

ROLE OF CENSUS DATA & POPULATION IN DISASTER MANAGEMENT

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Introduction

In recent times there has been a significant increase in the frequency and occurrence of natural calamities. In addition to the wide scale devastation caused, these calamities have a direct negative impact on people and population. To mitigate the devastation caused by these catastrophes, it is imperative to have accurate and complete information on population distribution at the desired demographic scale.

Risk assessment is the central pillar of the hazard risk management framework. Risk is defined as the probability of a loss occurring. It depends on the frequency and intensity of the hazard, the people and structures exposed to those hazards, and their vulnerability. The information provided by the assessment contributes to an informed decision making process that reduces the chances of surprises, and enables consequences to be managed and planned for in advance.

The census information in most of the developing and under developed countries is not frequently updated. Moreover, the available information does not have information on the micro level spatial distribution of population. This becomes a potential bottle neck for effective disaster management analysis and mitigation strategies.

Based on RMSI's extensive experience in natural disaster modeling, this paper explicates the close and critical relationship between census data and disaster management and preparedness.

Data Required for Vulnerability Mapping

The exposure and vulnerability modules of disaster management calculate the effect of a hazard with respect to the assets and the population of the affected area.

A critical component of any disaster risk model is the exposure module. In this module the elements at risk are categorized in a way that lends itself to the estimation of their vulnerability to that particular hazard. This requires the categorization of the elements at risk by their structural type, their height and their period of construction. The structural typology greatly influences the vulnerability of elements at risk, e.g. buildings from timber or steel may be stronger, while buildings made from traditional materials such as adobe may be weaker to the earthquake hazard. The period of construction also influences the vulnerability of the elements at risk because design regulations are gradually improved taking into account local and global hazard loss experiences.

Exposure Module uses the following data for its analysis:

- Building Construction types – Steel, Concrete, Masonry
- Height, No. of storey and age of the Buildings
- Occupancy and Type of Occupancy
- Type of Building – Residential, Commercial, Industrial
- Type of Structure
- Built area and non built area of the building

Vulnerability of the area is calculated in terms of both the physical and social functions. Social vulnerability is the susceptibility of populations to death and injuries, the assessment of which involves casualty modeling to compute mortality and injury rates associated with various catastrophic events. The physical vulnerability refers to the degree to which an asset would get damaged or destroyed in a hazardous environment caused by catastrophic events. The vulnerability module quantifies the damage susceptibility of each asset class with respect to varying levels of ground motion and collateral hazards.

Census Data in Disaster Management

RMSI has created a number of natural hazard models for countries such as Romania, India, US, and the Maldives amongst others. Each of these modeling initiatives were preceded by data collection activities where by relevant and accurate data with respect to the hazard model requirement was generated, collated or sourced.

RMSI developed the Romania Earthquake model and India Earthquake model which had similar objectives to be fulfilled i.e. calculation of loss and damages pertaining to the earthquakes caused in those regions. While the vulnerability of the areas was calculated in both of these modeling initiatives, the availability of data for both countries was very different. In the case of Romania, accurate block or commune level data was available with the census department which implied no assumptions with respect to distribution of buildings and the population affected by the earthquakes. On the other hand, the lack of block level data in the case of India posed a challenge for accurately distributing the losses in the buildings located there. Hence, it was assumed that all the buildings were equally impacted and suffered similar losses and damages by the earthquake.

Advantages of Having Reliable and Complete Data:

1. Accurate distribution of buildings in the area insures the accurate distribution of losses. This is of particular importance in case of flood hazards where the banks of the river, more prone to disaster are farther from central congested areas of the city. If the data was not accurate at the specified scale, the losses presented by the models would be skewed.
2. The accuracy of population data of the buildings is important in case of casualty modeling. Casualty modeling uses the population data to stimulate the extent and number of casualty a particular hazard can cost.
3. As per our observations while modeling disasters, most of the census data which is available is of residential areas while the more disaster prone commercial and industrial areas are not covered well. Lack of data for commercial and industrial zones result in inaccurate distribution of losses and therefore reduce the applicability of the models.

Use of Geospatial and Remote Sensing Technologies for Census Data Development – A Case Study

The problem of not having reliable data for modeling purposes can today be circumvented by using remote sensing techniques to generate the desired data.

The satellite based land use is a very important input for multiple applications. It is widely used in the telecom sector, urban and utility planning, environmental/hazard planning, etc. The land use map only depicts the relative density and sometimes relative height of buildings, but does not cover the number of people that are residing in the area. On the other hand, the census information is compiled at an administrative unit level; therefore, it lacks the spatial distribution or concentration of population within the administrative unit. To create data on the spatial distribution of population, RMSI has developed an innovative approach to derive micro-level population information & its distribution using both the inputs viz, administrative boundary level population statistics and satellite derived land use maps.

