. Air Force has operated imaging satellite sensors since the early 1970s. The current generation of OLS sensors has flown since 1976 with the primary goal of imaging clouds at night, and their ability to detect lights emitted from Earth's surface was a serendipitous by-product of this original, and still important, purpose. A digital archive of the data was established at the National Geophysical Data Center (NGDC), part of the National Oceanographic and Atmospheric Administration (NOAA), in 1992 (Elvidge et al., 1997). The maps of the Earth at night produced from this data set have received global publicity, and the data themselves have been used as proxies for level of development, and population change, extent, and location (see, for example, Elvidge et al., 1997; Sutton, 1997; Doll et al., 2000; Sutton et al., 2001).

The basic characteristics of the data are as follows: 3,000-kilometer swath; 2.7-kilometer ground sample distance; two spectral bands (visible and thermal); nightly global coverage; flown since 1972; and flights continue until ~2012. Global coverage and temporal change detection capabilities are the strengths of these data. NGDC has produced a time series of annual cloud-free nighttime lights composites for various countries (Figure 2.5); the time series allows the detection of change.

Spatial resolution is the main weakness of OLS. With coarse spatial resolution, an overglow effect is created because OLS lights are larger than sources on the ground. Biases include the phenomenon that urban centers are typically saturated and lighted roadways, shopping centers and so forth, may indicate the existence of population when, in fact, few people live there (Figure 2.6). Sutton et al. (1997) found that the population density of urban centers was underestimated and the population density of suburbs was overestimated. Lighted area can be used as a good estimate of built-up area. However, the blooming or overglow effect—lighted area extending beyond the area of settlement—begs the question of using the areal measurement to calculate settlement footprints. A more thorough study using high-spatial-resolution imagery is required in order to determine the relationship between nighttime light footprints and actual settlement extent. Currently

FIGURE 2.5 Time-series composite of the Nile Delta nighttime lights for the years 1992 (blue), 1998 (green), and 2003 (red). Note the different types of information that can be extracted from the images of Cairo (Figure 2.4) compared to this image. Image courtesy of Chris Elvidge (National Oceanic and Atmospheric Administration).

these data are not used in either GPW or LandScan products, but they are used in GRUMP.

At present, funding is still uncertain for the launch of a new NPOESS VIIRS (National Polar-orbiting Operational Environment Satellite System Visible Infrared Imager Radiometer Suite) satellite. It was set to launch in 2009, but a review by the House Science Committee in June 2006 put the funding in doubt. If launched, this will be a medium-resolution sensor with more quantization levels than OLS and spatial resolution sufficient to observe primary features found in cities and towns. Once operational, Elvidge (2006) has indicated that this improved sensor would be able to provide the following: (1) products depicting the geographic footprints of human settlements of all sizes, including the outline of developed areas, specific estimates or measures of constructed area, and vertical structures in urban

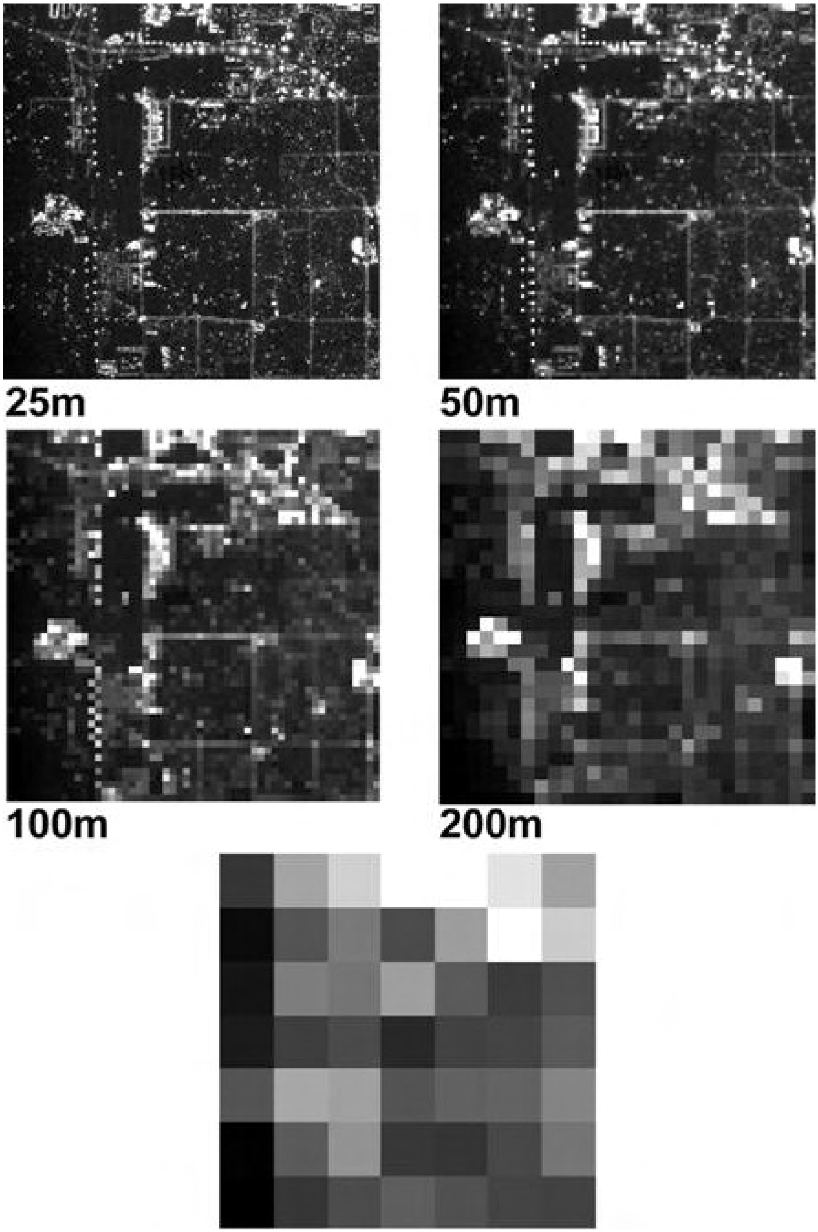

FIGURE 2.6 Simulation of 25-, 50-, 100-, 200-, and 742-meter (Visible Infrared Imager Radiometer Suite [VIIRS]) resolution nighttime lights imagery covering a portion of Las Vegas, Nevada, generated using a 1.5-meter resolution image. The images show the effect of spatial resolution on feature content in nighttime lights. Images courtesy of Chris Elvidge (National Oceanic and Atmospheric Administration).

cores; (2) the location and extent of sparse development in rural areas; (3) objective identification of intra-urban classes, such as classes of residential areas, commercial and industrial areas, and the distribution of vegetation types and open lands within urban areas; (4) vectors for streets and roads; and (5) measures of economic activity such as the extent and stability of the electric power grids.

Other Aerial Imagery

During and after an emergency, remotely sensed imagery from satellites or lower-altitude aircraft may be useful in estimating the number of people potentially affected by a crisis or disaster (Jensen and Hodgson, 2005). The use of imagery to assess damage in places such as Kosovo (as a result of conflict), Indonesia, Sri Lanka (as a result of the tsunami), and the U.S. Gulf Coast (as a of Hurricane Katrina) has been instructive and offers a way of assessing the geographic extent (and the degree of physical change of the landscape) of the affected areas so that the size of the population affected by an event may be determined. Additionally, oblique-angle aerial photography and digital videography used in response to Hurricane Katrina were successful for assessing damage.

Of course, repeated analyses of such places can offer estimates of the recovery of population in affected areas. Satellite imagery is constrained by its temporal resolution (how often it passes over a given place on Earth's surface) and by the occurrence of cloud-free passes over that place. Virtually all of the satellite imagery used for population estimation purposes to date is optically sensed and thus requires cloud-free scenes to be used effectively. As a consequence, remote imagery in some emergency situations may have to be acquired by other fixed-wing aircraft that can fly under the cloud cover. With relatively modest training, these data can be analyzed by people on the ground to estimate damage to homes and infrastructure in the post-event period.

Radar imagery can be used to "see through" the clouds, but the use of radar data in population estimation has been extremely limited. In one of the few published studies using radar imagery for these kinds of purposes, Tatem et al. (2004) utilized Japanese Earth Resources Satellite-1 (JERS-1) synthetic aperture radar (SAR) imagery in combination with Landsat TM imagery to map settlements in Kenya. To be useful for population estimation purposes however, the radar data must be combined with multispectral imagery such as Landsat TM, along with ancillary data such as road networks.

Risk Indicators

The world's populations are not evenly distributed, nor are the risks and hazards to which they are exposed. The World Bank produced a set of maps ("Hotspots" maps) that spatially delimit the populations of the world (in total population counts) that are at risk from selected natural hazards (cyclones/or tornadoes, earthquakes, floods, drought, volcanoes, and landslides) (Dilley et al., 2005). These maps use GPW and the disaster impact data of CRED (both mentioned earlier in this chapter) to calculate disaster risk at the subnational level in order to contribute to development planning and disaster prevention. Some populations are at risk from more than one of these hazards, so their overall exposure to natural hazards is additive. While the spatial overlay of total population by multiple hazard sources helps to prioritize areas by exposure, a more important question is the extent to which these populations include vulnerable subpopulations that are more sensitive to a hazard and have less resilience to cope with an emergency, such as the young, the old, the sick, or the poor. This type of a vulnerability analysis requires the existence of subnational population attribute data and hazard data for each area of interest, whether at a county level (Cutter et al., 2006), city level (Pelling, 2003), or for a small island nation (Pelling and Uitto, 2002).

SUMMARY

We take for granted the assumption that better data will improve humanitarian relief efforts, although admittedly this is a difficult proposition to prove. All respondents to our study, including those involved directly with humanitarian and development aid projects, indicated that better georeferenced population census and survey data, and maps to which the data could be linked, were desired and preferred for planning and execution of these aid projects. Nonetheless, we do not have similarly situated emergencies, one with good data and one without, with all other conditions held constant, that would allow us to quantify the importance of good data. In particular, we are unable to specify how many lives or livelihoods would be saved if better data were available. Thus, we cannot readily weigh the costs and benefits of spending donor resources on better data, and better training of people to use and disseminate those data, compared to other uses of the same resources. The committee has thus chosen instead to consider the narrower question of how best to generate the subnational population estimates that relief agencies believe will be of assistance to them. Chapters 3 and 4 explore the question of coordination and training within and among various responders who might use these data, because good data alone will not guarantee an effective emergency response.

The chapter began with an overview of the data required to prepare estimates of populations at risk of being involved in emergency situations. Since it is impossible to know in advance what events people might confront, the estimates for planning purposes need to be spatially explicit and sufficiently detailed in demographic terms so that they have broad applicability to a number of emergencies. Ideally, population registries would be universally accessible as sources of data at all geographic levels. In reality, censuses of population tend to be the best single source of data because they maximize the geographic coverage of populations and typically have enough detailed characteristics about each person in each household to permit the calculation of estimates of vulnerability. In theory, censuses are also ideal geographically because each household's location had to be known to the statistical agency undertaking the census, so the characteristics of people should be capable of being spatially identified with considerable precision. In practice, the exact location may not be recorded and so is lost immediately after the data are collected; even if the location is known, it may not be converted to a digital format that can be mapped easily. The committee concludes, therefore, that in much of the world the real issue is not the collection of data per se, but rather what happens to the data after being collected. Census and other data about households and individuals need to be georeferenced (with proper privacy safeguards), linked to accurate maps, and then analyzed by individuals with the appropriate training to undertake tasks.

A major shortcoming of census data (and most population registers as well) is that they are universally collected at places of residence, yet people are often at risk outside of their home. There is no simple answer to this dilemma of estimating the "daytime" populations (assuming that being away from homes is essentially a daytime activity), but modeling based on the results of survey data about out-of-home activities is the most common approach.

Most other problems in creating estimates of the population at risk are related to the fact that censuses are not conducted everywhere on a regular basis, and even where they are conducted, the national statistical agency may not have the resources to provide data at a local level, to prepare local-level maps coinciding with the census geography. To work around some of these issues, global population databases such as LandScan and GPW were developed to create population "surfaces" for the globe, but at the moment they lack the breadth of demographic characteristics that would allow users to create estimates of vulnerability beyond population counts and density in a given area.

Much of this chapter has examined what can be done when the ideal census data and corresponding maps are not available, recognizing that this is largely an issue for data-poor countries, which tend to have limited resources for training of personnel and collection of data. Proxy measures should not be preferably established over collection of census data and associated maps. The most important kinds of data that might be used in the absence of recent detailed census data include sample survey data, such as those collected in the DHS and MICS, as well as information derived from remotely sensed imagery. These kinds of proxy measures have tremendous potential to augment our knowledge of subnational populations, but they require the use of fairly sophisticated modeling techniques if they are to be employed in population estimation for at-risk groups, since they were not designed for that mission. Uncertainty is a component in any population estimate, but these proxy measures have less certainty associated with them than census-based estimates, and researchers must utilize the techniques that are emerging to evaluate error in these statistically unconventional models. While it is generally true that any data are better than no data in an emergency situation, the best decisions are those made with the best data or, at the very least, with the best understanding of the limitations of available data.

Overall, it seems doubtful that one approach to estimating populations at risk will fit all situations. The reality is that countries have different kinds of data available, different populations in diverse geographic locations, and different probabilities of needing to have data available. The committee has tried to provide a road map for estimating populations at risk given the kinds of data that are currently used for that purpose. This is, however, an evolving area of policy research, and it is imperative that we learn from each new emergency or disaster situation what is needed and how it is used, so that meeting these data needs in future disasters becomes a high priority for governments and emergency responders.

RECOMMENDATIONS

The preceding discussion provides the basis for the following committee recommendations:

- **Improve the capacity of census-poor countries, through training and technical assistance programs, to undertake censuses. Such improvement is critical for the long-term availability of subnational data that can assist in humanitarian emergency and development situations. Knowing the location, number, and critical characteristics of populations is pivotal to all planning, response, and long-term understanding of disasters. These data sets should have pre-existing protocols for data format, sharing, mapping, intercensal projections, and metadata that are consistent with international standards. [Report Recommendation 1]**

- **Support should be given to test the accuracy of estimates of size and distribution of populations based on remotely sensed imagery, particularly in rural and urban areas of countries with spatially, demographically, and temporally inadequate census data. Current**

efforts to render global spatial population estimation—LandScan and Gridded Population of the World—use different methodologies. An independent study of the state of the art in spatial population estimation would highlight the strengths and weaknesses of the existing methods and could serve as a guide for improvements in the methods and development of new ones for the purposes of understanding populations at risk. [Report Recommendation 8]

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3

Data Dissonance in Disasters

Demographic data are some of the most common data collected worldwide. The collection of demographic data, however, does not guarantee their availability before, during, or after disasters. More importantly, such data are generally not sufficient to assist the affected population. New crises need new data analyses. People who are responding to disasters complain that they are often operating in a data vacuum. These complaints vary in levels of frustration, but they are heard with respect to every kind of disaster and in all countries, whether rich or poor. Without appropriate demographic data, responders have difficulty setting short-term priorities, allocating scarce resources efficiently, or establishing strategic plans for longer-term recovery efforts. This chapter addresses the dissonance created by the existence of detailed local demographic data and the data vacuum that appears in the midst of most disasters.

This dissonance is illustrated through examples from three types of natural disasters (earthquakes, hurricanes, and tsunamis) in four different parts of the world (Turkey, Pakistan, India, and the United States) with affected populations in urban and rural settings. Although the examples are all natural disasters, the observations made from examination of the four case studies can also apply to populations-at-risk data in any setting.

This chapter discusses some of the important reasons why the existing data are underutilized by decision makers and, most significantly, how existing local area data would have to change to become more useful to decision makers who provide humanitarian assistance. The chapter also places the data dissonance in the context of broader information management, training, and technology considerations. Decreasing the dissonance in the underutilization of existing data requires better organization and management of the data and does not necessarily invoke significant additional direct costs. The difficulties in effecting better organization stem from a number of causes, both internal and external to the organization. These difficulties in obtaining and using data within existing organizational structures are highlighted in this chapter and discussed in detail in Chapter 4.

THE LOCAL CONTEXT

The examples presented in this chapter span diverse natural disaster settings and demonstrate that disasters can strike both rich and poor countries in a variety of inland and coastline terrains and can occur either instantaneously (sudden onset) or with ample notice. These disasters represent recent events for which the pre-impact planning and data were judged to be better than most and the committee had some knowledge based on the members' own field work in affected areas. The common theme is that in all four scenarios, the existing population and spatial data were underutilized, making the disaster response less effective and ultimately worsening the plight of victims.

The Izmit, Turkey Earthquake, 1999

Turkey is in a seismically active region affected by the northward collision of the Arabian plate with the Eurasian plate along the Anatolian fault system, which is more than 900 kilometers long (Figure 3.1). Eight major earthquakes have occurred along this fault during the past century resulting in more than 88,000 fatalities (CRED, 2006). On August 17, 1999, a 7.4 magnitude earthquake, the latest in this earthquake series, struck the Marmara region southeast of Istanbul (Figure 3.1) and resulted in more than 17,000 fatalities and more than half a million people left homeless (Scawthorn, 2000).

Turkey is a middle-income country with a per-capita income of $7,680 in 2005 (PRB, 2005). At the time of the earthquake, Turkey's population was approximately 73 million. Although the most recent population census had been taken in 1990, a housing census was taken as recently as 1997, two years prior to the Marmara earthquake. The next population census was not scheduled until 2000.

In the immediate period after the earthquake struck, geospatial data and technologies were employed, and the resulting images and maps were made available to responders, and more generally, on the Internet. For example, Landsat 5 images of the devastated area were widely available two days after the earthquake, and the U.S. Department of State also produced five maps using high-resolution satellite images for in-country

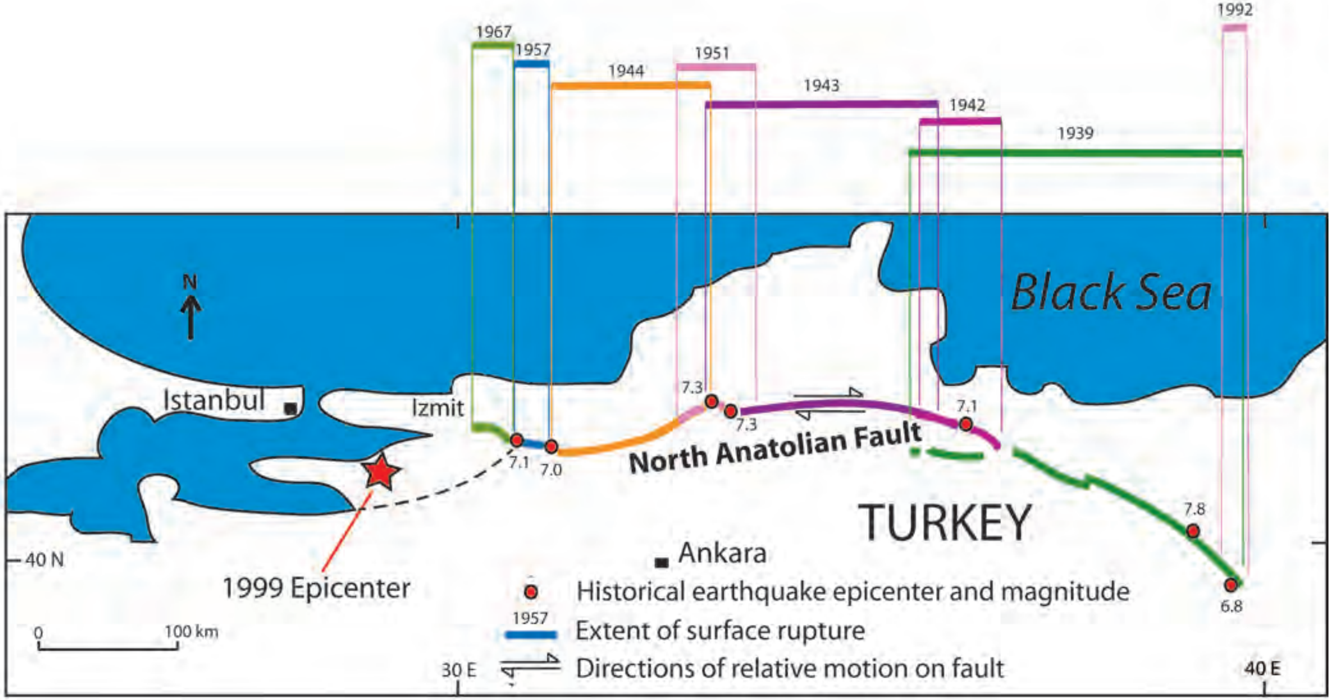


FIGURE 3.1 Location of major earthquakes in Turkey along the North Anatolian Fault prior to the 1999 Izmit earthquake. SOURCE: Adapted from USGS, *http://quake.wr.usgs.gov/research/geology/turkey/images/turkey_loc.gif*.

use. However, the maps and images were not combined with existing demographic data for the country and thus did not contain any information on the plight of the residents affected by the earthquake or relevant, local planimetric data such as street names; for the city of Adapazari, near the epicenter, the only local street map available to responders was a tourist map. Five weeks after the earthquake, no detailed disaster assessments were available when a joint Turkey-U.S. team went into the field (Eguchi et al., 2000a,b). At that time, physical damage assessments were made on the ground using geographic positioning and geographic information systems (GIS, including global positioning systems [GPS] data); although a delayed input to the recovery situation, these technologies made it possible to do in hours what used to take days to do. The new data were able to provide information about what roads were open and closed and the extent of the collapse of densely populated buildings; this kind of information was used to make some estimates of the number of people who had been affected by the event.

The fact that the epicenter was located near Istanbul, which was not extensively damaged, facilitated accessibility to the area and thus made the relief efforts more effective than they might otherwise have been, given the lack of correspondence between remotely sensed satellite images and maps, local planimetric data, and national and subnational population data. The proximity of the Marmara earthquake to Istanbul also encouraged authorities in Turkey to develop better emergency preparedness plans for the city, which is responsible for 60 percent of Turkey's gross national product and is home to 12 million people. Plans are currently under way to engage the public in disaster mitigation and preparedness and to invoke GIS and GPS technology and existing population data for this purpose (Ulgen, 2006). For the rest of the nation, however, population data are not available at subnational levels such as a city block or similar enumeration level. While personal locators and handheld GPS devices, or potentially, cell phones, for individual responders or the general public may be part of the future in some countries or specific communities, current technologies and population survey methods are still challenged by the issue of collecting demographic data when people are forced to migrate in response to a disaster. This issue is also explored in the section below on Hurricane Katrina and has been the topic of an earlier National Research Council report (NRC, 2001).

South Asian (Kashmiri) Earthquake, 2005

The South Asian earthquake (also referred to as the Kashmir or Pakistan earthquake) of 2005 occurred in an inaccessible part of one of the poorest countries in the world (Figure 3.2). The epicenter of the 7.6

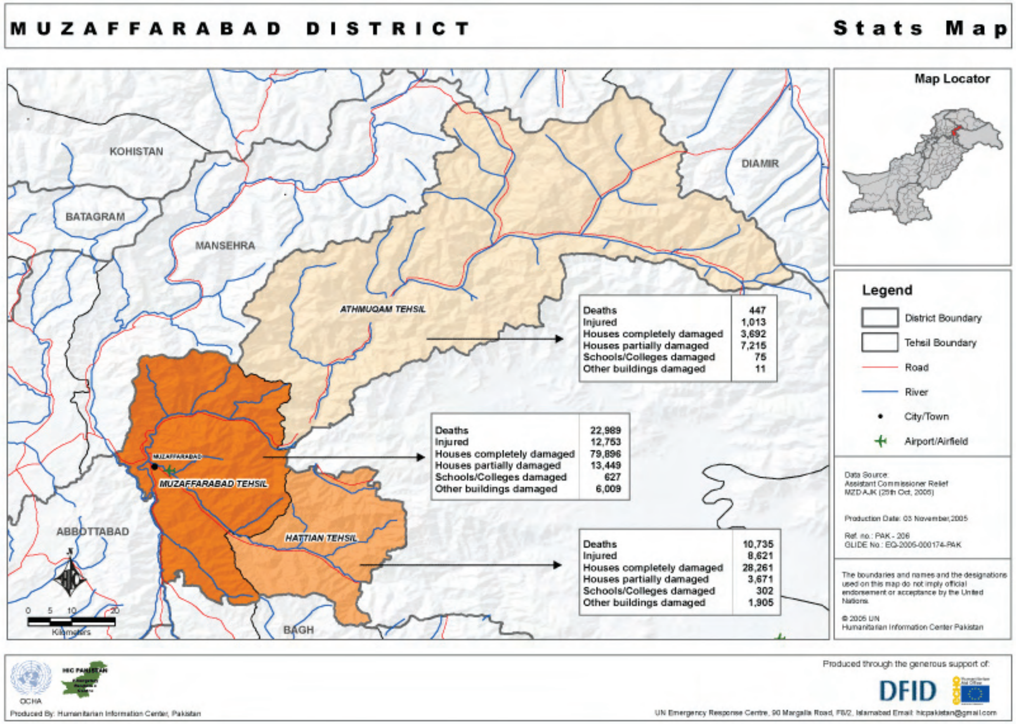


FIGURE 3.2 Status map of affected population and infrastructure on November 3, 2005. SOURCE: OCHA Humanitarian Information Centre Pakistan (HICP) and available on Relief Web, *http://www.reliefweb.int/rw/RWB.NSF/db900LargeMaps/JOPA-6J5D2H?OpenDocument&emid=EQ-2005-000174-PAK&rc=3/*.

magnitude earthquake was near Muzaffarabad. The earthquake resulted in an estimated 90,000 deaths and more than 80,000 injuries. Approximately 3 million people were made homeless, and about 575 health facilities were partially or fully damaged (Durrani et al., 2005). The location of the event in the disputed territory of Kashmir, now controlled by Pakistan, and the timing of the October 8, 2005, event just before the onset of winter in the Himalayas, were significant factors in rescue, relief, and recovery efforts. These circumstances exacerbated the demographic and geospatial data dissonance that occurred at the time of the crisis. Pakistan has a population of 165 million, which is 66 percent rural. Its gross domestic product per capita is less than one-third that of Turkey (CIA, 2007). Pakistan's most recent census had been taken in March 1998.

Extensive mapping of the communities affected by the Kashmir earthquake was undertaken by a number of agencies and organizations. The maps provided detailed information, satellite imagery, and radar data showing the changing landscape as a result of the earthquake and massive landslides and the damage to buildings, roads, bridges, and other infrastructure. For example, the U.S. Geological Survey (USGS; *http://earthquake.usgs.gov/eqcenter/eqinthenews/2005/usdyae/*), the Earthquake Engineering Research Institute (EERI; *http://www.eeri.org/lfe/clearinghouse/kashmir/observ1.php*), the Centre for the Observation and Modeling of Earthquakes and Tectonics (COMET; *http://comet.nerc.ac.uk/news_kashmir.html*), and the Mid-America Earthquake (MAE) Center (*http://mae.ce.uiuc.edu/Publications/cdseries/Cd%20series%20files/05-04/Report05-04.pdf*), among many others, collected, analyzed, and distributed a significant amount of data, generated maps, and have made accessible a number of reports focusing on the physical impact of the earthquake (Figure 3.2).

In some of the most severely affected regions, more than 95 percent of the buildings were destroyed, while lifelines (water, electricity) and the communication infrastructure were essentially rendered useless. The magnitude and extent of the Kashmir earthquake encouraged significant local and international response to this disaster. Initially, disaster relief aid was extremely slow to reach disaster victims, particularly in the most affected regions (e.g., Muzaffarabad, Balakot) and in remote mountain villages. A number of these remote communities were inaccessible for weeks after the earthquake and remained cut off from relief supplies even by helicopter or airplane. The rough terrain and the severity of the disaster combined with the lack of adequate disaster planning and response initiatives at the local level to hinder disaster relief strategies in the initial days following the event.

As is typical following a disaster of such proportions, a massive convergence of materials and supplies from international sources resulted in an excessive amount of goods. This aid did not reflect the immediate needs of the local population, was not responsive to local norms and circumstances, and was not delivered to the places most in need. The fact that the census information was dated made its use problematic; the census data had not been supplemented by newer sources of information that might have been derived from household surveys or a Demographic and Health Survey (DHS), nor were the census data available in electronic form for responders. The distribution of disaster relief aid following the Pakistan earthquake was more a function of who was at the right place at the right time, than of any systematic assessment and placement of vehicles for distribution of the necessary aid (Bilsborrow, 2006). Information on the affected population, including people's demographic and economic characteristics, and their locations—data that should be available from a prior census or household survey—was difficult to obtain and thus could not be utilized in a meaningful way in the distribution of disaster relief aid or other humanitarian assistance once data from the post-earthquake community mapping initiatives were available.

South Asian Tsunami, 2004

The South Asian tsunami was produced by a large, undersea 9.0 magnitude earthquake near the Andaman Islands on December 26, 2004. Within 15 minutes, the large wave began affecting the Thai and Indonesian coasts and radiated eastward from the epicenter. A short time thereafter, it began to impact other countries bordering the Indian Ocean to the north and west including Sri Lanka and India. Seven hours after the earthquake, the resulting tsunami had traveled across the Indian Ocean to Somalia (Figure 3.3). The human death toll remains uncertain years later, but official estimates suggest that approximately 250,000 perished (UNEP, 2006) and millions of people were displaced from their homes and livelihoods. Overall damage to the region was estimated at $10 billion (UNEP, 2006).

Indonesia, India, and Sri Lanka suffered the highest fatalities. All three countries had taken population and housing censuses every 10 years since 1961, except Sri Lanka, which had a 20-year lapse from 1981 to 2001. Indonesia had a census in 2000, and India and Sri Lanka both had censuses in 2001. Therefore, up-to-date, local area demographic data were available in these countries when the tsunami struck. In India, the national statistical office (NSO) had also digitized population maps based on the last census. This information existed in the NSO and the state government offices of Tamil Nadu. The data, however, were not available to the first, second, and third responders to the disaster at the local level (Subramanian, 2006). Considerable aerial photography was collected of affected areas (Figure 3.4), but few ancillary data were available to responders on the number of

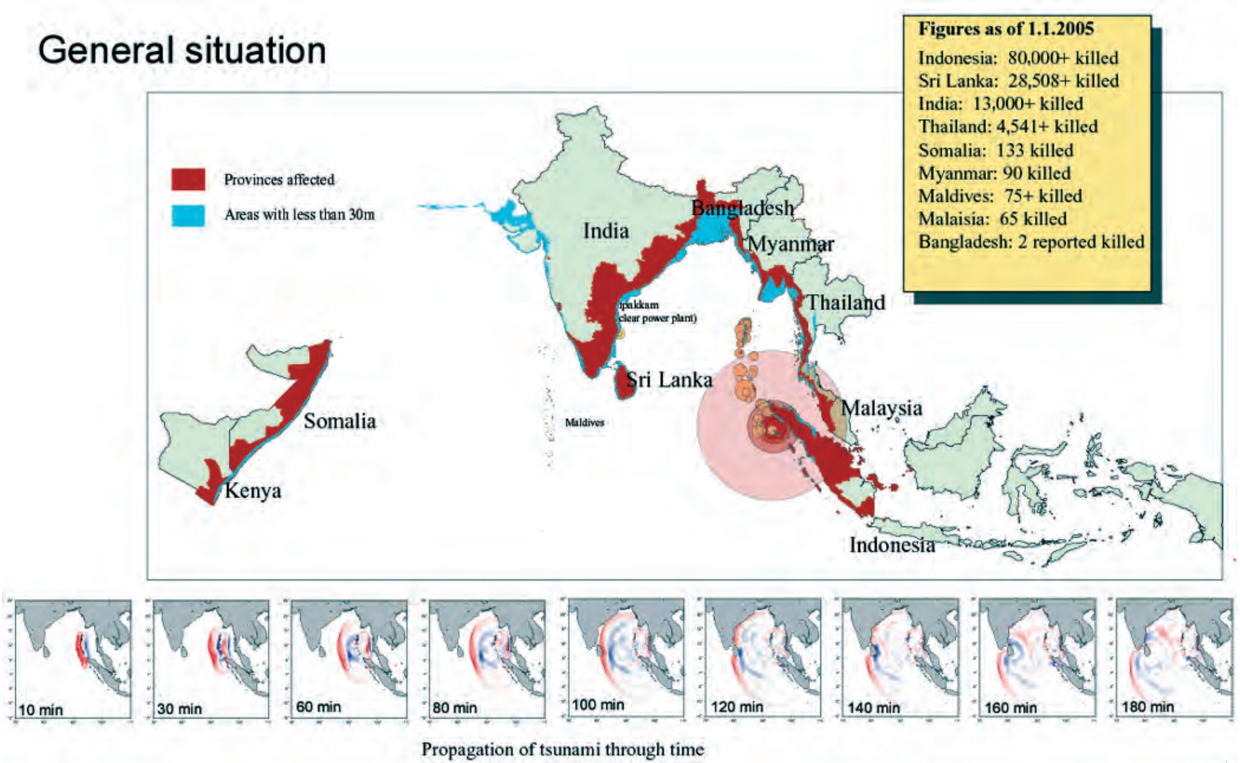


FIGURE 3.3 Impact area of the 2004 South Asian tsunami. SOURCE: International Coordination Group for the Tsunami Warning System in the Pacific (*http://ioc3.unesco.org/itic/*). Image available at *http://www.unep.org/tsunami/images/ image001.png*.

FIGURE 3.4 The top satellite picture of Kalutara, Sri Lanka, was taken about an hour after the first tsunami wave hit on December 26, 2004. Water is rushing back out to sea after inundating the land. The lower picture shows what the same area looks like under standard daily conditions. SOURCE: Courtesy of Windows to the Universe, *http://www.windows.ucar.edu*. Image available at *http://www.windows.ucar.edu/earth/images/tsunami_NASA_ EO_sm.jpg*, 324 × 426 pixels- 160k, image may be scaled down and subject to copyright.

people likely to have been in the area at the time, including both residents and tourists.

While other data sources, such as administrative records, vital statistics, or perhaps tax records, could have been used, these data were largely unavailable for local coastal villages, so information about the pre-disaster population was in many cases derived from interviews with survivors. Lacking digitized census maps to determine how many people had been affected, relief teams in the field relied on hand-drawn maps of local villages such as Kameswaram (Figure 3.5). Ultimately, the numbers of people who were killed or affected were reconstructed through interviews of survivors, but these numbers lacked the support that could have been provided from pre-existing demographic data. Furthermore, data on the age and gender of the victims were not recorded, so it was difficult to project the longer-term impact on demographic patterns in the affected regions.

Responders traveling through India and Sri Lanka in the immediate aftermath of the tsunami stated (Rodríguez et al., 2006, pp. 170-171) that they:

> observed a variety of irregularities or inequities, particularly related to the distribution of disaster relief aid. We also received reports of challenges in the provision of relief and recovery services. For example, in some instances, NGOs duplicated efforts or provided assistance not suited to the locale or to the varying population sizes. Further, while in some communities there seemed to be an abundance of aid, in other communities, particularly remote ones, the distribution of aid seemed to be quite slow and limited. In Sri Lanka, the ongoing conflict between the government and the Liberation Tigers of Tamil Eelam (better known as the Tamil Tigers) generated a variety of concerns regarding how aid was distributed which made understanding the difference between political and disaster response issues complicated.

Hurricane Katrina 2005

In the previous three cases of disasters, the countries were relatively poor, the governments had few resources for population data collection and analysis, and the disasters occurred without warning. None of the three conditions existed in the case of Hurricane Katrina when it struck the United States. Unlike the previous three examples, Hurricane Katrina struck the world's richest country, which had a wealth of data appropriate to tackle the disaster. The hurricane developed over a period of days, with hourly warnings on many public broadcast systems. Disaster preparation plans had been developed long in advance for just such a circumstance and were in place when the hurricane struck New Orleans and other parts of Louisiana, Alabama, and Mississippi. The amount of data and plans avail-

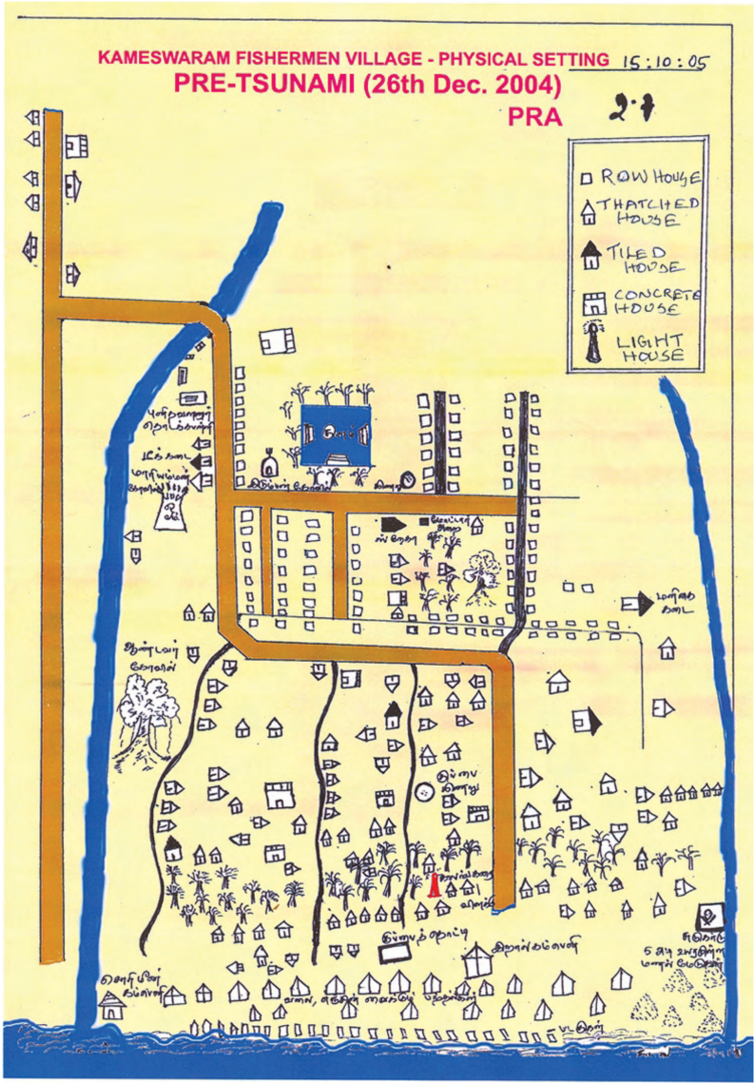
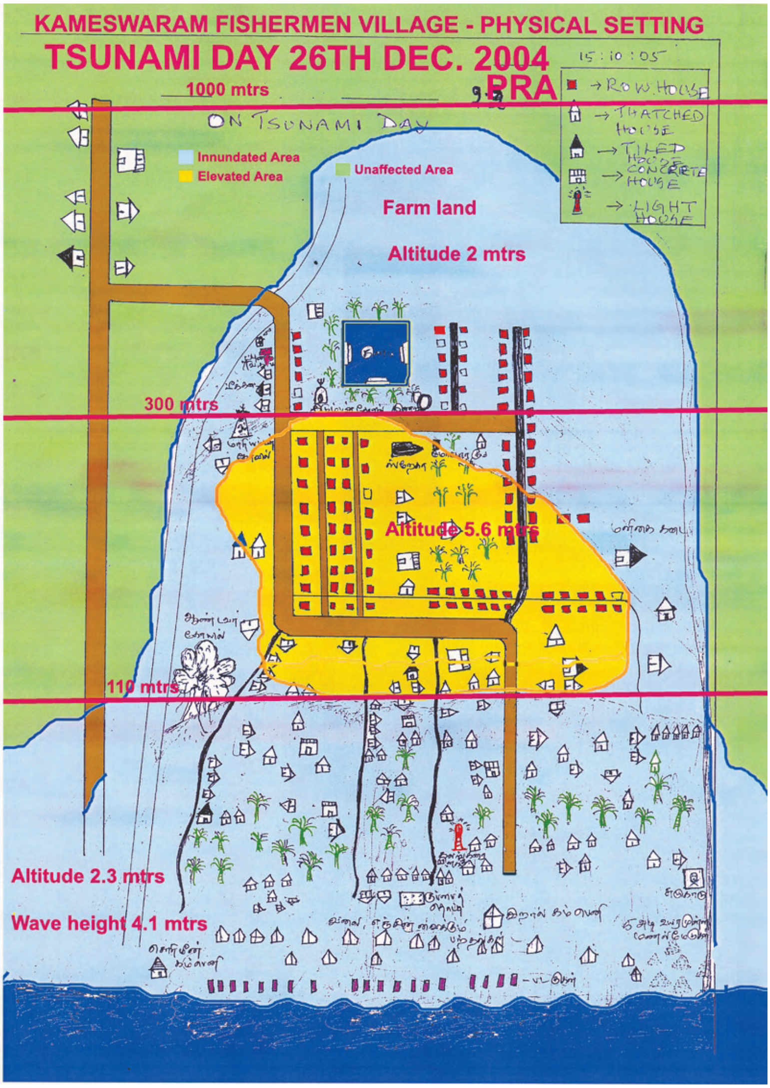


FIGURE 3.5 Hand-drawn maps of Kameswaram village, derived from information collected from villagers by aid responders (Subramanian, 2006). The map on the left shows the village prior to the tsunami, and the map on the right shows the water inundation of the village on the day of the tsunami. Despite an enormous contribution of international relief aid to areas affected by the earthquake and tsunami, and the advanced technology available to some responders, immediate relief efforts and



assessments of the condition and numbers of the affected population relied on hand-drawn maps in this region. This map contains not only subnational, but village-specific, population data relevant to assistance providers and demonstrates that adequate aid does not necessarily require advanced technology—rather advanced technology requires appropriate and timely input of data. SOURCE: Courtesy of Abbiah Subramanian, Madras Christian College, India.

able before the disaster, however, did not guarantee that the data would be used well after the hurricane hit the Gulf coast.

