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Rapid estimation of affected population figures

Desk Review

Assanke Koedam

ACAPS

Contents

1 Introduction

1.1 Why to estimate population size in emergencies?

Most crises disrupt communities and many displace people. The size and demographic characteristics of the affected population may change because of deaths, migration or destruction of infrastructure. Timely, accurate and reliable information on the numbers and locations of people affected by a crisis is crucial for an effective and efficient humanitarian response (WFP 2007).

Therefore, the quantitative expression of the size and characteristics of the population affected by a disaster is a central part of the assessment process (ECLAC 2006). Quantitative information is only part of the picture and may be of only limited use in the longer term. However, without a reasonably accurate estimate of numbers, the delivery of assistance to beneficiaries, particularly in the early stages of an emergency, will be impaired. Global numbers and an ethnic, gender and age breakdown are clearly important for a range of humanitarian assistance activities as programme planning, protection, fund-raising, and advocacy. Without statistics, effective assistance and protection would ultimately become impossible. Furthermore, beneficiaries have the right to be counted as accurately as possible, since this is a pre-condition for assistance or protection (RNN 1997).

1.2 How to estimate population size in emergencies?

Estimations of affected population numbers are clearly needed in various phases of a disaster. During the preliminary phase, baseline data as population number for an area which is susceptible to a shock is needed. The first phase asks for producing an operational figure within the first 72 hours of a disaster, while in the second phase (the first two weeks of the disaster) formal assessment takes place and population figures need to be consolidated in order to quantify needs. During the long-term third and fourth phase, monitoring and assessment coordination takes place (WFP 2006, ACAPS 2012). Ideally, a government census or a recent survey provides the number and characteristics of people in the affected area and the number of people in need of assistance. Unfortunately, estimating population estimations imposes several challenges during these phases of a disaster:

- Crises seldom occur entirely within an administrative boundary which serve as the basis for the collection and reporting of population figures;
- Crises sometimes affect a specific population group such as nomads or an ethnic group for which reliable or current population data does not exist;
- In many crisis-prone countries population data are not available, outdated or inaccurate;
- Geographic information systems and population databases may not be available or familiar to the teams sent for the assessment;
- Crises often involve population movements, that can be temporary, permanent or back-and-forth, consequently existing demographic data would not represent the current situation;
- The crisis-affected regions may be inaccessible or insecure and make contacts with local authorities and other informants who could provide information on population size difficult; and,
- The reported population size may be influenced by political influences (WFP 2006).

Each type of an emergency affects the impacted area and the population living in that area differently. This also calls for different approaches in estimating population size. An earthquake of flood may cause significant destruction and many deaths, but may not result in large population movements. In contrast, complex emergencies and slow-onset disasters such as famine or drought generally produce large population movements. Next to the nature of the emergency, choosing a suitable method also depends on factors as the stage of the emergency (pre-crisis phase, in the immediate response phase or in the recovery phase), the time and resources available, the availability of pre-disaster information (a list of households, population size, the location of the impacted population) and the extent and accessibility of the disaster site (WFP 2006). For instance, UNHCR and WFP (2004) differentiate between methods which may be used when people are on the move, when there are very large numbers spread over a large area, when the site is small or orderly, or when the site is very large or not very orderly.

Several agencies and academics have provided handbooks, manuals and guidelines with methods used to estimate population size. Methods vary from simply counting individuals in a refugee camp, to sampling and extrapolating information in affected areas and using proxy measures of population size and distribution with remote sensing methods. This variety of methods is used individually or in combination to estimate total affected populations or displaced persons and their characteristics. These methods may also be used to cross-check figures reported by the affected population themselves or by local authorities or to check the plausibility of figures that may be out of date.

For instance, following a sudden-onset emergency, existing data from local government agencies and local or international agencies working in the affected area may be identified, acquired and assessed. Furthermore the quality and appropriateness of the data is evaluated, and updated if necessary. The initial figures will probably have a large margin of error and can be updated in the course of the crisis as more accurate and current information is acquired. When access is limited, aerial photography or satellite imagery may be used, while flow monitoring methods may be implemented when the population is moving across national borders or through major transportation routes. In the recovery phase of a sudden-onset disaster, during a slow-onset disaster, or in the case of a small affected area, sampling methods may be more appropriate (WFP 2006).