Geographical Information System (GIS) helped in integrating the two datasets to derive the number of people living in each land use unit within an administrative unit. The information thus derived would be very helpful in urban utility planning and disaster management.

Introduction and Objective

For disaster management, information about the demographic details and its spatial distribution is imperative for assessment of human population at risk before the disaster and even for quantification of affected population after any disaster event. The maps generally available are either in the form of population density map or population maps depicting absolute population with respect to administrative boundary. In such maps, within the administrative boundary, where and how many people are residing is not known.

Collection and Collation of Data Inputs

The data used for the current study included primary as well as secondary database. The team collected the administrative ward boundary maps and accurately geo-referenced them with the help of topographical maps. The maps were then digitized in a GIS platform and corresponding population statistics was attached to each ward polygon. Simultaneously two sets of satellite images, i.e., IRS 1D LISS-III and Pan images with a spatial resolution of 23.5 and 5.8 meters respectively, were procured from the National Remote Sensing Agency of India. These satellite images were merged together and geo-referenced to represent the real world coordinates.

The merged geo-referenced satellite images were used for creation of land use/ land cover classes.

Mapping and Assigning Weights to Land use Classes

The land use map was classified using third level classification scheme. At the first level the built up areas were classified into broad classes, viz. residential, commercial and industrial areas. The residential class was further categorized into second level classes, Urban and Suburban. In the third level classification Urban and Suburban were again categorized into urban high dense, urban medium dense, urban low dense, suburban high dense, suburban low dense and villages (see figure 1).

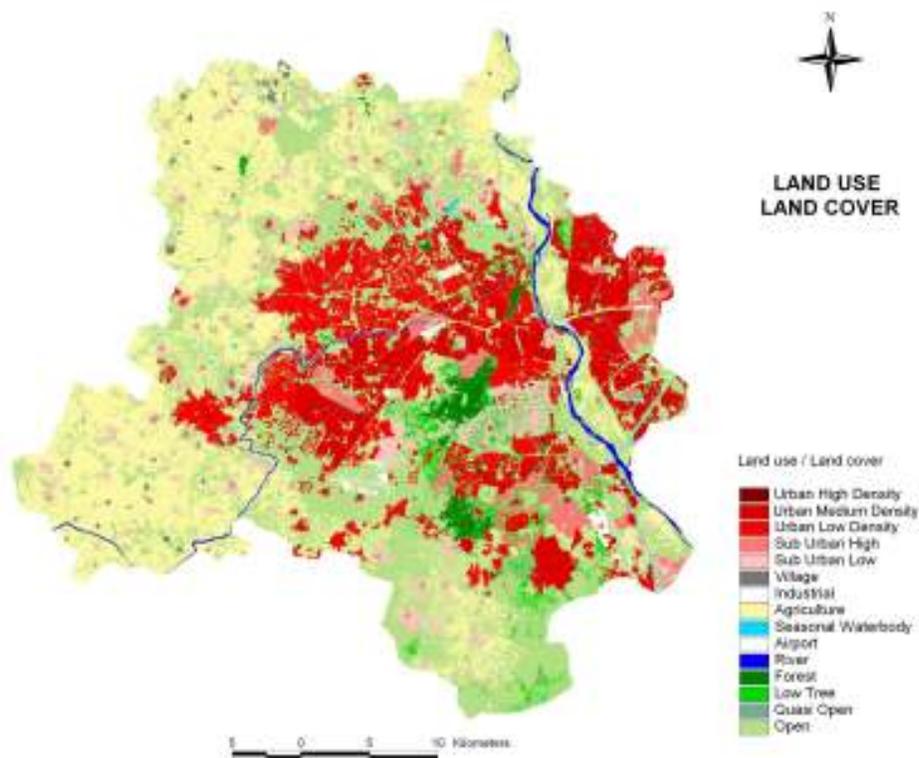


Figure 1: Land use/ land cover map

The basic assumption for distributing population based on land use classes was that the population would be concentrated only within residential classes and the density of population will be more in urban high dense areas and will reduce as we move towards suburban and villages. Based on these assumptions simple weights were assigned to each residential class ranging from 1 to 6. The highest weight, i.e., 6 was assigned to high dense areas and lowest weight, i.e., 1 was assigned to villages. Weights for classes between high dense and villages were assigned accordingly from 2 to 5 based on density.

Administrative Ward Boundary with Population Statistics

The administrative boundary level ('Ward' in present study) census demographic data was linked to the digitized ward boundary map in GIS environment. The linking was done based on the unique ward numbers that was common in both population table as well as GIS map (see figure 2).