Hurricane Katrina occurred five years after the decennial U.S. population and housing census, not unlike the timing of the decennial censuses relative to the natural disasters in the preceding examples. However, local area data had already been used to apportion congressional seats for the 2002 elections, and many of the data were publicly available. The U.S. Census Bureau makes detailed digitized maps of its address files before every population census, and many local area maps are available from the Topologically Integrated Geographic Encoding and Referencing (TIGER) system files for local area planning. The maps include major landmarks, such as road and train lines, and the Greater New Orleans Community Data Center (GNOCDC) had used these data extensively in preparing community demographic and economic profiles for the metropolitan area, an effort designed to democratize data and make them readily available to community-based organizations on the web (*http://www.gnocdc.org*). Further, the data were used in preparing evacuation plans and testing them in the hypothetical training exercise called Hurricane Pam, developed by city, state, and federal officials (Laska, 2004; FEMA, 2004). Local authorities knew not only the distribution of the population at potential risk, but also its characteristics. However, in the immediate post-disaster environment, the availability and quality of data were another issue altogether (Box 3.1, Figure 3.6).

WHY DECISION MAKERS DO NOT USE EXISTING DEMOGRAPHIC DATA IN DISASTERS

Local-area census data could be invaluable in times of disaster. Census data provide a basic platform from which to evaluate the effects of a disaster. The rates of displacement, morbidity, and mortality cannot be calculated without accurate census data. Without updated, place-based census numbers, responders cannot evaluate the number of affected people or their ages, gender, or education levels; without this information a sampling frame for post-disaster surveys cannot be constructed accurately. Why are the available demographic data not used more often?

As demonstrated in the preceding examples, the underutilization of existing demographic data in a crisis is not necessarily a function of having too few data, too little money, or a lack of local and international response to help disaster victims. Data dissonance—or the lack of coordination between existing demographic and geospatial data sets and their accessibility and use by responders—is rather a function of several features of the data themselves and the operations of the institutional structures employing the data. The inadequacies in the data can be characterized under three headings:

BOX 3.1
Democratizing Data: Where Are the Residents of New Orleans Now?

Hurricane Katrina resulted in the largest internal displacement of Americans since the 1930s Dust Bowl. Nearly half of the residents of metropolitan New Orleans no longer live there; their housing and livelihoods were destroyed by the levee-breach flooding. In the aftermath of Hurricane Katrina, three important data needs confounded recovery and reconstruction efforts. First, there were few spatially referenced data corresponding to those who voluntarily evacuated and where they went. Estimates indicate that upward of 80 percent of the residents in the region evacuated, but we know little about which communities they left, for example. Second, residents who did not evacuate the city, but went to shelters such as the Convention Center or Superdome, became internally displaced and were relocated throughout the United States. While there are gross counts on the number of people internally displaced (based on registry data for individual assistance payments at the state level), data on their original locations (home addresses) and current ones are not readily available. Finally, it is not known with any certainty who is returning to the metropolitan area and from which places they are returning. Proxy data based on rapid population estimate surveys are available for estimation of repopulation of the metropolitan area, but they are not sufficiently georeferenced to provide an adequate picture of the geographic and demographic nature of recovery at the community and block levels (GNOCDC, 2006).

1. The data are old and not representative of the current population or settlement patterns, as in the case of the Turkey and Pakistan earthquakes.

2. The data are not at the correct spatial scales or are missing key characteristics, as exemplified by the lack of detailed data at local levels in the tsunami or the earthquake examples.

3. The data are inappropriate for the needs of decision makers, as demonstrated by the availability of remote sensing imagery of affected regions that lacked corresponding overlays of population data or, as in the case of Hurricane Katrina, where data tracking the relocation of evacuees were not systematically recorded.

Out-of-Date Data

Census demographic data are the most detailed data available for local areas, and the age of the data is one important aspect of evaluating how likely population determinations derived from the data are to represent the present-day, local situation. Nonetheless, age is not the sole criterion on

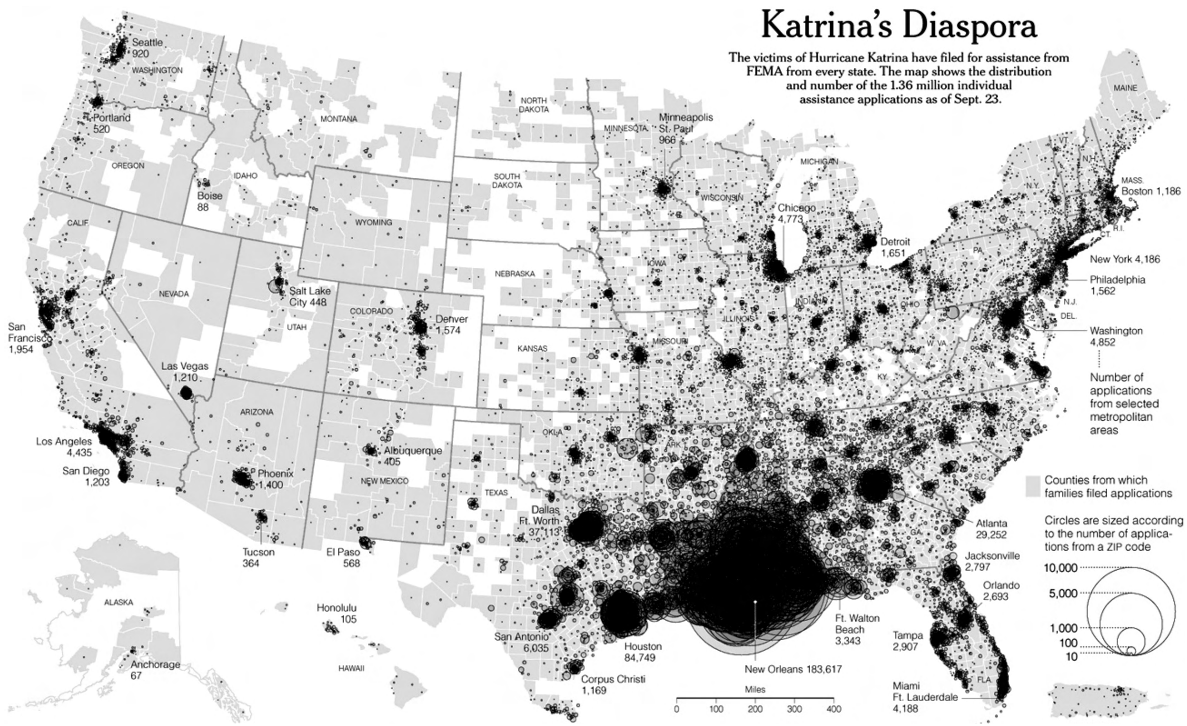


FIGURE 3.6 Gross counts of internally displaced people subsequent to Hurricane Katrina showing their widespread geographic distribution and impact outside the immediately affected Gulf Coast region. Hurricane Katrina became the costliest natural disaster in U.S. history (nearly $125 billion and counting) and represents 79 percent of all global disaster losses for 2005. SOURCE: New York Times, used with permission.

which to evaluate data reliability or usefulness. Most countries conducting regular censuses do so only once every decade, so it is the quality and reliability of these initial data, whether or not they are georeferenced, the degree to which they can or have been disaggregated to subnational levels, their accessibility, and whether or not they have been updated with intercensal surveys that help determine whether older data can be used with confidence. For the four examples discussed in this chapter, the census data were nine years old when the earthquake struck Turkey, seven years old at the time of the Kashmir earthquake, and five years old when Hurricane Katrina hit New Orleans. India had the most recent census data, which were only three years old at the time of the tsunami. These cases show that the age of the data is of less importance than other factors such as coordination between response agencies and governments, political will, and data accessibility and format in getting aid to the populations in distress.

While the expense and resource commitments needed to conduct national censuses with greater than 10-year frequency are prohibitive, methods for updating these data are outlined in Chapter 2, and could be used to update the census population data with information from ongoing demographic surveys. Between censuses, movement of people in and out of regions, especially in cities (Entwisle and Stern, 2005) does occur, and censuses cannot capture migration dynamics. In addition, census data are based on residence and therefore do not describe the distribution of the population when people are not at home. If a disaster occurs after work hours, the census population distribution is likely to be reasonably accurate at local scales in describing the population affected. However, given the commuting distances that many people around the world encounter on an ordinary workday, the differences between daytime and nighttime populations in a given location can be of orders of magnitude (see also discussion in Chapter 2). Simple algorithms to estimate these intercensal changes are rarely employed in pre-disaster preparedness or post-disaster response situations but would greatly improve data accuracy and usefulness in the event of a disaster response situation and could also be used for other types of normal development and planning programs in education, health care and housing.

Inaccessible and Incomplete Data

Even if demographic data were up-to-date, accessing the information is likely to be a continuing problem during a disaster, such as in Turkey or Pakistan (Buchanan-Smith and Davies, 1995). Also, while demographic data were available at the Tamil Nadu's (India) state offices, they were not available at local levels. Furthermore, having complete data on population characteristics (e.g., age, gender) is critical, especially when examining differential mortality or post-event trauma needs of the injured. Having the right data at the right spatial scale is critical for an effective disaster response.

One of the first casualties in a disaster is the infrastructure for data transmission. Electricity and telephone lines are disrupted. Computers cannot function at all or for very long, therefore, Landsat and other satellite data that may be available outside the disaster area cannot be downloaded into the field where they could be useful. Even if a computer could still function, the bandwidth available might be too narrow to capture all of the data available for field use. Some of the inaccessibility of the data occurs because the demographic data and the geographic boundary files are so voluminous that they overwhelm the transmitting systems (Bagiire, 2006). This raises the issue of how appropriate the data are for decision making if they cannot be used in the field during crisis situations. Linking demographic and geographic data is the first step toward an effective emergency response. The second step is the need for simple, large-scale maps of local areas affected by disasters.

Inappropriate Data for Decision Making

If demographic data are up-to-date, complete, and accessible in the field, they still may be underutilized because they are not in a form that can be used for decision making (Maxwell and Watkins, 2003). For example, disasters happen in real time to real places as do relief efforts. Therefore, both the disaster and the disaster relief can best be understood spatially; unfortunately, most available demographic data are aspatial (Liverman et al., 1998). Most countries do not combine their census data with other geographic data (including enumeration districts discussed in Chapter 2). Without such georeferencing, these data are of limited use in a disaster. Furthermore, in many disasters, more than two dimensions of the spatial data are needed. Floods, in particular, require elevation data as well as horizontal spatial data in order to identify the households most at risk. The disconnection between the spatial requirements for disaster responders (where) and the aspatial nature of the available data (how many) often renders the data inappropriate for place-based decision making in times of crises (Messick, 2006).

Another issue is the availability of too many data, which can be as inappropriate as too few available data and may overwhelm responders. In the United States, considerable demographic data are available, but the data can overwhelm decision makers. Identifying the most relevant data in hundreds of pages of tabulated numbers is daunting to everyone. By the time that the third responders from outlying areas arrive, many people with different data needs are involved, and the cognitive dissonance of too many needs and too many responders is already in place (Messick, 2006).

An agreed standard of the minimum information needs in various types of disasters and at different stages in a disaster scenario would be an important step in making data more complete and accessible to decision makers in times of crises or disasters without simultaneously overwhelming these responders. Recognition of these needs would also provide guidelines for data provision at the time it could be used most effectively. The concept of minimally useful data sets would begin to address this issue (Noji, 2005; NRC, 2007; see next section).

CHANGES NEEDED TO MAKE EXISTING DEMOGRAPHIC DATA ACCESSIBLE TO DECISION MAKERS

In order to make the existing demographic data more useful in responding to disasters several steps would have to be taken:

- Update local-area census data routinely (at least every five years) as part of a comprehensive planning or emergency preparedness planning.
- Provide local area data in both spatial and tabular, preferably digital, form.
- Develop an agreed-upon minimum set of requisite data for post-event response as well as pre-impact disaster preparedness.

Update Local Area Census Data Routinely

Several different sources of data collected between censuses could be used to update census local area demographic estimates. The U.S. Census is used for the sampling frame for other surveys throughout the following decade, such as the Current Population Surveys (CPS). The new American Community Survey (ACS) is now providing reliable, updated demographic data at a local level every three years for areas with populations of 20,000 or more and every five years for those smaller communities (Mather et al., 2005). More questions and attributes are available, but at a coarser level (subcounty minor civil divisions) than the decennial census (blocks, block groups, tracts). For example, estimates of poverty rates, daily commutes, and group homes and the homeless (the latter two are future ACS collection plans) would be available every three to five years, but only at the county or in some instances the subcounty level (such as a small town or city). In developing countries, DHSs are taken every three to five years and can also be used to update the census population estimates (Montana, 2006). Updating local area estimates could be time-consuming and expensive if done for each individual enumeration area on an annual basis. The timing for these updates does not have to be annual in places where populations do not change rapidly. These conditions would have to be evaluated on a country-by-country, or region-to-region, basis. Projection algorithms already exist that, if implemented by appropriately trained people, could provide regularly updated estimates at the local level, as long as good baseline data exist as a foundation for the projections.

Provide Local Area Data in Spatial and Tabular Form

At their best, maps are "instruments for reasoning about quantitative information" (Tufte, 1983). Maps can be designed to have at least three viewing depths: the overall structure of the distribution, the more explicit details, and the underlying framework for both. If the data are not presented in a form for rapid and accurate decision making, they would not be used no matter how good they are. This realization is as important for pre-disaster demographic data as for post-disaster data.

Mapping demographic data is now done with computer-based GIS used to analyze spatial problems and to allow the user to visualize the data in a dimensional form that many people, regardless of their training, can use as a common platform (Box 3.2). The main use of GIS in disaster risk assessment and mitigation among practitioners is to provide maps for decision makers. For example, maps can depict the location of people and facilities at risk and the available resources for responding to that risk. Remote sensing, real-time photos and videos generated by GPS-enabled devices can improve data collection in the field before and after a disaster has occurred (Ulgen, 2006). The overlying functions of GIS can link data for the areas impacted and facilitate analyses. The discussion in Chapter 5 about the floods in Mozambique illustrates the importance of having the elevation of a disaster area mapped when flooding is a major threat. The map can quickly provide responders with information about which areas would be most threatened and which areas may be destinations for refugees because their elevation is above the flood level. A review of the many current and potential applications of GIS and GPS in humanitarian response is provided by Kaiser et al. (2003).

Humanitarian Information Systems (HIS) provide and integrate information to assist humanitarian emergency response and decision making, especially in the early stage when quick response is needed (Maxwell and Watkins, 2003). Conventional HIS components include early warning systems and response monitoring. In addition to the magnitude or severity of the hazard, the potential and actual impact on populations according to their differential vulnerabilities is a necessary component of HIS. When integrated with spatial information using GIS, post-disaster assessments of

BOX 3.2
Spatial Tools for Organizing, Displaying, and Analyzing Data

Data exploration and visualization can reveal unknown spatial patterns in highly interactive environments. Methods, including symbolization, highlight subsets of data via either focusing (for a subrange of the data) or brushing (for an arbitrary set of spatial entities), creating multiple views, animation, linking with other forms of display (tabular and graphical displays), or spatial data mining that enables patterns to be detected automatically.

Data exploration software involves high-dimensional graphics. Examples include StatMapper by DHS, 3-D Mapping Software, ExploreMap, MapTime, ArcGIS/ArcView, HealthVisPCP, Vis5D, and CommonGIS. CommonGIS provides web users easy access to visualizations of attribute data associated with enumeration units or point locations. It has the ability to automatically select the appropriate method of symbolization given a set of attribute data that a user wishes to map. Peckman (2004) used it to visualize global databases such as LandScan.

Geographic visualization is the use of concrete visual representations—whether on paper or through computer displays or other media—to make spatial contexts and problems visible, so as to engage the most powerful human information-processing abilities, those associated with vision (MacEachren and Cai, 2006). Analytical techniques and geovisualization methods can greatly enhance our understanding of risk and mitigation efforts.

Data visualization software can be used to present information on post-disaster population status and humanitarian assistance needs to decision makers and those involved in disaster response. An example of a data visualization and spatial statistics software package that is freely availability is GeoDa (Figure 3.7), which was developed by the Spatial Analysis Lab at the University of Illinois, Urbana-Champaign. By employing visualization software, users have interactive access to a vast amount of information that is displayed in a more readily understandable form. For example, spatial analysis of demographic data can help identify regions in which a particular event or need is concentrated. Information can be presented spatially by area-based rates, which can help guide the disaster response by targeting geographic areas (e.g., visually displaying unmet needs or reported service access). Information can also be presented by age- and gender-specific population subgroups as an event density, which can help identify particular population subgroups that may be at risk for certain disasters such as an earthquake or a hurricane (Doocy, 2007; see also Appendix E).

Spatial data analysis refers to the quantitative and statistical analysis of spatial data. For the analysis of the spatial relations among a measles outbreak, food distribution, acute malnutrition, and micronutrient deficiencies, a spatially weighted regression equation that relates measles cases to these areal attributes can be used to model and explain the spatial variation of the measles outbreak. Further, spatial statistical methods such as adjusted and smoothed rates, tests for spatial randomness, spatial heterogeneity, and spatial association can be used to examine the spatial patterns of the outbreak. Another possible method is inverse density-weighted smoothing, where more weight is given to closer samples and less to those that are further away (Isaaks and Srivastava, 1989). Spatial-temporal modeling of space-time data can also be undertaken. Examples include vector habitats and malaria over time.

surviving populations, including their movements, needs assessment, living conditions, and health data, provide a needed perspective for decision making and the timely delivery of resources (Doocy, 2007; see also Appendix E; Messick, 2006).

Box 3.2 and Figure 3.7 suggest the potential benefits of data integration, analysis and visualization. However, the cost of the equipment and software to generate these types of analyses, as well as the requirements for detailed local data and analytical training, may be prohibitive for many countries or local communities. Therefore, the feasibility and relevance of these sophisticated techniques for a disaster situation depend heavily on

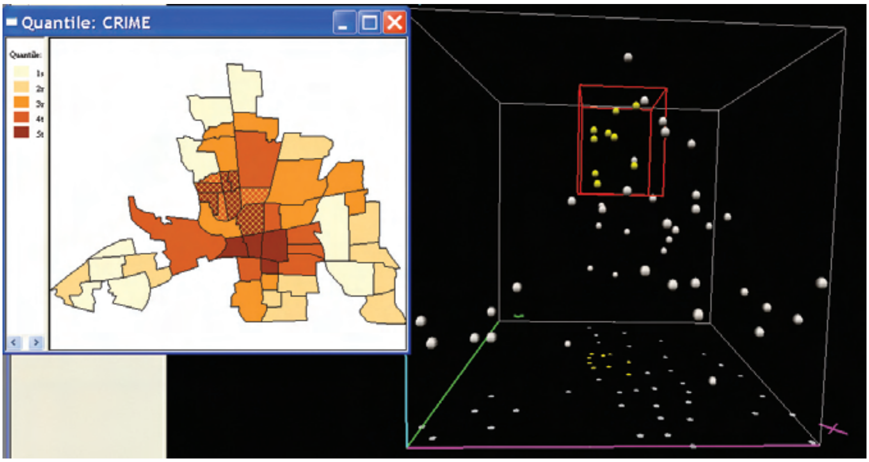


FIGURE 3.7 The three-dimensional scatter plot of GeoDa can be used to examine the relationship among three area-based variables and their spatial manifestation, dynamically linked with a map (see Anselin, 2004). In the right pane, the *x*-axis (pink) and *y*-axis (green) represent the geographical coordinates of the centroid of the neighborhoods shown on the left pane; the *z*-axis (light blue) represents the respective crime rate for each neighborhood. Neighborhoods in the three-dimensional scatter plot in the right pane can be selected using a three-dimensional selection box (red), whose position and size can be changed. The selected points (spheres) in the three-dimensional scatter plot are highlighted in yellow and are linked to the map in the left pane, which is a five-quantile choropleth map of crime rate of the study area (Columbus, North Carolina). While each of the five quantile classes is color-coded to represent the first, second, etc., class, additional shading is used to indicate the neighborhoods selected by the red 3D box in the right pane. Several three-dimensional point manipulations are supported by GeoDa, such as rotating and zooming, as well as linking and brushing. By these means, the geographical pattern of areal units with certain combination of characteristics (e.g., high poverty level, crime) can be identified on the dynamically linked map of the study area. SOURCE: Luc Anselin, University of Illinois, Urbana-Champaign.

the availability of adequate financial and technical resources in the local context. The committee thus recognizes the difficulties in achieving this level of technical capability with data visualization and analysis, but emphasizes the potential of these visualization tools to improve the abilities of local agencies to respond to disasters. Visualization tools and training are not a priority for countries or communities lacking data, but they should be recognized as part of the future toward which analytical capacities and technology for population data can aspire. Priority should be given first to the acquisition and maintenance of good base data, training of analysts to use the data, and coordination of organizations and governments through which these data must be transmitted for disaster or development aid projects. As noted elsewhere (NRC, 2007), effective emergency response begins with a map, and for many responders to humanitarian crises and disasters, the map may be most useful in paper, not digital form.

Adopt a Principle of Minimally Essential Data Sets

The pre-disaster demographic data provide a baseline to assess the human impact of the disaster, but the pre-disaster data themselves cannot provide an assessment of the post-disaster impacts. Each disaster leaves its own unique footprint on the population and the landscape. Interactions between the disaster, the people, and the environment mean that generalizations about the impacts of a disaster are difficult to make until a post-disaster survey is taken. The 2004 tsunami had different effects in both Indonesia and India. In Aceh Province in Indonesia a cluster sample survey of households found that women were almost twice as likely to have been killed as men (MacDonald, 2005). The most vulnerable age groups were the 0-9 year-olds and those aged 60 and over (Doocy et al., 2006). The effect of the tsunami was quite different in Nagapattinam District in Tamil Nadu, India. In that one district, 6,065 people died. Children were a smaller percentage of the dead than adults; 40 percent of the dead were adult women and 31 percent were adult men (Doocy, 2007).

Several different kinds of post-disaster survey designs exist, each with different strengths and weaknesses (Box 3.3). The challenge is that very different kinds of information are needed at different stages after the disaster and for different interventions. If one disaster precipitates another one of a different kind in the same region, then the information needed for that response will continue to evolve. The concept of a minimal essential data set (MEDS) is important so that only the most relevant and important data are collected for the particular kind of disaster at the right stage within the emergency cycle (Noji, 2005).

A framework for data for pre- and post-disaster situations would include data for both sudden-onset and chronic disasters. The data would

BOX 3.3
Minimum Population Data Requirements for Emergencies

Displaced persons are most in need of emergency assistance. Information collected during emergencies follows the pattern of an inverted pyramid. Whereas very few data are available at the start, the amount of information increases exponentially over time. This is also the case for population data. Due to the high mobility of displaced persons, population data should be updated on a regular basis. It is better to collect basic population data frequently, rather than detailed information only on an occasional basis. Basic population data are collected through a variety of data collection methods, including counting, estimation, rapid assessments, surveys, registration, and other administrative records. Several methodologies specific to post-disaster population surveys include cluster sampling, area probability sampling, the quadrate method, and the T-square method (Noji, 2005).

Most emergency interventions are organized according to sectors, such as health, food, water, nutrition, sanitation, and shelter. Some of these sectors have standardized data collection methodologies (e.g., mortality measurement, nutrition). In practice, the different sectoral interventions often require similar population data. Arguably, the denominator (i.e., total population size) is the most important population data need for all actors. Surprisingly little attention has been devoted to defining minimum standards for demographic data collection, developing methodologies and tools for rapid demographic assessment, and improving population estimates.

The need for population data collection depends greatly on the geographical region, the capacity of the host country, the type of emergency, and the scope of the response. While an earthquake in Pakistan, a hurricane in the United States, displacement of Sudanese by conflict, and refugees crossing an international border occur in different geopolitical contexts, each requiring a tailored response, the needs for basic population statistics during first phases of the emergency are surprisingly similar. For example, data collected on shelter residents displaced by Hurricane Katrina were quite similar to information collected on refugees in sub-Saharan Africa. Standardization is also promoted because international agencies use standardized forms and templates in responding to emergencies. However, there is no formal agreement between agencies on the population data to be collected. At a minimum, the collection and georeferencing of population data should be linked with the existing coordination mechanisms on the ground.

Surveys are critical for assessing the needs and characteristics of the survivors of any emergency situation. However, only when the total surviving population is compared to the total pre-disaster population from the census or administrative records can accurate counts of the number of people killed be made.

Specific Place-Based Data Needs

At the Border. When refugees cross an international border, host country authorities, often aided by international agencies, seek to determine the scale of the influx by counting or estimating the number of persons crossing the border. If feasible, the new arrivals are registered. Population data collected at the border include the total number of persons (“rate of arrival”), a count or estimate of the number of males, females, and children and an indication of their place of origin.

At the Reception Area. To provide basic protection and deliver emergency assistance to displaced persons at the reception area (camps or centers), it is necessary to establish a total population count, to capture basic demographic characteristics, and to record every individual. Typically, all individuals will be issued a unique identification number.

Registration during emergencies is often conducted at the family level. Data collected from each family include: name; place of origin; current location (site, block, shelter no.); date of arrival; and number of males, females, and persons with special needs, including children under age 5. As soon as possible, all persons should be registered on an individual basis. Data collected from each individual include name, relationship to head of household, place of origin, current location, date of arrival, gender, date of birth, and special needs (if any). When people leave the site, their date of departure and destination should also be captured. To simplify data collection, answers to these questions should be pre-coded with a limited number of answer categories. Collecting few data and entering them quickly is the golden rule. Once the emergency is over, more data can be collected, including educational level and skills.

For registration to provide population statistics, it is essential that data are entered as quickly as possible. Unfortunately, data entry often does not keep pace with the rapidly evolving situation on the ground. Moreover, registration figures are often inflated, because of the inherent incentives of being registered and lack of disincentives for de-registration. Separate counts are held of the number of people arriving (departing) and in particular headcounts of those who are present. Shelter counts based on satellite imagery or observations on the ground, combined with a shelter survey providing the average number of persons per shelter, are often used to estimate the total population. Shelter surveys can also used to provide a basic demographic profile by gender and broad age group.

Key Emergency Indicators

In the humanitarian community, there is widespread agreement about a limited number of indicators to trigger emergency interventions. These key emergency indicators include the crude and under-5 mortality rate; nutritional status; minimum requirements for clean water, food, energy, shelter, and sanitation; as well as the reported cases of measles, respiratory infections, and diarrhea (UNHCR, 1990). Most indicators require the total population size as denominator. The mortality rate, arguably the most important emergency indicator, is another area in which population and census experts can lend their expertise.

include both the physical characteristics of the area that has been affected and the population characteristics. Physical characteristics would include spatial data on the extant transportation network, including roads, bridges, airports, rail systems, and ports. Most disasters also would require spatial information on the health care systems, such as hospitals, clinics, nursing homes, and health institutions (e.g., mental hospitals); most disaster responses will also require spatial information on settlements and their power grids, alternative sources of power, gas stations, and backup systems.

The development of a matrix of needed data for different kinds of disasters at different stages of recovery is essential to help make the best use of scarce resources. Currently, several groups, among them George Washington University (see discussion of data availability below), the United Nations, and Environmental Systems Research Institute (ESRI), are surveying the international disaster response community for the kinds of data they need at different stages of a disaster. Their plan is to develop a template of needed data that can serve as a guide for in-country responders as well as the international community. In addition, the UN Office for the Coordination of Humanitarian Affairs (OCHA) is also trying to standardize some of the definitions and concepts that people use during disaster reporting. Both efforts are essential to providing decision makers the right kind and level of data for decisions that must be made immediately. The goal should be to get the best data to the field as soon as possible in a form that can "promote the ordered, sequenced, hierarchical flow of information from the graphic to the mind's eye" (Tufte, 1983) for decision making.

Peruse Household Survey Data

As noted above, surveys are often the only source of data in many developing countries. Surveys are carried out by a variety of local, national, and international agencies for a variety of purposes. However, a common feature of most of these surveys is that they include basic data on the sociodemographic characteristics of the population and indicators of their well-being. Both in contingency planning and in responding to disasters, knowledge of recent household surveys carried out in the area and, particularly, the availability of the specific indices collected as part of those surveys is important. Emergency responders would gain great benefit from resource investment in collecting and maintaining existing household survey data in accessible databases.

BROADER INFORMATION MANAGEMENT, TRAINING, AND TECHNOLOGY ISSUES

Data Access

Population data expressed as aggregates even in very small enumeration areas are some of the better examples of public goods. Most countries make their population counts—and, at some geographic level, other information—publicly available and usually at no cost provided that no spatial (boundary) data are also being distributed. Individual unit records from censuses are subject to confidentiality agreements and are not made publicly available. In many countries, such data are available for use at the

NSO or related data enclaves. When census data are publicly available, they are usually available through NSO web sites. At present there appears to be no capacity within these agencies for systematic collection, processing, or dissemination of subnational data through a centralized or distributed system.

Spatial data associated with commonly needed census variables are not commonly available to the public, nor are they widely available to nongovernmental organizations (NGOs) and other disaster response entities. Increasingly, the practice is to make census boundaries available, usually through collection of a fee, because the "business model" for producing these data has been one of cost recovery, either for the total investment or on an on-demand basis for a particular data product.

Distributed Archives

Census data are normally available through NSO web sites, and for global aggregations of population estimates the official repository is the UN Statistics Division (*http://unstats.un.org/unsd/demographic/*). Several NGO collections exist: the African Census Analysis Project (ACAP) at the University of Pennsylvania, the Centro Internacional de Agricultura Tropical (CIAT), the Center for International Earth Science Information Network (CIESIN) at Columbia University (see also Chapter 2), and the Integrated Public Use Microdata Series (IPUMS) project at the University of Minnesota (see Box 3.4). Each of these has both national and subnational census data. Many countries disseminate subnational data tables and spatial boundaries, but many do not. Further, as Table 3.1 shows, the resolution of spatial inputs (by area or population) varies tremendously. However, no subnational data are redistributed by the main producers of population estimates and projections, namely the UN Population Division, the U.S. Census Bureau's International Program Center, or the International Institute for Applied Systems Analysis (IIASA).

Technology now allows for distributed archiving systems in which data holdings would remain in a country but conform to international standards so that they could be integrated seamlessly from a single repository. This approach has the advantage of keeping ownership within a country but allowing easy access by individual researchers, policy makers, and agencies.

Such distributed systems require some degree of interoperability of systems and standards, but with moderately small investments in computing infrastructure and the associated human resources, such a system is within reach of most of the world. A more challenging issue is determining an ideal home for the gateway to the distributed network. Such a gateway could, but would not necessarily, also have to double as an archive, or offsite backup location, for the various data sets under discussion. A working

BOX 3.4
Nongovernmental Organizations with Collections of Regional or Global Aggregations of Population Estimates

ACAP specializes in demographic research and training to maximize the use of African census microdata for academic and policy-oriented research to benefit African governments and research (*http://www.acap.upenn.edu*).

CIAT is a nonprofit organization that conducts social and environmental research oriented toward reducing hunger and poverty and preserving natural resources in developing countries (*http://www.ciat.cgiar.org*).

CIESIN specializes in online data and information management, spatial data integration and training, and interdisciplinary research related to human interactions in the environment (*http://www.ciesin.org*).

IPUMS collects and provides in database format U.S. census microdata and census data from around the world, for social and economic research at no cost to the user (*http://www.ipums.umn.edu*).

example of such a data gateway is housed at the Socioeconomic and Data Applications Center (SEDAC; *http://sedac.ciesin.columbia.edu*) at CIESIN, Columbia University, which serves simply as an example of the architecture; this particular gateway currently serves gridded demographic data but not population data associated with finely resolved subnational units.

Data Availability

Simply sharing existing population data is admirable but may be insufficient if disaster management is to be effective. Other data—on population characteristics (e.g., demographic, health, socioeconomic) as well as the location of roads, facilities (e.g., hospitals, clinics, schools), and elevation and slope—may be critical. With the exception of elevation and slope, none of these data are currently available to the extent of population data. Roads are perhaps the most glaring omission of a data set for which there is a clear, unmet need and for which the private investment (e.g., commercial road maps) might make the construction of a public global good particularly challenging. A recent initiative supported by academia, the private sector, and UN agencies is developing a GIS data model for humanitarian action (Box 3.5).

Data collected and acquired in the relief and recovery process may be useful for longer-term development activities. However, data acquired under conditions of disaster response may be the most perishable and decentralized and subject to the greatest variation in ownership, consistency, and quality. Nevertheless, these data may present important details about

TABLE 3.1 Spatial Resolution Associated with Available Population Data: Examples from the Gridded Population of the World (GPW) Data Collection

	Country	Resolution (km)	Population per Unit (in thousands)	Area (km^2)	Administrative Area Type	Number of Administrative Units	Population (in thousands) (UN, 2000)
1	South Africa	<1	1	1,217,645	Enumeration Area	83125	43,309
2	Guam	2	1	546	Block Group	203	155
3	Slovenia	2	0	20,224	Settlement	5989	1,988
4	Malta	2	6	315	Locality	67	390
5	Macao	3	142	19	Peninsula/Island	3	444
6	Maldives	3	13	189	Atoll	21	291
7	Malawi	3	1	94,958	Enumeration Area	9219	11,308
8	Mauritius	3	6	1,993	Municipal Ward/ Village Council Area	186	1,161
9	Netherland Antilles	3	2	818	Geozone	71	215
10	United States Virgin Islands	3	3	374	Blocks	32	121
11	Czech Republic	4	2	78,616	Obec	6258	10,272
12	Switzerland	4	2	38,975	Commune	2912	7,170

(continued on next page)

TABLE 3.1 continued

	Country	Resolution (km)	Population per Unit (in thousands)	Area (km^2)	Administrative Area Type	Number of Administrative Units	Population (in thousands) (UN, 2000)
223	Papua New Guinea	152	241	464,043	Province	20	4,809
224	Botswana	156	71	559,502	Census District	23	1,541
225	Serbia and Montenegro	159	2,658	101,561	Settlement	4	10,552
226	Sudan	171	358	2,492,385	Muhafazat	85	31,095
227	Algeria	219	634	2,302,498	Wilaya	48	30,291
228	Libyan Arab Jamahiriya	254	223	1,611,363	Mohafada	25	5,290
229	Angola	264	1	1,251,924	Municipio	18	13,134
230	Mongolia	265	108	1,546,294	Aimag	22	2,533
231	Chad	298	527	1,243,139	Sous-Prefecture	14	7,885
232	Saudi Arabia	386	1,604	1,938,837	Emirate	13	20,346

NOTE*:* "Resolution" is calculated as the square root of the land area divided by the number of administrative units.Only the finest and coarsest resolutions are shown."Population per unit" is the average population per administrative unit (2000 population estimate divided by the number of units).

BOX 3.5
GIS Data Model for Humanitarian Action

The purpose of the Humanitarian Data Model (HDM) is to promote GIS usage and data sharing among humanitarian organizations. The model would provide a "ready-to-use" template or framework from which various agencies and organizations could build their internal system. The current model consists of both geodatabase design and application framework.

Those currently participating in the ongoing development of the model are the International Charter on Space and Major Disasters; UN OCHA Humanitarian Information Centers; UNOSAT; the RESPOND Consortium; UN Geospatial Information Working Group (UNGIWG); the U.S. Department of State's Humanitarian Information Unit; the Open GIS Consortium (OGC); and the Institute for Crisis, Disaster, and Risk Management (ICDRM) at George Washington University.

Proposed Applications of the Model:

- Risk assessment
- Capacity and vulnerability analysis
- Loss estimation
- Emergency relief management
- Infrastructure mapping

Base Universal Layers:

- Critical infrastructure
- Settlements
- Land use
- Simple geography
- Political boundaries

The draft HDM will consist of (1) a conceptual database design document, (2) an analysis diagram, (3) Unified Modeling Language (UML) documentation and Geography Markup Language (GML) schema, and (4) sample database and map documents.

After it has been developed and stabilized through peer review, the HDM will then be ready for publication on ArcOnline and the ICDRM web site. The developers would then begin construction of a short book that documents the data model design. Published by ESRI Press, the book would provide a concise description of the thematic groups and classes in the model, and would serve as a reference book for teams working on projects.

The paper discussing the development of the model referenced the Homeland Security, Defense-Intelligence, and Transportation Data Models are potential references for the structure of the HDM.

SOURCE: *http://www.humanitariangis.com/?q=node&from=10.*

migration flow and individual, household, and community characteristics, all of which might aid longer-term recovery and development efforts. However, agencies that collect and share data for relief aid may differ from those that collect data for longer-term recovery and development.

Data Documentation

Metadata for humanitarian applications are often not available or are poorly documented. Government agencies should be held responsible for including metadata using one of the standard available formats, as long as doing so does not hamper the publication of data during the crisis. This requirement could be incorporated with a larger mission of cost-effective investment of national resources to improve the level of geographic detail. Data should be subnational and should include more spatial units, boundaries, and sufficient detail for future updates and replication either by the original data collector or by another entity. These requirements could be explored in practice through disaster exercises or dress rehearsals where national-level actors interact in a simulated crisis environment to see where communication and data flows can break down.

Data Sharing Needs During the Response Phase

Rapid access to relevant information is crucial for the immediate response to the event and to mitigate its consequences. Various data about the affected areas are needed for this purpose, including building plans and footprints, local streets, utility lines, and critical facilities such as hospitals. Emergency responders must to be able to search, retrieve, assemble, and use existing geospatial information quickly (Goodchild, 2003a). Data sharing among agencies or units would greatly facilitate emergency response, but such exchanges are constrained by operating cultures (see Chapter 4) and information technology issues of interoperability.

Interoperability is the ability of systems to exchange information, based on shared understanding of meaning (semantic interoperability) and mutually agreed formats (syntactic interoperability) (Goodchild et al., 1999). The data needed may be difficult to assemble or integrate because of incompatible formats and inaccuracies. Geospatial data standards that facilitate data sharing and interoperability need to be developed and adopted long before disasters occur.

In addition, there are several important considerations when establishing the database or information system for emergency response (Goodchild, 2003b). First, the system should not only incorporate important geographic information but also have spatial analytical and modeling capabilities to facilitate effective response to disasters—for example, the capability to display, identify, and analyze critical spatial patterns or relationships among event locations, shelters, transportation routes, and the population at risk. The system should also permit interactive and dynamic visualization of the temporal progression of both the disaster situation and the evacuation of the affected population from the disaster site (see Box 3.2, for example).