1.3 About this desk review

This desk review has been driven by the necessity to map this variety of methods used and described by different agencies and practioners, and to relate these methods to case studies or validation studies if possible. It has been acknowledged that several desk studies have been conducted on population estimation methods. For instance, WFP (2006) initiated a desk review to inventory the methods available to estimate total population size in a humanitarian crisis, to describe the strengths and weaknesses of each method and to provide guidelines on which methods to use. The literature review of Treacy-Wong (2011) aimed to identify and review the different population estimation methods that can be used in complex emergency settings.

However, the need was felt to produce an exhaustive and structured review of methods, which have been incorporated by humanitarian agencies or that are of potential for use in estimating human population size in an emergency context. This structure should allow readers to thoroughly compare the identified methods, and to provide just enough information to understand these sometimes complex methods. On one hand, this review serves as the foundation for a decision tree and technical brief which provides support to assessors in choosing the right method depending on a range of circumstances and implementation criteria. On the other hand, this review functions as reference material, providing more insight in the use of each method. It hopefully encourages readers to consult the (hyperlinked) references for more guidance.

In order to make this review of use for practioners planning or implementing population estimation activities in one of the phases of an emergency, the review will provide a quick overview of:

- By who or which organization the method is used;
- A brief overview of the method;
- Where and when the method is most appropriate;
- The (data) prerequisites for the method;
- Which steps need to be taken;
- The strengths and limitations of the methods;
- If available, case studies or validation studies.

Methods have been identified by analysing a broad range of handbooks, manuals and guidelines with methods described by humanitarian agencies, supplemented by academic publications. These reports and studies were identified by earlier work of an independent consultant on the humanitarian profile, supplemented by a systematic literature research of the author of reports described in earlier reviews, and by consulting internet databases and key-persons.

A total of five broad categories of population estimation methods have been identified. Every method has been organized in one of these categories:

- Sampling methods
- Site estimation methods
- Counting methods
- Remote estimation methods
- Estimations using population data sets

2 Sampling methods

2.1 Quadrat method

2.1.1 Method reported in

MSF (1997), Brown et al. (2001), NRC (2002), CIEDRS (2003), UNHCR/WFP (2004), Grais et al. (2006), MSF (2006), UNHCR (2007), WFP (2007), IDMC/OCHA (2008), Treacy-Wong (2011)

2.1.2 About the method

The quadrat method is the variant of a method also called ‘mapping’ or ‘area method’. Quadrat sampling is borrowed from ecology, which divides a study area into equal-sized squares and then measures flora and fauna in a sample quadrat (CIEDRS 2003).

Vincent Brown of Epicentre/MSF in Paris introduced the quadrate method which is frequently used in very acute emergency situations (NRC 2002). It estimates the population size and characteristics of a small representative area and extrapolates this information to a larger area. It has been used to estimate the population in refugee camps but the method has also been adapted to be used in other defined geographical areas (WFP 2007).

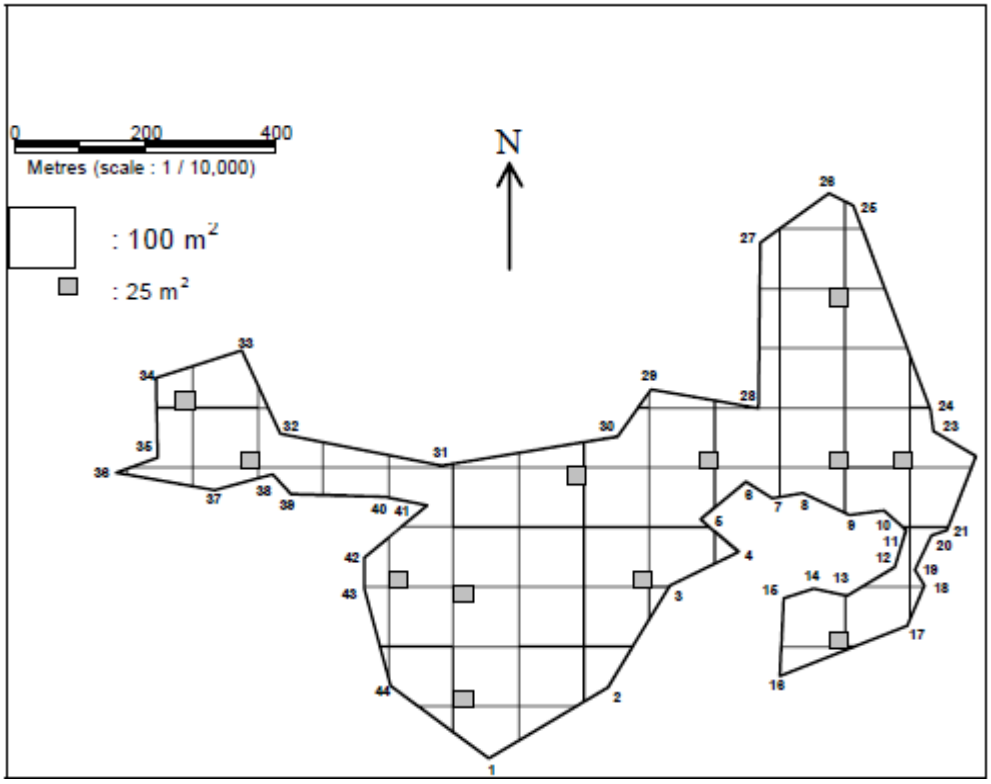
2.1.3 When appropriate?