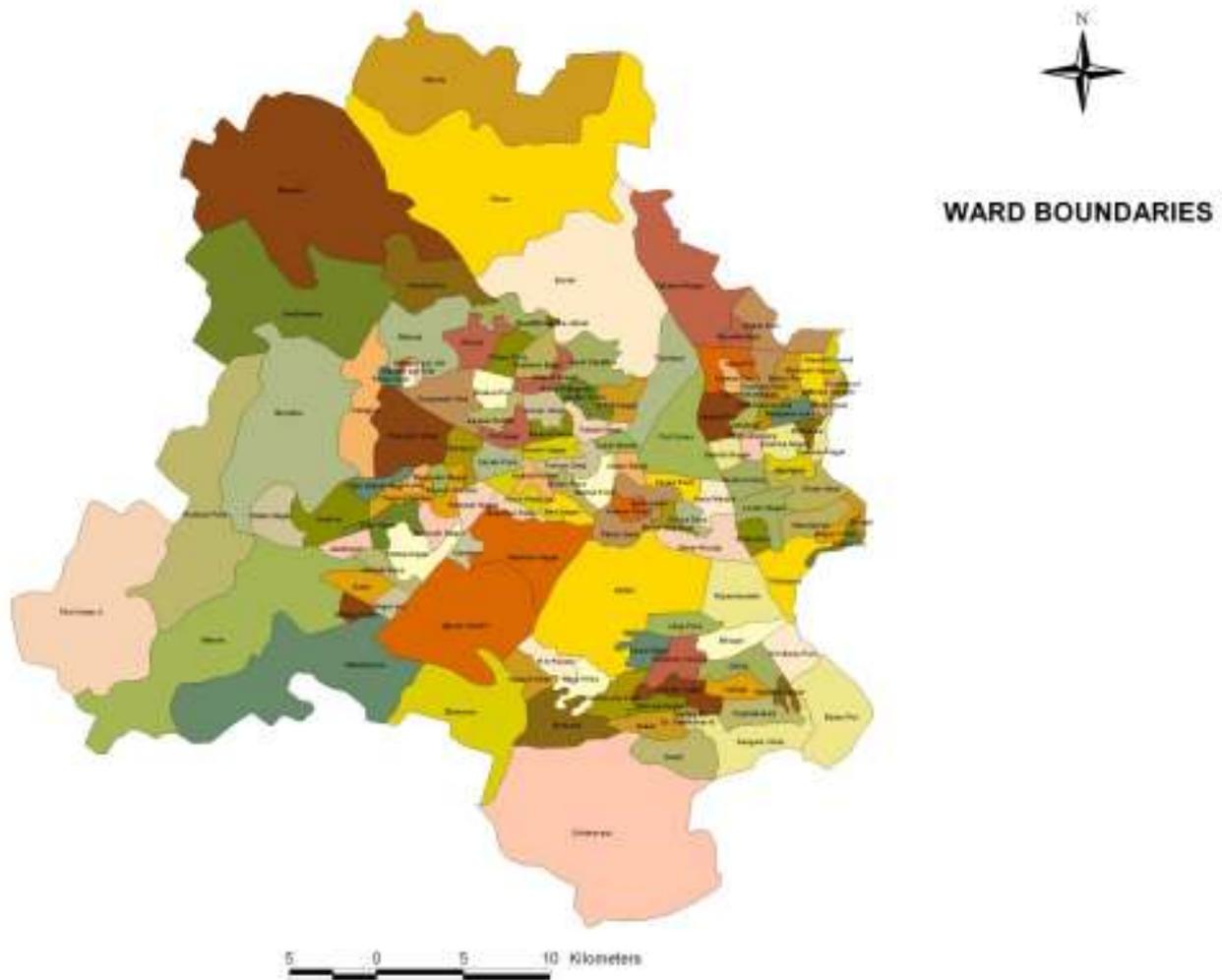


Figure : Administrative Ward Boundary map

Data Integration and Analysis

The land use map was converted from original raster to vector format compatible with vector ward boundary map. The area of each land use polygon was calculated using GIS software. Once all the input data was brought into a compatible GIS platform, it was further analyzed to derive the population distribution map. The ward boundary map was overlaid and intersected with land use map. The derived intersected output map now detailed the ward number, ward name and area of respective ward attached to respective land use polygons within the respective ward boundary. The derived map was then run through an in-house developed statistical model to estimate population of respective land use polygon within each ward boundary using total population of respective ward as the primary base input including area and weights of respective land use classes falling within respective ward boundary (see figure 3). The model works on the algorithm described below:

$$\frac{A \times P}{T}$$

A = Area of each Polygon x Land use Weightage

P = Ward Population

T = Sum of A of all polygons for each ward

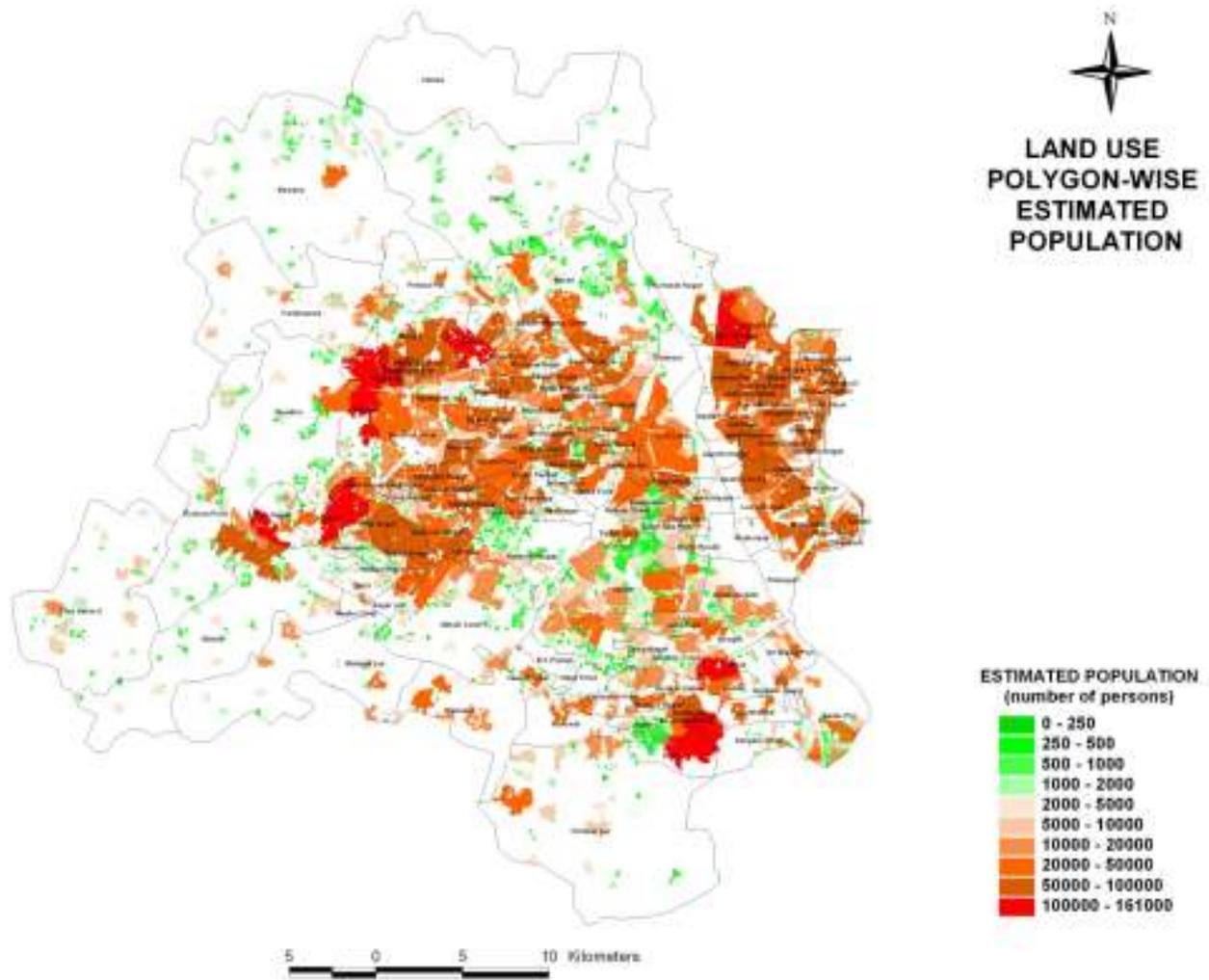


Figure 3: Spatial distribution of Population

Usability in Disaster Management

In the event of any disaster and even for disaster preparedness and mitigation, information about the distribution of population in space is a pre-requisite. The innovative methodology adopted by the RMSI team to generate information about the spatial distribution of population would prove to be a watershed for such studies. The population distribution map can be generated from the existing information and database in a quick turnaround time and in a cost effective manner.

For undertaking catastrophic risk analysis, location specific information about the people living there would help in estimating the probable risk to human life. This would also help in taking remedial measures for development of appropriate action plan to minimize loss of human life in case of any disaster. The associated advantage of this approach is that it helps in location specific quantitative assessment of population which is not represented with respect to any administrative boundary.