Since the risks at a disaster site can change swiftly and unexpectedly, decision support in real time for both emergency response personnel and the affected population is an essential function of such a system. This means that the system should be able to collect and disseminate information about the current condition of the disaster site in real time. The system should also allow responders to model or simulate possible trajectories of change in the disaster conditions and to formulate alternative decision scenarios. Furthermore, the database infrastructure should have a distributed architecture and allow for wireless and mobile deployment. As emergency crews work at a site, mobility and self-reliance (without requirement for hard-wired connections, even if available) are critical for information and decision support. The ability to communicate decisions and desirable actions effectively among all affected persons and emergency personnel is, therefore, essential for any geospatial data sharing infrastructure (Messick, 2006). To remain operational during a disaster situation, such infrastructure could be built upon a highly flexible and distributed system architecture, where the geographic database and decision support functionalities remain accessible to emergency personnel through multiple channels including wireless and mobile communications technologies. Most importantly, strong coordination mechanisms should be created at the field level between all actors involved in population data collection. For this to happen, population data management could be considered a separate "cluster," similar to water, sanitation, and shelter. Although population data are cross-cutting, creating a population data cluster in each emergency would ensure proper resources and coordination opportunities.

Training for Effective Data Use

Of course, better data management and technology will require better training for the people who will be expected to use the data more efficiently. Some people will have to be trained to integrate demographic data with GIS technology, but many more people will have to be trained to analyze the demographic data, in both tabular and spatial form. This training does not necessarily have to be sophisticated, but it does have to be appropriate to emergency situations in general. Training is not free, but it need not be expensive if it is integrated into the job requirements of those who will be expected to use data during a disaster. Demographic data training is essential for basic disaster management competency and is also important for promoting an organizational culture that is more efficient, flexible, and collaborative during disasters and beyond. Not every person involved in disaster relief needs data training; in fact, the selection of a subset of people, such as geographers and demographers, for training will be more cost efficient.

One of the obstacles to the full employment of spatial demographic data during disasters, despite the clear need to do so, is the pressing human resource issue. Responding to disasters and humanitarian crises requires shared geographic and demographic thinking and training. At present, relatively few units, especially in developing countries, have sufficient trained expertise in both demography and geospatial tools and technologies. Improvements in the training and commitment of the national statistical office and other staff for each country are essential, to include both demographic projection methodology in local areas and the use of appropriate spatial administrative units in map form. There are a number of mechanisms for building such capacity, the first of which is recognizing the importance of the skill sets required for disaster preparedness and response. The second is formalized training. Such training programs could be part of overall capacity building and funded by bilateral aid programs, such as the U.S. Agency for International Development, or through broader country capacity-building programs, such as those conducted by the U.S. Census Bureau with support from the World Bank or the United Nations. The United States experience suggests that improvement in the capacity to prepare for and respond to disasters saves lives and reduces economic costs when an event occurs.

SUMMARY

The selected vignettes of disasters in countries with different levels of resources all demonstrate the same problem. A pervasive gap exists between the data that are available for use in disaster situations and the underutilization of those data when they are most needed. Each disaster seems to receive a new approach without any systematic understanding of what information is needed and the form it should take.

Although each disaster has its own unique characteristics and each country has its own unique data collection and dissemination systems, the uniqueness of the disaster and of the national, local, and urban institutions does not obviate the more fundamental requirements for demographic data before and after disasters strike. The sense of each disaster being unique (in terms of both the event characteristics and the impact on particular places) has hindered the ability to generalize across disasters and countries in terms of common information requirements, especially among response communities.

Remedies for data dissonance in disasters rely less on new money than on the better organization and coordination of the data and resources that already exist. National, local, and urban governments should coordinate the release of specific data sets that are vital to disaster management and planning based on what has been called the "good Samaritan" principle (Iwata and Chen, 2005). Protocols for data sharing drawn up before disasters could facilitate sharing during and after disasters. Protocols for data formatting could also be developed before disasters. Local and urban area data sharing before disasters would also facilitate disaster response.

A template of illustrative local area population and other data could be developed for different kinds of disasters for different kinds of responders over time. At least two efforts to do this are taking place, the Humanitarian Data Model (see Box 3.5) and the Structured Humanitarian Assistance Reporting Effort (SHARE) effort by OCHA. Both efforts stress common formats for reporting data. Focus of both efforts on short-term response and on what is needed for long-term recovery efforts would be useful.

To improve the effectiveness of response, the integration of spatial data and demographic data would be most useful prior to the disaster, not afterward. The development of MEDS to provide the baseline for preparedness and response is one avenue for reducing the demographic dissonance that plagues so many responders to disasters.

RECOMMENDATIONS

Based on the preceding discussion, the committee makes the following recommendations:

- **Develop a template of minimum acceptable population and other geospatial data sets that are required by disaster responders. The data sets should be updated frequently (at least mid-decade if not more frequently) and include digital census enumeration units and other census maps in digital form. [Report Recommendation 4]**

- **The standard of open-access census data and sharing (as practiced, for example, by Brazil, South Africa, and the United States) should serve as a model for other agencies and for countries that currently do not operate in an open geospatial environment. This access includes spatial data such as digital boundary files or subnational units of countries of the world. Governments should release specific data sets that are vital to disaster planning and response. Furthermore, international standards should be developed for the release of subnational population data to maintain confidentiality. Countries**

financially unable to comply with confidentiality standards should be offered incentives to do so. [Report Recommendation 5]

- **Establish a centralized system of access, such as distributed archives and data centers for publicly available subnational data, including data from surveys. The archive would function as such a repository for shared local data and would have the primary responsibility for re-dissemination of data to the appropriate response communities during a disaster. The archives should build upon existing data resources. [Report Recommendation 6]**

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4

The Operational Environment and Institutional Impediments

This chapter addresses the two overlapping contexts for using data to assess populations at risk: (1) the *prevention context*, where the need is to develop capacity to improve response over time and enhance the resilience of local populations; and (2) the *response context*, where short-term needs call for data to estimate damage and provide relief. A key issue to be taken into account is the fact that fundamental differences exist between the key actors and institutions in terms of their organizational structures and the contexts within which they operate, whether in times of emergency response or in the prevention-development context. These differences can function as obstacles to effective communication and resource use during times of disaster response or planning and executing a prevention project. In a disaster or humanitarian crisis, for example, the sheer number and variety of institutional actors is potentially confusing, necessitates strong coordination mechanisms at the field level, and should include provisions for population data management. This chapter recognizes and examines the organizational differences between the various actors, some of which are inherent in their predefined roles and some of which are affected by the scale and duration of the disaster or prevention scenario. Based on these observations, the chapter concludes with several recommendations designed to assist these varied institutions and organizations in linking their domains more efficiently to collect and use georeferenced population data in disaster response and development projects.

INSTITUTIONAL MILIEU

The organizational structure of international disaster response is consistent with the phases of the emergency management cycle (Figure 4.1), except that a wider array of governmental, nongovernmental, and intergovernmental entities is involved. There are many inherent dichotomies in how, when, where, and in what capacity organizations respond to disasters and humanitarian crises. First, fundamental differences exist between organizations that provide demographic data (which are usually aspatial) and those that provide spatial or geographic data (flood zones, urbanized areas), and rarely do the two work in concert to provide spatial demographic data (as noted in Chapter 2). Second, the distinction between the need for basic information technology (ability to communicate in the field and transmit data) and the equally important need for geospatial data (maps, aerial photography, geographic information systems) requires different organizational and technical approaches (Chapter 2). Finally, a dichotomy is evident between those organizations whose fundamental mission is development and those organizations whose primary concern is rescue and relief in the face of disasters and humanitarian crises. In the former, the perspective is to develop and nurture the capacity for future resilience over the long term (years to decades), while in the latter, the primary focus is immediate rescue and relief to reduce human suffering in the very short term (days to months). As might be expected, these differences reveal themselves in terms of conflicting visions and goals, the types of actors and resources involved, and organizational cultures.

As depicted schematically in Figure 4.2, while statistical and other data providers may overlap with development and response agencies, very little overlap exists between agencies engaged in development and those

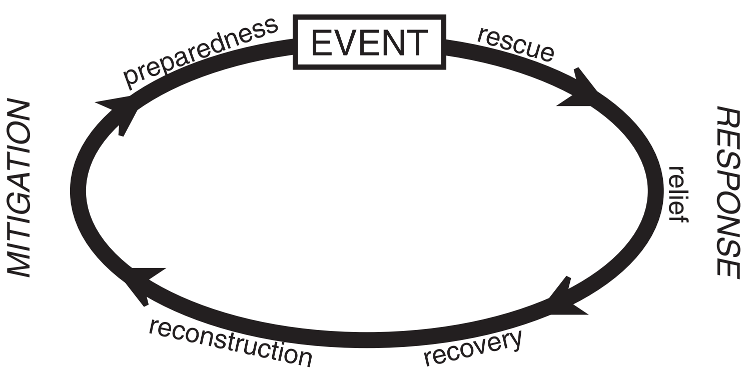

FIGURE 4.1 Emergency response cycle.

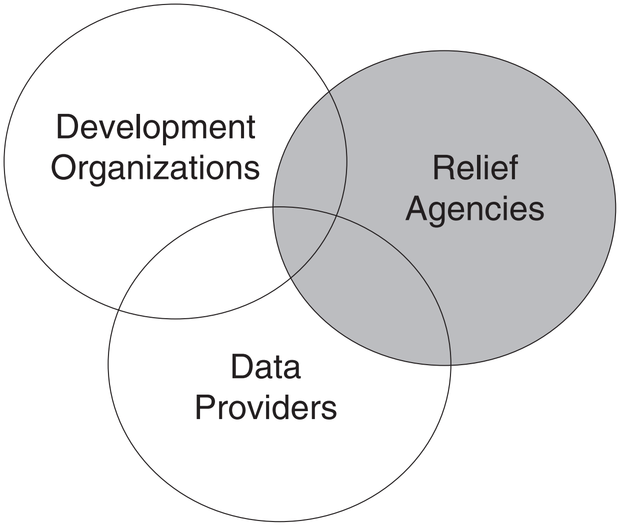

FIGURE 4.2 Organization of international actors in disaster response and schematic depiction of overlapping areas of interest and activity.

engaged in response. For many years, attention has been drawn to the "gap" in post-conflict settings when humanitarian agencies are pulling out and development agencies have not yet arrived (Van Rooyen et al., 2001). Improved coordination and cooperation between these actors in post-conflict situations ought to be extended to include population and spatial data with the understanding that because the mandates of these actors are quite distinct, their data needs are likely to differ as well.

Development Organizations

Generally speaking, the primary vision of development organizations is to foster international trade, global monetary cooperation, and sustainable economic growth and practices and to reduce poverty. The vast majority of these efforts are designed to build or enhance capacity at the local level in many of the world's less-developed regions. The provision of direct economic assistance for infrastructure, debt relief and restructuring, and assistance in reconstruction after disasters falls within the mandate of multilateral agencies such as the World Bank and the United Nations Development Programme (UNDP), and bilateral actors such as the Overseas Development Institute (ODI).

Although highly centralized, many of the development institutions have shared the responsibility for program development between headquarters and "in-country" personnel. While the financial assets may be controlled centrally, the available assets and infrastructure for emergency response operate at a more local level and are responsive to local needs. Development assistance organizations are also regional in scope, operating in conjunction with trade and economic alliances such as the Organization of American States (OAS).

Disaster and Humanitarian Crisis Response Agencies

Response agencies have, at the core of their missions, the desire and ability to respond to disasters or humanitarian crises anywhere in the world. This capability is in near real time, where the agency can mobilize rescue and relief resources immediately and move them into areas of need. With sudden-onset disasters such as earthquakes, tsunamis, flooding, or refugee crises, relief agencies can mount a presence in the affected area within hours to days depending on the magnitude of the disaster and its location. For slower-onset humanitarian crises or ongoing pandemics (e.g., HIV/AIDS) assistance is readily available and assets are deployed when the situation worsens from a "normal" level to one that becomes critical.

Humanitarian actors include international organizations (e.g., UN High Commissioner for Refugees [UNHCR], UN Children's Fund [UNICEF], World Health Organization [WHO], International Federation of Red Cross and Red Crescent Societies [IFRC]), bilateral organizations (e.g., U.S. Agency for International Development [USAID], ODI), and national and local authorities and nongovernmental organizations (NGOs), which can be either national or international (e.g., Save the Children, Médecins Sans Frontières [MSF], Oxfam). Some actors focus on operational activities whereas others specialize in advocacy. Most of the assistance is generally delivered by NGOs working at the grassroots level, while national authorities, assisted by the United Nations, have a coordinating function.

The role of the relief agency is to arrive with help and supplies in support of the rescue and relief operations. Once the emergency period has passed and the affected area is in a recovery phase, the services of relief agencies are generally no longer needed and they leave the area, ostensibly to prepare for the next disaster or humanitarian crisis. Relief organizations such as the IFRC, MSF, or Church World Services have both staff and resources pre-deployed and often on standby, waiting for mobilization.

Regionally based relief agencies include private-sector organizations. During the Indian Ocean earthquake and tsunami, as a case in point (see Figure 1.1), more than 50 agencies and organizations were involved in disaster relief and recovery throughout the affected area. This aid did not include foreign direct investment from other nations (more than 50 nations committed financially) or the millions of dollars raised by the private sector and donated to the relief efforts. The coordination and distribution of the aid created its own series of problems and issues, although amidst the grief over the scale of destruction there was also a sense of satisfaction with the overall outcome of the relief operation (UN, 2005). A longer discussion of the tsunami effort is provided in a summary discussion of the Medan Indonesia Workshop coordinated by the United Nations (UN, 2005).

Humanitarian situations of a chronic or protracted nature are often called "forgotten crises" because attention and resources tend to diminish quickly after the emergency phase of a crisis. In practice, millions of people are displaced for many years, often outside the attention of the media, with very few agencies providing assistance. Due to underfunding, such situations can escalate easily into new emergencies if, for example, food security becomes an issue and malnutrition levels rise or sanitation facilities and clean water cannot be maintained in camps or villages and lead to an increase in illness and disease.

Knowledge and Technology Institutions

A plethora of actors is involved in both disaster response and development capacity-building operations, including those who supply necessary population data. National statistical offices (NSOs) often collect, analyze, and house demographic (and other) data that are invaluable during disasters, but the extent of collaboration between NSOs and relief organizations is extremely limited. As outlined in Chapter 2, geographic information systems (GIS) and information technology (IT) are important elements in population estimation, and their use in emergency response is vital. Unfortunately, GIS have delivered less than they have promised because most uses of the tool continue to be related to the display of data rather than data analysis (Currion, 2006) (see Chapter 3).

The hindrances to integrating GIS and IT techniques in census operations are well known (Tripathi, 2001) and include continuing challenges in finding and retaining trained staff, inadequate financial resources, and inexperience with both outsourcing and inter- or intragovernmental cooperation. All of these are amplified greatly by the traditional "boom-bust" cycle of census operational funding, which inhibits the development of permanent editable census databases and the retention of staff with census-taking experience. Many of these challenges threaten the promise of technologies such as GIS, global positioning systems (GPS), mobile computing and data collection, and Internet dissemination of census results and analysis (see Chapter 3).

INSTITUTIONAL CHALLENGES

Management Vision and Complexities

Many international relief and development organizations have large bureaucracies and complex management structures. In some organizations the functions are vertically integrated or organized by sector or function, while others have horizontal structures that facilitate working across sectors. Some of the organizations have centralized staff and others have a decentralized management structure in which local offices have a large degree of autonomy at the individual country level. This allows the country office to be more responsive to the client government being served and to tailor assistance programs to the specific needs of the country. However, the decentralized management authority also adds to the complexity of disaster response capacity. An example from the World Bank (Box 4.1) illustrates some of these issues.

In view of the large number of actors or partners involved in humanitarian crises, coordination remains a critical precondition for effective response. Stephenson (2005) notes that no single agency, even those chartered to coordinate responses, enjoys a mandate to command national governments or NGOs to act in certain ways. Studies of information and communications systems in humanitarian relief NGOs found that field offices may operate autonomously from their headquarters and, potentially, from other organizations stationed in the same area; the field manager role is a critical one as the point of contact and coordination for local operations and support of an effective field team (Moore et al., 2003; Van Rooyen et

BOX 4.1
How Institutions Work: The World Bank

In a large development organization such as the World Bank, the country office manages the response to a disaster emergency. Disaster management capacity is a small, centralized team located at headquarters. Country offices are not obliged to use the disaster management experts and in some cases may not be aware of the support available from this central capacity. Also, while a country office may have top experts in various sectors, they may not be experienced in operating in a post-disaster context, which implies time pressures, a greater need to coordinate with a large number of stakeholders, and specific tools and methods for gathering and sharing the data necessary for an effective response. If the country office does not utilize the central disaster management capacity available to it, the country team and hence, the assistance program are not informed by global experience and run the risk of “reinventing the wheel” or repeating mistakes committed in the past.

al., 2001). A situation of concern was highlighted in the conclusions of a study of network coordination during the response to the flooding in Mozambique in 2000 wherein Moore et al. (2003) indicated that local NGOs, with ties to the local community, tended to function outside the central network of responders that included large, international NGOs. This study suggested that the influence of the international NGOs could function to foster undesired dependence of the local community on external assistance, instead of fostering self-reliance for communities to develop their own capacities to respond to future disasters. The international NGO role thus requires sensitive local management.

Working across sectors (water, food and nutrition, shelter, social services, protection, etc.) is a challenge for many large aid organizations, especially those that are structured vertically rather than horizontally. Cross-sector work requires taking a holistic view of development and making the linkages between a number of sectors or disciplines. Perhaps nowhere is this truer than in emergency response, which includes both disaster management and humanitarian assistance. Preparing for and responding to emergencies both require advanced planning on the part of aid agencies, governments, and local communities. Planning requires securing procedures, infrastructure, and agreements prior to a disaster event. The formalization of such institutional arrangements does enhance the financial and organizational capacity for effective response and recovery. Yet, oftentimes such institutional partnerships are lacking. In place of these partnerships is a set of informal, interpersonal relationships between key individuals within organizations who have worked with other key individuals in different organizations on prior projects. This informal network model transcends restrictive institutional boundaries and enables those closest to the scene to get the work done, rather than trying to work within the bounds of the formal institutional plans. While similar to the ad hoc response noted earlier, this adaptive or flexible operational environment has seen some success in disaster response (Stephenson and Schnitzer, 2006) although it does not necessarily reflect political will on the part of national-level actors.

Empowering National Statistical Offices

Although the past few years have clearly indicated the limitations of GIS in humanitarian crises, dedicated financial resources for the development of GIS databases would help ensure the timely delivery of spatially referenced population data in an emergency (Kaiser et al., 2003). This requires funding a permanent year-round or decade-round staff with dedicated field crews for updating spatial boundary files, and staffing GIS units within each agency not only with traditional cartographers but also with dedicated geographic analysts skilled in computer mapping, spatial analysis, and database operations. These staff members would also need computers, other hardware such as scanners and plotters, and GPS units, which implies financial support from bilateral donors and international aid organizations.

Involving other national stakeholders and potential data users within a given country, ostensibly through an individual country's national spatial data infrastructure (NSDI) effort, would help as well. An NSDI effort is marked by cooperation among national data-producing agencies, including the national mapping agency, which are empowered administratively to create and share boundary information and sometimes have geodetically corrected files that can be shared freely or for a small fee. When available, the sharing of data often does not occur because of competing bureaucratic jurisdictions or lack of recognition by the leaders of a given country. Lacking a sufficient level of support from national leaders, national statistical agencies often need either to recycle outdated maps from the previous census or to go about remapping the entire country on a tight schedule—neither of which is an acceptable option from the standpoint of accurate and up-to-date information. Far better would be the creation of a continuously maintained georeferenced database of administrative boundaries, point and line features, and locations of housing units and other structures. The use of innovative techniques (see Chapter 2) in an operational environment would help address some of the pressing needs for spatial population data (see Box 4.2), but undertaking this effort would require political will on the part of decision makers in the country and some reallocation of resources.

Elevating the NSOs to effective partners of first responders in national emergencies will require commitment, training, and reallocation of resources for this new role. The United Nations, disaster agencies, and the U.S. Census Bureau should convene a meeting of NSOs around the world to explore what this new responsibility will entail, what new training will be required to fulfill the new responsibilities, and how it could be implemented efficiently. NSOs should be encouraged to share local data with international humanitarian agencies and bilateral actors participating in the response (e.g., the U.S. Census Bureau) or with other organizations that then would share responsibility for getting the data into the field as rapidly as possible after a disaster and updating the data as the disaster and its aftermath unfold.

THE ETHOS AND CULTURE OF THE OPERATIONAL RESPONSE ENVIRONMENT

Political Challenges

The period immediately following a disaster event, particularly a sudden-onset disaster, can be extremely chaotic, with the many different

BOX 4.2
Spatially Enabled Demography: How We Will Estimate Populations at Risk in the Future

To move forward training of the NSO staff in projecting local area census data and in digitizing the census will be needed. The largest training of NSO staff takes place at the International Programs Center (IPC) of the U.S. Census Bureau, paid for by USAID, Drylands Development Center (formerly UNDP Office to Combat Desertification and Drought [UNSO]), and other groups including national governments. This training should include both estimation and projection methodology in local areas and digitization of local maps and data. Institutions that want data available immediately after a disaster should be willing to pay for the training and data updating before the disaster since IPC operates on a strictly cost-reimbursable basis. Box 4.3 provides an overview of the structure and operations of the U.S. Census Bureau with particular focus on international operations in the context of population data acquisition, management, and training.

Using hybrid analog-digital techniques would enable census practitioners to focus energies on high-priority areas such as fast-growing urban perimeters and transient populations. Mosaics of medium- and high-resolution satellite imagery could quickly and accurately locate 95 percent of the population, leaving to field crews the task of focusing on the remainder, as well as detection of errors in the field. A study conducted by UN-Habitat (Turkstra, 2006) in Hargeisa, Somaliland, explored the technical issues surrounding the use of high-resolution imagery to create a building database for tax purposes. The authors concluded that the technique represents a cost-effective and fast procedure to respond to urgent data needs in cities in developing countries and in post-conflict and disaster zones. However, decision makers need to be brought on board to endorse the efforts.

types of actors responding to the emergency. UN agencies, humanitarian organizations (including the IFRC, large international NGOs, local groups), the military, census providers, and private-sector organizations, all have different mandates and organizational cultures, which can make sharing information difficult. Each of these organizations may have its own internal challenges to overcome in gathering and sharing data. The taxing nature of the situation is compounded further by the tensions, insecurities, and lack of mechanisms for organizations to share information with each other to produce the most accurate picture of the situation on the ground. Having said this, it is important to note that some humanitarian actors have coordination responsibilities (e.g., the UN Office for the Coordination of Humanitarian Affairs [OCHA] for complex emergencies, UNHCR for refugee crises). Such coordination mandates should also officially include the coordination of georeferenced population data.

A major impediment is the time pressure faced by all actors—response agencies and governments alike—to produce assessment reports and relief or recovery plans based on very little information. Typically in developing

BOX 4.3
The U.S. Census Bureau: Mission, History, and Innovations; International Subnational Population Estimation

The U.S. Census Bureau (*http://www.census.gov*) is the authoritative source of information on the population and economy of the United States. Part of the Commerce Department, the Census Bureau is tasked with conducting decennial population and housing censuses in years divisible by 10, and with fielding, analyzing, and disseminating results from numerous surveys and censuses on population, economy, and many other topics.

Existing as a stand-alone agency for more than 100 years, the Census Bureau has a long history of scientific innovations, including:

- The first data-processing machines, used for the 1890 census;
- The first civilian computer, the UNIVAC in 1950;
- One of the first automated mapping programs, GBF-DIME (Geographic Base File-Dual Independent Map Encoding), later TIGER (Topologically Integrated Geographic Encoding and Referencing), used from 1970 on; and
- The Internet-based data dissemination system, American Factfinder, deployed to display results in tabular and map form from Census 2000.

The Census Bureau maps the territory and possessions of the United States in detail and makes its geographic products available to Congress, state legislatures (for redistricting), and the public. Its TIGER system was the progenitor of today's Internet mapping sites such as MapQuest.

The Census Bureau is also charged with providing data and analysis on countries worldwide. Existing under various names since the aftermath of World War II, the International Programs Center (IPC)—now part of the Census Bureau's Population Division—studies foreign country populations and provides training and technical assistance to statisticians and demographers worldwide.

The international technical assistance function is enshrined in the U.S. Census Bureau's Mission Statement:

> *The Census Bureau serves as the leading source of quality data about the nation's people and economy. We honor privacy, protect confidentiality, share our expertise globally, and conduct our work openly. We are guided on this mission by our strong and capable workforce, our readiness to innovate, and our abiding commitment to our customers.*

In contrast to the domestic operations of the Census Bureau, the international programs in its Population Division are mainly externally funded by agencies such as USAID, U.S. military and intelligence agencies, and international organizations such as the United Nations. Staffed by statisticians, demographers, geographers, software programmers, and training specialists, international programs have catered to the training and technical assistance needs of more than 100 countries. Trainers and technical advisers have assisted thousands of national statistical organization professionals in survey methodology, sample and questionnaire design, census planning and publicity, cartography and GIS, and data collection, processing, analysis, and dissemination.

International population estimation at the national level is conducted using published demographic data from NSOs worldwide and a variety of techniques including cohort-component and extrapolative methods. Such estimates and projections normally factor in changing birth, death, and migration rates and may be adjusted, for example, in countries with high HIV prevalence. National estimates and projections are disseminated through the International Database (*http://www.census.gov/ipc/www/idbnew.html*).

The collection of data maintained by the IPC tends to be coarser than the Census block data in the U.S. domestic collection. Another contrast with the domestic U.S. Census data is that the subnational data in the international collection are not disseminated. To acquire more finely resolved subnational population estimates, the Census Bureau assists Oak Ridge National Laboratory's LandScan Global by supplying coarse population estimates for its ambient population data. More recently, new data sources including nighttime lights and high-resolution satellite imagery have been used with experimental methodology in a few test cases. The U.S. Census Bureau has collaborated with the U.S. Office of Foreign Disaster Assistance (part of USAID), the U.S. Department of State, and the National Geospatial-Intelligence Agency to improve the accuracy and precision of populated place points and polygons to assist with the delivery of humanitarian relief supplies and in force protection.

countries, poor baseline data are common at the outset and census data may also be poor or outdated (see Chapter 2). What few data are available may have been destroyed by disaster or conflict. Numerous examples of the unreliable nature of data are provided in the literature and in post-disaster agency reviews (Guha-Sapir et al., 2005; Van Rooyen et al., 2001; UNHCR, 1998). Although it is not easy to distinguish intentional overestimation of need from well-intentioned precautionary judgment based on limited data, these studies also emphasize that accurate data collection does not necessarily require more time and resources than the time and resource investment that can be saved by effective distribution of appropriate levels of aid to populations in need.

Despite the difficulties that organizations experience in obtaining access to accurate data, agencies and governments are under great pressure to produce needs assessments and reports based on scarce, perhaps unreliable data. In addition to the very real need for getting help to affected people to mitigate the impacts of a disaster, governments and the international community also have a political need to be perceived as responding quickly and generously. Governments and aid agencies should respond quickly with figures of damages and needs in order to capitalize on the fleeting global attention that a major disaster brings and raise as much support as possible for relief and long-term recovery. For example, following the Indian Ocean tsunami, the government of Indonesia requested assistance from the World Bank to lead a damage and needs assessment mission of the affected areas of Aceh province in preparation for a donor meeting in mid-January 2005, four weeks after the event. The meeting of donors had been planned around other development issues prior to the tsunami, and the Indonesian government justifiably wanted to take advantage of this consultative opportunity to appeal for international assistance to support long-term reconstruction and recovery. However, this required undertaking a damage and needs assessment for reconstruction at a time when critical relief operations were getting under way to save lives and many communities still could not be reached due to destroyed transportation infrastructure. The existence of solid baseline data and satellite imagery to define the impact zone was critical to getting a preliminary assessment of the reconstruction needs. However, while Indonesia had complete digital maps at the lowest administrative level (Desa), inconsistent coding schemes made it difficult to link the digital maps with population census data, delaying the process of producing usable information by critical days and weeks.

Producing credible data is critical to advocating for and mobilizing international support for relief and reconstruction. While it is tempting to exaggerate figures to gain attention and garner a greater amount of support, unsubstantiated or exaggerated numbers can be discredited while accurate numbers can increase donor confidence in the missions of the organizations they support (Guha-Sapir et al., 2005; Van Rooyen et al., 2001; I. Bray, personal communication, January 2007). A study of recovery efforts following the 2000 floods in Mozambique attributed to the credibility of the damage and needs assessment document the 100 percent response rate of donors to the government's appeal for $160 million in emergency assistance (Wiles et al., 2005).

There is also the issue of updating damage and needs assessments to capture the changing situation as more data become available. Unfortunately, damage and needs assessments are typically undertaken as "one-time" exercises that are not updated. It would be beneficial to establish mechanisms for periodic updating of assessments to ensure a better understanding of shifting needs and allow for adjustments in programming for more appropriate support.

Increased attention to monitoring needs would also allow for more meaningful consultation with affected communities to ensure that recovery programs truly reflect their needs and priorities. It is a challenge to balance the need for getting recovery programs up and running quickly against taking the necessary time to engage affected communities in the process of assessing damage and needs and designing recovery programs. However, not taking the time to engage communities in a meaningful way can result in inappropriate and wasted efforts. For example, following the December 2004 tsunami in Aceh there was a major effort to replace lost fishing boats. A report on progress one year after the event found that while most of the need was met in terms of numbers, many boats were unsuitable in size, design, and durability. In many cases, fishermen were not consulted first, and those that were, sometimes ignored (UN, 2005). Initial damage and needs assessments, therefore, should serve as a baseline in the ongoing process of monitoring and implementation that allows for participatory planning.

In addition to the desire to increase visibility and raise as many resources as possible to assist affected communities, post-disaster and post-conflict situations engender a competitive environment in which all relief entities, including NGOs, governments, and international organizations maneuver for relief areas, opportunities, and resources. In a climate where the first responders to the scene of the disaster may attract media attention and potentially draw in new donors (Stephenson, 2005), a competitive environment may ensue among response entities and create an atmosphere of secrecy, in which players are less likely to share information, data, and resources.

Issues related to an agency's protection of the relief area selected for concentrated attention and of the resource base are in no way limited to times of crisis. In a world of shrinking aid budgets, agencies are forced to compete for donor support, which further fuels the competitive atmosphere and does a disservice to the vulnerable populations they serve.

As the lack of willingness or ability of agencies to share data is overcome, there is also a need to improve the mechanisms for sharing data. Tools such as GPS, common formats for compiling data (e.g., the Research and Information System for Earthquakes-Pakistan; see *http://www.risepak.com*) and the aforementioned Humanitarian Data Model (Chapter 2) would go a long way toward equipping responders with critical information. This would help to avoid the common occurrence of communities being assessed time and time again, often without knowing why they are being assessed and what they can expect as a result in terms of aid. Government officials are also overburdened in the post-disaster phase with a steady stream of agencies demanding information on affected areas.

The Role of the Military in Disaster Response

The military has traditionally performed a vital role in disaster response, supplying the logistics and planning capacity to deal with large-scale crises both inside and outside the United States. This function shows signs of growing in the coming years (Mannion, 2006). Internationally, the Office of Foreign Disaster Assistance (OFDA) in USAID routinely works with military partners to ensure the delivery of supplies and information. The OFDA also houses experts from specific areas seconded from other offices. Different operations within government, both civilian and military, require the same kinds of information.

For large-scale mapping of population distribution worldwide, the U.S. Census Bureau contracted with the military for the purposes of logistical planning and ensuring compliance with Geneva Conventions regarding targeting civilian populations. The P-95 program began in the mid-1950s to delineate on a subnational scale the approximate locations of all population centers of 25,000 or greater. The rationale for the involvement of a civilian agency in this activity was that the U.S. Census Bureau housed demographic and geographic expertise not found elsewhere and provided the neutrality needed for detailed distribution of the population (U.S. Department of Defense, 1980). Such methodology, if updated and applied using new data sources, including remote sensing, GPS, and digital boundary and attribute data, could serve as a valuable resource for response efforts worldwide.

With increasing involvement of the military in civil affairs and disaster response in general, the firewall that has existed between civilian and military applications is eroding. This could potentially be a threat to the sense of trust that exists among statistical organizations, especially the bonds that have developed between the international training and technical assistance components of the U.S. Census Bureau and the countless NSOs that rely on assistance from the U.S. government. Involvement of the military and intelligence communities in demographic and geographic analysis has a long tradition; however, the relationship has maintained safeguards to ensure that sensitive or confidential information from censuses and surveys does not pass outside the civilian organization. It is essential that this firewall continue if the sense of trust among statistical organizations is to be maintained.

SUMMARY

A number of conclusions can be drawn from this chapter. First, data needs, operational plans, and response coordination are different depending on the phase of the disaster. In particular, information to enhance preparedness has often been neglected. Second, in general, while institutional actors compete for resources, coordination mechanisms exist and should be respected and enhanced. Third, no single coordinating entity exists in practice. As a consequence, a cacophony of voices and approaches can occur in the disaster response and can lead to a gap between the response and recovery phases of a humanitarian aid operation. Finally, much more could be done to integrate NSOs in all phases of preparedness and response.

Overall the problem can be distilled to a lack of leadership and a lack of awareness that information ought to be shared.

Every community needs accurate, place-specific population and population attribute data for improved disaster planning and response. The most critical data are total population and age-specific counts at the finest geographic scale possible. The level of geography (spatial resolution) is essential as well. While it may be impractical to get individual household data, aggregate counts by census tract or small enumeration area are key to effective disaster management. Equally important is the ability to aggregate these enumeration units into other geographies or spatial units, such as physical zones (e.g., coastal areas, steep slopes, floodplains) or social zones (e.g., urban areas). The enumeration unit must be georeferenced and provided in digital (polygon) form with hard-copy maps available for field responders. The georeferenced total population and age- and gender-specific counts are the minimum data sets required for disaster response. Population attribute data such as race or ethnicity, religion, socioeconomic status, and education are important as well and will improve the effectiveness of the response. It goes without saying that all data should be as accurate as possible and consistent with standard estimation methods and their statistical confidence.

Although the use of geographic information systems in humanitarian crises is still in its infancy, cases in which it has been used clearly demonstrate its benefits. NSOs need to commit financial resources to the development of GIS databases to ensure the timely delivery of spatially referenced population data in an emergency. This requires funding a permanent staff with field updating and spatial analysis capabilities, along with the necessary hardware and software, using resources from bilateral donors and the United Nations.

National stakeholders and potential data users within each country should be involved in national spatial data infrastructure efforts, in order to create and share boundary and attribute information. Creating a continuously maintained georeferenced database of administrative boundaries, point and line features, and locations of housing units and other structures would assist in humanitarian response efforts, but undertaking this will require political will on the part of decision makers in the country and reallocation of resources as well.

In its responses to humanitarian disasters worldwide, the U.S. government must command the efforts of many bureaus and agencies with different areas of expertise. However, for both population data and analysis, no single resource exists upon which the response community can rely for estimating populations at risk and populations affected by disasters. The U.S. Census Bureau has the international demographic and geographic expertise to be the collaborator of first resort at the time of disaster. To perform this function, however, it needs adequate resources to permit it to organize itself bilaterally with other country governments and with the United Nations and humanitarian NGOs to develop capacity to estimate populations at risk.

RECOMMENDATIONS

Based on the preceding discussion, the committee makes the following recommendations:

- **National and international disaster response and humanitarian agencies and organizations should elevate the importance of demographic and specifically spatial demographic training for staff members. Further, census staff and others working in NSOs throughout the world should be encouraged to undertake such training in order to promote the analysis and use of subnational data before, during, and after emergency response situations. [Report Recommendation 3]**

- **Relief agencies should broaden their collaborative relationships with NSOs to ensure the acquisition of real- and near-real-time data that complement and are compatible with existing data used for disaster response. [Report Recommendation 7]**

- **The U.S. Census Bureau should be given greater responsibility for understanding populations at risk and should be funded to do so. These responsibilities could include greater capacity and authority for training international demographic professionals in the tools and methods described in this report, and providing data and analytical capabilities to support the U.S. government in international disaster response and humanitarian assistance activities. The U.S. Census Bureau should also have an active research program in using and developing these tools and methods, including remotely sensed imagery and field surveys. Existing research support models that involve government-academic-private consortia could be explored to develop a framework for the U.S. Census Bureau to adopt these added responsibilities. [Report Recommendation 10]**

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5

Population Data and Crisis Response in Mali, Mozambique, and Haiti

In this chapter the committee examines three countries to assess how population data and tools were used by governments and agencies to provide humanitarian assistance following different types of natural and human-induced disasters. The selection by several of the study sponsors of these three countries—Mali, Mozambique, and Haiti—was based, in large part, upon the range of assistance resources directed to those countries in accordance with key U.S. government policy initiatives (for example, Millenium Challenge Account and the President's Emergency Plan for AIDS Relief) and other priority lists. The country examples compare and contrast data use in disaster preparedness and response between nations with relatively good, georeferenced population data disaggregated to the level of villages (Mali and Mozambique) and one nation (Haiti) with outdated national population records at the time of the disasters.

The comparisons illustrate that good, georeferenced population data exist, as indicated in Chapter 2, but that the presence of good population data sets and the tools and skills to use them does not in itself guarantee effective within-country or international aid response to a subnational population affected by a disaster (see also Chapters 3 and 4). The country examples show that adequate response to assist populations at risk depends not only on access to high-quality population data, but also on general disaster preparedness, adequate infrastructure, and communications and coordination within the country and between government(s) and aid agencies (see also Chapter 4; Doocy, 2007, and Landau, 2007; see also Appendix E). This analysis leads to the chapter's main recommendations to integrate national statistical offices (NSOs) in disaster response coordination and to improve subnational vulnerability analyses.

For each country the committee has addressed the background to and nature of the disaster, the results of the disaster for the affected population, and the response to the crisis in terms of data and geospatial information used. A focus on these issues was deemed more important, in the committee's view, than an exhaustive historical overview of each country. The historical context, where relevant, has been developed from several general resources and the committee found United Nations reports, in particular, to be sufficient and thorough for this purpose. The committee would like to acknowledge the information sources it employed otherwise in this chapter, as we placed high value on gathering input from individuals in the national statistical or emergency management and development offices in each of these countries to accomplish the requested task. To this end, we contacted professionals from these countries with a set of questions regarding this study, together with invitations to our workshop. With direct and very valuable comment and participation received only from Mali, the committee supplemented its factual knowledge regarding population data and its use in emergency and development situations in Mozambique and Haiti by contacting other persons and organizations external to the national offices of these countries. These included humanitarian and development organizations of different sizes and purviews, as well as the U.S. Census Bureau which had established projects for several years in Mozambique. Personal interviews were also supported by information the committee acquired and determined applicable from disaster assessment reports issued during and after the countries' crises by various international agencies like the United Nations, Save the Children, and the World Health Organization.

COUNTRY EXAMPLES

Mali

Background and the Disasters

About two-thirds of Mali, north of 15 degrees north latitude, is covered by desert or semidesert of the Sahara and bordering short grasslands of the Sahel region (Figure 5.1). Northern Mali is inhabited principally by nomadic people of the Touareg and Arab-Berber (Moor) groups. The agricultural zone of the Niger River Basin in the south and east of the country is populated by at least six major ethnic groups including the Bambara, the Soninke, the Malinke, the Songhai, the Dogon, and the Voltaic peoples. The Human Development Index (HDI) of the United Nations Development Programme (UNDP, 2005a) places Mali among the poorest countries in

FIGURE 5.1 Map of Mali showing some of the primary geopolitical areas. The broad opaque band across the map represents the Sahel—the border region to the Sahara Desert in the north of Africa. SOURCE: Used with permission from *http://www.maps.com.*

the world in terms of combined factors of longevity, health, education, and living standards for the population. Approximately 64 percent of Mali's population lives below the country's poverty line (UNDP, 2005b). Much of Mali's population thus falls under the definition of "vulnerable" or at-risk as defined in Chapter 1. Two crises are discussed for Mali in this chapter: a locust infestation and a civil rebellion. These crises became humanitarian disasters affecting vulnerable groups of people and demonstrate how both natural and human-induced events exerted pressure on subnational populations in terms of food security, health, and economic stability. This discussion of Mali draws heavily from Konaté (2007; see also Appendix E), in a technical paper prepared specifically for the committee.