- In refugee and IDP camps in (the initial phase of) an emergency (Brown et al. 2001).
- Disaster-affected populations are in a reasonably well-defined area but the numbers and area are too large to do head counts or habitation counts (CIEDRS 2003).
- Houses are one or two storeys tall, uniformly distributed, topography is flat and undisturbed by streams, rivers or gullies and distances between houses are small (e.g. towns, villages, suburbs, refugee camps) (WFP 2007).
- Uniform distribution of the population in the target area. Zones with no or very few people should be excluded from the target area in order to avoid an overestimation of the estimated population size (WFP 2007).

2.1.4 Prerequisites

- Pre-crisis population size and location provides guidance on the areas to sample and the relative population sizes among villages (WFP 2007).
- If no detailed local maps are available it may be necessary to create them (e.g. displacement situations where refugee/IDP settlements are evolving) (CIEDRS 2003).

Figure 1 Map showing quadrats of Kumgogo camp, Tanzania 1993



Source: Brown et al. (2001)

2.1.5 Population estimation steps

1. Obtain an aerial view or draw a map of the area of interest. E.g. a satellite image, an aerial photograph or photo-mosaic, a published map or a hand-drawn map (MSF 1997, CIEDRS 2003, UNICEF 2010).

2. Measure the perimeter of the area. Choose a starting-point or landmark. All external limits of the area are defined by their bearings, which can be measured in degrees using compass headings or using GPS handheld receivers. At each point for which a new direction is taken, GPS provides coordinates for the geographical point at which one is standing (CIEDRS 2003, UNICEF 2010).

For each new direction taken, measure distances from one point to the next by measured pacing (e.g. 1 step = 1 m), by using a planimeter, or by using a car's odometer (CIEDRS 2003). A hand clicker facilitates the counting of steps (MSF 2006).

3. Create a scale outline of the area. Use a piece of paper at a 1:10,000 scale (1 m measured at field level corresponds to 0.01 cm on paper). The outline can also be drawn by entering the longitude and latitude data from GPS into a computer (mapping software is needed). Grids are then super-imposed on the scale outline. Depending on the size of the area, these could be 25 x 25 m quadrats or 100 x 100 m quadrats (figure 1) (CIEDRS 2003).

4. Measure the total area by counting the number of full and partial quadrats. The area of a full quadrat = length x width. The area of partial quadrats (irregular shapes) can be estimated by creating smaller geometric shapes and summing the total (area of a square or rectangle = length x width, area of a triangle = ½ base x height). On average, the area of the partial square is half the area of the full squares (CIEDRS 2003).

5. Select a random sample of quadrats. MSF/Epicentre recommends selecting anywhere from 5 to 25 small quadrats (measuring 625 m²) or selecting at least 3 large quadrats

(10,000 m²). Within each sample quadrat, a head count should be undertaken (CIEDRS 2003). Brown et al. (2001) suggest taking a random sample of 5 – 12 blocks. This can also be accomplished by using E-pop software (MSF 2006). E-pop is an excel tool for rapid population estimates by area sampling in emergencies.

6. Extrapolation. The average population density measured in the sample quadrats can be extrapolated directly to the entire area for an estimate of total population size (CIEDRS 2003).

Alternative: A population is never regularly distributed equally among a camp. Population density is higher in the middle of the camp where most facilities are initially located, while it is dispersed at the periphery (Brown et al. 2001). Select blocks based on observed high-density, medium-density, and low-density settlement patterns, adding up the estimated populations in each and then extrapolating to the entire area (CIEDRS 2003).

2.1.6 Strengths

- Simple to perform and flexible enough to be employed under a variety of field conditions (Grais et al. 2006).
- Relatively accurate (NRC 2002).
- Visualization of squares is easy (NRC 2002).
- Well adapted to camp settings (IDMC/OCHA 2008).

2.1.7 Limitations

- Issues relating to population density and the number and size of blocks to be selected require further research (Brown et al. 2001).
- Field implementation of the t-square method yielded a better population estimate than the quadrat method (Grais et al. 2006).
- Relies on the average population of individuals per quadrat to estimate population size and is highly sensitive to relatively small changes in quadrat population (Grais et al. 2006).
- Resource intensive and relatively slow (NRC 2002).
- Potential for omission or duplication (NRC 2002).
- Can be cumbersome to delineate the grids on the ground, and may require satellite imagery to draw the map (IDMC/OCHA 2008).
- Requires access to, and familiarity with GIS and GPS tools (IDMC/OCHA 2008).

2.1.8 Case studies / validation studies

- MSF/Epicentre used the quadrat method in six camp settings in Bangladesh, Kenya, Tanzania and DRC. All mapping and population estimates were completed in one to two days. In Leboi camp in Kenya, the rapid estimation yielded a figure of 43,000, which appeared to be validated by a UNHCR registration a few weeks later estimating the population at 45,000 (Brown et al. 2001).
- The population estimates in the camps around Goma, DRC, were far less precise and numbers varied from 500,000 to 800,000. In Bangladesh the evaluation of camp surfaces was mainly based on the measurement of length and width of all camp sections. The identification of camp coordinates with a compass or GPS was likely to achieve better precision. In DRC, GPS proved to be efficient, but in practice depended on good exposure and an easy access to satellites. Area-sampling was

based more on purposive sampling rather than on probability sampling. Mainly driven by working conditions met in an emergency (Brown et al. 2001).

- A comparison of validation studies (Espié 2000, Grais et al. 2006) by Treacy-Wong (2006) show that the quadrat sampling simulation conducted by Espié (2000) gave unbiased and very precise results (regardless of population spatial distribution). However the quadrat method performed badly in the field test of Grais et al. (2006), underestimating the census by 19%. This could have been caused by the large range in population density (populations in the sampled blocks ranged considerably, between 7 to 68 people). Explicitly stratifying for density would have been a better approach than relying on a systematic sample to address this potential source of bias (Treacy-Wong 2006).
- The simulation analysis of Grais et al. (2006) suggested that the quadrat method generated reasonable population estimates employing fewer blocks than recommended. The size and number of blocks can be a potential source of bias: for a clumped distribution pattern the numbers of individuals per block will be greatly influenced by doubling the block size, whereas when distribution is random, doubling the block size has no impact. The study of Espié (2000) validated what statistical principles also suggest: the higher the number of blocks selected, the more accurate the sample because it would be more representative, and selecting more smaller blocks is better than selecting fewer larger blocks. Results of the simulation analysis by Grais et al. (2006) suggest that the number of blocks could be reduced to anything above 15 (all provided population estimates ±5% of the census), and no added accuracy was provided by having >25 blocks (Treacy-Wong 2006).
- Following the simulation of Grais et al. (2006), the average number of shelters per quadrat instead of the actual numbers of individuals provided a population estimate closer to the census (Treacy-Wong 2006).

2.2 T-square method

2.2.1 Method reported in

NRC (2002), Grais et al. (2006), Bostoen et al. (2007), IDMC/OCHA (2008), WFP (2009)

2.2.2 About the method

The t-square method is a modified version of a method used in ecology to determine the spatial distribution and density of trees and plants in large areas. The number of trees is calculated by measuring the distance from a random point to its closest tree, which is related to density. When multiplied by the total area, the total number of trees in an area is estimated (WFP 2009).

Modified to emergency settings, the method can be used to estimate human population size and demographics by measuring the distance between a random point and an occupied house and counting the number of occupants in the house (WFP 2009).

2.2.3 When appropriate?

- A sampling frame is unavailable, unreliable or outdated, and it is difficult, expensive or laborious to construct one (WFP 2009).
- The sampling frame is complex (WFP 2009).
- The survey takes place during the recovery stage of a crisis (WFP 2009).