Locust Invasion of 2004. Beginning in June of 2004 during the agricultural season, the first swarms of desert locusts moved from the spring breeding grounds in Morocco and Algeria to the Sahel. Intensive control operations in Northwest Africa, mounted by the relatively resource-rich countries of Morocco, Algeria, Tunisia, and the Libyan Arab Jamahiriya, contained the locusts (FAO, 2004a). The situation was different in Sahelian West Africa when the swarms moved southward into Senegal, Mauritania, Mali, and Niger (FAO, 2004b). The Sahel is a poorer region with substantial subsistence agriculture and limited resources for locust control and surveillance. Under these conditions, Mali suffered its worst locust infestation in 15 years beginning in July 2004 (Konaté, 2007; see also Appendix E). The destruction in the agricultural belt of Mali was not complete; however, harvests and pasture were severely affected in several areas, and the situation was compounded by a drought triggered by an early end to the rainy season. In all, two-thirds of the country was affected by the locust invasion. The area struck most severely by the locust hazard lies between 14 and 21 degrees north, and includes the regions of Timbuktu (Timbouctou), Mopti, Gao, and Kayes (Figure 5.1). The majority of the population in these regions of Mali was vulnerable to the locust infestation, and a food security crisis ensued in Mali and other West African countries (UNCAP, 2005).

According to the coordinator of the Unit for Migratory Locust Control (ULCP) and the African Project for Emergency Control of Migratory Locusts (PALUCP), “As technicians we expected this, because in 2003 we saw a build-up (of locusts) in the region. We treated almost 40,000 hectares in Mali. . . . From the month of February (2004) the FAO [Food and Agriculture Organization] launched an appeal to the international community announcing that as soon as rains arrived in the Sahel there would be locusts. By the month of March, we had drawn up an action plan that we presented to the Ministry of Agriculture and all the other Ministries involved, as well as to the development partners. Unfortunately there was no reaction. We then presented this plan more than ten times before the month of July. There was no response. It was from July that we began to have the first swarms, and people, or at least the authorities, began to move. First an operational headquarters was set up . . . From the month of August . . . It was from September that we began to receive responses from partners” (Konaté, 2007; see also Appendix E).

A small part of a locust swarm can consume the acreage of cropland needed to provide food for 2,500 people. The 2004 invasion affected both crops and pastureland. Approximately 88 percent of Mali’s poor live in rural areas. Approximately 1.7 million farmers (UNCAP, 2005) were affected, and a nutritional survey conducted in the affected areas by the Malian government and the UN World Food Programme (WFP) indicated acute malnutrition rates up to 16 percent in Gao and Kayes. The worst-hit provinces were Gao (Bourem) on the Niger River, Kidal in the remote Adrar des Iforras hills of the northeast, and in the regions of Kayes (Nioro) and Koulikoro (Nara) (WFP, 2005) (Figure 5.1). In addition to the food crisis due to crop destruction by locusts, the added effects of the drought led to an unseasonal population movement: nomadic herders migrated earlier and to different locations than usual in an effort to find water and food for their livestock. In some cases, the herders were in direct competition with sedentary, subsistence farmers for the same scarce resources, thus exacerbating the crisis situation (UNCAP, 2005).

Touareg Rebellion. Between June 1990 and March 1996, Mali experienced a civil war in the north known as the Touareg rebellion (Konaté, 2007; see also Appendix E). This rebellion, which took place directly after the 1987-1989 locust infestation, resulted from years of dissatisfaction of the people of northern Mali with what they interpreted as uneven distribution of national wealth and services and political marginalization (UNHCR, 1998). The Touareg people initiated the revolt in 1990 and were joined by Arab-Berbers.

From 1991 to 1995, negotiations between the Malian government and the insurgents, with mediation by international groups and local elders from various ethnic communities, facilitated several efforts to obtain peaceful settlement to the conflict. However, the various components of the primary peace agreement established in 1991 proved difficult to implement, and insurgent activities were renewed periodically during the succeeding four years throughout much of the northern territory of Mali (the Azaouad). By mid-1995, security conditions in northern Mali had finally improved through negotiation mediated by cooperative efforts between the international community and local elders. The militias agreed to lay down all arms in April 1996 at a symbolic container, the "Flame of Peace," constructed in the middle of Timbuktu under the aegis of the United Nations (UNHCR, 1998).

In addition to the injury and death of combatants and civilians and the disruption of daily activities and services associated with the armed civil action, the rebellion caused displacement of 150,000 refugees into neighboring countries of Niger, Algeria, Burkina Faso, and Mauritania (UNHCR, 1998) (Figure 5.1). The population crisis that resulted from this conflict thus involved (1) repatriation of refugees who were returning to their homeland when peace was restored, and (2) assistance to the local populations who remained in northern Mali and faced shortages of food and water and disrupted access to basic services after six years of civil strife.

Data Used in Response to the Crises. Population data have been collected in Mali during the past several decades (Konaté, 2007; see also Appendix E), and some of these data are digitally georeferenced to the village level. Existing population data in Mali at the time of the 2004 locust invasion included two National Censuses of Population and Habitat (1976, 1998); three Demographic and Health Surveys (1987, 1995-1996, 2001); budget and consumption surveys (1987, 1989); a national household activity survey (1989); and various agricultural surveys. During the 1990-1996 civil conflict, some of these same data also would have been available, with the exception of the most recent national census (1998) and Demographic and Health Survey. Other international and national institutions based in Mali also have produced information on population and related samples of different sizes. Among the international institutions involved in these activities are the Famine Early Warning System Network (FEWS NET), the African Sub-Saharan Economic and Statistical Observatory (AFRISTAT), and the Sahel Institute (Konaté, 2007; see also Appendix E).

Although not the "gold standard" described in Chapter 2, Mali had, at the time of these crises, some population, demographic, and geospatial data to use in prevention and relief efforts, although the census in Mali does not include questions on ethnicity, a practice continued since the period of French colonial rule (Konaté, 2006). The committee was unable to obtain specific information on the accessibility of the existing population data to outside agencies either before, during, or after the crises, or the degree to which these data were employed and disseminated by the government prior to and during the crises. The fact that the locust invasion and ensuing food crisis occurred at all, despite early warning and calls to the international community to react, indicates an ineffective response that either did not employ the population and demographic data or did not employ it early enough to alleviate the food security crisis that ensued (UNCAP, 2005). Box 5.1 gives examples of the manner in which population data in Mali can be used in the future to prepare for and respond to the danger of locust invasions.

The committee did not locate published analyses of the use (or lack of use) of previously existing population data in connection with the Touareg rebellion; such data could have been employed for purposes of relief and repatriation of refugees displaced to neighboring countries during the con-

BOX 5.1
Applications of Population and Demographic Data in Preparedness and Response to Threat of Locusts

- To coordinate local communities prevention, surveillance, and control measures, mitigating the need to respond to a food security crisis and reducing expenses of air support to conduct intensive crop protection spraying and surveillance activities
- To plan food stores (to mitigate effects of future locust invasions) and to distribute more and specialized crop seeds (for planting during curtailed growing seasons)
- To identify those areas and people who are most vulnerable to the threat of an agricultural crisis and the potential damage from a locust invasion
- To coordinate food relief when a crisis ensues

flict, although as noted above, existing national census data were 20 years old at the time of the repatriation and likely of limited use unless they had been supplemented in the intervening years by additional surveys (household, health, or other surveys as described in Chapter 2). Although not a substitute for national census data, the baseline from which aid and development responses can be centrally coordinated, systematic collection by relief organizations of the vital characteristics of displaced and affected persons through local surveys in refugee camps provided information essential for relief and repatriation efforts during and after the conflict. The UNHCR (1998) report provided specific evaluation of the collection and use of refugee population data by UNHCR and the WFP in 1995-1998 related to these repatriation and relief efforts. The experience gained in collecting and using these data is illustrative of the network of factors involved in estimating and putting to use subnational population data collected during and immediately following a disaster, and is explored briefly here.

The refugee and repatriation situation was one focused upon distributing food aid, ensuring access to clean water, and facilitating cross-border registration and peaceful transfer of refugees back to Mali. These activities were part of an international effort with challenges that included regional coordination of relief efforts between Mali, the four countries hosting the refugees (Niger, Mauritania, Burkina Faso, and Algeria), and international aid agencies, primarily UNHCR and the WFP (UNHCR, 1998).

Central to the relief efforts was identification of the numbers of refugees in various camps within the countries of asylum. Censuses within the camps were conducted, but only the camp census conducted in Mauritania produced reliable figures. A former government in Mauritania had apparently produced some refugee numbers early in the crisis, but a review by UNHCR officials of these numbers by observation of aerial surveys, clinic and school attendance, and number of inhabited dwellings indicated that this initial number of refugees, 85,000, appeared to be inflated. A new census of refugees conducted through coordination between the government of Mauritania, the UNHCR, the WFP, and other donor partners revised that original number by half. These data allowed accurate amounts of food, clothing and transportation to be provided to these people and facilitated border crossings and resettlement of the people back into Mali. Unreliable census figures for refugees in the other asylum countries were attributed to varying government policies in countries and lack of sufficient international (UNHCR) staff in the field. Dispersal of refugees in isolated centers would not have been a significant factor contributing to these inaccurate counts had sufficient staff with appropriate government support been engaged in the census-taking processes in these countries. The relative accuracy of the refugee census in Mauritania greatly facilitated effective refugee repatriation from this country compared to repatriation from the other asylum countries (UNHCR, 1998).

Mozambique

Background and the Disaster

Flooding, especially due to cyclones, is a perennial problem in Mozambique (Figure 5.2). In February-March of 2000, severe flooding affected 4.5 million people representing nearly 25 percent of the country's population. Due to this event, 700 fatalities were recorded and more than 650,000 people were displaced. In the ensuing several years, flooding again caused displacement of 220,000 people in the same central provinces (in 2001), while in 2003 flooding affected 100,000 people in the northern provinces (Gall, 2004). In addition to immediate food crises for hundreds of thousands of people displaced from their homes, the floodwaters and lack of sanitation increased risk of waterborne diseases, and flooding raised the risk of longer-term food security issues as livestock died and cropland and seeds

FIGURE 5.2 Map of Mozambique. SOURCE: Used with permission from *http://www.maps.com*.

were destroyed. Shelter and clothing, and a basic transportation infrastructure, essential to the distribution of assistance, were also lacking.

As is the case with Mali, information from the HDI of the UNDP places Mozambique among the poorest nations of the world (UNDP, 2005c). The floods should be set in the context of the significant impact of the war for independence (1962-1974) and the civil war (1976-1992) in Mozambique, coupled with several years of drought that produced a devastated economy, a crippled infrastructure, and millions of refugees and internally displaced persons (IDPs) (*http://www.state.gov/r/pa/ei/bgn/7035.htm*). Although by 1996, the government had begun to register real annual economic growth (UNGA, 2002), Mozambique did not have the resources to respond adequately to and recover from disasters of these scales in the absence of humanitarian and development assistance. In 2000, the year of the most extensive flooding, external assistance accounted for 23 percent of the country's gross domestic product (GDP; UNDP, 2002). The repetition of these floods—categorized as sudden-onset disasters—in consecutive years increased the vulnerability of the populations because the recovery and development period between flooding events was very short.

Data Used in Response to the Crisis

At the time of the first flooding in 2000, Mozambique had conducted (1997) and published a national population census (INE, 1999) and a Demographic and Health Survey (MDHS, 1998). The INE (Instituto Nacional Estatistico) data were used during the crisis, primarily by the National Institute for Disaster Management (INGC) of Mozambique, an institution established in 1999 under the Ministry of Foreign Affairs and Cooperation to manage natural disasters and to serve as the central body with which international organizations (donors and aid agencies) would interact in a disaster response situation. The INGC had worked together with UNDP, the WFP, the International Federation of the Red Cross and Red Crescent Societies (IFRC), and domestic emergency teams in a simulated disaster exercise in 1999 (UNGA, 2002). However, at the onset of flooding in early 2000, the INGC was still completing its final structural arrangements, the protocol for the government and international organizations to follow during disaster response was not yet fully established (UNICEF, 2000), and the magnitude of the flooding was beyond what the disaster simulations had attempted. The INGC, in conjunction with the Mozambique National Statistical Office, was nonetheless able to use and distribute the 1997 census data, in digital, georeferenced form and make them available to international aid organizations present in the country throughout the emergency response period. The accessibility of the georeferenced data was the end product of a development initiative for Mozambique carried out between

1997 and 1999 by the U.S. Census Bureau and the Mozambique NSO, and supported financially by the U.S. Agency for International Development (USAID; G. Ferri, personal communication, January 2007).

The U.S. Census Bureau had been asked by USAID to conduct a technical assistance and capacity-building program with the Mozambique NSO associated with preparation, execution, and analysis of the Mozambique 1997 national census. An officer from the U.S. Census Bureau with expertise in census data processing, analysis, and dissemination was assigned to Mozambique in 1997-1999 as a local adviser for this purpose. The end product of this work in 1999 was a compact disc (CD) containing census microdata, some of which had been georeferenced, with summary tables and thematic mapping tools. The project was being completed at the time of the 2000 flood, and USAID recalled the U.S. Census Bureau officer to Mozambique to provide technical support to the Mozambique NSO during the flood relief period. The digital census data on CD were linked to geographic information systems (GIS) and new local population surveys conducted during and directly after the flood to produce updated population and demographic data in real time to relief agencies for use in aid acquisition and distribution. After that flood, the Mozambique NSO took full responsibility for the census data and its management (G. Ferri, personal communication, January 2007).

Direct uses of the 1997 census data are cited in numerous agency reports on the flooding crisis, for example: "The government has estimated that roughly two million people have been affected by flooding, including 650,000 IDPs. The 650,000 figure cited by most agencies is an estimate based upon census data conducted in 1997, combined with information on which areas were flooded. This figure is also used by WFP to calculate emergency food beneficiaries. Of those displaced, 463,000 were living in 121 accommodation centres and an unknown number were in isolated areas. According to government figures, an additional 300,000-400,000 people were seriously affected in their needs for medical and other non-food assistance. An additional 900,000 people were indirectly affected, according to the figures" (OFDA, 2000; *http://cidi.org/disaster/00a/0122.html*). The government in this case refers to the INGC.

A contingency plan for the 2001 flood was developed by the INGC and international organizations using experience and data gained from the 2000 flood; these contingency plans allowed the WFP, for example, to have pre-positioned food stores in place prior to the onset of the floods in 2001. The 2001 floods, however, brought slightly different challenges because of topographic and demographic differences among the flooded areas: the highly populated southern part of the country was affected in 2000, while the dispersed population in the center of the country, with correspondingly difficult access conditions, was most affected in 2001 (UNGA, 2002). One example of the visualization of the georeferenced population data during the 2001 flood is the thematic map shown in Figure 5.3. Other examples of these types of maps were also produced with various themes (e.g., rainfall, flood warnings, population) and show the flexibility of georeferenced population data applied to the disaster relief situation.

Population figures based on estimates from the 1997 census could be revised during both of the flooding crises as refugee shelters and centers for displaced persons were established. Field personnel provided estimates of numbers of people and demographic characteristics to coordinate distribution of aid and supplies. During the 2001 flood, the WFP hosted the mapping center where data on populations, floodwaters, shelters, and other factors were collected and updated.

Subsequent to the emergencies, resettlement programs were not entirely successful and the need for improvements in disaster assistance led to an assessment of shelter access and an analysis of the socioeconomic impacts of the 2000 floods. A rapid flood assessment and the development of a hazard mitigation strategy were conducted under an emergency aid agreement between Austria and Mozambique (Gall, 2004). Part of that emergency aid assistance involved a geospatial site suitability analysis of shelters based on remotely sensed data on land cover, population, and in situ measurements (global positioning system [GPS] measurements and interviews) (Gall, 2004). The study found that spatial analyses should be incorporated into the disaster management procedures of the INGC and development agencies alike. Furthermore, the research concluded that spatially referenced data sets were critical; that sharing of these among the stakeholders was essential; and that detailed, up-to-date, and complete georeferenced data were required for vulnerability assessments including the provision of health care and food aid at the subnational level (Arndt and Tarp, 2001; Gall, 2004). Further efforts to increase disaster preparedness through better analysis of population data after the floods also emerged through technical cooperation between USAID, INE, and the International Programs Center (IPC) of the U.S. Census Bureau in 2002-2003. A Census Bureau staff member with expertise in statistical data handling and population data was sent to Maputo at the request of USAID and INE to help develop estimation procedures for the 2002-2003 *Inquérito aos Agregados Familiares* (IAF, a national household income and expenditures survey) results from the first two quarters, to finalize the weighting procedures and standard errors for the IAF, and to review the sampling considerations for a follow-up annual poverty indicator survey (see *http://www.census.gov/ipc/www/imps/activ0303a.htm*). At present, the U.S. Census Bureau with support from USAID is also providing some technical assistance to the Mozambique NSO as it prepares to conduct the 2007 national census (G. Ferri, personal communication, January 2007).

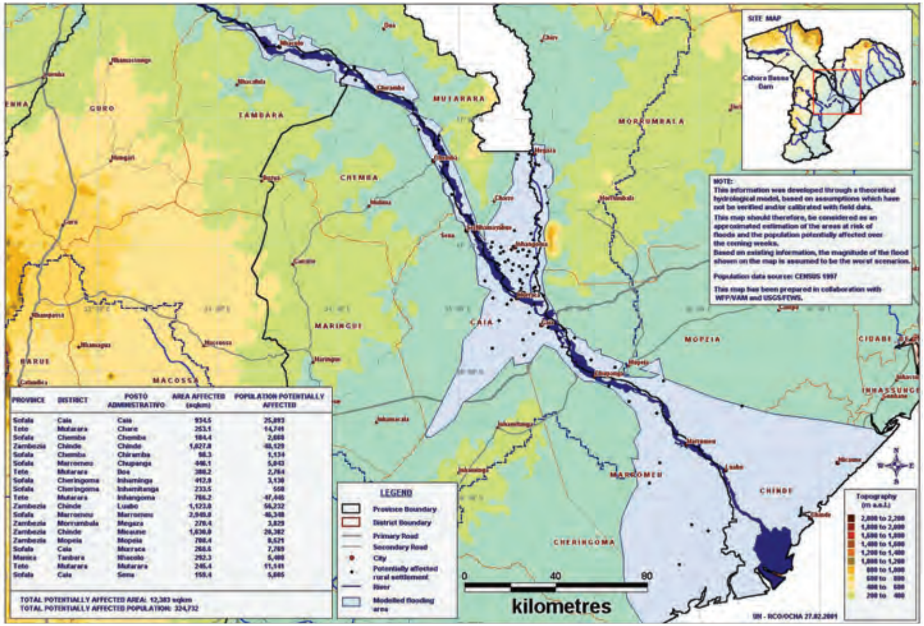

FIGURE 5.3 Map of flood-affected populations in Mozambique contains geographically referenced population data from the Mozambique census together with geographically referenced data including the location of the Zambezi River, shelters, cities, potentially affected settlements, primary and secondary roads, and modeled flood areas. Although hand-drawn maps like that shown in Chapter 3, Figure 3.5, are practical and accurate, digital maps that incorporate census data are most desirable because the digitally referenced data can be updated quickly and potentially distributed widely to responders and emergency managers, if the appropriate hardware and power or electrical requirements can be assured. SOURCE: UN Resident Coordinator/OCHA (*http://wwwnotes.reliefweb.int/w/map.nsf/wByCLatest/D6763F6AE583A41585256A010053D8A5?Opendocument/*).

Haiti

Background and the Disaster

Small island states are particularly vulnerable to natural and human-induced disasters, and research suggests that Haiti (Figure 5.4) is among the most vulnerable (Pelling and Uitto, 2001; see also Chapter 1). The states suffering the greatest number of serious disasters in the 1970s and 1980s were island states (13 out of 25), and the statistical vulnerability of island states to disasters has been known for 15 years (Briguglio, 1993). Analytically, Pelling and Uitto (2001) tied increased vulnerability to lack of integration with the world economy, local poverty, and the resilience of the local economy. Moreover, poverty always increases vulnerability to disaster—one of the principal and most robust findings of international disaster research. Haiti is the most disaster-prone island in the Greater Antilles—a group of islands that are, themselves, some of the most disaster-prone islands in the world (Pelling and Uitto, 2001). Haiti was near the bottom of the UNDP "Disaster Risk Index" (UNDP, 2004), with some of the worst health indicators and economic indicators in the western hemisphere (PAHO, 2001).

FIGURE 5.4 Map of Haiti. SOURCE: Used with permission from *http://www.maps.com*.

Haiti is located in a region that is particularly subject to tropical storms and hurricanes and to significant flooding from the rainfall that ensues from these storms and hurricanes because of two factors: (1) deforestation of slopes, which increases runoff, and (2) concentration of population along coastal areas and near rivers. Thus, the secondary effects of storms are intensified.

Tropical Storm Jeanne in 2004 did not meet the wind-speed criteria for designation as a hurricane, but the storm was slow moving and spawned extremely high rainfall as it began to affect the Haitian coast and then the highlands on May 23, 2004 (Regan, 2004). The winds from the tropical storm were not unusually damaging; however, the resulting flooding was destructive and killed more than 2,000 people, leaving several hundred thousand people displaced. Gonaives, the third most populous city, was most seriously affected (Farmer, 2005).

Much of the flooding was due to the fact that 98 percent of the land is deforested, as a result both of an attempt to cultivate one sector of an export economy and of the need for domestic timber. Deforestation of mountain and hill slopes increases both the magnitude and the velocity of runoff, thereby increasing its destructive power. Thus, land degradation and deforestation are specific contributors to Haiti's vulnerability and to the effects of severe storms such as Jeanne. While deaths were attributed to a variety of factors, a statistical basis for the link between deforestation, poverty, and enhanced population vulnerability after Tropical Storm Jeanne has been suggested by comparison between the 2,000 dead in Haiti, which has had extensive deforestation, and the 19 dead in the adjacent Dominican Republic, which has retained most of its forest cover (*http://news.bbc.co.uk/2/hi/americas/3685534.stm*).

Data and Organizational Structures Employed in the Crises

Until recently, population data for Haiti were absent or very difficult to access. This condition resulted from a combination of factors including lack of resources to conduct censuses or surveys (Figure 5.5) and government disarray following former president Duvalier's fall in the late 1980s. The year 2004 was particularly difficult for Haiti: the coup d'etat in early 2004 was followed by a May 2004 flood and accompanying mudslides that were responsible for more than 2,000 deaths in both Haiti and the Dominican Republic. This background is important in understanding the response to Tropical Storm Jeanne and the use of population data in the disaster relief and recovery period.

A national census was undertaken in Haiti in 2003 and was released on CD in May 2006, with a plan to make it available on the web, according to one UN official (H. Clavijo, personal correspondence, May 2006).

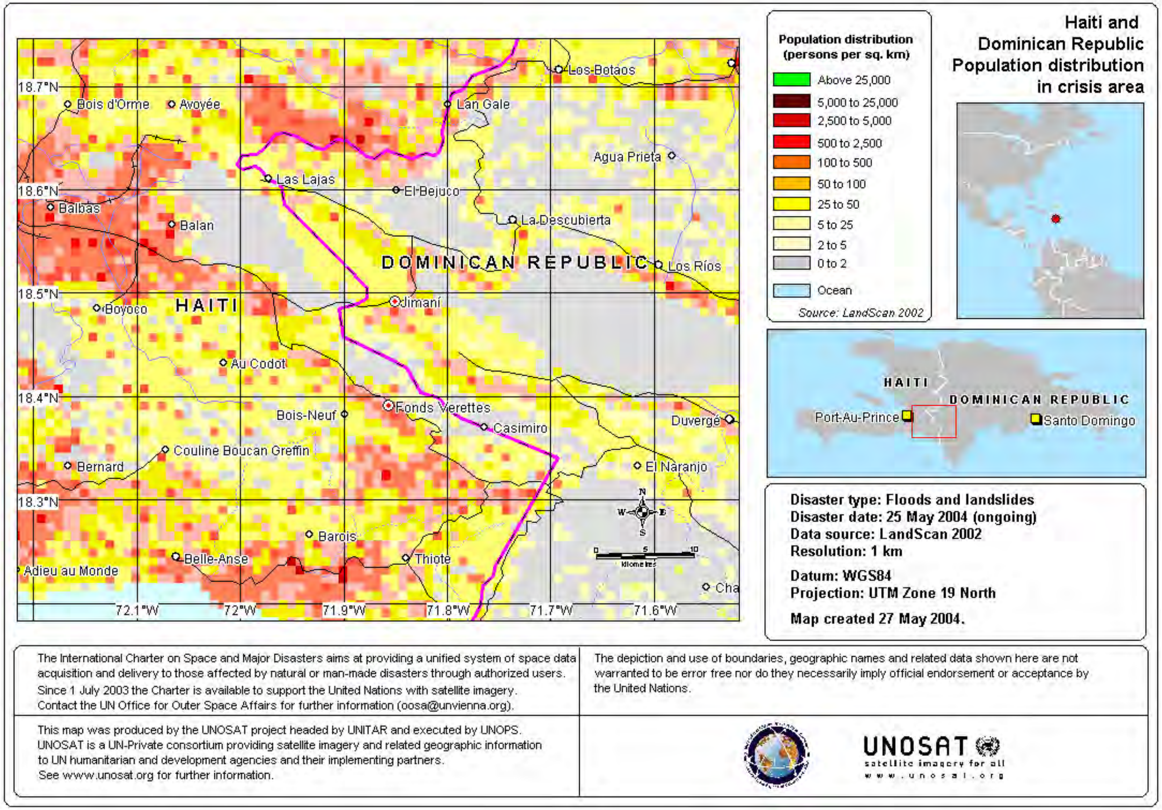

FIGURE 5.5 Estimated population distribution for Haiti and the Dominican Republic based on LandScan data. SOURCE: UNOSAT, LandScan 2002, Global Insight Plus / Europa Technologies Ltd.

However, at the time of Tropical Storm Jeanne the data were neither completely analyzed nor readily available for use by government or aid organizations. With the last census conducted in 1982, many relief organizations were thus dependent on population estimates available from public sources such as the United Nations (e.g., UN Population Information Network [POPIN], *http://www.escwa.org.lb/popin/index.asp*; the UN Population Fund [UNFPA], *http://www.unfpa.org/publications/index.cfm?filterPub_Type=5*; the UN Statistics Division, *http://unstats.un.org/unsd/cdb/cdb_help/cdb_quick_start.asp*); the World Health Organization (WHO, *http://www.who.int/whosis/en/*); and Save the Children (*http://www.savethechildren.org.uk/foodsecurity/publications/manual.htm*) or on data provided by local partners at shelters and health centers (I. Bray, personal communication, January 2007; D. Smith, personal communication, January 2007).

The Haitian population was highly vulnerable prior to the onset of Tropical Storm Jeanne, and its vulnerability was compounded by the political and natural events of a particularly turbulent year. Given the needs of the country in terms of basic health care facilities and programs, infrastructure, and education, the committee finds it difficult to determine whether or not full access to georeferenced population data from a national census would have significantly improved international, U.S. government, and local agencies' abilities to provide efficient relief aid to the affected populations. The response to Tropical Storm Jeanne was, in reality, a response to a population already in a vulnerable state from circumstances of the past year. However, the relief and development organizations involved in the response effort with which the committee spoke indicated that more and better demographic and epidemiological data, preferably georeferenced, would have enabled their activities to operate more efficiently for the affected population. Further correspondence with a UNDP official in Haiti revealed that population estimates after major disasters, such as after Tropical Storm Jeanne's impact on the Haitian city of Gonaives, have been highly inaccurate and have affected the efficiency of subsequent interventions (E. Ergin, personal correspondence, 2006).

STRENGTHS AND LIMITATIONS OF POPULATION DATA EMPLOYED IN DISASTER RELIEF AND DEVELOPMENT

Digitally accessible, current, georeferenced national census data can play an important role as part of a disaster relief effort. The example from Mozambique demonstrated the strengths of access to georeferenced data linked to GIS, in a situation where the local government was empowered to make the data accessible and had the capacity in its own NSO to use and analyze the data. Although the aid response effort was not completely efficient and coordination between agencies, organizations, and the

Mozambique government could have been improved (Moore et al., 2003), the massive influx of international aid (more than 49 countries and 30 NGOs providing humanitarian assistance [Moore et al., 2003]) was distributed in a manner that assisted the people in need in a reasonable time period relative to the development of the disaster situation. The national data were available at a subnational level and, could be linked to thematic data including, for example, administrative boundaries, city and settlement locations, rivers and waterbodies, and flood levels and projections in GIS. Updates with new population surveys of displaced persons in various locations could thus be added in real time to these thematic maps. The national data, with additional information from the new surveys, were then incorporated into contingency plans by the INGC that were put into use when the next year's floods arrived. No relief or preparedness planning effort is based solely on the existence of national, georeferenced census data, but the committee's view is that the effective delivery of relief aid and preparation for subsequent flood events in Mozambique were enhanced by the existence of such data, and by the capacity of the local NSO in conjunction with the INGC and cooperating international agencies to administer them.

Systematic data collection through surveys during and immediately after natural or human-induced disasters provides a reliable source of information for planning relief response quantities, types, and targets, allows the cost and time effectiveness of the response effort to be evaluated, and can be used in planning and executing recovery and development programs (Guha-Sapir et al., 2005; Van Rooyen et al., 2001; NRC, 2001). Effective use of accurate survey data can also serve to raise donors' confidence regarding the manner in which their contributions are being used (I. Bray, personal communication, January 2007). These positive aspects of accurate survey data collection are particularly enhanced in the presence of current georeferenced census data.

The repatriation program for Malian refugees in the aftermath of the Touareg rebellion illustrates the benefits of good data collection and the limitations of inaccurate survey data collection in refugee camps. Inaccuracies in the initial refugee data were identified by UNHCR and the WFP using analysis of aerial photographs, attendance at schools and clinics, and observation of inhabited dwellings. Inaccuracies, in this case overestimation of the refugee population, are not uncommon (Guha-Sapir et al., 2005; Van Rooyen et al., 2001; NRC, 2001) and can serve to delay and inhibit an effective response—smooth repatriation, in the case of the Malian refugees. Resampling and resurveying the refugee group in the case of the Malian refugees in Mauritania proved to be a worthwhile exercise that enhanced the efficiency of the repatriation of those displaced persons; as Van Rooyen et al. (2001: p. 218) indicated, "It is an unfortunate myth that statistical analysis is too time consuming to perform during a humanitarian crisis. On the contrary, because of time constraints, lead agencies can't afford NOT to perform accurate and statistically sound assessments. Without doing so, organizations will risk misplacing much-needed assistance." The delays and obstacles to repatriation of refugees from the other asylum countries where refugee survey data remained inaccurate likely used more resources than were necessary. The UNHCR assessment of the situation indicated that placement of more trained personnel in the field in these other asylum countries could have solved this problem. A cost-benefit analysis of conducting accurate initial field demographic and epidemiological surveys in emergency situations gauged against time and resources lost when repatriation or relief efforts are executed ineffectively was beyond the committee's scope, but could be useful for decision makers in weighing their allocation of human and material resources in response to disaster situations. Forced migration of populations as a response to disasters remains a challenge for responders, with one of the most basic difficulties being to obtain accurate numbers and characteristics of the people who have moved from their normal residences (see also NRC, 2001). Improvements in combining field surveys with developing technologies, including remote imagery and GPS, could be more actively pursued in an effort to achieve more consistent, reliable data for these important groups of people.

Lack of data, or the existence of good data that are employed ineffectively, does not preclude disaster relief aid from reaching the populations in need but presents significant challenges to promoting timely, appropriate, and cost-effective relief response. While Mali and Mozambique both had georeferenced data, the response in Mali to the locust invasion was hampered by data quality (census data were old) and, importantly also, the speed with which the response to the crisis was effected. Warnings issued by the PALUCP and ULCP using the monitoring capabilities provided by early-warning networks, established through international development efforts, and appeals from the FAO for donor response issued long in advance of the locust invasion went unanswered by the international community. Early-warning systems designed specifically for this purpose had been employed correctly, but the necessary response to make the early warning systems useful did not arrive in a timely fashion. Population data quality or access in this situation was not the problem; when the data exist in a response vacuum, whatever the cause, they cannot be put to effective use.

In Haiti, relief and development organizations responded immediately to the disaster produced by Tropical Storm Jeanne, but they did not have access to accurate and recent national census data. Public sources for population figures and estimates, including those from the United Nations, WHO, Save the Children, demographic and health surveys, and databases such as Gridded Population of the World (GPW) or LandScan, are viable options in these situations, and many organizations rely upon them—

because they do not themselves collect demographic or health data or do not have the capacity to analyze and display raw data. In the case of Haiti, the preexisting vulnerability of the population required response not just to the effects of the tropical storm but to a debilitating year and decades of economic instability.

The committee suggests that resources necessary to collect national census data should not replace development programs that include education, basic health care, and food security, but that these activities should be combined with accurate information on the numbers, vital characteristics, and locations of the people that the programs intend to assist. National census data have a variety of uses outside of emergency situations, and the stabilization of Haiti's government may lead to the implementation of more accurate and regular census coverage that ideally will inform humanitarian responses to natural disasters and development programs designed to decrease the vulnerability of the population.

Accurate national population figures with demographic details are necessary for planning and executing an appropriate response for any emergency relief, recovery, or development activity. The locations of the populations affected by the disaster are also necessary to promote an effective response. National censuses are some of the basic data that may be available, but frequently subnational population counts are not part of these data sets, either because the national governments have not publicly released the data in a table as part of the statistical agency's data releases, or because the data are not readily accessible to relief agencies and donor organizations. When such data are not available, it is difficult or impossible to estimate mortality and morbidity in the days and weeks following a disaster.

CONCLUSIONS

The examples from these three country analyses reinforce some of the main issues brought forward in the preceding chapters of this report: (1) national census data, available digitally, in georeferenced form, and disaggregated to a subnational level, are of basic importance to efficient aid allocation in large, multi-organizational, international disaster response situations; (2) digitally available, georeferenced national census data are also useful for effective planning, execution, and completion of disaster preparedness and long-term development projects; (3) population survey data collected before, during, and after a disaster that have been accurately collected to include basic demographic and epidemiological information are not a substitute for national census data, but are needed for effective delivery of relief aid and post-disaster recovery activities, including repatriation; (4) availability of good data alone does not ensure efficient relief or development aid response because of the dependence of international, government, nongovernmental, and local organizations on efficient coordination and timely response to crises; (5) in lieu of either recent national census or local survey data, publicly available population data sets from international and private organizations, based on established population estimation methods or projections, can and ought to be employed in the distribution of aid. Lacking recent census information, these proxy data ought to be used with the understanding that they likely will not accurately represent the situation on the ground and will incorporate some inherent inefficiencies in delivery of relief or development aid.

While the extent or frequency of a disaster should not alter fundamental preparedness schemes to respond to humanitarian crises, clearly the more extensive a disaster, or the higher the frequency of crises in a given region, the more people are affected, and correspondingly, the challenge to humanitarian assistance becomes greater. The presence of population and corresponding demographic data is prerequisite to providing timely, appropriate, and cost-effective response. New, geospatially referenced survey data can be acquired during a crisis, but responders would benefit from the existence of geospatially referenced disaggregated national data prior to the crisis that could serve as a baseline for coordinating the response. Data can then be more accurately revised using field surveys, supplemented by population databases and models, and remote estimates made using airborne and satellite data. Critical to employing any data is the coordination between and within local governments and international aid and donor organizations. Establishing a central government institute or body for disaster management purposes with a clear protocol for communication with foreign aid organizations is a basic element in facilitating efficient humanitarian response. The presence of a body such as the INGC in Mozambique, established specifically to manage disasters and coordinate prevention activities, including the development of a detailed hazard exposure and population information base in risk areas (see *http://www.undp.org.mz/anmviewer.asp?a=22*), was apparently useful, despite its relative infancy at the time of the first floods in 2000. The ability of government and agencies to enact preparedness schemes and coordinate relief efforts for subsequent emergencies was demonstrated in fairly coordinated responses during repeated flooding in successive years in Mozambique.

International capacity-building endeavors, as demonstrated in the case of Mozambique prior to and following the flooding events, are important as well; in resource-poor countries, the engagement of external expertise to assist and train local people in analysis, management, and use of their own population data is critical to increasing disaster preparedness (see also Chapter 4) and decreasing vulnerability. Employing natural disaster exposure and risk assessments and increasing the capacity of local governments to conduct their own monitoring efforts (for any natural hazard or conflict) can increase the ability of institutions to manage humanitarian crises more effectively.

RECOMMENDATIONS

Based on the preceding discussion, the committee makes the following recommendations:

- **Integrate the national statistical offices (NSOs) into the national preparedness and response teams for national emergencies. This role would involve the development of pre-disaster geospatial databases and experience in working at subnational levels relevant to hazards of all kinds. The aim is to improve the capacity of NSOs to generate and modify existing data in a timely fashion to enhance emergency response and crisis decision making. [Report Recommendation 2]**

- **Improve subnational analyses of vulnerability to natural disasters and conflict in order to delineate hazard zones or exposures where routine, periodic data collection ex ante could occur. The development of such georeferenced vulnerability analyses could help provide accountability to decision makers in preparedness and prevention and establish priorities for risk reduction investments by all stakeholders. [Report Recommendation 9]**

In constructing this chapter, as well as the rest of the report, the committee has been conscious of the need to balance information obtained from individual relief and development workers "on the ground" regarding their needs and desires for georeferenced population data collection and distribution with broader agency-level assessments and information from peer-reviewed articles on such data. The committee concludes that an independent, detailed study of one country, like Mali, Haiti, or Mozambique, and its use of population data in an emergency situation would be a very useful exercise. Such a study could include a statistically rigorous set of interviews with relief personnel at the field and central management levels, and in national statistical and emergency coordination offices. If conducted by a large international body with relatively good access to country-level data, results of such a study could serve to leverage the observations in this report which show that access to high-quality, geo-referenced population data can be of assistance in generating more effective disaster response.

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6

Recommendations

National census data serve as the foundation for measuring populations at risk from the impacts of natural or human-induced disasters. Improvements in subnational data are vital to enhance decisions on humanitarian intervention, disaster relief, and development assistance to populations vulnerable to a wide range of hazards potentially leading to disasters. Yet various acute, but in many cases resolvable, limitations in geospatial data, methods, and tools for improvements of subnational demographic data often preclude their use under normal conditions for planning, let alone during periods of crises.

Recognition of these needs and limitations leads us to reinforce at least two principal findings of other National Research Council (NRC) committees and reports. The report of the Committee on Planning for Catastrophe, *Successful Response Starts with a Map: Improving Geospatial Support for Disaster Management* (2007), found, and this committee reaffirms, that "in all aspects of emergency management, geospatial data and tools have the potential to contribute to the saving of lives, the limitation of damage, and the reduction in the costs to society of dealing with emergencies" (p. 2). The committee concurs as well with the NRC (2002) report *Down to Earth* that "USAID [United States Agency for International Development] and the U.S. Bureau of the Census should provide financial and technical support to national census offices and bureaus in Africa to help them complete censuses, geographically reference the data, and make the data available in disaggregated form to decision makers" (p. 66). The committee would, however, expand the geographical reference to Africa to include developing countries worldwide.

Moving beyond these reinforcing findings, our overarching conclusion is that ***the data and analytical capacity or potential capacity to address populations at risk exceeds the actual use of such data and appropriate analysis as judged by recent disasters in the United States and globally. Further, governments, emergency response organizations, and other types of responders need to be educated and trained in the importance, need, use, and contributions of such data and to be proactive in seeking and utilizing such information to enhance the distribution of disaster relief aid.*** The recommendations that follow represent the basic themes and issues that should be addressed to begin to make improvements in the operational environment and policy context for disaster relief and humanitarian intervention. It is noteworthy, however, that readily available, appropriate data and advanced analytical capacities alone do not ensure robust preparedness planning or responses to disasters or humanitarian crises. In the end, appropriate interagency coordination and cooperation hold the key to the timely and effective use of data and analysis for disaster response and human emergencies.