- The area where the survey will be conducted is larger than 10 km² (WFP 2009).
- Most of the houses in the survey area are single-storey residences (WFP 2009).
- Most of the houses are randomly distributed (WFP 2009).

2.2.4 Prerequisites

- Detailed maps are available (WFP 2009).

2.2.5 Population estimation steps

1. Select a random point (WFP 2009). A number of points (P), typically 60, are distributed across the area using computer software (either randomly or systematically) (Grais et al. 2006).

2. Measure the distance from this point to the nearest occupied house (WFP 2009): from each point (P) the distance (d1) to the nearest house is measured (see figure 2) (Grais et al. 2006).

3. Go to this house, find the occupied house nearest to it, and measure the distance (d2) between the two houses (Grais et al. 2006; WFP 2009).

4. Count the number of people living in the two houses and calculate the average (WFP 2009).

5. Estimate the total area of the survey (WFP 2009).

6. Calculate the average space occupied by these houses and its surroundings (WFP 2009).

7. Calculate the total number of houses in the survey area by dividing the total area of the survey by the average space occupied by each house and its surroundings (WFP 2009).

8. Calculate the population size by multiplying the number of houses in the survey area by the average number of people in a household (WFP 2009).

2.2.6 Strengths

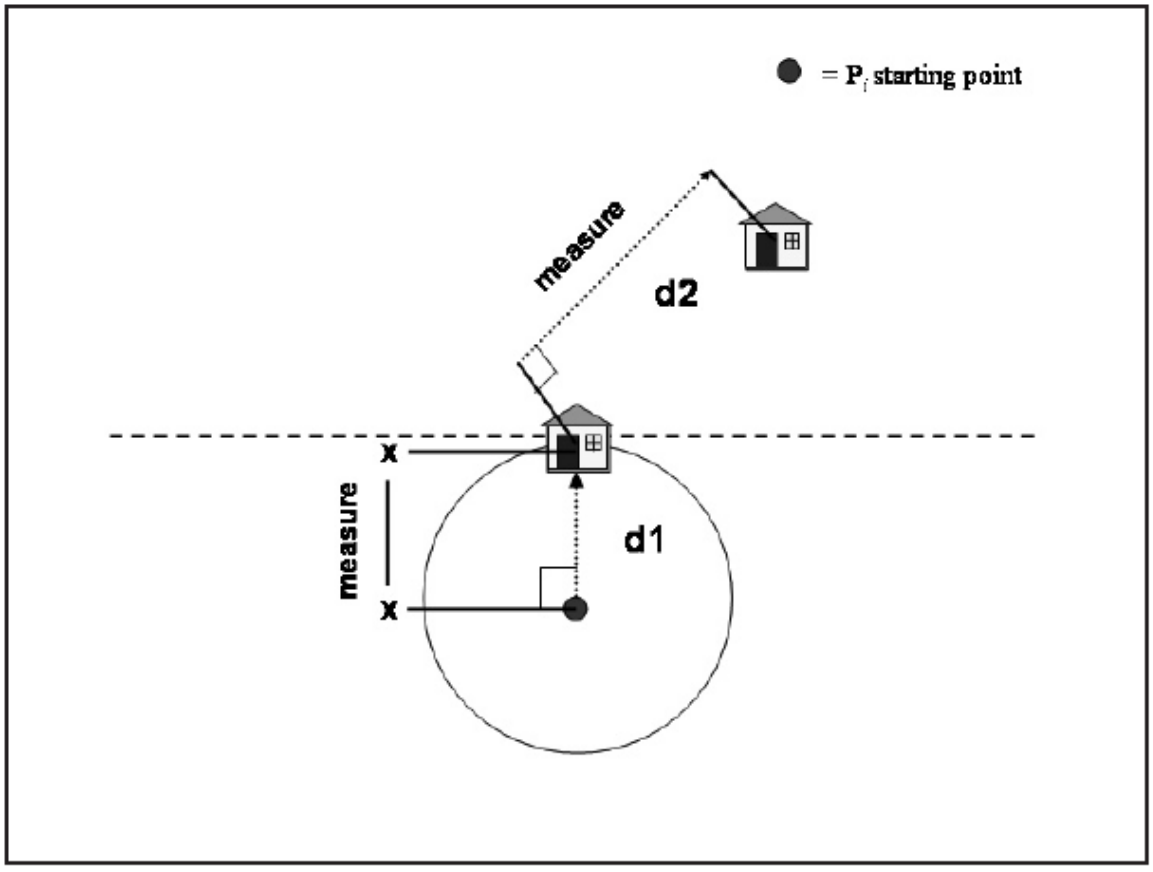
- Relatively accurate (NRC 2002).
- Rapid (can be done in one-third of the time of the quadrate method) and uses relatively few resources (NRC 2002).
- Provides more reliable results than classical transect walks (IDMC/OCHA 2008).
- Expedient and cost-effective (IDMC/OCHA 2008).
- Human population density can be estimated even when not every household per unit area is detected (Bostoen et al. 2007).
- The same population density estimate can be calculated from data independently collected by multiple observers (Bostoen et al. 2007).
- A relatively small number of distances need to be measured (Bostoen et al. 2007).