This report makes 10 major recommendations pertinent to improving assessments of populations at risk for the decision-making community at large and for agencies responsible for making such assessments on behalf of the United States and other bilateral and international actors. The first three recommendations address *the improvement of the institutional capacity for a baseline census*.

The need for subnational population data that are current and provided in real time is the key to effective planning and responses to disaster or humanitarian crises. Estimation of the total population at risk is critical as are the characteristics of that population (e.g., age, gender). The spatial referencing not only of the population data but also of other ancillary data, such as road networks, shelter availability, and so on is a key foundational layer for planning and mounting any humanitarian response.

1. **Improve the capacity of census-poor countries, through training and technical assistance programs, to undertake censuses. Such improvement is critical for the long-term availability of subnational data that can assist in humanitarian emergency and development situations. Knowing the location, number, and critical characteristics of populations is pivotal to all planning, response, and long-term understanding of disasters. These data sets should have pre-existing protocols for data format, sharing, mapping, intercensal projections, and metadata that are consistent with international standards.**

One of the obstacles to the full employment of spatial demographic data during disasters, despite the clear need to do so, is the pressing human resource issue. Responding to disasters and humanitarian crises requires shared geographic and demographic thinking and training. At present, there are relatively few units, especially in developing countries, with sufficient trained expertise in both demography and geospatial tools and technologies. Improvements in training and commitment by the national statistical office (NSO) and other staff for each country to include both demographic projection methodology in local areas and the use of appropriate spatial administrative units in map form are essential. There are a number of mechanisms for building such capacity, the first of which is recognizing the importance of the skill sets required for disaster preparedness and response. The second is formalized training. Such training programs could be part of overall capacity building and funded by bilateral aid programs, such as USAID, or through broader country capacity-building programs, such as those supported by the World Bank or United Nations. The United States experience suggests that improvement in the capacity to prepare for and respond to disasters saves lives and reduces economic costs when the event occurs.

2. **Integrate the national statistical offices (NSOs) into the national preparedness and response teams for national emergencies. This role would involve the development of pre-disaster geospatial databases and experience in working at subnational levels relevant to hazards of all kinds. The aim is to improve the capacity of NSOs to generate and modify existing data in a timely fashion to enhance emergency response and crisis decision making.**

3. **National and international disaster response and humanitarian agencies and organizations should elevate the importance of demographic and specifically spatial demographic training for staff members. Further, census staff and others working in NSOs throughout the world should be encouraged to undertake such training in order to promote the analysis and use of subnational data before, during, and after emergency response situations.**

The next set of recommendations highlights the need for *improvements in the base census and the release, availability, and archiving of data*. Every community needs accurate, place-specific population and population attribute data for improved disaster planning and response. The most critical data are total population and age-specific counts at the finest geographic scale possible. The level of geography (spatial resolution) is essential as well. While it may be impractical to get individual household data, aggregate counts by census tract or small enumeration area are key to effective disaster management. Equally important is the ability to aggregate these enumeration units into other geographies or spatial units, such as physical zones (e.g., coastal areas, steep slopes, floodplains) or social zones (e.g., urban areas). The enumeration unit must be georeferenced and provided in digital (polygon) form with hard-copy maps available for field responders. The georeferenced total population and age- and gender-specific counts are the minimum data sets required for disaster response. Population attribute data such as race or ethnicity, religion, socioeconomic status, and education are important as well and will improve the effectiveness of the response. It goes without saying that all data should be as accurate as possible and consistent with standard estimation methods and their statistical confidence.

4. **Develop a template of minimum acceptable population and other geospatial data sets that are required by disaster responders. The data sets should be updated frequently (at least mid-decade if not more frequently) and include digital census enumeration units and other census maps in digital form.**

One of the most persistent limitations to the effective use of subnational population data is the low level of access to sensitive data and of data sharing among agencies and organizations. As noted above, this impediment is also true within countries such as the United States (see NRC, 2007). Data sharing between different agencies or parts of agencies is a medium-term goal. In the short term, greater sharing between agencies with disaster response and humanitarian assistance purposes is paramount.

It is common practice in many countries for governments to charge for access to data. One-time use fees or common licensing agreements enable statistical agencies to generate a revenue stream for their work and products. This cost recovery process enables the agency to recoup some of its expenses in data collection, data analysis, and data management. One of the drawbacks to cost recovery is that data are not freely available and issues of reimbursement costs often delay the acquisition of population and geographic data for use in planning and response to emergencies. Therefore, strong incentives should be put in place to make census and administrative boundary data freely accessible, even if this means a government subsidy to ensure wide and equitable access. Further, some appropriate reimbursement costs to the government agencies that collected the data should be negotiated between governments and the responder community. Special protocols could be developed to ensure timely access to detailed census data by humanitarian agencies in times of crisis.

5. **The standard of open-access census data and sharing (as practiced, for example, by Brazil, South Africa, and the United States) should serve as a model for other agencies and for countries that currently do not operate in an open geospatial environment. This access includes spatial**

data such as digital boundary files of subnational units of countries of the world. Governments should release specific data sets that are vital to disaster planning and response. Furthermore, international standards should be developed for the release of subnational population data to maintain confidentiality. Countries financially unable to comply with confidentiality standards should be offered incentives to do so.

Large differences in access to the requisite data and in data sharing exist among countries. The more restrictive cases effectively inhibit disaster planning and responses. Given the increasing international character of disaster response, the decision-making communities would benefit not only from access to the required data but from maintenance of appropriate safeguards regarding data confidentiality.

One such mechanism is a centralized repository for subnational population data worldwide. This Archive and Data Center could take a variety of forms based on such existing models as Interuniversity Consortium for Political and Social Research and the Integrated Public Use Microdata Series, and could be administratively located in the United Nations, a nongovernmental organization, in a UN-university consortium made up of key players, or the U.S. Census Bureau's Populations Division. Funding could be provided by aid agencies such as the World Bank or USAID. To be successful, countries contributing subnational data ought to be assured of confidentiality protections. Approaches such as those that will likely result from the 2007 Africa Symposium on Statistical Development (January 2007, Kigali, Rwanda) with a symposium theme of "Africa Counts: Towards a Complete Enumeration of the African Population and Housing Censuses" (*http://www.statssa.gov.za/asc2007/index.asp*) may outline collaborative solutions between African countries and research and analytical institutions toward establishing such a data archive for Africa. Part of any such effort, regardless of the location of the coordinating organization, is the need for consistent protocols for inclusion, standardization, georeferencing, and analysis of the population data included in such an archive.

6. **Establish a centralized system of access, such as distributed archives and data centers for publicly available subnational data, including data from surveys. The archives would function as a repository for shared local data and would have the primary responsibility for re-dissemination of data to the appropriate response communities during a disaster. The archives should build upon existing data resources.**

The next set of recommendations focuses on *institutional and decision-making needs*. There are many instances in which disaster response and assistance decisions are made in the absence of credible data from the field.

While agencies commonly anticipate data and information needs in advance (the preparedness phase), oftentimes other critical informational needs arise during and after the event (response phase)—such as which road networks were destroyed, how many people were displaced, and where they went, in addition to the designated shelters or camps. It is beyond the capability of many NSOs to conduct field surveys of affected populations living outside officially designated camps or to obtain ancillary data (such as fixed-wing airborne imagery or satellite imagery) to assist in determining the number and characteristics of the affected populations. Relief agencies, in contrast, typically have this capacity and should work closely with local NSOs to ensure that such data complement not duplicate, existing data sets for disaster and humanitarian relief. Therefore, the committee recommends the following:

7. **Relief agencies should broaden their collaborative relationships with NSOs to ensure the acquisition of real- and near-real-time data that complement and are compatible with existing data used for disaster response.**

One of the charges to the committee was to assess the strengths and weaknesses of the existing methods and proxy measures for estimating vulnerable populations. The committee found various approaches both to population size estimation and to approaches to understanding the vulnerability of subnational groups. To better identify at-risk populations, additional research is warranted to ascertain which approaches or methodologies might prove the most successful. At present, there are a number of differing approaches to spatial population estimation, but little guidance as to which are most useful to local responders. At the same time, there is little consistent information on the subnational delineation of hazard exposures and georeferenced vulnerability analyses. Additional research into subnational vulnerability assessments could help to establish a scientific basis for risk reduction investments.

8. **Support should be given to test the accuracy of estimates of size and distribution of populations based on remotely sensed imagery, particularly in rural and urban areas of countries with spatially, demographically, and temporally inadequate census data. Current efforts to render global spatial population estimation—LandScan and Gridded Population of the World—use different methodologies. An independent study of the state of the art in spatial population estimation would highlight the strengths and weaknesses of existing methods and could serve as a guide for improvements in the methods and development of new ones for the purposes of understanding populations at risk.**

9. **Improve subnational analyses of vulnerability to natural disasters and conflict in order to delineate hazard zones or exposures where routine, periodic data collection ex ante could occur. The development of such georeferenced vulnerability analyses could help provide accountability to decision makers in preparedness and prevention and establish priorities for risk reduction investments by all stakeholders.**

How to prioritize resources for preparedness and response is one of the most vexing aspects of disaster and humanitarian crisis management. Objective data on hazard vulnerability and population are often lacking, as are subnational population data. Tensions and impediments exist between federal agencies with respect to spatial and demographic data for disasters and humanitarian crises. From an operational and policy standpoint, these issues lead to inefficiencies and are often duplicative of human and financial resources. The committee's last recommendation addresses the interorganizational structure of U.S. government data providers.

10. **The U.S. Census Bureau should be given greater responsibility for understanding populations at risk and should be funded to do so. These responsibilities could include greater capacity and authority for training international demographic professionals in the tools and methods described in this report, and providing data and analytical capabilities to support the U.S. government in international disaster response and humanitarian assistance activities. The U.S. Census Bureau should also have an active research program in using and developing these tools and methods, including remotely sensed imagery and field surveys. Existing research support models that involve government-academic-private consortia could be explored to develop a framework for the U.S. Census Bureau to adopt these added responsibilities.**

Taken together, these recommendations provide a pathway for improving demographic data, methods, and tools and their application to the identification of at-risk populations. Carefully planned and implemented, they would help improve decision making on disaster relief, humanitarian intervention, and recovery and development assistance after the initial crisis subsides.

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Appendix A

Biographical Sketches of Committee Members and Staff

COMMITTEE

SUSAN L. CUTTER, *Chair*, Ph.D., in geography from the University of Chicago, is a Carolina Distinguished Professor and Director of the Hazards Research Lab in the Department of Geography at the University of South Carolina in Columbia. Her areas of expertise include hazards research, risk analysis, vulnerability science, human dimensions of global environmental change, and environmental policy, management and justice. Scientifically, Dr. Cutter has a breadth of experience in the discipline of geography, especially with vulnerability and risk analysis pertaining to hazard situations and international research studies. Dr. Cutter is a member of the Geographical Sciences Committee of the Board on Earth Sciences and Resources. She serves or has served on several National Research Council (NRC) efforts including the Committee on Disaster Research in the Social Sciences; the Steering Committee for Earth Science and Applications from Space: A Community Assessment and Strategy for the Future; the Committee on Planning for Catastrophe: A Blueprint for Improving Geospatial Data, Tools, and Infrastructure; and the Panel on Social and Behavioral Science Research Priorities for Environmental Decision Making.

MARGARET ARNOLD, M.A., in International Communications from American University is a Senior Program Officer with the Hazard Risk Management Team at the World Bank. Ms. Arnold provides operational technical support for conducting post-disaster damage and needs assessments, design of recovery programs, and disaster risk management projects.

She led research initiatives to document the economic and developmental impacts of natural disasters, assess country capacity to manage disaster risk and promote investments in disaster risk reduction. Ms. Arnold is currently serving as head of the ProVention Consortium in Geneva, Switzerland, on a two-year-long Staff Exchange Assignment.

DEBORAH BALK is associate professor at the Baruch School of Public Affairs and acting associate director of the Institute for Demographic Research at the City University of New York. Until the fall of 2006, she was research scientist at the Center for International Earth Science Information Network at Columbia University. There she was also lead project scientist for the Socioeconomic Data and Applications Center, funded by the National Aeronautics and Space Administration (NASA), where she worked on large-scale integration of geographic, survey, and administrative data. Among her current projects, she is principal investigator on two studies of urbanization and another project on emerging infectious disease funded by the National Science Foundation (NSF). She is currently a member of the International Union for the Scientific Study of Population Working Group on Urbanisation. She received a Ph.D. in demography from the University of California at Berkeley, and master's and bachelor's degrees from the University of Michigan, in Ann Arbor.

BELA HOVY, advanced degree from Utrecht University, The Netherlands, is the chief of the Migration Section of the Population Division of the United Nations in New York. His areas of expertise include refugee demography, statistics, forced migration, and data management and analysis. He has extensive experience with population statistics and field experience in analyzing refugee population statistics. Dr. Hovy serves on the NRC Planning Committee for a Workshop on Forced Migration Typologies for Humanitarian Relief and Policy and the Roundtable on the Demography of Forced Migration.

MEI-PO KWAN, Ph.D. from the University of California, Santa Barbara, is a Distinguished Professor of Social and Behavioral Sciences at Ohio State University in Columbus. Her areas of expertise include urban, transportation, and economic geography; geographic information systems (GIS); geospatial analysis; and three-dimensional geovisualization. She is a member of the board of directors of the University Consortium for Geographic Information Science, a national councilor of the Association of American Geographers (AAG), and Chair of the AAG GIS specialty Group.

JONATHAN D. MAYER, Ph.D. in geography from the University of Michigan, is a professor in the Departments of Epidemiology, Geography, and

International Health at the University of Washington in Seattle. He is adjunct professor of medicine (infectious diseases), family medicine, and health services, and clinical consultant with the Tropical Medicine and Infectious Disease Service at the University of Washington Medical Center. His areas of expertise include medical geography including comparative public health systems; geographical patterns of disease, with an emphasis on infectious disease; disease ecology; new and emerging infectious diseases; infectious disease epidemiology; and clinical applications of medical geography. He travels to Africa frequently to do field work. Dr. Mayer is a member of the Geographical Sciences Committee of the Board on Earth Sciences and Resources. He is a member of the NRC Committee on Research Priorities in the Earth Sciences and Public Health, and a member of the National Institute of Health's committee on the Epidemiology of Clinical Disorders and Aging. He was a member of the joint Institute of Medicine/National Academy of Sciences Committee on Climate, Ecosystems, Infectious Diseases, and Human Health.

DAVID R. RAIN, Ph.D. from Pennsylvania State University in University Park, is an assistant professor of geography at George Washington University in Washington, D.C. His areas of expertise include demography, population and the environment, international development, urban geography, and U.S. federal census GIS analysis and applications. He has experience analyzing international population data at the national and subnational scale, analysis of data on the international geographic distribution and redistribution of population, geographic information systems, and international experience. Dr. Rain is a member of the Urbanization Working Group of the International Union for the Scientific Study of Population, the Roundtable on Sustainable Forests, and the Population-Environmental Policy Forum.

HAVIDÁN RODRÍGUEZ, Ph.D. from the University of Wisconsin-Madison, has been appointed vice provost for academic affairs at the University of Delaware in Newark where he is a professor of sociology and core faculty member of the Disaster Research Center. His areas of expertise include sociology, disaster research, population composition, geographic distribution, and analysis of population vulnerability. His research has focused on population composition, geographic distribution, national hazards, and vulnerability in the coastal regions of Puerto Rico. Dr. Rodriguez serves on the NRC Disasters Roundtable and served on the Committee on Assessing Vulnerabilities Related to the Nation's Chemical Infrastructure.

BARBARA BOYLE TORREY, M.S. from Stanford University, is a visiting scholar at the Population Reference Bureau in Washington, D.C. Her areas of expertise include demography, international policy, population vulnerabilities, and comparative economics. She has been the primary author on several population dynamics and population-economic studies. Ms. Torrey served on the NRC International Advisory Board, the Board of the Population Reference Bureau, and the Science Committee of the International Institute of Applied Systems Analysis (IIASA) in Vienna. She is the former executive director of the NRC Division of Behavioral and Social Sciences and Education, and the Census Bureau's Center for International Research. She was a member of the NRC Committees on Population and the Human Dimensions of Global Change. She has edited two books, one entitled *Population and Land Use Change*. She is a fellow of the American Association for the Advancement of Science (AAAS).

BILLIE L. TURNER II, NAS, Ph.D. from the University of Wisconsin at Madison, is the Milton P. and Alice C. Higgins Professor of Environment and Society and director of the Graduate School of Geography at Clark University. Dr. Turner is an internationally recognized scholar who examines human-environmental relationships. His recent work is focusing on global to local land-use and land-cover change to enrich understanding of relationships among population, technology, political economy, and environment across different temporal and spatial scales. He is a member of the Board on Agriculture and Natural Resources and the Board on Earth Sciences and Resources.

JOHN R. WEEKS, Ph.D. from the University of California, Berkeley, is professor of geography and director of the International Population Center at San Diego State University in California. His areas of expertise include remote sensing, demography, geographic applications to demography, international demographic applications, and public health. He applies geographic science to population and public health issues. Dr. Weeks is a member of the Advisory Board of the GIS and Population Science Program at the Center for Spatially Integrated Social Science and is principal investigator of a study funded by the National Institute of Child Health and Human Development (NICHD) that uses remotely sensed imagery and GIS to model health inequalities in Accra, Ghana. Dr. Weeks has been a demographic and statistical consultant and expert witness in nearly 200 criminal and civil legal cases.

TUKUFU ZUBERI, Ph.D. from the University of Chicago, is the Lasry Family Endowed Professor of Race Relations and director of the Center for African Studies at the University of Pennsylvania in Philadelphia. His areas of expertise include demographic research, research in mortality in Africa, interracial contact and social status, African migration system, and population and health. He has demographic research expertise and experience with national census efforts in Africa, international applications, and African migration studies. Dr. Zuberi is the director of the African Center Analysis Project (ACAP).

STAFF

ELIZABETH A. EIDE, *Study Director,* is a senior program officer with the Board on Earth Sciences and Resources at the National Academies. Her areas of expertise include geochronology and petrology applied to crustal processes. Prior to joining the Academies, she worked overseas managing a noble gas geochronology laboratory, and administrating personnel, budget and research programs in geology and geophysics. She received her Ph.D. in geology from Stanford University and B.A. in geology from Franklin and Marshall College.

BARNEY COHEN is director of the Committee on Population at the National Research Council. For the past 14 years he has worked at the National Research Council on numerous domestic and international population-related issues. He has an M.A. in economics from the University of Delaware and a Ph.D. in demography from the University of California, Berkeley.

CAETLIN M. OFIESH is a research associate with the Board on Earth Sciences and Resources at the National Academies. Since graduating from Amherst College with a B.A. in Geology, where she focused on structural geology and tectonics, she has worked in the Boulder, Colorado, office of Environmental Defense, and spent a semester teaching geology to high school sophomores in Zermatt, Switzerland. Prior to that, she interned at the American Geological Institute in Alexandria, Virginia, and worked as a research assistant at the University of Virginia's School of Engineering, where she published a paper on global food and water supply issues.

NICHOLAS ROGERS is a senior program assistant with the Board on Earth Sciences and Resources. He received a B.A. in history, with a focus on the history of science and early American history, from Western Connecticut State University in 2004. He began working for the National Academies in 2006 and has primarily supported the Board on Earth Sciences and Resources on earth resource and geographical science issues.

TONYA FONG YEE is a program assistant with the Board on Earth Science and Resources. She received her B.S. in business administration with a focus on marketing, from the University of Florida in Gainesville, Florida. Before coming to the National Academies, she interned at the Substance Abuse and Mental Health Services Administration, working on the Safe Schools/Healthy Students Initiative.

Appendix B

Acronyms and Abbreviations

ACAP	African Census Analysis Project
ACS	American Community Survey
ADPC	Asian Disaster Preparedness Center
AFRISTAT	African Sub-Saharan Economic and Statistical Observatory
CE-DAT	Complex Emergency Database
CIAT	Centro Internacional de Agricultura Tropical
CIB	Controlled Image Base
CIESIN	Center for International Earth Science Information Network
COMET	Centre for the Observation and Modeling of Earthquakes and Tectonics
CPS	Current Population Survey
CRED	Centre for Research on the Epidemiology of Disasters
DHS	Demographic and Health Survey
DMSP-OLS	Defense Meteorological Satellite Program-Operational Linescan System
DRI	Disaster Risk Index
EERI	Earthquake Engineering Research Institute
ESRI	Environmental Systems Research Institute

FAO	Food and Agriculture Organization of the United Nations
FEWS-NET	Famine Early Warning System Network
FGDC	Federal Geographic Data Committee
GIS	geographic information systems
GNOCDC	Greater New Orleans Community Data Center
GPS	global positioning systems
GPW	Gridded Population of the World
GRUMP	Global Rural-Urban Mapping Project
HDI	Human Development Index
HDM	Humanitarian Data Model
HICP	Humanitarian Information Centre Pakistan
HIS	Humanitarian Information System
IAF	Inquérito aos Agregados Familiares
ICDRM	Institute for Crisis, Disaster, and Risk Management
IDP	internally displaced person
IDRISI	Imagery Classification Software
IFRC	International Federation of Red Cross and Red Crescent Societies
IIASA	International Institute for Applied Systems Analysis
INEGI	Instituto Nacional de Estadística e Informática
INGC	National Institute for Disaster Management of Mozambique
IPC	International Programs Center
IPUMS	Integrated Public Use Microdata Series
IT	information technology
IUSSP	International Union for the Scientific Study of Population
JERS-1	Japanese Earth Resources Satellite-1
MAE	Mid-America Earthquake Center
MAUP	modifiable areal unit problem
MEDS	minimal essential data set
MICS	Multiple Indicator Cluster Surveys
MODIS	Moderate Resolution Imaging Spectroradiometer
MSF	Médecins Sans Frontières

NCGIA	National Center for Geographic Information and Analysis
NGA	National Geospatial-Intelligence Agency
NGDC	National Geophysical Data Center
NGO	nongovernmental organization
NIMA	U.S. National Imagery and Mapping Agency
NOAA	National Oceanic and Atmospheric Administration
NPOESS VIIRS	National Polar-orbiting Operational Environment Satellite System Visible Infrared Imager Radiometer Suite
NRC	National Research Council
NSDI	national spatial data infrastructure
NSO	national statistical office
OAS	Organization of American States
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
ODI	Overseas Development Institute
OFDA	Office of Foreign Disaster Assistance
OGC	Open GIS Consortium
ORC Macro	Opinion Research Corporation
ORNL	Oak Ridge National Laboratory
PALUCP	African Project for Emergency Control of Migratory Locusts
PUMA	Public Use Microdata Area
PVI	Prevalent Vulnerability Index
SALB	Second Administrative Level Boundary
SAR	synthetic aperture radar
SEDAC	Socioeconomic and Data Applications Center
SHARE	Structured Humanitarian Assistance Reporting Effort
TIGER	Topologically Integrated Geographic Encoding and Referencing system
UCSB	University of California, Santa Barbara
ULCP	Unit for Migratory Locust Control
UNCAP	United Nations Consolidated Appeals Process
UNDP	United Nations Development Programme
UNFPA	United Nations Population Fund
UNGIWG	United Nations Geospatial Information Working Group

UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations Children's Fund
UNPD	United Nations Population Division
UNSD	United Nations Statistics Division
UNSO	Office to Combat Desertification and Drought
USAID	U.S. Agency for International Development
USGS	U.S. Geological Survey
VMap	Vector Smart Map
WFP	United Nations World Food Programme
WHO	World Health Organization

Appendix C

Glossary

Administrative Data—Data collected by a government or other large entity for purposes other than demographic uses. These data might be land parcel data used for taxation and land tenure purposes or utility data collected for billing purposes. They are among the types of data that can be used to fill in gaps in population coverage from other sources.

Block or Block Group—The smallest entity for which the U.S. Census Bureau collects and tabulates decennial census information; bounded on all sides by visible and nonvisible features shown on Census Bureau maps. A block group is a combination of census blocks that is a subdivision of a census tract. It is the lowest level of geography for which the Census Bureau tabulates sample data.

Capacity Building—Strengthening the ability to undertake tasks, especially by improving the technical skills of people through the provision of technology, such as computers and software, and the training of individuals to use data in conjunction with the necessary technology.

Census—An official enumeration of an entire population, usually with details as to age, gender, occupation, and other population characteristics; defined by the United Nations as the total process of collecting, compiling and publishing demographic, economic, and social data, at a specified time or times, for all persons in a country or delimited territory.

Census Tract—In the United States, a small, relatively permanent statistical subdivision of a county in a metropolitan area or a selected nonmetropolitan county, delineated by a local committee of census data users for the purpose of presenting decennial census data. Census tract boundaries normally follow visible features but may follow governmental unit boundaries and other nonvisible features in some instances; they always nest within counties. Designed to be relatively homogeneous units with respect to population characteristics, economic status, and living conditions at the time they were established, census tracts usually contain between 2,500 and 8,000 inhabitants. They may be split by any subcounty geographic entity.

Chronic Disaster—An event that affects the exposed population incrementally, perhaps imperceptibly at first, but may ultimately push the resilience of the system to a tipping point and into a disaster phase. In many cases, society fails to respond to the incremental problem, and thus becomes a factor in generating and accelerating the disaster.

Cohort-Component Method—A population projection made by applying age-specific survival rates, age-specific fertility rates, and age-specific measures of migration to the base-year population in order to project the population to the target year.

Complex Emergency—A humanitarian crisis in a country, region, or society in which there is a total or considerable breakdown of authority resulting from internal or external conflict that requires an international response that goes beyond the mandate or capacity of a single agency and/or the ongoing United Nations country program (IASC, 2004).

Demographic Data—Data that pertain to population size, population processes (mortality, fertility, migration), population characteristics (age, gender, education, etc.), and/or population distribution.

Demography—The scientific study of human populations.

Disaster—A singular, large, nonroutine event that overwhelms the local capacity to respond adequately (NRC, 2006). The events that produce disasters can be natural or human-induced, and can be sudden-onset (e.g., an earthquake) or chronic (e.g., a protracted civil conflict). See CHRONIC DISASTER and SUDDEN-ONSET DISASTER.

Enumeration Unit, Area—Comparable to a CENSUS TRACT.

Geographic Data—Data that contain references to the location of the information.

Geospatial—The combination of spatial software and analytical methods with geographic data sets.

Hazard—Events that arise from the interaction between society and natural systems (e.g., earthquakes, tsunamis, tropical storms) or between society and technology (e.g., chemical accidents, nuclear power plant accidents), or within society itself (e.g., war, civil and ethnic strife, persecution, human rights violations). Hazards have the potential to harm people and places, including ecosystems.

Heuristic—A teaching device that aids discovery. A heuristic model does not answer a question in and of itself, but rather helps create a means for answering a question.

Humanitarian Crisis—An event or series of events representing a critical threat to the health, safety, security, or well-being of a community or other large group of people, usually over a wide area.

Internally Displaced Persons (IDPS)—Individuals or groups of people that have moved away from their homes but stayed within their own national borders.

Metadata—Data about data; descriptions of data sets that provide background and context for the derivation and use of the data.

Microdata—Individual census records.

Population Data—See DEMOGRAPHIC DATA.

Refugees—Victims of conflict, civil or ethnic strife, or persecution who flee across international borders and who are protected under international law.

Resilience—The ability of social groups or places to recover from a hazard and to buffer themselves and adapt to future ones; coping capacity.

Risk—The likelihood of incurring harm—that is, the chance of injury or loss, in this case, from the hazard event.

Sample Survey—A method of collecting data by obtaining information from a sample of the total population, rather than by a complete enumeration.

Sensitivity—The degree to which social groups or places are initially harmed by exposure to a hazard.

Subnational—Any level of geography below national boundaries (e.g., regions, states, counties).

Sudden-Onset Disaster—"Big-bang" events—such as earthquakes, industrial accidents, or surprise attacks—whose surprise and sheer magnitude over a very brief period overwhelm the exposed population.

Vulnerability—The degree to which a system or unit (such as a population or a place) is likely to experience harm due to exposure to perturbations, stresses, or disturbances from natural, technological, or human-induced sources.

This glossary draws from the following sources and references:

GARM (Geographic Areas Reference Manual). Available online at *http://www.census.gov/geo/www/garm.html.*

IASC (Inter-Agency Standing Committee), 2004. Civil-Military Relationship in Complex Emergencies—An IASC Reference Paper. 57th Meeting of the IASC, Geneva, Switzerland, June 16-17. Available online at *http://ochaonline.un.org/ DocView.asp?DocID=1219* [accessed February 6, 2007].

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Appendix D

Workshop and Meeting Agendas and Attendees

WORKSHOP
COMMITTEE ON THE EFFECTIVE USE OF DATA, METHODOLOGIES, AND TECHNOLOGIES TO ESTIMATE SUBNATIONAL POPULATIONS AT RISK

National Research Council of the National Academies
Geographical Sciences Committee
Committee on Population
Keck Center, Room 201 (morning, 3/13),
Room 100 (afternoon and all day 3/14)
500 Fifth Street, N.W.
Washington, DC 20001
Meeting, March 13-14, 2006

Day 1—Monday, March 13, 2006

08:30-16:45 OPEN SESSION (Open to public)

08:30-08:45 Welcome and introductions
Susan Cutter, Chair

08:45-10:15 Session 1
Moderated by Deborah Balk and John Weeks
Assess the strengths and weaknesses of existing data, methods, and tools for estimating subnational populations

Panelists: Eric Noji (Centers for Disease Control and Prevention)
Livia Montana (ORC Macro)
Mark Pelling (King's College London)
Chuck Conley (Vietnam Veterans of America Foundation)
Jerry Dobson (University of Kansas)
Chris Elvidge (National Oceanic and Atmospheric Administration [NOAA])

Panelists will each give ~15-minute presentations

10:15-10:30 *Break*

10:30-12:00 Session 1, General panel discussion
Moderated by Deborah Balk and John Weeks

12:00-13:00 *Lunch*

13:00-14:30 Session 2
Moderated by David Rain and Havidán Rodríguez
Identify the limitations of current institutional structures in using existing demographic and other data and tools for estimating subnational populations

Panelists: Rhonda Davis-Stewart (U.S. Agency for International Development [USAID])
C.J. Terborgh (World Bank)
John Kelmelis (U.S. Geological Survey [USGS]-State Department)
Glen Lauber (National Geospatial-Intelligence Agency [NGA])

Panelists will each give ~20-minute presentations

14:30-14:45 *Break*

14:45-16:00 Session 2, General panel discussion
Moderated by David Rain and Havidán Rodríguez

16:00-16:45 Concluding remarks, Sessions 1 and 2
Susan Cutter, Chair

16:45-18:00 *Reception (in the Keck Center building)*

Day 2—Tuesday, March 14, 2006

08:30-16:30 OPEN SESSION (Open to public)

08:30-08:45 Welcome and introductions
Susan Cutter, Chair

08:45-10:15 Session 3
Moderated by Barbara Torrey and Mei-Po Kwan
Identify ways subnational demographic and geographic data and tools could be used to help decision makers (federal agencies, foreign governments, international organizations, international partners) provide information to populations at risk and respond to needs for humanitarian assistance

Panelists: Abbiah Subramanian (Madras Christian College)
Suha Ulgen (United Nations)
Shawn Messick (Vietnam Veterans of America Foundation)
Shannon Doocy (Johns Hopkins School of Public Health)
Nate Smith (Greenhorne and O'Mara)

Panelists will each give ~20-minute presentations

10:15-10:30 Break

10:30-12:00 Session 3, General panel discussion
Moderated by Barbara Torrey and Mei-Po Kwan

12:00-13:00 Lunch

13:00-14:30 Session 4
Moderated by Jonathan Mayer
Using case studies from a variety of countries including, but not limited to, Mali, Mozambique, and/or Haiti, examine the role of data and tools in improving the ability of U.S. government agencies to respond to population crises. The session will examine the strengths and limitations of existing and new techniques and tools for improving data collection

Panelists:	Mamadou Kani Konaté (Caref.org, Mali)
	Loren B. Landau (University of the Witswatersrand)
	Vincent Bagiire (Bridges.org)
	Eric Sawyer (USAID)

Panelists will each give ~20-minute presentations

14:30-14:45 *Break*

14:45-16:00 Session 4, General panel discussion
Moderated by Jonathan Mayer

16:00-16:30 Concluding remarks, Sessions 3 and 4

End of open session

Other Workshop Attendees:

Jean Arkedis	State Department
Lee Schwartz	State Department
Nate Heard	State Department
Alan Davis	State Department
Noam Unger	State Department
Tammany Mulder	State Department
Gina Weatherup	State Department
Carol Christian	State Department
Jacob Adetunji	USAID
Michael Hildebrand-Faust	USAID
Steve Sposato	USAID
Paul Schaefer	NGA
Mark Napoli	NOAA
Andrew Stancioff	Consultant
Nancy Schectman	U.S. Census Bureau
Mark Perry	U.S. Census Bureau
Anika Juhn	U.S. Census Bureau
Jim Fitzsimmons	U.S. Census Bureau
Robert Leddy	U.S. Census Bureau
Bill Anderson	National Research Council
Budhendra Bhaduri	Oak Ridge National Laboratory (ORNL)
Eddie Bright	ORNL
Sean O'Connor	bridges.org
Teresa Peters	bridges.org
Eric Smith	Wyle Labs

WORKSHOP
COMMITTEE ON THE EFFECTIVE USE OF DATA, METHODOLOGIES AND TECHNOLOGIES TO ESTIMATE SUBNATIONAL POPULATIONS AT RISK

National Research Council of the National Academies
Geographical Sciences Committee
Committee on Population
Keck Center, Room 202
500 Fifth Street, NW
Washington, DC 20001
Meeting, April 20-21, 2006

Day 1—Thursday, April 20, 2006

08:00-09:30 CLOSED SESSION (Committee and NRC staff only)

09:30-11:00 OPEN SESSION (Open to public)

09:30-10:15 Production and use of population estimates and projections by the U.S. government
Tammany Mulder, U.S. Department of State

10:15-11:00 The use of population data in estimating the size and condition of displaced populations
Dr. Richard Bilsborrow,
University of North Carolina, Chapel Hill

End of open session

11:00-17:00 CLOSED SESSION (Committee and NRC staff only)

Day 2—Friday, April 21, 2006

08:00-16:00 CLOSED SESSION (Committee and NRC staff only)

Appendix E

Technical Papers

As part of its information gathering, the Committee on the Effective Use of Data, Methodologies, and Technologies to Estimate Subnational Populations at Risk held a workshop on March 13-14, 2006, at the National Academies Keck Center in Washington, D.C. As part of this workshop, the committee requested voluntary technical paper contributions from each panelist related to the topic of his or her panel session (see Appendix D for workshop agenda). These papers were intended to supplement the information the panelists presented during the workshop and served as references for the committee's use during the course of the study.

The technical papers that the committee received are presented here for reference, along with biographical sketches of the contributing authors. *The statements, opinions, findings, and conclusions or recommendations made in the authored papers are those of the individual authors and do not necessarily represent positions of the committee, the National Academies, or the sponsors. Mention of trade names or commercial products does not constitute their endorsement by the U.S. government.*

LIST OF TECHNICAL PAPERS

Assessing the Strengths and Weaknesses of Existing Data for Estimating Subnational Populations at Risk from Disasters Associated with Natural Hazards
Mark Pelling, King's College, London

In Harm's Way: Estimating Populations at Risk
Jerome E. Dobson, University of Kansas

Organizational Impediments to Estimating Populations, and Acquiring, Accessing, and Using Population Data
John A. Kelmelis, U.S Geological Survey and Department of State, Washington, D.C.

Political Geography and Emergency Relief
Wm. Glen Lauber, National Geospatial-Intelligence Agency, Washington, D.C.

Identify Ways in Which Subnational Demographic and Geographic Data and Tools Could Be Used to Help Decision Makers Provide Useful Information to Populations at Risk
Shannon Doocy, Johns Hopkins University Center for Refugee and Disaster Response, Baltimore, Maryland

Cognitive and Institutional Limits on Collecting and Processing Data on Populations at Risk: Preliminary Reflections on Southern African Responses to Displacement
Loren B. Landau, Wits University's Forced Migration Studies Programme, Johannesburg, South Africa

Strengths and Limitations of Information and Data Analysis in Responding to Crisis in Mali
Mamadou Kani Konaté, CAREF, Bamako, Mali

ASSESSING THE STRENGTHS AND WEAKNESSES OF EXISTING DATA FOR ESTIMATING SUBNATIONAL POPULATIONS AT RISK FROM DISASTERS ASSOCIATED WITH NATURAL HAZARDS

Mark Pelling, King's College, London

INTRODUCTION

This paper offers a review of international disaster databases. It draws on Pelling (2005a,b, 2006). Four publicly accessible, international databases are described, and challenges facing the use of these data for subnational analysis are assessed.

THE INTERNATIONAL INSTITUTIONAL ARCHITECTURE FOR COLLECTING DATA ON DISASTER LOSS

Table E-1 presents a summary of the characteristics of four disaster loss databases: EM-DAT, NatCat, Sigma, and DesInventar. These are discussed in turn below.

TABLE E-1 International Disaster Databases

	EM-DAT	NatCat	Sigma	DesInventar
Web site	*http://www.cred.be/emdat*	*http://www.munichre.com/*	*http://www.swissre.com/*	*http://www.desinventar.org/*
Management	University (CRED)	Private (MunichRe)	Private (SwissRe)	University/NGO (La Red)
Coverage	Global	Insured risk	Insured risk	Americas
Hazard types with which disasters are associated	Natural and technological	Natural (rapid onset)	Natural and technological	Natural and technological
Criteria for disaster entry	At least 10 deaths or 100 affected, or state of emergency, or call for international assistance	1980-present: any property damage and person injured or killed. Before 1980, only "major" events	At least 20 deaths, or insured losses of at least U.S. $15.1 million or total loss of U.S. $74.9 million[a]	Any social loss
Principal data source	Humanitarian agencies, governments, international media	Insurers, international media, supported by site visits	Insurers, international media	Local/ national media, agency and government reports
Time for new entry	Four weeks	Around three weeks	Annual revision	Around one week to one month
Period covered	1900-present, with good accuracy from 1980	Good accuracy from 1979	1970-present	1970-present
Data fields (not all data are available for every disaster event)[b]	Mortality, injured, homeless, total people affected, estimated economic loss	Insured and economic losses Includes data on human losses for large-scale disasters	Insured losses Economic loss, mortality, missing, injured, and homeless are also noted for large-scale disasters	Mortality; injured or missing victims; affected, destroyed, and affected houses; evacuated areas; roads, education centers, or livestock lost; economic losses

NOTE: NGO = nongovernmental organization.
[a]Using 2004 U.S. dollars, monetary values annually adjusted.
[b]No data set covers ecological loss.

THE EMERGENCY DISASTERS DATABASE

The Emergency Disasters Data Base (EM-DAT), managed by the Centre for Research on the Epidemiology of Disasters (CRED) at the Université Catholique de Louvain, Brussels, is the most complete, internationally accessible, public database on disaster loss at the national scale. It produces estimates of human and economic losses from disasters. The database includes relatively small disasters for which reliable data exist. The main aim of EM-DAT is to support research, and great effort is put into the verification of input data; nonetheless, many challenges to data quality and completeness remain. The verification process means that data often are not posted on EM-DAT until four weeks after an event. Even at this stage the data are subject to change over periods of 12 months or more when, for example, people described initially as missing are re-categorized as dead.

The contribution of EM-DAT is primarily constrained by a lack of systematic and standardized local and national disaster data collection. A particular problem from the perspective of this workshop is the lack of spatial specificity found in international reports upon which EM-DAT builds much of its database. Consequently, EM-DAT catalogues events by country, making it difficult to identify subnational patterns of disaster loss, with changes in international borders complicating historical analysis. Subnational loss patterns can be deduced as a proportion of national population or population exposed to a particular hazard type, for example, but the results are rough estimates at best.