2.2.7 Limitations

- The nearest neighbour to a random point on the edge of the target area may be outside the survey area. Only houses that are within the area must be selected, and the nearest neighbour in the survey will not be the house closest to the random point. The nearest neighbour distance may be overestimated (WFP 2009).
- Difficult to select true random points (NRC 2002).

- The reference point used to measure the distance from one house to another may vary when the shapes and sizes of houses vary (WFP 2009). Problematic to locate the initial GPS when it falls inside of a household, and to make projections from there (Grais et al. 2006).
- Is designed to estimate the density of households, and an alternative method should be used when there is clustering (WFP 2009).
- Insecurity, long distances and access to survey areas can hinder survey teams' ability to travel to survey sites (WFP 2009). Survey teams can face difficulties when calculating distances between households due to challenging environmental conditions (Grais et al. 2006).
- Repeating the same measurement between households takes time, which is prohibitive during an emergency (Grais et al. 2006).
- Complicated to conduct and for survey teams to understand the methodology quickly (Grais et al. 2006).
- Calculations to obtain the final population size estimate are complex and have to be done by an expert (IDMC/OCHA 2008).
- Nearly always underestimates population density and size (IDMC/OCHA 2008).
- Does not produce confidence intervals (NRC 2002).
- Potential for measurement errors (NRC 2002).

Figure 2 Measurement of distances between households for the t-square method



Source: Grais et al. (2006)

2.2.8 Case studies / validation studies

- A comparison between validations of the t-square method (Espié 2010, Grais et al, 2006 and Pinto et al. 2007) by Treacy-Wong (2006) shows that except the study of Pinto et al. the t-square method gave very accurate population estimates in the field tests. However there was substantial under-estimation when the heterogeneity or clustering of the spatial distribution increased. In the study of Espié and Grais et al., the test for non-randomness found that the households were distributed non-randomly, so confidence intervals around the population estimate were not possible to calculate. The simulation of Grais et al. (2006) also found that more than fifty points are needed to be measured to get within ±5% of the census (Treacy-Wong 2006).

2.3 Spatial interpolation method

2.3.1 Method reported in

Pinto et al. (2007), Treacy-Wong (2011)

2.3.2 About the method

The spatial interpolation method (described in Pinto et al. 2007) is based on the assumption that things closer together are more similar than things further apart. If it is measured how similar they are, it is possible to extrapolate to the unknown area. The method estimates the unknown value of a point using the known values of surrounding points (Treacy-Wong 2011).

2.3.3 Population estimation steps

1. Map the affected area and calculate the surface area (Treacy-Wong 2011).

2. Select a number of points (e.g. 50), and distribute them across the total surface area (randomly or systematically) (Treacy-Wong 2011).

3. Establish a circumference around the points (e.g. 25 metres) (Treacy-Wong 2011).

4. Measure the distances between the point and all the shelters in the defined circumference, and count the occupancy in each shelter (Treacy-Wong 2011).

5. The mean of all these distances and occupancy gives a population density for that one point (Treacy-Wong 2011).

6. The 50 population densities are then collated in a semivariogram (which demonstrates how similar they are) (Treacy-Wong 2011).

7. The density is obtained from a spatial smoothing (Kriging) method applied to the non-sampled area on the basis of the observations within the sampled circles (Treacy-Wong 2011).

8. Density multiplied by the total area gives the population estimate (Treacy-Wong 2011).

2.3.4 Case studies / validation studies

- Following a study of Pinto et al (2007), the interpolation method was tested twice. One estimation performed badly, underestimating the population by 18%. A computer simulation was carried out on the interpolation data, and the 30m grid spacing was found to be more accurate than estimating for an area of fifty metres (Treacy-Wong 2011).