REINSURANCE DATABASES: NATCAT AND SIGMA

NatCat is managed by Munich Reinsurance (MunichRe). Beyond holding data on insured loss, MunichRe has built a methodology for calculating total economic losses for large-scale disasters (excluding those associated with drought) from this database. Economic losses are calculated based on insured loss, with weighting for the country affected and the natural hazard trigger type. Economic losses include damage to physical assets and infrastructure but do not incorporate losses from the interruption of productive, distributive, and marketing activities and secondary effects on the national economy, all of which are difficult to calculate. The accuracy of the methodology is verified by comparison with final loss estimates from the field. The georeferencing of individual buildings means that very high resolution loss studies can be undertaken, with MunichRe having also developed an urban risk index.

Sigma, managed by Swiss Reinsurance (SwissRe), presents information on insured property losses and on economic and human loss due to natural and technological disasters in its annual loss reports. Sigma uses the event (which may include multiple countries) as the basis for each entry. This contrasts with the use of country categorization in NatCat and EM-DAT.

Both insurance databases provide only limited information on countries and populations with low insurance density. This reduces coverage for Africa and also for Asia and Latin America. In particular, rural areas lack comprehensive data, and losses associated with drought are not covered. However, the inclusion of data from sources beyond insurance reports enables the databases to provide some information even on these areas.

DESINVENTAR

DesInventar is of special interest to this workshop because it is the only internationally accessible database that holds locally georeferenced data for human and economic loss. A comparison of loss data of EM-DAT and DesInventar has shown differences. For example, DesInventar tends to record higher numbers of people affected by disaster (WG3, 2002) than does EM-DAT. Differences in data have been explained by alternative data collection approaches.

DesInventar is managed by a regional coalition of academic and nongovernmental actors and covers 16 countries in Latin America and the Caribbean. DesInventar's focus on local disasters introduces a number of specific challenges for data quality:

- The media is a prominent source of information; not only is there no systematic method for media reporting on losses, but reliability is debatable.
- An aim of DesInventar is to collect information on secondary impacts and losses to infrastructure, but it is found that this information is unevenly reported, even locally.
- Sometimes DesInventar has to draw on national sources of data, and in these cases it is very difficult to disaggregate to determine the local distribution of losses.

Subnational DesInventar databases also exist for individual states in the U.S., Brazil, Colombia, South Africa, and India.

KEY CHALLENGES

Lack of Standardized and Systematic Subnational Data Collection

The absence of standard guidelines for local disaster loss data collection is compounded in most countries by an ad hoc system of data collection by local media, government, or civil society groups. Local data are collated and fed to international databases by intermediaries. Not only do intermediaries not have a standard set of definitions to order data, but they might be tempted to exaggerate or suppress data for professional, political, or economic advantage (DFID, 2004).

Mortality is the cleanest indicator of disaster loss. Even here, however, the distinction between deaths and people missing creates uncertainty, with some countries requiring that people be declared dead after they have been missing for 12 months. Wide variance in reports of mortality is common. For example, in the Bam earthquake, mortality was put at 43,200 by the UN Office for the Coordination of Humanitarian Affairs (OCHA), at 31,884 by the French Agency Press, and at 26,796 by the International Federal of Red Cross and Red Crescent Societies (IFRC).

Data are most incomplete for economic losses. Over the past three decades, economic losses were reported for less than 30 percent of all natural disasters, with the least data for developing countries (Pelling, 2005b). Scarcity of data is compounded by the lack of a standardized methodology for reporting economic losses. Generally it is only direct losses that are reported with no breakdown of losses by sector. Having few international data sources makes verification difficult. In Bam, economic loss estimates ranged from U.S. $1 billion by SwissRe to U.S. $32.7 million from the U.S. Geological Survey. A possible model for a standard methodology for reporting losses has been developed by the Economic Commission for Latin America and the Caribbean (see *http://www.proventionconsortium.org/toolkit.htm*); this model is becoming widely used.

When disasters are associated with hazards that impact more than one country, such as the Indian Ocean tsunami or Hurricane Mitch, potential problems with double counting in data sets may also occur. Losses might be recorded for individual countries and for the event as a whole. A harder challenge to overcome is a product of disaster cascades—this happens when an initial hazard triggers a secondary event, for example when landslides follow seismic activity or flooding. This challenge may be addressed partly by an agreement among agencies to use a common and unique Global Identifier Number (GLIDE) for each event. GLIDE has been available since 2004.

Defining Hazards and Distinguishing Events

Strict physical definitions for hazards can be proposed so that their distribution and frequency might be mapped. Associating hazards with recorded loss data to measure severity of impact is not as easy to do. In each database and for each hazard type, the quality of attributed loss data is compromised by other intervening and overlapping causes of loss.

Drought hazard and associated loss present the greatest challenge (drought is also the hazard type associated with most human loss). A common definition of drought does not exist, and it may be defined using a range of meteorological, hydrological, or agricultural variables. Thus, no common rubric is used to draw spatial and temporal limits around drought events, creating challenges for the comparative analysis of drought impacts. The slow-onset nature of drought makes it very difficult to separate the relative contribution of associated environmental and human factors, such as soil loss, armed conflict, or HIV/AIDS, to loss data. Overall this can make it difficult to judge whether a drought period is a cause, product, or context for reported losses.

The 20-year time span of reliable information from loss databases makes it difficult to use past losses as a basis for assessing current vulnerability and risk status for low-frequency, high-impact hazard types such as volcanic eruptions or tsunamis.

Projecting Past Vulnerabilities into the Future

Care should be taken when using loss data as input to vulnerability and risk indexing. Loss data speak toward past events. While strong historical correlations between events may be apparent, this should not lead to an assumption that trend lines will continue similarly into the future.

This assumption becomes more problematic at finer resolution where development pressures, such as rapid urbanization and local environmental changes linked to global climate change, have the potential to alter radically the local distributions of population, wealth, hazard, and vulnerability over a short time period relative to hazard frequency. It is also possible that losses during past disasters will lead to local learning and the building of resilience, rather than the continuation of vulnerability, so that past impacts might locally be associated with future security rather than vulnerability. Regular assessments accompanied by contextual analysis of pressures shaping hazard, vulnerability, and disaster risk management can help overcome this challenge for measuring local risk.

Measuring Human Vulnerability

Mortality is arguably the most reliable comparative indicator of local human loss at the global scale. Data on people affected, injured, or made homeless are far less reliable. Reliance on mortality gives statistical rigor but limits policy impact. This can be seen most clearly in drought events where complex interactions between drought, political violence, chronic disease, and economic poverty can make it very difficult to ascribe mortality. It would be more useful for policy makers if the impacts of a drought on livelihood could be measured, but this can only be done on the ground and at the local level.

Where economic impacts are to be used to indicate vulnerability or risk, three challenges should be considered. First, economic loss data do not routinely include long-term economic impacts (sometimes called secondary losses) including changes in national balance of payments, international debt, or fluctuating levels of employment or price inflation in the years following disaster. Second, the destruction or erosion of household livelihoods is not accounted for in economic loss estimates. Third, a focus on gross domestic product (GDP) excludes the informal sector from analyses. Finally, economic loss as a proportion of national wealth as well as in absolute terms should be measured. Low-income countries have fewer economic assets to lose, but damage can be felt as a high proportion of national or local wealth.

Building Multihazard Measurements

The challenges discussed above are magnified when trying to build multihazard vulnerability or risk indicators. A particular challenge is how to combine hazards measured using different metrics, for example, combining the hazardous nature of drought (measured by frequency) and landslides (measured by probability).

CONCLUSION

The greatest need is for standardized collection and systematic collation of local disaster data. This should include agreed protocols for the start and end dates of disasters, for their georeferencing, for distinguishing between cascading hazards, and for measuring impacts, in particular economic impacts, which should include secondary and livelihood losses and ecological impacts. In addition to this, the quality of international disaster databases would be greatly improved by guidelines for standardization in disaster event and loss reporting among intermediaries.

Subnational baselines of social, economic, and ecological status would enhance the accuracy of disaster loss measurement and allow the verification of vulnerability and risk assessments through disaster impact. This will be enabled where the local disaster loss data are compatible with aggregation-disaggregation to the finest level of resolution routinely available for social statistics, such as a census tract. Developing baselines goes beyond the capacity of the disasters community, but is an agenda in which disasters data managers could usefully participate. The recommendations presented here in part respond to the Hyogo Framework for Action, which endorsed the need for more work on disaster data and analysis to feed into disaster risk reduction.

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Mark Pelling is a Reader in Human Geography, King's College London. Before this he lectured at the University of Liverpool and the University of Guyana. His research interests are in assessing and understanding human vulnerability, resilience, and adaptation to natural hazards including those associated with climate change. Recent publications include *The Vulnerability of Cities: Natural Disaster and Social Resilience* (Earthscan) and *Natural Disaster and Development in a Globalizing World* (Routledge). He has acted as a consultant for the United Nations Development Programme-Bureau for Crisis Prevention and Recovery, the United Nations-Human Settlements Program (UN-HABITAT), Tearfund, the UK Department for International Development, and the UK Environment Agency. He is chair of the Climate Change Research Group of the Royal Geographical Society and a member of the ProVention Consortium Advisory Committee.

IN HARM'S WAY: ESTIMATING POPULATIONS AT RISK

Jerome E. Dobson, University of Kansas

My charge is to assess the strengths and weaknesses of existing data, methods, and tools for population analysis at subnational levels. First, I ask, what is the intended purpose and what are the risks to be addressed? What are the scopes and resolutions of risks against which each database must be judged? What spatial and temporal resolutions are required to meet each data need, and what methods are required to produce appropriate databases? I conclude with recommendations on policy, institutional frameworks, methods, and delivery mechanisms.

PURPOSE

A narrow definition of the term "populations at risk" implies that the end use will be emergency management and humanitarian relief. Usually, such risks are categorized as natural disasters, technological accidents, epidemics, and wars including regional conflicts and terrorism. A broad definition would cover all types of risk, including economic crises, environmental degradation, disease outbreaks, and social upheavals. It would be in the national and global interest for the committee to adopt a broad definition and address a wide range of risks.

SCOPE OF RISK

Risks come in all sizes, shapes, and durations. Consider, for example, extreme weather events. Tornadoes, hurricanes, and climate change place whole regions at risk on a long-term basis, but they differ greatly in the spatial and temporal extent of individual incidents. Each tornado is highly precise in duration (minutes to hours) and spatial extent (from a single building to at most a long, narrow swath of buildings, fields, and forests). Each hurricane typically impacts a coastal strip several hundred kilometers long with high winds and ocean surges, and even its most violent impacts may extend a hundred kilometers or more. Climate changes cover vast territory on the order of whole regions, continents, or even the entire planet. Population data requirements thus differ greatly depending on the type of weather event. Hence, an ideal system for tornado response would require data resolutions on the order of individual buildings, or roughly 15 meters. An ideal system for hurricanes should support evacuation planning at least as precise as neighborhood (1 kilometer) or preferably block (90 meters). An ideal system for climate change, however, might suffice with census data typically available for countries, districts, and minor civil divisions, and no disaggregation would be required.

Likewise in war, conventional wisdom during the Cold War era was that population estimates would suffice at very coarse resolutions because blast effects would cover cities, say tens of kilometers, and radiation effects would cover hundreds of kilometers. The rise of terrorism in the 1990s sparked an immediate demand for more precise population data resolutions of 1 square kilometer or finer.

TIME

Time is crucial for most types of emergency response. To what precision can the timing of each incident be predicted? Tornadoes, volcanic eruptions, earthquakes, tsunamis, and terrorist attacks often happen with little or no warning. Hurricanes form for days, but always with uncertainty as to where and when they will make landfall. In our lifetimes, remarkable advances have been made in forecasters' abilities to predict when and where tornadoes and hurricanes will strike, but error bands remain broad. Wars, climate changes, economic crises, and environmental catastrophes form over years, but warning signs can be interpreted in many ways with regard to the timing and certainty of their most violent manifestations. Hence, it is essential to have suitable databases prepared ahead of time and updated as often as possible.

In contrast, some incidents can be predicted with absolute certainty. If, for example, an asteroid was hurtling toward Earth, its time of impact could be predicted to the minute. That is a rare event, of course, but the same scenario has occurred several times with man-made satellites descending from orbit. Similarly predictable categories include military air strikes by allied forces and certain pre-announced or pre-detected terrorist attacks. Many other types of events are predictable after the incident has begun. A tsunami's arrival, for instance, can be predicted with great certainty once a given surge is observed to be propagating across a given sea.

The most important determination is whether an incident will occur at night or during the day. Census counts measure where people sleep at night or, at least, on most nights. Substantial analysis and modeling are required to estimate whereabouts in daytime. Thus, census counts are preferred when the incident occurs at night, while modeled population estimates, even with broad error bands, are preferred when the incident occurs in daytime. Twenty-four hour ambient population densities are adequate, and may even be preferred, when the timing is random or unknown.

Adding to the complexity is the fact that many emergencies are combinations of large and small disasters. Paradoxically, for instance, floods often cause fires and may cause all sorts of other local disasters such as building collapses, chemical releases, power outages, and transportation accidents. Wars typically are complex emergencies consisting of disasters intended by one protagonist and unavoidable for the other. Ideally, population data would be updated in real-time as each disaster unfolds, but this would require an exceptional capability for data acquisition, analysis, computation, and dissemination that does not exist at present.

ELEVATION

Terrain is a key factor for many types of disasters, which greatly increases the need for fine-resolution data for both population and elevation. Hurricanes, tsunamis, volcanoes, and the blast effects and airborne contaminants of terrorist attacks and industrial accidents are constrained by land surface elevation, slope, and relief. In the immediate aftermath of the 2004 tsunami in Southeast Asia, for example, humanitarian agencies desperately sought estimates of the number of victims in each narrow coastal strip, and elevation was crucial. For reference, consider that a 10-meter surge on an 8 percent slope, typical of many residential areas, would extend a mere 125 meters inland. The best available data, however, were at 30-arc-second resolution (1 square kilometer at the equator and getting finer toward the poles), suitable for flat shores where the land surface slope is 1 percent or less. Elsewhere, more spatially precise population data are needed. Even on flat shores, finer-resolution data are needed to ensure that population data can be intersected in three-dimensional space with geographic features such as streets and buildings. Not long ago, intersections of such precision were considered impractical for most professional applications; now they are expected by the public due to the advent of GoogleEarth.

METHODS AND TECHNIQUES

Various cartographic and statistical techniques are available for smoothing, interpolating, and disaggregating census counts from native census geometries to subcensus polygons or cells. A great distinction lies in whether they are performed on population variables only or, conversely, involve one or more ancillary variables. For multivariable analyses, the standard cartographic technique is dasymetric interpolation, first proposed by John K. Wright of the American Geographical Society in 1936 (Wright, 1936). This technique is applicable to many geographic distributions, but Wright's initial application was population. He started with choropleth maps of population density, but he reasoned that the uniform densities produced by this traditional cartographic technique masked certain known or knowable factors affecting the actual distribution. He first distinguished uninhabited from inhabited areas. He then weighted the inhabited areas by land use and settlement characteristics. Wright called his technique dasymetric mapping, but Chrisman (2002) later proposed that it should be considered more properly a form of areal interpolation. By implication, Tobler et al. (1995) were advocating dasymetric interpolation when they called for a "smart interpolation or co-Kriging" and suggested that global population density estimates can be improved in accuracy and precision by incorporating ancillary data such as location and size of towns and cities, roads, railroads, natural features, and nighttime lights.

CURRENT DATABASES

The de facto world standard for estimating populations at risk in natural disasters, technological accidents, and wars is the LandScan Global Population Database. It comes in two resolutions, 30 arc-seconds for the whole Earth and 3 arc-seconds for much of the United States. In the interest of full disclosure, I note that I led the development of LandScan at Oak Ridge National Laboratory (ORNL) from its inception in 1997 until I moved to the University of Kansas in 2001. I no longer have any connection with the project. Annual updates of LandScan Global are available free on the ORNL web site to government, education, and not-for-profit users, and a fee is charged for commercial licenses. LandScan Global is copyrighted. LandScan USA has not been released by the Department of Homeland Security. A patent application was submitted for LandScan USA after my departure, and it is pending. I am one of four patent applicants.

LandScan is ideal for certain purposes, but no existing database suits all. The utility of LandScan Global could be improved by finer spatial resolution, and some steps in that direction are underway. The land-cover database, for instance, has progressed from Advanced Very High Resolution Radiometer (1 kilometer) in 1998 and 2000 to MODerate Resolution Imaging Spectroradiometer (500 meters) in 2001 to Landsat Thematic Mapper (30 meters), which covered much of the world in 2004 and most of the world in 2005. LandScan Global continues to improve through increasing use of databases that are more "local" in scale, though often less "global" in coverage. Because of updates and improvements in the resolution of land cover and other input variables, population estimates within a province may appear to "move" about when compared to earlier versions of LandScan. Hence, users are warned not to make such temporal comparisons. If a village location is corrected or an urban boundary is adjusted through imagery analysis, people appear to "migrate" when, in reality, there was no spatial redistribution at all.

For many types of risks, LandScan could be improved by finer temporal resolution, foremost by distinguishing daytime and nighttime distributions. Progress in doing so for the entire globe will demand more ancillary databases at finer resolution than presently available. LandScan is designed for first responders, whose greatest need is for in situ populations in real time. It stops, however, at the onset of each incident and has no capability to monitor changes that occur during and immediately after an unfolding incident. LandScan has many actual and potential applications in social, economic, and environmental analyses, but it has no capability to project populations forward or backward. Caution must be taken in certain types of modeling to ensure that output variables, such as land cover, are independent of LandScan's input variables.

The Center for International Earth Science Information Network's (CIESIN) Gridded Population of the World (GPW) was originally developed to study land use and land cover in relation to population densities. It has been used to study the distribution of population density by altitude (Cohen and Small, 1998) and in biodiversity hotspots (Cincotta et al., 2000). The GPW was also used to estimate global populations at risk from volcanic hazards (Small and Naumann, 2001) and from coastal hazards (Small et al., 2000; Nicholls and Small, 2002), though it clearly does not meet the resolutions needed for tsunamis. Each grid cell (2.5 minutes by 2.5 minutes) is 25 times larger than a LandScan Global cell, and 2,500 times larger than a LandScan USA cell. The principal difference between the two models is that GPW employs a cartographic interpolation of population data only, while LandScan employs a dasymetric interpolation of population data plus distance to roads, slope, land cover, and (formerly) nighttime lights. Nighttime lights are no longer used because they underestimate poor people, overestimate energy-rich people, and unrealistically spread urban populations through "overglow"—the spread of city lights to surrounding areas.

GPW version 3 projects populations out to 2015. Globally, GPW includes more administrative units, many of whose digital boundary files are precise enough for georegistering with GPW cells but not with the finer LandScan cells. GPW's uniform distributions uninfluenced by other variables make it less precise and therefore less suitable for real-time emergency management and humanitarian relief applications. These same characteristics, however, coupled with its multi-temporal projections make it more suitable for visualizing provincial-level population changes through time and for many types of geographic analyses exploring causal relationships between population distribution and other geographic factors such as land cover, terrain, and transportation.

LandScan is approaching the limits of what can be accomplished with current global databases. An alternative approach developed by Dobson, Peplies, and Dunbar would create building occupancy coefficients that can be multiplied by building area once the location and type of buildings are known for any given disaster. This approach reduces the need for additional ancillary data, relying instead on fieldwork to collect building occupancy coefficients, which vary considerably by region and type of building, plus fieldwork or image interpretation to measure buildings. The approach has been tested through fieldwork in the United States, East Africa, northwestern South America, the Middle East, the Balkans, and East Asia.

It is technically feasible to conduct a co-verification analysis of building occupancy (field-based, bottom-up) against LandScan (census-based, top-down) at the finest level of individual LandScan cells. Both databases need verification and validation, and this can best be accomplished by comparing their results for a statistically valid sample in any given region. Each database could be a check against the other, but no such analysis has been done.

RECOMMENDATIONS TO THE FEDERAL GOVERNMENT

1. First, do no harm. Continue to fund current efforts at present levels or greater.

2. Assign principal responsibility for global population geography to a single federal agency that will then be its champion.

3. Promote and establish global population estimates and fine-resolution spatial distributions as an essential element of national security, economic security, emergency management, and humanitarian relief. Consciously tailor the collection of databases to provide appropriate spatial, temporal, and attribute characteristics for a wide range of applications.

4. Establish continuing programs for financial support of researchers in demography, population geography, and settlement geography. All three fields are essential to progress. Population estimation is now a labor of love practiced long term only by those who are willing to sacrifice for their science or the good of the nation. A principal goal of this committee should be to establish a regular basis for funding to advance the science, retain established expertise, and recruit new expertise into this vital effort.

5. Support the development of ancillary data that are essential to the improvement of population databases. Key examples include the following:

- *Administrative and census geometry:* Accurate boundaries are required in every effort aimed at improving population geography. Boundary databases are numerous in cyberspace, but most are spatially inaccurate and dated. The United Nations International and Administrative Boundaries Group is making an effort in this area through its Second Administrative Level Boundaries (SALB) database, but much more work needs to be done. The boundaries produced by the National Geospatial-Intelligence Agency (NGA) are usually spatially accurate, but they are limited in coverage especially for higher-order boundaries.
- *Land use:* Land use must be inferred from land cover, with additional fieldwork and field verification in every region of the world.
- *Land cover:* At a minimum, satellite imagery must be classed by land cover type.
- *Nighttime lights:* At present, nighttime lights are a by-product of meteorology programs, and the resulting spatial resolution (1 square kilometer) and temporal resolution (multiple observations aggregated for periods as long as two years) are far too coarse. Addressing populations at risk justifies a satellite sensor of its own at a spatial resolution approaching that available for land cover (30 meters) and a temporal resolution approaching real time.

6. Support fundamental research to determine what constitutes appropriate reference data for accuracy assessment and the fitness-for-use of population databases at various spatial and temporal resolutions.

7. Disseminate all population databases and certain key input databases through easily accessible web sites, restricting only those that are deemed to be security threats.

8. Design and execute a training program for worldwide deployment of essential technologies, databases, and models to first responders, coordinators, planners, and policy makers for real-time use in disasters.

9. Recognize that population estimation requires scientific advancement and should rank among the most important research priorities in the national interest. Efforts need to be devoted, for example, to exploiting the enormous, ongoing explosion of data (imagery and textual information) in a timely fashion using high-performance computing.

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ORGANIZATIONAL IMPEDIMENTS TO ESTIMATING POPULATIONS AND ACQUIRING, ACCESSING, AND USING POPULATION DATA

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INTRODUCTION

Population data are vital for decisions made in national and international policy, business and marketing, economics, disaster response, military operations, health planning and response, sustainable development and many other arenas. Some activities are impossible to conduct without population estimates. The flow of population information includes acquisition of raw data, refinement and analysis of these data to produce some type of database, storage and distribution of the data, access to the data by the user community, analysis for some specific purpose, supply of the analysis to the customer, and the development of new questions or requirements for the data; these new questions or requirements track their way back through the chain so that new or refined applications can be developed and produced and, ultimately, new requirements for the data articulated. At each stage of this process, organizations of one type or another participate. The manner in which these organizations participate affects the availability, quality, and the ultimate use of the data.

The charge given me by the Committee on the Effective Use of Data, Methodologies, and Technologies to Estimate Subnational Populations at Risk was to identify the limitations of current institutional structures in using existing demographic and other data and tools for estimating subnational populations. This question is broad, and the population data flow described above is used here to help provide structure to the answer. In addition, I was asked to make specific comments on the U.S. Department of State's (DOS) and the U.S. Geological Survey's (USGS) activities with regard to population data. Thus, broad community and specific agency questions are to be addressed.

In order to address the broad question, I received input from more than 25 people representing the USGS, DOS, Center for International Earth Science Information Network (CIESIN), Oak Ridge National Laboratory (ORNL), Centers for Disease Control and Prevention (CDC), U.S. Bureau of the Census, a number of other federal agencies, some academics, and members of other organizations. Input was received by responses to e-mail questions, direct interviews, and telephone interviews. The people with whom I discussed this topic are experts in their respective fields and represent producers and users of population data. I also sought and received input from the specific agencies about which I was asked to comment. This paper contains detailed information on several specific agency programs using population data and concludes with comments about the flow of population data and institutional impediments to that flow.

CONTEXT IN WHICH THE DATA ARE USED

Not surprisingly, population data are used for a wide variety of applications. In the DOS, for example, data can be used as a basis to brief policy makers at all levels up to and including the Secretary of State, Congress, and the President. At the USGS, data are used to identify how the hazards of the natural environment are likely to affect the social environment. I discuss below in more detail these two agencies' needs for population data.

DEPARTMENT OF STATE

Diplomacy is conducted in a variety of settings. Some of these are at the negotiation table, in public fora, in private conversations, or at high level meetings. Often demographic or other population data are needed to develop and support policy positions. Within the DOS, the Bureau of Oceans and Integrated Environmental and Scientific Affairs (OES) uses population data when assessing the human impact of deforestation in Africa and Latin America and applying geographic information systems (GIS) to public health issues in the western hemisphere. The Office of E-Diplomacy (E-Dip) is working with the Bureau of Intelligence and Research (INR), along with other offices, to promote the use of geographic information, including imagery, and GIS throughout the DOS. GIS applications abroad, including at embassies and our other foreign missions, need to incorporate into their databases subnational population and related socioeconomic data.

Although the DOS has a number of people trained in demographics, they work in other fields, and the DOS has hired another person with training and experience in population and demography to work specifically as a demographer. This work is in constant demand to provide high-quality demographic analysis to the Population, Refugees, and Migration Bureau and technical liaisons with UN demographers. This is an important positive step in improving the technical skill base in the DOS. However, the great demands on time for this work hinder application of these professional skills as a demographer to many other population- and demographics-related issues elsewhere in the agency. Limited technical staff and tools further preclude the DOS's ability to evaluate much of the existing data or to conduct more sophisticated analyses that could address some pressing issues such as making better estimates of national and subnational populations.

Application of Population Data

The DOS uses population data to meet many policy demands. The depth and intensity of use vary from bureau to bureau depending on the issues being addressed and access to the skills and technology to address them. Local to regional population counts are needed to respond adequately to natural disasters such as earthquakes and landslides or to social conflicts. The genocide problem in Darfur was officially recognized in 2005. Part of the analysis needed at the time required identifying the locations of ethnic groups within and around the region. The only map of the area available to analysts that described the ethnicity of the population was produced in the 1950s. This 50-year-old map was central to the analysis, yet was without doubt highly inaccurate in representing today's population distribution and composition. Many other countries lack recent, accurate population data that can be tied to modern maps.

Subnational population data do not apply only to disaster response situations. For example, GIS-based subnational population data are needed to track the population of the Solomon Islands for hazard mitigation, resource allocation, and economic development. The Solomon Islands have approximately 550,000 inhabitants distributed among 6 major islands and more than 900 smaller islands. Understanding the distribution, age profile, education level, and other characteristics of the population would be useful to help the government identify pools of potential workers and convince international investors to strengthen their positions in spice growing and the vanilla trade, and to establish other industries to avert the spread of poverty and possibly the spread of crime. Similar population distribution characteristics are required when implementing programs to promote the development of civil society, target public diplomacy campaigns, and provide support for elections at local levels.

Regional population studies or integrated regional analyses should be conducted on a continuing or frequent basis not only to ensure current population data but to obtain more in-depth information about the population. Maintenance of population databases must include updated information about population composition, social dynamics, availability of and access to societal and environmental goods and services, and the myriad of attributes and relationships affecting or affected by the region.

The crisis in Darfur is a good example in that it has resulted in a large refugee population and even larger population of internally displaced persons (IDPs). Often in times of crisis, women and children are sent away while husbands and fathers remain to protect their homes and property. Understanding and modeling this phenomenon will help identify certain populations at risk in certain types of situations. A sound understanding of the culture is important because all cultures do not respond similarly to crises or humanitarian assistance.

The DOS regularly makes use of available counts or estimates of those in need of humanitarian assistance for the purpose of identifying potential beneficiaries of aid, but at the same time there is poor knowledge of resident populations and local services, making it difficult to assess the environmental and social stress caused by large numbers of displaced persons. This limits the department's ability to track the distribution of resources and to ensure that aid is reaching those for whom it is intended.

Monitoring reconstruction and post-conflict conditions is of importance to policy makers as well. Subnational population information is critical here because variations in redevelopment among ethnic groups may be an indicator of continued internal stress and diversion of resources, internal policies of discrimination and repression, or other conditions that can lead to nutrition and health problems. Imbalance in reconstruction can result in dissatisfaction within the population leading to the reemergence of conflict. While not yet clear how a subnational geospatial population data set could be used for the analysis of trafficking in persons or other human rights violations, some testable hypotheses could be developed with such a database to attempt to monitor these issues.

In conclusion, at the DOS, population data are required for policy making, planning, and making operational decisions. The data could be part of the planning process to respond to complex humanitarian emergencies, to understand development needs, to monitor environmental impacts, to improve medical response, and to respond to natural disasters. The department also provides assistance to refugees and monitors elections, migration, and the status of women, and evaluates nations on such issues as trafficking in persons, human rights, and the nutritional conditions of inhabitants. All of these are population-related issues, though all might not use the same database.

U.S. GEOLOGICAL SURVEY

The USGS has very program-specific uses for population data. The USGS uses population data primarily in three programs, Prompt Assessment of Global Earthquakes for Response (PAGER), Volcano Disaster Assessment Program (VDAP), and the Famine Early Warning System Network (FEWS NET), and is considering using population data in other programs. Population data are also used by the USGS in a number of projects and experiments including urban dynamics modeling, local hazard and risk analysis, and response to specific Earth events such as the 2005 landslides in Pakistan. The USGS has incorporated population data into some of its databases, such as the Global GIS. Furthermore, USGS land-cover data are used by developers of population databases to help refine and disaggregate national data into subnational estimates. This paper concentrates on two programs, PAGER and FEWS NET, to describe the manner in which the USGS consistently uses population data.

Application of Population Data

PAGER. The system PAGER, a cooperative project with the U.S. Agency for International Development (USAID), is designed to transmit alarms by pager, mobile phone, and e-mail that include precise estimates of impact. The information transmitted includes earthquake location, magnitude, depth, an estimate of the number of people exposed to varying levels of shaking, a description of the region's fragility, and a measure of confidence in the systems impact assessment. Associated maps of shaking level, population density, and susceptibility to landslides are posted on the Internet. This information is made available within minutes of the determination of the earthquake's location and magnitude. Earthquake solutions are generally available within an hour for significant events, and improvements to the real-time earthquake detection system will soon decrease the response time to as little as 15 minutes (Earle, 2005).

Although the information processing and flow are straightforward, the scientific work to develop accurate shake maps is highly complex, involving understanding of the geologic setting, geophysical processes and properties, and overlying earth materials. Understandably, the accuracy of the shake maps is highly variable depending on the knowledge of regional geology. PAGER relies on established population databases to identify the vulnerable population; it then generates an impact statement by considering the fragility of the exposed population and infrastructure, the potential for earthquake-induced landslides, and if available, damage reports from nearby historic earthquakes. PAGER uses ORNL's LandScan database for population estimates. Scientists on the PAGER team indicate that both LandScan and the CIESIN population databases are important and should continue to be updated and developed (Earle, personal communication, 2006).

When the March 28, 2005, earthquake struck northern Sumatra three months after the great tsunami of 2004, the data from the then-experimental

PAGER analysis were transmitted to the first responders within three hours of the event. Those data provided the basis to prepare flight plans so helicopters could depart on rescue missions at dawn after the earthquake.

FEWS NET. While PAGER is designed for response to rapid-onset disasters (e.g., earthquakes), FEWS NET is a multi-organization, international program designed to address and prevent disaster from a slow-onset hazard, famine, in 26 participating nations in Africa, Central Asia, Central America, and the Caribbean. Funded by USAID, FEWS NET is designed to strengthen the abilities of participating countries and regional organizations to manage the risk of food insecurity by providing timely analysis and early warning and vulnerability information. FEWS NET develops and uses analytical tools to combine data on climate, meteorology, hydrology, soils, land cover, vegetation, topography, agriculture, and other variables to develop forecasts of future food security conditions and provide warnings in case of pending food security issues. Although FEWS NET will continue its role in monitoring and warning about food security problems, it is increasing efforts to identify underlying causes of food insecurity and provide that information to policy makers (FEWS NET, 2006). Because the ratio of population to available food varies from place to place and time to time, and can result in localized food shortages, better subnational population estimates are critical to this effort.

FEWS NET is truly a partnership among the nations and communities involved. Advanced analytical systems have been developed by all partners and have been contributed to the program. In addition, cooperative activities at the community level have produced maps and atlases to which communities have contributed. This involvement by potential users of the warnings has the potentially positive result of leading to more informed use of FEWS NET. The analytical modules are updated as improved data become available.

FEWS NET uses the LandScan database, population data from CIESIN, and population data derived directly from participant nations. With the exception of a few governments that sometimes do not want to release existing national or subnational population data for political reasons, FEWS NET managers have not noted many other substantial institutional barriers in getting access to existing population data. Insufficient funding remains a major issue for conducting censuses in many of the nations within FEWS NET.

Weaknesses in the data can result in very inaccurate assessments of food availability, food import, and food needs. For example, whether Zimbabwe has 13 million or 10 million residents, after massive emigration to South Africa and elsewhere, has a huge impact on what the country's government will have to import to supplement its failed harvests and what the donor community may have to plan to supplement and distribute. Such large magnitudes of potential error may be costly in terms of direct expenditures, nutritional stress on vulnerable populations, loss of livelihoods, (Eilerts, personal communication, 2006), and for decisions on where to ship food once it is in country.

INSTITUTIONAL IMPEDIMENTS TO POPULATION DATA FLOW

As outlined earlier, the flow of population information includes acquisition of raw data, refinement and analysis of these data to produce some type of database, storage and distribution of data, access to the data by the user community, analysis for some specific purpose, supply of the analysis to the customer, and development of new questions or requirements for the data; these new questions or requirements track their way back through the chain so that new or refined applications can be developed and produced and, ultimately, new requirements for the data articulated. This section outlines barriers within institutions that restrict aspects of this data flow scheme.

Availability

Due to lack of available subnational population data, specific questions from planners and field personnel have gone unanswered. This has led to additional costs, compromised activities, and in some cases, the failure of projects. In some instances the data have existed, but the lack of corporate knowledge of their availability has prevented their use.

Acquisition of Raw Data

1. The physical acquisition of population data in some subnational regions can be difficult and hazardous. For instance, in March 2006 a number of people were killed in ethnic violence as Nigeria started a five-day census. Religious, tribal, and regional rivalries resurfaced in several states as nationally appointed enumerators rioted when local authorities fired them and substituted their own officials. The violence stemmed from anger that the census would not record ethnicity or religion. The census fueled mistrust over the distribution of oil wealth and constitutional reform. Methods must be developed to obtain reasonable estimates of subnational population characteristics, including ethnicity, religion, tribal affiliation, and other attributes, in spite of difficulties caused by regional, national, and local conditions.

2. Lack of data below the provincial level and data gaps at the intra-urban (neighborhood) level have made detailed humanitarian aid and other socioeconomic planning difficult. Increased emphasis on subnational

population estimates specific to urban areas is a growing concern, particularly as an increasing global population becomes more urbanized than at present.

3. Obtaining specific census data by districts or quarters for a foreign city or village is extremely difficult. National- or provincial-level census data do not have the fidelity to provide the information needed for detailed analysis or planning. Also, frequent changes in administrative boundaries pose problems in reallocating populations if population data are not available at the appropriate scale.

4. Legal and political considerations place limitations on the sharing of not-yet-aggregated population data.

5. Thresholds of chronic and acute malnutrition and infant mortality rates are a major influence in the prioritization of perceived emergencies. The basic population data that drive calculation of these rates, in many of the most critical areas, are not very robust.

6. The U.S. government should work more closely with nongovernmental organizations to help obtain the necessary data. This partnership should include increasing access to existing data, tapping into existing surveys to extract data, and helping to design new surveys to obtain needed information.

7. Highly detailed population data are occasionally made available to embassies by host governments. It is not clear that these data find their way into databases or are available for use by analysts or operations personnel outside the embassy.

8. Some international organizations (e.g., the World Health Organization) are required by their position to report only the data released to them by countries, which can lead to extremely inaccurate databases. In many countries, this problem has been exacerbated by a combination of inaccessible terrain and a lack of international interest outside times of crisis that has quelled any initiative for population data gathering.

9. In truly large and socially diverse countries, great differences in exposure to risk can exist among internal population groups. The development of subnational population databases would be extremely helpful in these situations to delineate exactly which segments of the subpopulation are truly "at risk."

Requirements and Analysis of Data for Database Development

1. Land-cover data sets such as USGS Global Land Cover 2000 derived from the Advanced Very High Resolution Radiometer satellite and other sources, North American Land Cover derived from Landsat and other sources, and GeoCover LC, a commercial land-cover database derived from Landsat, are critical to refining global population databases. However,

the age of the data, their resolution, land-cover classes, and interpretation are problematic despite advances with additional analysis, high-resolution imagery, and application of geographic expertise. A global high-resolution land-cover database produced to the appropriate standards and specifications would be helpful for producing more accurate subnational population databases. Such a land-cover database should be updated periodically to reflect the rapidly changing land-surface environment. More frequent updates should be made in regions vulnerable to disasters and social upheaval.

2. Numerous development assistance programs require gathering of population, health, natural resources, and other data. No standard interoperable procedures exist for the data, data collection, or data sharing. These data usually do not reach official, organized databases and may be lost to the U.S. government. These assistance programs, funded by USAID and others, should be required to provide their data to a centrally operated repository to be archived and distributed, particularly since many data may already be supported by taxpayers or donors.

3. As storage media and technology change, data must be converted to the new storage and retrieval systems for their long-term survival. Both current and legacy data sets must be maintained. Some possible options for storage are the Library of Congress and the USGS Earth Resources Observations System (EROS) Data Center, both of which have experience in maintaining and refreshing large amounts of disparate data and have been established to store and manage information for the long term.

4. The International Programs Center of the U.S. Census Bureau maintains an international database containing population estimates and projections at the national level for more than 227 countries and areas. This database is updated to reflect the receipt of new data and changes in trends or methodologies. However, products for population estimates and projections are done on an ad hoc basis depending on the needs of clients. In addition, subnational population and demographic analyses, estimates, and other products are based on user requests and do not form a global database. A more effective approach for data maintenance and estimation of subnational populations would be to operate on a program basis with a consistent set of standards, specifications, methods, and revision cycle. A programmatic approach would help in establishing long- and short-term priorities as well, such as (1) performing comprehensive subnational population estimates for a group of predetermined high-priority countries on an appropriate periodic basis (in some cases annual), and (2) allowing the unit and its partners to mobilize quickly to collect and analyze subnational population data for a specific high-priority country on very short notice. Resources would be needed to accomplish this.

5. Refining data often requires ancillary data, including remote sensing and land cover, authenticated place names, current boundaries, and imper-

vious surfaces, and can be significantly improved at a highly detailed level with cadastral data. These types of data must be current.

Access

1. Online open-source population and census databases are easily accessible and can quickly be compared to other population databases. However, these comparisons are relative, not absolute. For example, the Population Reference Bureau (PRB) provides access to a wide variety of variables useful for analysis. The PRB also produces analyses on topics as varied as population and demographic change, immigration, health, morbidity, mortality, and many others. Yet PRB is not a portal with access to most geospatial population data and does not provide an opportunity to check spatial data against some accepted "known" data set.

2. One major obstacle involves host country government unwillingness to release population data for various reasons. Unfortunately, donors funding these kinds of studies often agree to these restricted release terms when working with a client government. Such behavior only perpetuates this impediment. If bilateral and multilateral donors funding census work would agree to use standard data release language as a requirement for all future censuses, the release of census data funded with donor resources could be ensured. This type of stipulation should be a requirement before signing an agreement to undertake data collection work.

3. Neither a clearinghouse nor a portal exists for access to all population data. Within the U.S. government these data could logically be housed at the Census Bureau, Department of Housing and Urban Development International Office, or USGS EROS Data Center. In addition, a reasonably comprehensive portal would be helpful in identifying overlaps and gaps in the data.