2.4 Modified cluster sampling method

2.4.1 Method reported in

WHO (1996)

2.4.2 About the method

The cluster-sampling method can be used to conduct rapid assessment of health and other needs in communities affected by natural disasters. It is modelled on WHO's Expanded Program for Immunization (EPI) method of estimating immunization coverage, and has been modified to provide estimates of the population remaining in an area, and to conduct estimations of the number of people in the post-disaster area with specific needs (WHO 1996).

2.4.3 When appropriate?

- When the extent of damage is widespread, such as after a tropical cyclone (WHO 1996).

2.4.4 Prerequisites

- Census information, aerial maps, and/or data from local officials (WHO 1996).

2.4.5 Population estimation steps

1. Divide the disaster site into a number of comprehensive, mutually exclusive blocks or clusters with well-defined boundaries (WHO 1996).

2. Estimate the number of household units in each block by using census information, aerial maps, and/or data from local officials (WHO 1996).

3. Select a sample of n blocks with probability proportional to the estimated number of housing units. The EPI method uses n = 30 clusters. Systematic probability proportional to size sampling is used on a sampling frame where the primary sampling units or blocks are ordered by geographical proximity (WHO 1996).

4. Within each sampled cluster, count all housing units (WHO 1996).

5. Assuming that all of the housing units in a given block are listed, choose an equal probability sample, without replacement, of the housing units. Systematic random sampling often is used when the housing units are listed by geographical proximity (WHO 1996).

6. Count the number of people living in each selected housing unit (WHO 1996).

7. The total post-disaster population can be defined by multiplying the preliminary estimate of the number of housing units in the cluster with the total number of blocks or clusters in the disaster site (WHO 1996).

2.4.6 Strengths

- Surveys can be stratified on variables as severity of damage. Disasters can differentially affect areas in the disaster zone, and separate surveys can be obtained for areas where damage is low, medium, or high (WHO 1996).
- Can be applied to obtain reasonably reliable and valid estimates of post-disaster populations and the magnitude of their needs over a period of time (WHO 1996).

2.4.7 Limitations

- More than one survey or a stratified survey may be needed if the affected area is large or the damage is heterogeneous (WHO 1996).
- Repeated surveys may be needed to assess changes in needs over a period of time (WHO 1996).
- The survey can only cover accessible areas, while some clusters selected during the first stage will be inaccessible. Estimates for these areas would not represent the population of the entire area initially targeted for the survey (WHO 1996).

2.5 Transect sampling

2.5.1 Method reported in

CIEDRS (2003)

2.5.2 About the method

A transect walk uses a compass and a (hand drawn) map to trace a straight line through an affected area. The assessment team follows the line from end to end and notes observations (e.g. settlement patterns, quality of shelters, landmarks, facilities). A transect sample of the population can be taken (CIEDRS 2003).

2.5.3 Population estimation steps

1. Prior to the walk, the assessment team establishes a width (e.g. 10 m on either side of the line, using a length of rope or measured paces) (CIEDRS 2003). During the walk, the team estimates the length of the line (planimeter, measured paces) and calculates a transect area (length x width) (CIEDRS 2003).

2. On the walk, the team counts the number of habitations within a 10 m width of the line and the number of household members within each habitation. If a habitation straddles the 10 m width, those more than half within the line should be included and those more than half outside should be excluded (CIEDRS 2003).

3. The total estimated population within the transect area divided by the area measured gives an estimate of population density (CIEDRS 2003).

4. If repeated in non-overlapping transects and the total area of interest can be estimated, a rough population estimate can be extrapolated (CIEDRS 2003).

2.5.4 Strengths

- May prove easier to implement than a quadrat sample (CIEDRS 2003).

2.5.5 Limitations

- Has not been validated in a disaster situation (CIEDRS 2003).

2.6 Enumeration

2.6.1 Method reported in

WHO (2010)

2.6.2 About the method

Enumeration methods are very similar to conducting a census. Instead of counting every individual, the counted number is scaled up according to the size and structure of the sample frame (WHO 2010).

2.6.3 When appropriate?

- When resources and time are limited (WHO 2010).
- To access hidden or hard to reach populations (WHO 2010).

2.6.4 Prerequisites

- Mapping or stratifying before beginning ensures the coverage of all possible geographic areas and counting of the full population (WHO 2010).
- Sampling frame or list (WHO 2010).