4. The U.S. government has no single arbiter of population data to evaluate the accuracy and other quality indicators of various data or to identify the best data for a particular application. Although the Census Bureau performs this role for the data under its purview, many data used by the U.S. government are produced by others and are not evaluated in the same fashion as those at the Census Bureau.

Analysis

1. The analysts' environment is high pressure. Results are usually needed on a short turnaround. Decisions that are made are often politically charged. Therefore, there is a tendency for analysts to use data and techniques that have been accepted in the past rather than take the risk of using a new data source or analytical technique that is not fully tested or understood. Here

again, population data experts who could keep abreast of new developments in data and techniques would be a valuable addition to the DOS team, whether they reside at the DOS, the Census Bureau, or elsewhere.

2. Much work is "just in time" and conducted by analysts with very broad portfolios. Not all analysts can be expected to be experts in population data evaluation; these data are among the many inputs to a wide variety of analyses that must be produced on short notice. Analysts must use the data that are available. Here again, expert vetting of population data in advance of a disaster or crisis would be useful.

3. Confidence in data quality is a great concern and can affect analytical results. In Africa, population databases at the subnational level are based almost entirely on estimates (at best). This uncertainty affects risk estimates. For example, an analyst must constantly overestimate the presence of infectious diseases, just to provide the safest assessment to the audience. This may lead to a distortion of actual disease risk and might encourage the channeling of humanitarian assistance resources or funding away from deserving areas and toward lower-risk ones.

4. The DOS has limited in-house capabilities to conduct population-related analyses and should raise the profile of and increase access to technical skills and resources in population, demographics, and other social sciences. One option is to emulate its current effort to reincorporate the physical and biological sciences, technology, and health into its programs. In that effort a number of internship and fellowship programs have been established to ensure that scientific expertise exists within the DOS and that links are maintained with the broader scientific community. Similar programs could be developed to expand the availability of technically trained demographers, population experts, and other social science technical skills into its personnel mix.

Provide Results

The value of analyses of population data can be improved by developing and using understandable ways to present the uncertainty of the analysis. The source of the uncertainty must be articulated clearly and may require improving the customer's understanding of the analytical tools and the types of data used.

Develop New Requirements and Standards

1. No systematic feedback mechanism exists to transmit potential user requirements for the data from the ultimate user of the data analysis (policy maker, strategist, response planner, responder) to those who analyze, acquire, and produce the data.

2. In many instances, no post-action analysis is conducted due to time limitations and constantly emerging issues. Post-action analysis might aid in improving decision making and the use of information to make future actions more effective.

Cross-Cutting Issues

1. Standard operating procedures for data collection and standards for data content, accuracy, acquisition, transfer, and interoperability should be developed. The Federal Geographic Data Committee; its international arm, the Global Spatial Data Infrastructure; and the Open GIS Consortium could provide models or a vehicle for developing standards for geospatial population databases.

2. Private producers of data are interested in selling the data for a profit; therefore, they divide the data into components to sell, while government producers generally provide the data at no or nominal additional cost to users because taxpayers have already borne the cost of data acquisition. Issues of trust, security, and cost arise when addressing the trade-offs between publicly and privately produced data.

SUGGESTIONS FOR CHANGES OR NEW CAPABILITIES

1. A repository for subnational data should be established. An entity within the government responsible for funding, collection, and storage of subnational data sets should be designated. With appropriate safeguards for privacy and security, access must be provided to original surveys from the many agencies and other organizations.

2. A catalog of subnational data sets held by each nation and the detail of these data should be created. For example: block-level census data should be available for any nation. Organization of ownership, content of data, and method of access should be included as part of the metadata.

3. Standards for data content, collection, quality, and format should be developed and used to ensure usefulness and interoperability. Requiring that funding be contingent on the use of these standards and providing the data to the appropriate accessible database or clearing house will help ensure conformity to the standards.

4. Collectors, policy makers, planners, and analysts should be educated on the importance and use of subnational data sets in their work.

5. Data collection and mapping companies and other entities such as LexisNexis, Environmental Systems Research Institute, Inc. (ESRI), Gallup, CIESIN, and ORNL should collaborate to obtain needed data.

6. Academic researchers should be engaged to conduct studies involving subnational data sets. Academia has the potential to access in-country information not otherwise obtained.

7. Access to demographic and regional studies, articles, reports, maps, and other documents produced by other countries should be improved. Translation services should be made available.

8. Regional population studies or integrated regional analyses should be reinstituted, modernized, supported, and funded as an important part of academia. As part of master's and doctoral studies, fieldwork conducted in particular regions should include mapping ethnicity, religion, and other cultural variables, as well as understanding the causes and effects of change in social, political, economic, health, and environmental conditions. The relationships between subnational populations and the broader regional contexts should be explored.

9. To help incorporate a variety of data sources and reduce costs of field data acquisition, modeling, statistical, and other analytical techniques should be used and improved. Attention should be placed on dynamic as well as static populations and the use and development of ancillary data to help improve understanding of what is taking place at the subnational scale.

10. A program for systematic global subnational population data collection and estimation, administered in the Census Bureau should be developed and funded. This should complement, not replace, the customer-driven, ad hoc, project-based subnational data collection currently in place. Recognizing that sufficient funds will not be available to acquire all of the desired data, such a program would work on a set of U.S. government-identified priorities, including a strong field collection and survey component, advanced estimation techniques, and a surge capacity for sudden-onset or unanticipated emergencies.

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POLITICAL GEOGRAPHY AND EMERGENCY RELIEF

Wm. Glen Lauber, National Geospatial-Intelligence Agency

When emergency relief is sent to a nation in crisis, responding organizations (foreign governments, nongovernmental organizations [NGOs], or the United Nations [UN]) often learn that the government accepting their aid does not have adequate data in a usable form to identify all administrative subdivisions and all populated places. Without these data, aid agencies do not know where precisely to send aid, resulting in prolonged suffering and the potential for additional illness and mortality.

Political geography should be part of the mitigation strategy for emergency preparedness. Relief agencies must know immediately what places are affected and what they are called. Villagers probably do not know the geographic coordinates of their village; they know the local village name, but this name may not be recognized by the government. If relief workers cannot find a name or the area of an administrative subdivision on a map, in a gazetteer, or in a geographic information systems (GIS) database, that place may not receive aid.

The proper place from which to develop these types of standardized geographic data is at the level of individual countries. Place names reflect millennia of culture, language, and history and rouse strong feelings in people so these names should be established and standardized by countries themselves. Well-designed databases with variant names and approved boundaries will limit the confusion for aid workers in emergency relief efforts and contribute toward generating and maintaining better estimates of subnational populations.

UN mechanisms already in place should be engaged to exhort those nations to toponymic and boundary-depicting action. This paper introduces and briefly discusses possible avenues for addressing the inadequacy of geographic place names and political boundary data in countries worldwide. Addressing these fundamental issues will aid in removing some of the structural impediments to organizations dispersing emergency aid and will facilitate international, national, and private efforts in making and retrieving population estimates that are part of emergency relief plans.

STANDARDIZATION OF GEOGRAPHICAL NAMES

The Mechanism

The best international organization to address worldwide geographic names standards is the UN Group of Experts on Geographical Names (UNGEGN, pronounced ŭn-gŭ-gŭn).[1] The UNGEGN mission, derived from UN resolutions recognizing the importance of geographic name standardization, is as follows:

> a. To provide encouragement and guidance to those nations which had no national organization for the standardization and coordination of geographical names to establish such an organization and to produce national gazetteers at an early date;
>
> b. To take the necessary steps to ensure the functions of a central clearinghouse for geographical names, including: the collection of gazetteers; and the tion concerning the technical procedures adopted by Member States for standardization of domestic names, and concerning the techniques and systems used by each Member State in the transliteration of the geographical names of other countries.[2]

According to UNGEGN approximately 25 percent of nations have a national authority for standardizing geographical names.[3] Many authorities were established since 1990 and remain immature. Three authorities can trace their toponymic roots to the 19th century (Canada, Norway, and the United States). Not documented but well known is the paucity of resources these authorities have to develop and make accessible a complete record of their place names. UNGEGN documentation makes it obvious that developing countries constitute the majority of countries without a names authority. Although all countries make maps of their land, without a place name authority to document and catalog place names according to a standard, the data will be incomplete and conflicted.

The UN recognized the importance of names standardization in 1948 and held the first Conference on the Standardization of Geographical Names (UNCSGN) in 1967

> to encourage national and international geographical names standardization; to promote the international dissemination of nationally standardized geographical names information; and to adopt single romanization systems for the conversion of each non-Roman writing system to the Roman alphabet.[4]

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[1] *http://unstats.un.org/unsd/geoinfo/ungegn.htm.*
[2] *http://unstats.un.org/unsd/geoinfo/mandate.htm.*
[3] *http://unstats.un.org/unsd/geoinfo/nnasummary.pdf.*
[4] *http://unstats.un.org/unsd/geoinfo/mandate.htm.*

The UNCSGN formally established UNGEGN in 1972 (an ad hoc group had been meeting since 1960) "to carry forward the programme of cooperation between conferences."[5]

To accomplish its task, UNGEGN is organized into 22 divisions of geography and linguistics,[6] and 10 working groups on topics and issues of toponymy.[7] Among the working groups are Publicity and Funding,[8] Training in Toponymy,[9] and Toponymic Data Files and Gazetteers.[10]

The Funding

UNGEGN is organized to promulgate place name standardization to as many countries as possible but is not funded for an aggressive campaign. The various divisions are urged to seek grants and search out other sources to fund training in their part of the world.

The Training

The typical UNGEGN course in toponymy lasts for 12 days including a day of field collection. The subject areas include the following: Functions of Official Geographical Names, UNGEGN Resolutions, National Geographic Names Authorities, Language Issues, Technical Issues and Toponymic Research, Cartography and Geographic Names, Field Work Preparation, International Issues, Toponymic Data Files, and Databases and Gazetteers.

The faculty is drawn from UNGEGN members through funding from either the UNGEGN Secretariat or a member country.

The Data

One UNGEGN principle is free access to all names data. Nations are perfectly willing to grant public access to their names for many economic and cultural reasons. The problem is implementing data access solutions that are useful for both routine and emergency situations.

Much work is yet to be done in this area. At its meeting in March 2006 the UNGEGN Working Group on Toponymic Data Files and Gazetteers recognized that relief organizations have specific needs; UNGEGN has agreed to achieve progress in this area by the ninth UNCSGN in August 2007 in New York.

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[5] *Ibid.*

[6] *http://unstats.un.org/unsd/geoinfo/ungegndivisions.htm.*

[7] *http://unstats.un.org/unsd/geoinfo/ungegnwgroups.htm.*

[8] *Ibid., see working group number four.*

[9] *Ibid., see working group number six.*

[10] *Ibid., see working group number two.*

The UNGEGN Secretariat[11] has initiated a project to develop a distributed database of place names, starting with national capitals and cities with a population of 100,000 or greater. The secretariat will not be ready to handle all places for some time. It relies on UN member nations to have their own digital database it can access. The United States and the United Kingdom will contribute their considerable experience in this field.

The Efforts of the United States

The U.S. Board on Geographic Names (BGN)[12] is responsible for the official U.S. government names of foreign places as well as U.S. places and maintains the official U.S. government database of foreign place names[13] as a publicly available resource.[14] Part of the BGN plan to improve the database's detail and currency is to train foreign countries in toponymy and help them maintain their capability, in exchange for access to their toponymic data files.

The BGN has been providing toponymy training to a limited number of foreign governments. This work continues in Latin America through the Pan American Institute of Geography and History (PAIGH),[15] and elsewhere directly with foreign governments.

The Proposed Way Ahead

- Government relief agencies and NGOs concerned with emergency relief and UNGEGN divisions and working groups should engage each other to create useful solutions to the problem of inadequate place-name data in emergency areas.
- NGO and UN Development Programme (UNDP) grants should be awarded to fund training, and government foreign aid should be allocated to the startup costs of national names authorities.
- Grants and aid should be awarded for a standard but flexible data management solution addressing routine and emergency management requirements.
- The International Organization for Standardization should be engaged to aid in standards development.

[11] *http://unstats.un.org/unsd/geoinfo/pubscontact.htm.*
[12] *http://geonames.usgs.gov/bgn.html.*
[13] *http://geonames.usgs.gov/foreign.html.*
[14] *http://gnswww.nga.mil/geonames/GNS/index.jsp.*
[15] *http://www.ipgh.org/english/.*

Financing is also an issue. Many governments have already invested a great deal of money over 130 years to reach the current data level. Continued funding for these efforts is necessary to make the suggested improvements.

ACCURATE GEOSPATIAL DEPICTION OF INTERNAL POLITICAL BOUNDARIES

The Mechanism

A leading resource for the science of political boundaries is the International Boundaries Research Unit[16] (IBRU) of Durham University in the UK. No UN equivalent to UNGEGN exists for political boundaries. The UN Geospatial Information Working Group[17] (UNGIWG, pronounced ŭn'-jē-wĭg) addresses boundaries but is only six years old and has other tasks as well.

Accurate and acceptable geospatial depiction at varied scales remains a challenge in work with political boundaries. Both IBRU and UNGIWG should be engaged by emergency relief organizations to help address administrative boundary inadequacies. Both organizations should be asked to lead the closing of the standards development gap.

IBRU was established in 1989 to "enhance the resources available for the peaceful resolution of problems associated with international boundaries on land and at sea, including their delimitation, demarcation and management."[18] Its chief contribution to this problem would be to host workshops providing training.

UNGIWG was created in 2000 to "address common geospatial issues—maps, boundaries, data exchange, standards—that affect the work of UN Organizations and Member States."[19] It answers to the UN Systems Chief Executives Board for Coordination[20] (CEB). Its mandate stems from the UN Economic and Social Counsel Resolution 131 (VI) of 1948. Most UNGIWG work to date focused on international boundaries, and only at 1:1,100,000 scale.[21] In 2001, UNGIWG began work on the world's first and second administrative order boundaries, also at 1:1,100,000 scale.[22]

UNGIWG Task Group 1 addresses international and administrative boundaries. Its objectives are to "provide the UN community, and when

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[16] *http://www-ibru.dur.ac.uk/index.html.*
[17] *http://www.ungiwg.org/index.htm.*
[18] *http://www-ibru.dur.ac.uk/index.html.*
[19] *http://www.ungiwg.org/about.htm.*
[20] *http://ceb.unsystem.org.*
[21] *http://www.ungiwg.org/inter.htm.*
[22] *http://www3.who.int/whosis/gis/salb/salb_home.htm.*

possible the international community, with validated information and maps regarding international and administrative boundaries for all the UN member countries."[23]

As with the proposed UNGEGN names database, the issue of scale is problematic with regard to UNGIWG. However, member nations would be valuable contributors if they were able to provide reliable data at larger scales, such as 1:50,000 or 1:24,000. Organizations such as UNGIWG will be left to guide the development of standards for the accurate geospatial depiction of administrative boundaries at a variety of scales.

The Funding

IBRU would have to be paid,[24] and UNGIWG would require additional funding to move beyond offering just one, small-scale administrative boundaries data set.

The Training

IBRU could be contracted to conduct workshops worldwide. UNGIWG does not offer boundary analysis training but should be invited to participate as a party interested in having more countries capable of sharing reliable data.

The Data

Much work is needed to make accurate and acceptable geospatial depictions of boundary data, particularly data that traditionally have been maintained in either textual form or undocumented historical memory. Even before the advent of widely available GIS, the large-scale cartographic depiction of boundaries was contentious and open to widely varying interpretations.

Treaties were traditionally vaguely written to a small-scale map on the conference table. Small-scale treaty description frustrates accurate large-scale geospatial depiction. Many countries face this problem in today's world (e.g., Eritrea and Ethiopia; Israel and Syria). Digitized depictions of a segment of boundary from different hard-copy sources will vary widely when displayed together on a GIS. The world must establish a set of standards for accurate and acceptable interpretations of a boundary between points in a treaty in a large-scale environment.

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[23] *http://www.ungiwg.org/inter.htm.*
[24] *http://www.dur.ac.uk/%7Edcm0www/DF/ibru.htm.*

The Efforts of the United States

The U.S. Department of State and the National Geospatial-Intelligence Agency work to establish the recognized U.S. government depiction of international and administrative political boundaries, consistent with the treaties each government accepts. They have recognized the need and accepted responsibility for developing large-scale geospatial boundary depiction standards for U.S. government use. Their work will significantly impact political boundary science.

The Proposed Way Ahead

- Government relief agencies and NGOs concerned with emergency relief should engage UNGIWG and IBRU to create useful solutions to the problem of inadequate administrative boundary data in emergency areas.
- UNGIWG and IBRU should support the Department of State and the National Geospatial Intelligence Agency (NGA) by acting as the test beds and mediators for negotiating acceptable standards.
- NGO and UNDP grants should be awarded to fund training, and government foreign aid should be allocated to the startup costs of national boundaries authorities.
- Grants and aid should be awarded for a standard but flexible data management solution addressing routine and emergency management requirements.
- Grants and aid should be awarded for the promulgation of large-scale boundary analysis standards.

Administrative boundary definition and depiction comprise a tougher problem than standardized place names. Countries seem less willing to share boundary information, and are perhaps reluctant to expose internal disagreements that might imply a weakness. Emergency relief agencies and organizations will have to convince these countries that it is in their best interest to share these administrative boundary definition and depiction data. The boundaries do not need to be declared definitive; they have always been subject to change. The boundaries do have to be accurate and acceptable for use in a large-scale environment.

CONCLUDING REMARKS

Disaster preparedness is not sexy, and memories of poor preparedness do not last long in the minds of political leaders and their constituents. Attention is quickly drawn to response and recovery. The money appropriated for improved preparedness is usually spent on visible items such as fire and rescue equipment, and not on the data required to efficiently direct those and other physical resources that NGOs and other relief agencies send.

Given the difficulty in garnering support for response requirements, it is critical that response agencies find a long-term economic solution to the problem of inadequate geographic place names and political boundary data.

UNGEGN, IBRU, and UNGIWG are a credible nexus for addressing the problems. They hold expertise, prestige, and an infrastructure directly applicable to these issues. A network should be built around them offering additional resources that would serve not only crisis needs but also the long-term good.

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IDENTIFY WAYS IN WHICH SUBNATIONAL DEMOGRAPHIC AND GEOGRAPHIC DATA COULD BE USED TO HELP DECISION MAKERS PROVIDE USEFUL INFORMATION TO POPULATIONS AT RISK

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INTRODUCTION

Over the past several decades, natural disasters have become more frequent, and the populations affected by disasters annually are following a similar and increasing trend (IFRC, 2003). The growing impact of natural disasters has triggered a need to enhance the understanding of vulnerability and to improve both the quality of data and the management of information that guides the humanitarian response following disasters. Disasters and the subsequent humanitarian response have a large impact on population well-being, and it is important that relief and recovery efforts be adequately informed in order to target assistance appropriately and facilitate recovery.

Modeling population vulnerability and risk in natural disasters and post-disaster assessments of surviving populations enables governments and humanitarian organizations to make rapid, informed decisions under conditions of great uncertainty (McEntire, 2001; Kunreuther, 2002). Post-disaster surveys of affected populations that incorporate aspects of population movements, needs assessment, living conditions, and health data with spatial modeling are ideal tools for providing information on disaster vulnerability and impact and have a practical role in assisting governments and humanitarian organizations in disaster response by promoting informed management and decision making. Information generated from these approaches can also inform rehabilitation, mitigation, and preparedness. The advantage of using modeling before or immediately after a disaster is that it can help target and guide post-disaster activities, including surveys, to obtain higher-quality data for consequent analysis. Current advances in spatial data organization, including the availability of analysis with geographic information systems (GIS), provide an opportunity for improvements in rapid assessments as well as rapid analysis and dissemination of findings to governments and organizations involved in the ongoing disaster response (Herold et al., 2005; Mansor et. al., 2004; Zerger and Smith, 2003; Chen et al., 2003; Simonovich and Nirupama, 2002).

HUMANITARIAN INFORMATION SYSTEMS

Humanitarian Information Systems (HIS) constitute an essential element of the response to emergencies because they provide a basis for decision making. This is particularly critical in the chaotic early stages of disaster response where priorities must be established in order to quickly reduce the impact of the disaster on those affected and save the most lives. Conventional HIS components include early warning systems and response monitoring. Early warning systems identify the processes that trigger emergencies, while response monitoring supports the management and delivery of relief. Early warning systems usually focus on the size of the hazard; the impact on populations according to vulnerabilities is a weaker part of an early warning system. Tying this anticipated impact to specific vulnerabilities and providing this information to responding governments and international organizations are the functions of the information system, in which innovative informatics play a critical role.

The initial early warning response is the nucleus from which the full HIS will grow; it is constantly adjusted and reshaped as the disaster and the response unfold. The information system plays an important role in tracking the ongoing response to ensure that it effectively meets the needs of all vulnerable populations. New vulnerabilities develop as the response unfolds. An effective evidence-based system can track these as they emerge and alert responders to intervene. While HIS are critically important in disaster response, a variety of factors have been identified as limiting their utility including the ineffective and inefficient use of existing tools or methods, difficulties in accessing information, and the fact that HIS are often poorly linked with decision making, resulting in untimely or inappropriate responses (Buchanan-Smith and Davies, 1995). As a result, information systems that are put into place to help guide emergency response are often incomplete, ineffective, or inefficient (Maxwell and Watkins, 2003).

AVAILABILITY OF SUBNATIONAL DEMOGRAPHIC DATA

Demographic information is often provided on a national basis, but global environmental and other cross-disciplinary studies usually require data at the subnational level. Ideally, subnational demographic data are referenced by geographic coordinates, such as latitude and longitude, rather than by political or administrative units. In practice, major limitations exist in the availability and quality of subnational demographic data. In many cases, subnational population figures are outdated and incomplete; have been collected using imperfect methodologies; or were developed using unknown models. However, in many instances, particularly in the post-disaster context, decision makers are forced to rely on the best available information, regardless of methodological constraints. In addition to problems that may arise due to the quality of population data, subnational demographic information is typically provided by an administrative unit, which may create challenges when describing populations at risk or affected by disasters because disaster-prone regions are seldom congruent with administrative boundaries.

A recent innovation and resource for characterizing populations at risk of and affected by disasters is spatially distributed demographic data. Gridded Population of the World version 3 (GPWv3) and the Global Rural-Urban Mapping Project (GRUMP) are the latest developments in the rendering of human populations in a common georeferenced framework and are produced by the Center for International Earth Science Information Network at Columbia University (see *http://Sedac.ciesin.columbia.edu/gpw/*). GPWv3 depicts the distribution of human populations across the globe. GRUMP builds on GPWv3 by incorporating urban and rural information, allowing new insights into urban population distribution of human settlements. Spatially distributed demographic data from GPWv3 and GRUMP are based on the most recent available demographic data and face similar data quality constraints as those discussed in the preceding paragraph.

Developed between 2003 and 2005, GPWv3 and GRUMP provide globally consistent and spatially explicit human population information and data for use in research, policy making, and communications. In the pre-disaster context, GPWv3 and GRUMP, when combined with environmental risk models, can serve to estimate the population at risk of disaster. This information is equally important in the post-disaster context where it can be used to verify estimates of affected and surviving populations in need of assistance (which often vary significantly by organization and time and can be highly inaccurate).

ASSESSMENT OF POPULATION STATUS AND VULNERABILITY

The availability of spatially distributed demographic data allows for the quantification of the population at risk of or affected by a disaster; however, it does not provide an indication of the status of the population or of humanitarian assistance needs in the post-disaster context. Assessment of surviving population status and conditions immediately following the disaster is an essential HIS component that should occur in the earliest phases of the disaster response. In many disaster situations, integrated needs assessments and population surveys that are representative of the entire affected population are not conducted or are implemented using inappropriate methods. The result is a dearth of information or inaccurate information that complicates decision making and planning of the humanitarian response. In addition to methodologically sound assessments of the status and needs of the disaster-affected population, the spatial distribution of selected indicators of population needs and status is an ideal means of providing information for decision making to governments and international organizations involved in the response.

Concentrating humanitarian response on the most affected populations requires an analysis of vulnerability and needs. The desire to focus assistance on the most vulnerable is based on the assumption that they have the least capacity and resilience to deal with sudden change, uncertainties, and other disaster-associated impacts. Identification of vulnerable groups is essential because characteristics of vulnerable populations vary by disaster and relate to a combination of social and environmental factors. An integrated approach to the examination of environmental and social risks in the natural disaster context is ideal.

Combined assessments that incorporate environmental risk models with post-disaster population surveys that characterize population status and social risk factors are ideal because vulnerability to disasters is related to both human and environmental conditions. Spatial modeling of environmental risk factors can identify the levels of impact across disaster-affected areas. Human factors in vulnerability include social and demographic variables such as population age structure, sex, and socioeconomic status; the latter encompasses education, occupation, and other measures of social and economic status such as wealth or membership in certain group.

Environmental risk models can be combined with spatially distributed subnational demographic data to provide an initial characterization of disaster-affected populations. In the post-disaster context, combining environmental risk models with population status and needs data (from surveys of disaster-affected areas) can aid in identifying at-risk and vulnerable populations that require humanitarian assistance. The integration of post-disaster survey data with GIS allows the mapping of populations that report specific needs or substandard living conditions; it can facilitate the identification of population subgroups and geographic regions that are particularly at risk and can be used to guide disaster response.

DATA VISUALIZATION SOFTWARE

Data visualization software can help to present information on post-disaster population status and humanitarian assistance needs to decision makers and those involved in disaster response. An example of one data visualization and spatial statistics software package that is freely availably is GeoDa (see *https://geoda.uiuc.edu/default.php*), which was developed by the Spatial Analysis Lab at the University of Illinois, Urbana-Champaign. By employing visualization software, users have interactive access to a vast amount of information that is displayed in a more readily understandable form. For example, spatial analysis of demographic data can help identify regions where a particular event or need is concentrated. Information can be presented spatially, either by rates or by accounts per administrative unit, which can help to guide the disaster response. This approach targets geographic areas (for example, through visual display of unmet needs or reported service access) or age- and gender-specific population subgroups as an event density. Identification of particular population subgroups in this manner may delimit those who are at risk for certain outcomes such as a disease or malnutrition.

CONCLUSIONS

The integration of spatially distributed demographic data with environmental models of disaster risk and vulnerability allows for enumeration and mapping of the population initially at risk of disaster. This is particularly important in developing countries where current and reliable subnational demographic data are not available. In addition to estimating the affected population, maps of buffer zones of disaster impacted areas, when applied to spatially distributed demographic data, provide a reference population (those exposed to immediate hazard) that not only can be considered in the design of post-disaster population surveys and impact assessments but also can delineate areas for future disaster mitigation and preparedness activities.

Post-disaster assessments are highly varied in methodology and outcomes. Key limitations to assessments in the post-disaster context relate to lack of accurate information on the size and location of the surviving population. Logistical difficulties in the rapidly changing post-disaster context can further limit the ability to make these assessments and include the destruction of infrastructure, limited availability of qualified personnel, transportation, cultural and linguistic barriers associated with working in foreign and unfamiliar environments, and other complications. Ideally, these assessments are population-based surveys that employ appropriate sampling methods to select a representative sample of individuals or households from a larger reference population. In most contexts, the sampling frame comprises displaced disaster survivors and key indicators including morbidity, mortality, living conditions, and immediate survival needs. Estimates of surviving and displaced populations are generally available from local governments and the United Nations in the post-disaster context and serve as the basis for many assessments and the planning of humanitarian assistance.

Spatially distributed demographic data, environmental risk models, and population-based assessments of disaster-affected regions are important tools that can aid decision makers in characterizing vulnerable populations and humanitarian assistance needs in the aftermath of disasters. Integrated assessments that incorporate environmental and social risks, indicators of population status, and spatial data are ideal for the identification of population subgroups and regions that are particularly vulnerable and in need of humanitarian assistance. Recent developments in GIS and spatial analysis, including spatially distributed demographic data and data visualization software, should be considered as new and innovative tools for the communication and provision of information on populations at risk of disasters as well as those in need of humanitarian assistance in the post-disaster context.

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COGNITIVE AND INSTITUTIONAL LIMITS ON COLLECTING AND PROCESSING DATA ON POPULATIONS AT RISK: PRELIMINARY REFLECTIONS ON SOUTHERN AFRICAN RESPONSES TO DISPLACEMENT

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INTRODUCTION

This paper explores how cognitive and institutional structures limit researchers', policy makers', and service agencies' efforts to collect and process critical information on mobile and displaced populations. It begins from the assertion that policy and research in all fields are shaped by assumptions and institutional structures. These boundaries, along with practical difficulties, embedded sets of ethical values, and institutional imperatives, work together to shield key aspects of vulnerable populations from consideration.

This paper explores two concerns related to displaced populations in southern Africa. Although sound research design, representative sampling, and objectivity are the hallmarks of good academic and policy-oriented research (Jacobsen and Landau, 2003), those of us attempting to meet these standards quickly discover that research soundness has little to do with our influence on policy and practice. This is generally frustrating for academic researchers and becomes even more so when the research is commissioned by governments and aid agencies. When our research is used, it rarely serves to challenge potentially faulty fundamental principles or to introduce previously unrecognized dimensions of potentially vulnerable subgroups. Instead, we often find it merely serves to refine or harden existing policy parameters. Indeed, commissioned research is often of such limited scope that it could hope to do little else. Such tendencies seem all the more pronounced in discussions of vulnerable subpopulations in times of crises. The narrow scope of data collection and the underuse and abuse of data emerge from a combination of institutional and cognitive constraints. Using examples from research and policy making regarding refugees in southern Africa, this paper outlines some of the most significant ways in which the close relationship between policy discussions and research limits our ability to learn about displaced persons.

The remaining pages proceed through four stages in highlighting the institutional and cognitive limits on production and consumption of knowledge on migration, displacement, and humanitarianism in southern Africa. The first draws on sociological treatments of formal organizations and (superficially) literature on the philosophy of science and construction of academic knowledge. The second segment discusses how stylized and incomplete information—often taking the form of unverifiable or unverified "truths"—exerts particular power in discussions surrounding immigration and asylum. The third section identifies five tenets that reflect and shape public attitudes, policy making, and research on displacement in southern Africa. Although many of these are empirically suspect, they are deeply embedded within cognitive schema and continue to shape parameters of debate. The paper ends by suggesting a pragmatic and critical approach to research on displacement and humanitarianism that recognizes (and challenges) our own cognitive limitations and the mechanisms through which knowledge is processed, consumed, and implemented as policy.

Much of the following analysis is based on personal experience gained through participation in primary research, analysis, and policy discussions on migration, displacement, and humanitarianism in eastern and southern Africa. In particular, I draw on research and discussion with policy makers and aid workers during a year and half of fieldwork in western Tanzania (1999-2000) and through my role at the Forced Migration Studies Programme in Johannesburg and as chair of the executive committee of South Africa's National Consortium of Refugee Affairs. In these latter roles, I have had opportunities to interact extensively with migrants, service providers, advocates, and government officials from throughout southern Africa. Many of the findings reported here are drawn from this participant observation in professional meetings and workshops with government officials in local, provincial, and national governments. They are, as such, incomplete impressions and should be read as provocations for consideration, not as firm conclusions.

ORGANIZATIONAL AND COGNITIVE LIMITS ON RESEARCH AND POLICY

In emergency situations, policy makers and operational agencies often justifiably complain that the lack of sound information on the populations they are trying to assist compromises their decisions. The scarcity of data is problematic—a point I return to later—but even when data are available, values and political priorities are often equal determinants of policy outcomes. Value systems are, after all, the keys to present problems that need to be solved and that provide many of the criteria for evaluating possible solutions. Where political systems are fragile and legitimacy is scarce, local leaders may see emergency assistance primarily as a political, not a humanitarian, resource. The greater the symbolic currency at stake, the more likely are such factors to determine an outcome, although such criteria may be hidden by post hoc justifications couched solely in technical terms. These are rational outcomes—based on considered cost-benefit analysis—but outcomes that result from priorities different from those held by international agencies and donors. Understanding outcomes requires that we account for them.

The values informing various policy fields add symbolic value to responses and frame the range of "legitimate" policy options. In domestic and international humanitarianism, elements of this normative framework are visible in legislation, treaties, and principles (e.g., SPHERE standards). The Sphere project aimed at developing minimum standards for humanitarian relief operations (for further information, see *http://www.sphereproject.org)*. Reflecting the language of the 1951 UN Refugee Convention that established it, the office of the UN High Commissioner for Refugees (UNHCR), for example, will often ignore any aspect of humanitarian assistance that is considered overtly political or developmental. The research the UNHCR commissions similarly focuses on displaced persons' short-term "protection" needs, leading to a focus on emergency settings. Moreover, the UNHCR focus is almost entirely on those areas in which humanitarian action is likely: camps and border-areas. The fragmentation of agencies and organizations into those concerned with health, sanitation, security, or food creates further analytical boxes in which questions are framed and answered. Coordinating bodies may partially transcend these divisions, but they also bring with them interests and cognitive limitations. Given the close relationship between research and policy in the humanitarian field, these paradigms or *problematiques* often serve to identify problems worthy of scholarly attention. This has been well noted in studies of "development," where dominant policy discourses define a set of concerns and metrics for measuring progress (see Escobar, 1995; Leys, 1996; Ferguson, 1994). Such frames are often even more important in humanitarian fields where the framework for data collection is compressed and the evident need to save lives overrides careful conceptualization and other considerations. That the language and policy that characterize southern African responses to asylum seekers so evidently echo those in Europe, Australia, and North America, illustrates the power of discourse in shaping policy frames. Regardless of their precise origins, researchers wishing to say anything about immigration or asylum cannot dodge these considerations but consider how the parameters of these paradigms shape research questions, findings, and dissemination strategies.

Contesting institutionally embedded wisdom is, of course, easier said than done. Most importantly, it requires levels of self-awareness that elude many researchers. Those explicitly working on behalf of government or aid agencies may, moreover, have few reasons to challenge the paradigms in which they work. For those without the financial security that such affiliations provide, stepping outside paradigmatic boundaries may mean losing crucial research funding and exclusion from research forums. Such exclusion may be formal and conscious, or it may occur simply because analyses asking unfamiliar questions or using unusual methods become unintelligible to policy makers. Paradoxically, the more specialized and trained the consumers are, the narrower and more formulaic is the information they require, whether that information takes the form of economic indicators, epidemiological projections, or meteorological readings. Their training and relative isolation within specialist departments can create situations where those with the authority to make decisions and positive change "often cannot even conceive of appropriate alternatives" (Powell and DiMaggio, 1991:11). Rather than draw on "radical" analyses to question the principles underlying policy (or the ways they make decisions), organizations are far more likely to "muddle through"—to make minor adjustments in the face of failed policy in ways that leave structures and imperatives intact (see Lindbloom, 1959; Haas, 1990; Crozier, 1964; Argyris, 1982).

There are also significant limitations on organizations' ability to process the information they do collect. Simon's (1957) work on "bounded rationality" describes a tendency to "satiscfice": for decision makers to accept the first plausible or acceptable solution rather to consider a range of alternatives and likely outcomes. Cohen et al.'s (1972) "garbage can" metaphor of decision making in which organizations are bins filled with concerns looking for solutions, solutions looking for issues to which they might be attached, and "decision makers looking for work." The consequence is that policy prescriptions and problems are attached due to a mix of chance and calculation. Where decisions must be made quickly, chance will consistently trump calculation. This does not suggest chaos or total randomness within organizations or agencies that collect and process data on vulnerable subpopulations. Rather, it argues that there are always random elements and institutional constraints on how questions are framed and how they are answered. While these tendencies are present within all policy fields, they deserve particular attention in attempting to develop effective, evidence-based responses to humanitarian crises. Through its discussion of limitations on research and policy discussions on migrant populations in southern Africa, the following section illustrates these limitations and variables.

HEIGHTENED CONSTRAINTS IN MAPPING DISPLACEMENT

No policy arenas exist in which scientific inquiry consistently dominates symbolism, values, and political priorities. Although further consideration would reveal others, this paper speaks of four primary reasons why cognitive limitations, bounded rationality, political legitimacy, and institutionally embedded assumptions are particularly likely to shape research and analysis of displaced populations. Schmidt (2005) raises many of the points discussed here in a broader discussion of the relationships between researchers and the displaced, policy makers, and aid agencies.

1. *Information is scarce and practically difficult to collect.* Conventional wisdom is difficult to dislodge even when confronted with the most scientifically compelling, empirical counterevidence. Armed with patchy or irregularly collected data, the chances for effectively challenging policy presumptions are further limited. Southern Africa's shortage of trained demographers and migration specialists is partially to blame for this (e.g., Global Commission for International Migration, 2005). However, the region's social transformation coupled with its extended, highly porous borders makes it all but impossible to conduct accurate surveillance of human movements. As elsewhere in the world, people making these journeys often have compel-

ling reasons for remaining bureaucratically invisible (e.g., to avoid deportation, harassment, or discrimination). This applies not only to the millions of economic migrants within the region, but also to refugees who wish to avoid being warehoused in camps for years on end. Domestic migrants or those who have been internally displaced may have fewer reasons to hide, but they are also less likely to traverse established surveillance sites (e.g., borders, immigration check points) and are unlikely to encounter relatively well-resourced aid agencies that have incentives to count them. Moreover, states often actively suppress the numbers of internally displaced persons within their borders in an effort to promote their international legitimacy.

The challenges of generating good information are not limited to monitoring. Developing accurate projections on migration and displacement patterns would not only mean counting those on the move, but coding those movements in ways relevant to the policy discussions. These may include determining if individuals are involved in circular, seasonal, or permanent migration, and whether they are in transit, have been displaced or otherwise forced to move, or are simply tourists. It also means finding ways of predicting seasonal price fluctuations for labor and agricultural commodities, droughts, famines, wars, and other changes in broader economic and social conditions. Were resources available for this, the number of variables at work would limit any model's reliability and predictive power. At most, one might hope to derive generalized trends with limited predictive power.

2. *Accurate information about immigration and migration is not easily processed through standardized bureaucratic or political channels.* Many of the same reasons that make it difficult to collect and analyze information on migration—its unpredictability, its multiple causes and effects, the desire of those moving to remain invisible—make it tricky for planners to develop empirically informed policy responses. Scott's (1992) work on rational organizations—a category that includes most government bureaucracies and many large international agencies—is built on systems for regularly evaluating information and considering the consequences of various responses. Although few bureaucracies are as orderly as this model suggests, they nevertheless manage to filter out "noise": inconvenient or irregular information. The more irregular the information required for making sense of the outside world, the more difficult it is to process this information, and the more bounded the organization's rationality will become.

Given their organizational design, it is unlikely that governments and other large agencies could respond quickly and effectively even if able to overcome the practical problems of data collection and analysis. Budgetary and planning cycles, for one, make it difficult to prepare for populations that might arrive (or disappear). Perhaps more critically, the need for politicians to show short-term gains and policy responses makes it less likely that they will dedicate resources to building effective emergency response mechanisms when crises are so uncertain or may only be critical issues for their successors. Problems in responding to Hurricane Katrina illustrate the U.S. vulnerability to a surprise storm, despite prior efforts to coordinate its emergency response apparatus. In countries facing severe research scarcities—a category including most African states—the problems are even more acute. When a target population is not considered a political constituency, as in the case of migrants and refugees, the likelihood is even less that money will be earmarked for planning.

Researchers also suffer for the unpredictability that often characterizes instances of displacement. For academics, teaching and funding cycles make it difficult to be on the scene when refugees or flood victims arrive. Even for agency or organization researchers, the challenges of enumerating mobile populations tend to lead to rough estimates and a reliance on assumptions or experience gained elsewhere. Consequently, most representative research favors protracted humanitarian emergencies or resettlement schemes where the displaced are in relatively stable settings under conditions that are easier for outside researchers to navigate.

3. *Migration and displacement threaten deeply held values linking spatial origins with rights and identities.* Governments dedicate themselves to managing people and processes within a carefully defined geographic space: villages, municipalities, districts, provinces, or even countries. Such delimitations of authority and responsibility are not only administrative, but are often linked to more fundamental definitions of community. This is most obvious at the national level, where the politico-administrative distinction of citizenship reflects membership in a quasi-fictional nation, a group whose members claim almost exclusive rights to the country's territory and resources (see Arendt, 1958; Agnew, 1999; Malkki, 1992).

Under such circumstances, exclusionary social responses to newcomers claiming space and resources may degrade established legal protections, and people almost inevitably code and label those from outside their communities or countries as threats to prosperity, security, or sovereignty. As noted, the conflation of migration and security in the post-9/11 era means that we are limited both in the scope of our discussions and in our power to convince governments to break from the status quo unless we are advocating further restrictions on migration and asylum. That a migrant presence is so often blamed for political failings makes it *less* likely that politicians will support even the most well-informed policy prescriptions if they facilitate movement, provide migrants with critical social services, or promote economic and political integration.

The connection between migration and values also influences how researchers frame questions. Debates about whether immigrants have the right to continue female circumcision or genital mutilation, for example, are so difficult that many simply dodge the issue. Even choosing one term over another can unwittingly position a person on one side of a highly contentious divide. Elsewhere, commitments to promoting the interests of the displaced among hostile policy makers may cause researchers to ignore or suppress data that portrays these groups negatively. Those who do so, or wander into any other such contentious circumstances, must be prepared for attacks from their peers and colleagues. This may be less so with government- or agency-commissioned research, but here, too, the values of the organization are likely to influence the questions asked and the kinds of data produced. Perhaps most fundamentally, many researchers simply accept the unnaturalness of refugees and implicitly endorse strategies to restrict them to camps or otherwise limit their mobility and livelihoods. Failing that, displaced populations are often treated as anomalous populations disconnected from the people and places surrounding them. Because these analytical distinctions are almost never reflected empirically, their conclusions suffer, as does what is known about displaced persons.

4. *Academic and policy fields are interdependent.* The close connections between displacement scholars, policy makers, and aid agencies create mutually reinforcing interests. Those who help shape a government or aid agency policy are far less likely to criticize it. The tendency to defend progeny—whatever form they take—cannot be dismissed. Other researchers are well aware that producing a radical or even undiplomatically worded critique may be costly in terms of the response they receive, including access to research funding or consulting projects. Poorly paid African researchers—those potentially most attuned to the sociopolitical subtleties of a displaced subpopulation—are all the less likely to rock the boat.

In cases where "hard" information is absent, difficult to collect, or carefully managed by public (or private agencies), rumor, paranoia, and political pronouncements often replace carefully established and verified causal explanations. Indeed, without empirical substantiation, socially and politically derived imperatives are the only possible bases available for policy formulation. Even more normal research, however, is bounded by cognitive limits and presuppositions. Similarly, institutions are often ill-equipped to process information that challenges fundamental operational principles or takes on unfamiliar forms. The following section outlines some of the parameters that structure research and policy discussions around displacement in southern Africa.

PARAMETERS OF THE POLICY-RESEARCH DISCOURSE ON DISPLACEMENT IN SOUTHERN AFRICA

As the previous pages discuss, decision makers and researchers tend to see only what they have predetermined is relevant or important to their policy deliberations. The following paragraphs identify five key tenets that help frame research and policy on migration and displacement in southern Africa. In many instances these are myths around migration and displacement that are easily falsified through reasoned analysis. The point here is not whether these tenets are objectively true, but rather to illustrate that even when they are not, they frame discussions and establish a demarcation and nodal point within policy and scholarly deliberations. Although informed by my experience working in southern Africa, these tenets are likely to be familiar to those working elsewhere.

Tenet One: Immigration is Structured and Controlled by National Policy

Southern African immigration and asylum policies are founded on a misplaced faith in governments' ability to prevent cross-border movements. The focus on identity documents, detention, and deportation is illustrative of this, as is the need for asylum seekers and refugees to report regularly to designated offices. Due in part to this belief, recent discussions about harmonizing regional instruments have tended to shy away from facilitating movements and have instead put forward new measures to control them. These include, inter alia, proposals to create asylum seeker camps and a computerized database listing all people crossing borders, refugees and asylum seekers entering the region, so that individuals may be traced and prevented from "asylum shopping" or undertaking irregular movements beyond state regulation. Apart from the ethical problems with such propositions, there are few reasons to believe that any country in the region has the capacity to track such movements when so many citizens—who have few incentives to hide from the state's eyes—continue to live without identity documents and effectively outside of state regulation. The result is rather that migrants will find new ways of becoming invisible and the system will be further opened to corruption and irregularities (Landau, 2005). Perhaps more fundamentally, the widespread presupposition continues that national policy structures migration dynamics. Although policy is important, the power of law and the influence of policy are minimal throughout much of Africa. Rather, people tend to live largely outside state regulation. What comes to matter in these instances is the response of local leaders and peoples (Misago and Landau, 2005).

The focus on control and policy has also infiltrated the research community. The fixation on counting and identifying migrating population flows stems in part from a belief that doing so could help regulate and structure people's movements or is necessary for developing a policy response. While such information may be useful—if the ability exists to process it—policy deliberations in many other areas continue from equally shaky empirical foundations. Unfortunately, migrant flows tend to conform to something approximating the Heisenberg uncertainty principle where the act of counting and categorizing may change the nature of what is being studied. There is also a danger of creating legal categories for migrant populations (e.g., refugee, asylum seeker, illegal) that inappropriately draw attention away from commonalities and relationships among them (see Zetter, 1991). Most importantly, the assumption that migrant populations may best be helped through formal responses has drawn attention away from the tens of thousands of people who receive no such assistance and the factors influencing their reception by host communities.

Tenet Two: The Deluge

The fixation on control and regulation mentioned above in part stems from a sense that the region is being flooded by migrants and refugees. The ongoing conflict in the Democratic Republic of Congo, crisis in Zimbabwe, HIV/AIDS, and poverty-economic transformation throughout the region do, indeed, continue to spawn new movements of people. The fear of these movements, however, is often disproportionate to the numbers. This is most evident in South Africa where the unmanaged arrival of foreigners starkly contrasts with apartheid-era controls on human mobility. The government-funded Human Science Research Council's (HSRC's) alarmist figures of 2.5 to 5 million *illegal* immigrants continue to shape public discussion, despite the council's formal retraction (Crush and Williams, 2001). That the HSRC figures remained on the Department of Home Affairs (DHA) web site throughout Mangosotho Buthelezi's term as minister (1994-2004) is indicative of how research confirmed deeply held suspicions and was then used to justify them. That said, government officials have not restricted themselves to such "scientific" data, but have independently begun citing figures of between 7 and 8 million "illegals" in the country. These elevated numbers (and their presumed effects on everything from crime to food prices) have justified a series of disproportionate responses. Botswana has, for example, recently erected an extended electrified fence along its border with Zimbabwe, ostensibly to prevent the spread of hoof and mouth disease. South Africa continues to make plans to establish refugee camps—something prohibited except in cases of mass influx—among other efforts to restrict the movement and rights of nonnationals.

While South Africa's economic liberalization and regional integration have added new dimensions to the region's long-standing patterns of labor migration (see Rogerson, 1995), more objective analysis reveals figures of a different order of magnitude. The most recent census (2001), for example, indicates that there were 345,161 non-South African Africans in the country. Although this is certainly an undercount, the total number of foreigners is likely to be 500,000-850,000 (Crush and Williams, 2001); this number is possibly slightly higher now, given the trouble in neighboring Zimbabwe. These figures are significant, but by no means overwhelming. Similarly, widely touted, figures of 2-3 million Zimbabweans in the country are simply implausible (2-3 million represents more than 20 percent of that country's population). Even in those urban neighborhoods most affected by immigration, only one-quarter of the population (at most) is foreign born (Leggett, 2003). This represents a sizable increase compared to a decade ago, but hardly compares with cities like Toronto, Canada, where more than 40 percent of the *total* population is foreign born. However, perceptions—not carefully considered estimates—shape policy. Data on other countries are even harder to collect, opening additional space for myths and paranoid pronouncements.

The disparities outlined above have a threefold significance. First, through constant repetition, the elevated figures have taken on the status of Truth, something all but impossible to dislodge. In meetings where policy makers, bureaucrats, and the police are asked to justify their presumptions, they either simply reply that they know, refer to other government documents estimating migrants, or cite outdated and discredited scholarly studies. The HSRC report outlined previously features prominently in these discussions. The second reason these discussions are important is with regard to the way policy makers use research to legitimate already-known truths. In this instance, numerous studies—including some by their own statistics bureau—have been ignored simply because they do not reach findings that resonate with long-standing presumptions. When these studies are acknowledged, policy makers demonstrate an uncharacteristic awareness of their methodological limitations and dismiss them as undercounting the number of foreigners. In such instances, officials will almost always draw on anecdotal evidence of a neighbor who is employing an illegal domestic worker or of a relative who was robbed by a Zimbabwean. The last point I wish to raise through this example is how this fixation on numbers has served to structure the nature of research. Efforts continue on the part of Statistics South Africa and others to provide more precise estimates of the numbers of foreigners. Few, however, have asked whether such precise information is needed or if the South African government has the interest or capacity to respond to anything other than rough estimates. The fixation on numbers and on categorizing migrants by legal status has drawn attention away from other issues related to the composition and dynamics of migrant communities.

Tenet Three: Refugees Are Inherently Needy and Vulnerable

Not surprisingly, attitudes toward refugees and other migrants are often contradictory, with these tensions reflected in both policy pronouncements and research. Within this discourse, refugees and immigrants are implicated in destabilization of the region's economies while fostering crime, disease, and other social ills. Paradoxically, the power they exercise is rooted in their presumed vulnerabilities and inability to care for themselves. These sentiments were evident early in the post-apartheid era when, in his first speech to parliament following his appointment as the South African Minster of Home Affairs Mangosuthu Buthelezi reflected (and helped frame) such beliefs by proclaiming: "If we as South Africans are going to compete for scarce resources with millions of aliens who are pouring into South Africa, then we can bid goodbye to our Reconstruction and Development Program [RDP]." He went on to argue:

> The employment of illegal immigrants is unpatriotic because it deprives South Africans of jobs and . . . the rising level of immigrants has awesome implications for the RDP as they will be absorbing unacceptable proportions of housing subsidies and adding to the difficulties we will be experiencing in health care. (Reitzes, 1994)

Such perspectives are also present at the local level. In his State of the City 2004 address, for example, Johannesburg's executive mayor argued:

> In keeping with the international trend of growing migration, our city has become a magnet for people from other provinces, the African continent and indeed the four corners of the world. While migrancy contributes to the rich tapestry of the cosmopolitan city, it also places a severe strain on employment levels, housing and public services.

In countries where 40 percent or more of the population is unemployed, an inevitable result is some resentment against any group that may potentially fill jobs or push down the price of labor. However, little evidence exists that migrants are either needy public wards or stealing jobs from South Africans. Although mine and agricultural labor (formally imported through formal guestworker schemes) have disempowered South African workers and unions, new immigration patterns appear to be increasing job opportunities for South Africans. Wits University research in inner-city Johannesburg, for example, found that non-South Africans were far more likely to have hired someone to work for them in the past year than the South Africans amongst whom they lived. While just 20 percent of South Africans report having paid someone to do work for them, 34 percent of migrants surveyed had. Even more significantly, more than two-thirds (67 percent) of those hired by migrants were South Africans. Hunter and Skinner's (2003) work in Durban also identifies a positive economic impact from immigration, and the city government has adopted policies that allow nonnationals to apply for street-trading permits. Bakewell's (2000) work on self-settled refugees in Zambia confirms the potential benefits of displacement for host communities. Internationally, there is evidence that immigration provides a net benefit to national economies, although some groups are always likely to face negative consequences (see Simon, 1995; Smith and Edmonston, 1997).

Little evidence has been presented to back claims that nonnationals represent a significant drain on the state's financial resources. Summarizing work done in South Africa and elsewhere, Meintjies (1998:20) reports:

> Immigrants are, in fact, net contributors, not parasites. Immigrants are, on average, healthier, more energetic and better educated than people in the host population. Consequently, they draw comparatively less on social welfare and other social services. Many pay tax and, through their entrepreneurship, make a positive injection into local economic development.

In the South African context, refugees are more likely than other immigrants to make such contributions for the simple reason that while Zimbabweans and Mozambicans can easily enter the country, those from elsewhere must already be endowed with resources for extended travel. This creates a selection bias in favor of the wealthy, educated, and entrepreneurial. This is not to deny that the presence of additional people—whatever their origins—can burden public services. However, given the relatively small number of immigrants using these services—and their ability to contribute economically—it makes little sense to single them out as a primary cost to government or a threat to South Africans' economic prospects. Throughout the region, cities are struggling to manage burgeoning populations, but most of those coming to the cities are citizens. Local capacity and budgets are not being overwhelmed by immigrants and refugees.

Regardless of refugees and other migrants' actual impact on the southern African economy, the dual presumptions that refugees are inherently needy or vulnerable and steal jobs continue to shape how scholars produce and disseminate information about refugees. Much of the debate around migrants generally is about whether they have a positive or negative impact on South Africans. Such a question cannot be answered definitively and depends largely on the level of analysis and the metrics used (see Landau, 2003). Moreover, given the extraordinary dynamism within the region, identifying the impact of a single variable on the economy is almost impossible. Wherever possible, advocates will try to minimize the costs to host societies out of fear that this will harden attitudes (and policies) toward refugees. Paradoxically, many of those working in the field—whether in academia or on behalf of aid organizations—share assumptions about vulnerability or have interests in highlighting the need to enhance funding flows to cash-starved assistance programs. Research commissioned by aid agencies certainly tends to look for instances of exploitation and marginality. Since little other research exists on communities living in remote or inhospitable areas, these findings give an impression of generalized vulnerability. Many policy-oriented researchers, even when they see self-sufficiency and adaptation, are unwilling to publish work highlighting refugees' economic capacities out of fear that this will cause them to be classed as economic migrants or will reduce funding for assistance programs. The result is an almost bimodal portrayal of refugee populations. In some forums they are economic assets (or at least not liabilities), on the other hand, they are a vulnerable population that will not survive without external assistance.

Tenet Four: Women Are Universally Victims of Displacement

Nowhere is the discourse of vulnerability more pronounced than in discussion of refugee women. As the numbers of unaccompanied women (i.e., those without spouses or male offspring) increase, so too have deliberations around trafficking, prostitution, and collapsing families. Without denying the risks women face during displacement, assumptions are made about women's experiences that blind both policy makers and researchers to aspects of their realities. These blinders are not surprising given the bias toward research in refugee camps and settlement schemes, sites that disproportionately attract vulnerable women. Assumptions of vulnerability, however, often cause scholars to overlook the active role women play in the migration process.

New research is slowly drawing attention to a broader range of women's experiences and revealing activities that have previously been invisible or that reframe vulnerability in more empowering language. While scholarship on female migration often speaks of women moving only after urging from male relatives or after being abandoned by them (see Gugler and Ludwar-Ene, 1995; Adepoju, 1995), many women (refugees and otherwise) in the region's urban centers independently chose to move and have done so without male guardianship (Kihato, 2005; Raimundo, 2005; Sander and Maimbo, 2003; Adepoju, 2006). Sexual networking provides an additional example. Although such activities present considerable dangers in an era of HIV/AIDS, many women speak nonchalantly about their ability to generate income. As Augustin (2005:378) notes, "Many thousands of women who more or less chose to sell sex as well as all women working in domestic or caring services are 'disappeared' when moralistic and often sensationalistic topics are the only ones discussed." Others simply speak about how displacement has freed them of patriarchal demands levied on them at home. Even women's stories of vulnerability and victimization can be valuable resources. Given their audience's expectations, the articulation of predictable narratives of violent exclusion and hardship—whether founded or false—may elicit sympathy, material resources, or other economic opportunities.

Tenet Five: Migration Policy Is Only a Concern of National Governments

In describing the character of the nation-state system, Arendt (1958:279) writes that sovereignty is nowhere more absolute than in matters of "emigration, naturalization, nationality, and exclusion." Indeed, there continues to be a widespread belief that as an issue of state sovereignty and international relations, immigration and asylum policy should be formulated and implemented solely by national government departments. However, as political decentralization and devolution continue, responsibility for responding to refugees and asylum seekers is, de facto, being transferred to the local governments already charged with overseeing and spearheading community development. Although there are examples of cooperation among government officials across the range of departments and levels (e.g., interministerial committees, links between the army and the police), responsibility for the immigration and asylum regime remains a matter almost fully within the bailiwick of the national government The tendency of international agencies to deal only with ministries enforces these boundaries.

Apart from the inability of national governments to respond at the local level, this tenet has implications for the way research is conducted and disseminated. Throughout the region, the focus of policy deliberation remains almost entirely regional or national, and researchers associated with these processes tend to focus only on aggregate statistics and blanket policy considerations. Rarely are efforts made to disaggregate refugee populations and to map spatial variations in gender, age, experience, or vulnerability. Where localized studies exist, the data they generate are typically proprietary or difficult to integrate with similar studies elsewhere. Similarly, little research attempts to integrate local considerations into national policy debates. Cape Town and Johannesburg have begun considering how migration may affect local planning, but they have yet to dedicate significant resources to understanding the dynamics of refugees and asylum seekers living in their cities. Elsewhere in the region—where resources and researchers are scarcer—efforts have been even more minimal. Perhaps more importantly, the continued international focus on camps and areas receiving international aid draws researchers away from what may well be larger numbers of self-settled refugees whether in urban or rural settings.

CONCLUSION: HOW DO WE LEARN (MORE) ABOUT MIGRANTS AND DISPLACED PEOPLE?

There is no easy way to conduct research on displaced or mobile populations. The movements of such people are almost impossible to predict, although we could do better. That the populations are so highly dynamic—normal death and birth rates combined with special health risks and mobility—make it almost impossible to create reliable data sets with a shelf-life of more than a few weeks. In addition to these obstacles, we must negotiate hostile or unsupportive leadership and find funds to support our work. Our efforts may also be stymied by host governments, aid agencies, and refugees who all have reasons to distort the size and character of these subpopulations themselves. Making projections may be possible, but given the variables at work, their accuracy is far from guaranteed. Overcoming the technical obstacles also does little to ensure that the data generated will provide a holistic view on the populations concerned. Moreover, experiences can lead researchers to believe that the more comprehensive and timely the data produced, the less likely it is to be used to influence policy decisions.

Rather than ending with specific suggestions on improving how data are collected and used, I wish to conclude with three generalized recommendations.

1. *Work toward mechanisms for objective tracking of forced migration while recognizing the limitations of such measures*. Accepting that displacement will continue means developing institutional mechanisms within the African context that treat it as a normal rather than truly exceptional phenomenon. This not only means coordinating emergency response institutions, but creating technically equipped research teams with ready funding that can be deployed rapidly to emergency situations and to areas where displaced populations are living.

2. Rather than relying on politicians and or self-interested operational agencies to generate estimates of migration and its impacts, *efforts are needed to train population scientists that can collect longitudinal and comparative data throughout the region*. In South Africa, for example, there are fewer than 20 full-fledged demographers; the number in Mozambique can be counted on one hand. Most of these have little expertise or interest in migration, but instead focusing on fertility and mortality. There is, therefore, a need to bolster local expertise. This expertise should not, however, be in technical demography alone. In order to meet the objectives outlined above, training and research must pair those with technical demographic skills with those with skills in anthropology and organizational sociology. Until these groups work together, it is unlikely that researchers will be in a position both to identify and to challenge the parameters of existing approaches. Moreover, by complementing demographic analysis with studies of organizations and institutions, we may better target our dissemination strategies in ways that may positively influence policy and practice for the benefit of vulnerable subgroups.

3. To move beyond existing lines of inquiry or promote institutional adaptation (rather than learning), *scholars must identify the social and*

political *arrangements that buttress the existing policy and research regime.* Simply producing new data is not enough; there is also a need to consider what is motivating the creation of myths, their propagation, and their maintenance. Challenging these tenets means learning to present information that is at once legible to institutions—private, public, academic, or activist—but does not simply confirm that which they already know. As a corollary, there are good reasons to move beyond simply generating empirical information about migration—although this is certainly critical—and include efforts to trace how those data are produced and used. To do otherwise may provide scholars with short-term influence and professional benefits, but may risk our long-term effectiveness in assisting the displaced.

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STRENGTHS AND LIMITATIONS OF INFORMATION AND DATA ANALYSIS IN RESPONDING TO CRISIS IN MALI

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INTRODUCTION

Given the natural disasters that Mali has experienced since the country's independence in 1960, one might expect to find a real culture of preventive measures or of response to these events. Empirical evidence of the practices of Malian societies with regard to handling such crises leads to the conclusion that, in fact, responses to them are rarely foreseen.

Over the last 45 years to which we refer, two examples come to mind in relation to ecological crises and famine where research shows that the events were not anticipated. First, the cyclical nature of drought in the Sahel (the sub-Saharan African region) did not encourage early research to develop specially adapted seed varieties. The same delay was evident with regard to research on social behavior and practices to facilitate improved management that could have preserved the natural environment, despite demographic pressure that increases every year. Second, periods of food shortage have not led to the development of techniques to transform and conserve food supplies to ensure that surplus production could cover times of food shortage. To date, research in this sector is still at its early stages.

The conclusion relating to research concerning the management of ecological crisis is equally valid for the social domain. Social crises often manifest themselves in the form of conflict in the primary sector. Farmers, herders, and fishermen are often in conflict concerning management of areas that are vital to their subsistence economies. Social equilibrium is permanently in a state of disruption and rearrangement. Traditional mechanisms to regulate conflict are disowned because of demographic growth. A more and more pronounced gap exists between national legislation ("Law in books") and the vital and practical rules determined by communities ("Law in action"). These developments challenge the responses applied to social crises. As a result, the responses do not seem to be adapted to the situation. In this context, more pertinent and durable approaches are needed.

The political and administrative domain is also responsible for failure to predict these crises. Populations expect that the centralized state will help them during times of natural catastrophe. In these regular natural crises, the state's duty takes the form of forecasting and planning. For exceptional events, responses are commensurate with the means available at the time of their occurrence. However, in the context of Mali, to a certain extent the inadequate nature of response to repeated ecological crises in the semidesert in the north, combined with lack of development of the state presence there, contributed to the rebellion that lasted for five years.

Whatever form they take, the crises and their effects generate a mass of information. Analysis of this information generates better knowledge relating to the crises and a deeper understanding. Data analysis can provide elements toward future forecasting. From these elements of forecasting, response strategies can be developed. While some countries or organizations can speak toward data visualization as one element of data analysis and distribution, the tools or technologies needed for visualization are largely not available in the context of Mali. Geographical information systems or global positioning systems are currently used by few research institutions. Visualization is not discussed further in this contribution.

This paper focuses on several central questions: What is the experience of Mali with regard to the crises experienced since the country gained independence? In which sectors do crises occur periodically? What types of information are used for prevention of crises? What information is used to produce responses? What methods are put in place to generate the data necessary to analyze these crises and to develop responses to them? What are the limitations of the available information or data? What approaches can we use to advance beyond current practices and methods?

STRENGTHS OF ANALYSIS FOR INFORMATION AND DATA IN RESPONDING TO CRISES IN MALI

Data collection and analysis in a poor, French-speaking country such as Mali were, until recently, limited to national-scale operations including the following, which were taken from a more exhaustive list:

- National Census of Population and Habitat (1976, 1998)
- Demographic and Health Surveys (1987, 1995-1996, 2001)
- Budget and consumption survey (1987, 1989)
- National household activity survey in 1989
- Continuous agricultural surveys

Other international and national institutions based in Mali produce information on samples of different sizes. Among the international institutions are the Famine Early Warning System (FEWS), the African Sub-Saharan Economic and Statistical Observatory (AFRISTAT), and the Sahel Institute.

Most of these institutions help national structures to produce one-off information or to do routine surveillance. They also produce data themselves, often at a subregional level, together with analyses and results.

Although in certain contexts such as famine, drought, and plagues of locusts, information generated at a macro level can be useful, in more localized instances, macro data present limitations that can make their use nearly impossible. The typical example is that of census details that are limited to a certain number of variables.

Faced with the AIDS pandemic, for example, orphans have become an increasing subpopulation. Mortality analyses from census data can give the proportion of orphans who have lost one or two parents. However, these data do not allow calculation of the proportion of children orphaned due to AIDS because cause of death is not a variable considered in the census.

The same considerations apply to social crises. Variable determining factors in the consideration of social conflicts are not always available at the time these occur. Numerous ethnographic or anthropological studies of the human groups in Mali's different regions do exist. However, the findings of these studies are little used in planning or decision making. A strong tradition of administrative or political decision making occurs and is rarely based on the results of studies; sometimes these decisions are the source of conflicts.

The most topical example is provided by the application of decentralization to Mali. According to Mr. Aboubacrine Ag Indi, technical adviser at the Commissariat for Institutional Development in Mali, this has been defined as "the transfer of power from the Central State to decentralised local government bodies. Thus it is simply a matter of enabling communities at a local level to manage their affairs through their elected representatives."

In Mali, ethnicity is still not recorded as a variable in the census. In countries where the ethnic group variable is recorded, data from a general census of the population facilitate determination of useful indicators such as the comparative size of ethnic groups. We call this comparative because, more than ethnicity, it is the ethnic background during socialization that determines individuals' beliefs and behavior. Social ethnicity will therefore have a more determining influence than ethnicity inherited through birth. Mutation of family names after about two generations' change of residence is evidence of the preeminence of social ethnicity which over time will mutate into the ethnic origins of succeeding generations.

These examples lead us to assert that the objectives of collection determine the type of information collected. Indeed, one of the advantages is that some variables can be used on later occasions for other types of analysis. In using data to proceed to secondary analysis, attention should be drawn to the degrees of relevance that can be attained. These degrees of relevance, among others, may include the following:

- The time that has past since the data were collected;
- The fact that the variables used allow for only indirect or approximate estimation of the phenomena being studied; and
- The difference between the characteristics of the surveyed population and the characteristics of the population at the time of a crisis.

The limits inherent in analyses based on secondary use of the data are a constraint with which Mali is now confronted. Despite the considerable number of data collection operations that have been carried out, very few have been specifically conducted to document a situation that could lead to a crisis. Four examples are used to illustrate the lack of specific information to resolve crises. The first example concerns a natural crisis involving invasion by swarms of locusts in 2004. The second example discloses a social crisis relating to management of natural pasturage. A third relates to the school crisis after the social revolution of March 1991. The Touareg rebellion in the north completes the partial typology of crises that Mali has experienced during the past 10 years.

EXAMPLE OF NATURAL CRISIS MANAGEMENT

The most recent, final, nationwide report drawn up by the Ministry of Agriculture gives the following description:

> Mali experienced a massive invasion of locusts during the agricultural season 2004-2005. Two-thirds of the country, particularly the area between the 14th and the 21st northern parallels, was affected between June and September 2004. The phenomenon took the form of what was called a "locust hazard" equivalent to being on a war footing. This danger affected 7 Regions, 26 Circles and 130 Communes.

It is noted that Regions, Circles, and Areas are the administrative subdivisions in Mali.

Modern Administrative Management

Existing surveillance structures at the Ministry of Agriculture technical services gave the alert before June 2004 to prevent invasion by swarms of locusts. According to Mr. Fakaba Diakité, Coordinator of the Unit for Migratory Locust Control (ULCP), and the African Project for Emergency Control of Migratory Locusts (PALUCP):

> As technicians we expected this, because in 2003 we saw a build-up in the region. We treated almost 40,000 hectares in Mali. . . . From the month of February the United Nations Food and Agriculture Organization (UN-FAO) launched an appeal to the international community announcing that as soon as rains arrived in the Sahel there would be locusts. By the month of March, we had drawn up an action plan that we presented to the Ministry of Agriculture and all the other Ministries involved, as well as to the development partners. Unfortunately there was no reaction. We then presented this plan more than ten times before the month of July. There was no response. It was from July that we began to have the first swarms, and people, or at least the authorities, began to move. First an operational headquarters was set up . . . from the month of August. . . . It was from September that we began to receive responses from partners.

The national coordinator's explanations show the following sequence of management of the invasion by locusts in Mali in 2004:

1. Preventive activities are limited to treatment of a part of the surface infested by larvae, given the limited stocks of pesticides.
2. The alert was given in good time at both national and international levels.
3. Intensive advocacy was conducted at national level for about six months.
4. The conclusion was that no action had been taken despite all these preliminary stages.
5. An attempt was made to provide a response as soon as the first swarms began to move.

This model is one of centralized administrative management of the crisis. It leads to limiting the crisis for a much longer period and calls for more logistical and financial resources. In looking at the analysis of control of migratory locusts that is made by Mr. Fakaba Diakité, it is evident that "in locust control, as soon as you see them here (in the southern areas), it means that everything we have done has failed." In other words, prevention is the best means of managing invasion by swarms of locusts.

Before preventive control, there has to be political will. In Mali since the 2004 crisis, the government has made a commitment to provide a national budget allocation of 1 billion francs for locust control. Despite this commitment, the coordinator of the Locust Control Unit judges that "unfortunately we never have a line of credit at the level of our State budgets to enable us to conduct real, permanent surveillance, because when you look at what we spent on cricket control in 2004, it is about 7 billion CFA francs (about U.S. $13,207,547 at a rate of $1.00 to 530 West African CFA francs). In our calculations we thought that with seven billion we could conduct control activities for over twenty years if there was preventive control."

Currently the government budget allocation going to the ULCP is sited within this structure. This institutional arrangement means that the budget is not devoted exclusively to prevention of locust invasion. Surveillance of other pests is also funded from the same allocation.

Traditional and Community Means of Management

At the level of prevention, members of communities can be very useful. Community members can be trained in techniques of unearthing eggs. In managing the infestation, instead of exposing them to chemical products used for treatment, they will be effective by using ditches to bury the locusts that fall into them because these insects always move forward in the same direction.

Early Warning System

The Early Warning System (SAP) was set up in Mali in 1982 (Tékété, 2002). Its objectives are

- forecasting situations of food shortages or abundant production, and
- improving availability and provision of necessary assistance.

Early warning is ensured by collaboration of several structures and institutions in Mali. These are grouped in a multidisciplinary working group including an American nongovernmental organization, FEWS. In Mali the early warning system has developed to respond to needs linked to food security.

The SAP "is based on permanent information collection concerning rainfall, crop evaluation, livestock, market prices, migration of populations, their habits and food stocks, as well as their health status. . . . The SAP systematically surveys zones that are traditionally at risk, that is to say the zones having experienced and quasi-permanently experiencing severe food shortage. These zones are generally the arrondissement subdivisions located to the north of the 14th parallel" (Tékété, 2002). The arrondissement is the third-level administrative subdivision in Mali, following the Region and the Circle, which are the largest geographic entities.

According to Tékété (2002), the methodology utilised by the SAP is based on a certain number of activities:

- Collection of information
- Verification and rapid treatment of information
- Distribution of information

These operations often vary according to whether they are situated at the regional or national level. They are produced on a 10-day basis.

FEWS has been cited as an early warning system in Mali. This structure that existed in Mali from 1985 to 2000 has been succeeded by FEWS NET. "The general aim of FEWS NET is to facilitate installation of food security and more efficient and more sustainable planning networks which will then be managed by the governments involved. . . . In Mali and indeed in general, FEWS NET carries out climate monitoring (Meteosat images), of vegetation (vegetation indicators), and cereal prices in various markets. This information is provided by FEWS to other working groups of which it is a member, in particular SAP and the GTPA (Multidisciplinary Working Group for Agrometeorological Assistance" (Tékété, 2002). FEWS NET publishes a monthly bulletin that is posted on an Internet site.

The basis of this early warning mechanism was access to costly logistical and technological tools. Less expensive means can now be substituted for them. In addition, the mechanism is designed and conducted by administrative structures. Little place is provided for communities in the process of data collection and analysis. It has to be recognized, however, that community members are involved in daily evaluation of their own environments. In countries such as Mali with limited means, the emphasis should be above all on human investment. Sentinel surveillance is an approach to explore. It is permanent. It can be conducted by communities themselves. The accompanying measure to ensure that it becomes effective is the training of resource persons among the communities for the collection, systematic analysis, and transmission of data in real time. This approach is just as valid for natural as for social crises and can contribute to making early warning more effective because it documents phenomena over a longer period of time through qualitative and quantitative chronological series.

MANAGEMENT OF SOCIAL CRISES

Social crises in Mali, whether or not they are documented by research studies, typically occur between two communities (or within the same community) concerning management of natural resources (pasture land, agricultural land, water, and products derived from water). Implementation of decentralization policy is currently at the origin of localized social conflicts whose management varies from one location to another. "Decentralization" is the legal framework installing modern local government bodies.

The discussion begins with the last of these aspects. A second example is cited that relates to management of natural pasturage. Specific types such as urban sociopolitical conflicts and the Touareg rebellion in the north conclude the analysis of social crises.

Conflict of Traditional Chiefdoms

The first example describes establishing local management structures in the framework of decentralization. A persistent conflict is present in the area of Bamba, situated midway between Gao and Timbuctou. Transfer of local power from the master group to the traditionally administered group following communal elections is at the origin of this situation. After numerous clashes and loss of lives, the Malian state currently maintains troops on the spot to prevent continuing clashes. Negotiations have still not led to reconciliation of the different points of view on the new approach to management of local government.

In factual terms, at stake are the defense of prerogatives and failure to accept challenge to the local traditional mode of administration. The possible causes behind the origin of this conflict could be lack of preparation through preliminary studies of local management of power and/or failure to identify potential mechanisms and degrees of acceptable change, as well as their mode of operation.

Conflict Concerning Management of Pasturage

This example describes the clash between two Fulani communities; the clash concerned disputes regarding pasturage situated in the Inner Delta of the Niger River in Mali (the Niger Bend) in 1993. The final count included 20 dead and 42 wounded. According to Maïga (2005), numerous studies of the Niger River Inner Delta have been conducted, but "on the other hand, very few have taken an interest in the stakeholders in negotiations for access to 'bourgou' pasturage in the context of decentralisation." Choice of the zone of his study "is justified by the recurrent conflicts that occur there, proof of an exacerbation of competition surrounding 'bourgou' pasturage." The

Niger Inner Delta includes an area of 30,000 square kilometers of wetlands subdivided into three protected sites linked to the International Convention on Wetlands, which are of international importance particularly because of their biological diversity. The area is noted as the habitat of water birds.

In his approach, Maïga (2005) questions two fundamental aspects: first, the interactions between state law and customary law, and second, prospects for access to pasturage and the future of traditional chiefdoms in the context of decentralization (local government). The problem of recognition of customary law in the Interior Delta was posed during the colonial period when addressing relations between the Fulani and Touareg ethnic groups. Establishing recognition from the colonial administrator of the right to movement to and from seasonal pasturage was considered to be the reason for no longer observing the rules of those who controlled customary management of pasture land. These realities still persist and regularly bring to the fore the question of primacy of one of the two types of law or their simultaneous application.

Beyond customary regulation of pasturage conflicts, two problematic aspects are highlighted. On one hand, understanding which legal system is intelligible, applicable, or weightier for the protagonist populations is needed during conflicts. On the other hand, understanding the influence of decentralization on reorganization of the chiefdoms or on the power of the masters of the land is also important.

In pre-decentralization law in Mali, Dembélé (2005) noted that "[natural] resources are determined by the law to be part of the State's natural public domain," while "neighboring villages consider them to be part of their heritage and regulate their operation." This customary tendency is still alive today. Parallel operation of the two jurisdictions is an additional source of conflict that does not make management of crises any easier.

Sociopolitical and Urban Conflicts

Two types of sociopolitical conflict have emerged in the urban setting in Mali during the past 10 years: the school crisis and the claim for democracy. The origin of the school crisis was the demand by high-school and higher education students for better educational conditions. Mali inherited responsibility from the colonial system for total coverage of school costs for all those who obtained access to secondary education. Economic difficulties at the end of the 1970s are the basis for revising this system. Installation of scholarship awards according to certain criteria and the difficulty of honoring payment of these scholarships led to disruptions that recurred and were generalized in 1991. The background clamor for democracy made use of this fertile ground, which then became the factor that triggered popular revolution. The military regime fell on March 26, 1991. The Third Republic emerged in Mali. Democracy has been installed since this date.

Although intertwining of the school crisis and claims for democracy temporarily benefited both causes, delays in meeting students' claims became the source of recurring disruption in schools and colleges in urban settings in Mali. The role played by students in social change became a source of demands and blackmail whose disorderly manifestations paralyzed Malian towns on a sporadic and partial basis. Public authorities did not attempt to analyze the school phenomenon in order to understand its mechanisms and consider taking appropriate measures. They chose instead the method of long and uncertain negotiations with various splinter groups of the student movement. In the end, the formula of mediation that brought about the beginning of calm and pacification of campuses and schools was established under the aegis of a committee made up of all parts of civil society. This calm is still precarious; during the twenty-third summit bringing together African and French heads of state in Bamako on December 3-4, 2005, youth delegates from the continent delivered an ultimatum (read by the Cameroonian, Marie Tamoifo NKom) that said in essence "if politicians do not take notice of youth, the wind of change, in a democratic context, will lead young people to settle the business of the politicians so that their commitments take on a meaning."

The Touareg Rebellion

The last type of social conflict presented is one that was expressed through taking up arms. Touareg communities in the north of Mali judged that they had been ignored during the process of development since independence. The imbalance between the south, the center, and the north in investment choices and installation of infrastructure was becoming more and more marked. Faced with this situation, the Movements for Liberation of the Azaouad launched the rebellion. National and international mediation were the mechanisms that resolved this social crisis. This led to

- upgrading the north of Mali with the design of dedicated development programs;
- setting up a dedicated administration (the Commissariat for the North);
- organization of a symbolic Flame of Peace under the aegis of the United Nations during which the arms laid down by combatants in the rebellion were burned; and
- integration in March 1996 of some of combatants of the rebellion into the various branches of the military.

LIMITATIONS OF INFORMATION AND DATA ANALYSIS IN RESPONDING TO CRISIS IN MALI

Examination of macro-level data collected in Mali as well as those connected with certain types of crises and their resolution does not highlight the information to be collected in order to respond to crisis. Since this paper is not based on the findings of a systematic evaluation or a specific study, it is difficult to evaluate the contribution made by information analysis. One exception is management of the invasion of migratory locusts, which was supported by prior technical information collection. Even in this particular case, however, a lack of consideration of the population dimension was evident. This determining feature in measuring both quantitative and qualitative impacts does not appear clearly in the cases presented.

In response to the question of which types of information are used in crisis prevention, the following answer can be made: Specific and systematic information was used from the early warning system concerning agricultural crises and their impact on food security or concerning natural crises such as swarms of migratory locusts. In all the other cases considered, relevant information is largely from administrative sources.

By way of methods installed to generate the necessary data for crisis analysis and providing responses to them, the first to be noted is the early warning system. Routine information generated by the administrative system and secondary treatment of certain data collected in connection with other operations are used to provide complementary analysis. The limitations of these approaches have already been mentioned. Given the conclusions reached through the cases examined in this paper, which approaches will lead to advancing beyond practices and methods that are currently used?

CONCLUSION: APPROACHES TO ADVANCING BEYOND CURRENT METHODS AND PRACTICES

Approaches to the anticipation of natural or social crises exist, but in the current context of Mali, very little investment has been made in this area. At the level of state structures, the example of locusts has shown the limitations of rapid and appropriate reaction. Affected communities are also unprepared, either because of ignorance of what they can do or through lack of initiative, or both.

To advance beyond this situation, two levers need to be activated. The first is that of information, and communities must be provided with the means of acquiring improved knowledge regarding the natural risks that they may experience in their environment. The second is to encourage local mechanisms of social organization to take part in permanent documentation of the process through sentinel surveillance in anticipating and reacting to early warnings.

More specifically, regarding management of social crises, anticipation is also a valid general approach for both authorities and communities. It should be preceded by sociological, anthropological, and ethnographic research studies in zones with recurrent conflicts.

To go beyond these approaches, positive partnership in prevention should be emphasized. A recent example is the signature of a convention between farmers and livestock owners in the Circle of Kangaba. This convention delineates areas for keeping livestock, "pasture zones," responsibilities of community surveillance brigades for application of the agreement and those of the forestry service agents, and a number of other provisions. All community and government partners have signed the document. Experience from its implementation will tell us if the formula is a good one and if it might be replicated elsewhere.

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