2.6.5 Population estimation steps

1. Start with a sampling frame or list (e.g. complete list of individuals, sites from which a sample can be chosen) (WHO 2010).

2. Choose a sample of units (e.g. brothels, shooting galleries) from that list (WHO 2010).

3. Count only the individuals in those chosen units (WHO 2010).

4. Scale up the number counted according to the size and structure of the sample frame (WHO 2010).

2.6.6 Strengths

- Straightforward to calculate (WHO 2010).
- Advantage of being understood by policy makers who may not be experts in public health statistical or sampling methods (WHO 2010).
- Enumeration covers a fraction of the population, and requires fewer resources and is less expensive to conduct than a census (WHO 2010).
- With well-trained community guides covering small areas, enumeration can provide better access to hidden populations (WHO 2010).

2.6.7 Limitations

- If the population is very hard to reach, census and enumeration methods tend to underestimate population size when compared to other methods (WHO 2010).
- If the population is poorly defined and persons who are not truly part of the population are captured in the count, the population will be overestimated (WHO 2010).

- If the census or enumeration is conducted over a period of time individuals might be counted twice leading to an overestimate (WHO 2010).

2.7 Household sample survey

2.7.1 Method reported in

CIEDRS (2003), Stone (2007), OCHA and IDMC (2008), UNFPA (2010), WHO (2010)

2.7.2 About the method

Sample surveys allow generalizations about a whole population by interviewing or observing a part. While not designed to produce estimates of population size per se, they are useful in validating or adjusting estimates (CIEDRS 2003).

A more detailed household survey (with probability sampling design and adequate sample size) can provide more precise estimates of basic demographic information as household size, age and sex composition, births, deaths and in-migration and out-migration (CIEDRS 2003).

2.7.3 When appropriate?

- In situations where IDPs are difficult to identify, and where it is necessary to interview a cross-section of the population to be able to compare the difference of vulnerability between IDPs and local population (OCHA and IDMC 2008).
- To provide more precise estimates of basic demographic information of affected population (CIEDRS 2003).
- When population is settled/stable and there is a need to ascertain and/or collect additional data (OCHA and IDMC 2008).

2.7.4 Prerequisites

- All households selected for the sample should be interviewed. Systematically including or excluding any particular kind of household/individual in a demographic survey would create an unrepresentative picture of the population of interest (CIEDRS 2003).
- All individuals who are members of the household should be included. The survey does not require physical presence of all members but asks the head of the household or another responsible adult to name all household members along with their age, sex and possibly other information (CIEDRS 2003).
- A household size estimate derived from a household demographic survey could make total population estimates more accurate if they are derived by extrapolation from average household size (CIEDRS 2003).
- If the study is retrospective, then all individuals who were members of the household during the recall period should be included (CIEDRS 2003).
- All the surveyors work in the same manner in order to be certain that the data can be compared (OCHA and IDMC 2008).

2.7.5 Population estimation steps

1. Questionnaire design. Make sure that the final information one wants to obtain can be derived from the questions (directly or indirectly) (OCHA and IDMC 2008).

2. Data analysis plan. The plan should include all subjects/themes for which analysis would be conducted and include the list of all tables which would be produced for the final report (OCHA and IDMC 2008).

3. Sample design. Design and plan the actual sample selection process, choose between random sampling and cluster sampling, and determine the baseline data source for the sample selection (a list of households of the target areas) (OCHA and IDMC 2008).

4. Sample selection. The actual selection process of the sample households (randomised or systematic) (OCHA and IDMC 2008).

5. Enumerator training. Instruct enumerators on how to use the questionnaire, how to conduct the interviews (OCHA and IDMC 2008).

6. Survey piloting. Test the entire survey process on a small subset of households, possibly in a different area, to see what logistical adaptations and adjustments need to be made (OCHA and IDMC 2008).

7. Actual survey. When the survey is carried out, the process should be monitored continuously and at all stages if possible (OCHA and IDMC 2008).

8. Data entry. The entry of the questionnaire data into a data processing system should start as soon as possible after the beginning of the survey itself (OCHA and IDMC 2008).

9. Reporting. Data cleaning, analysis and reporting are office based activities that can be carried out after the field activities have been completed (OCHA and IDMC 2008).

2.7.6 Strengths

- Information on age and sex composition derived from the survey could be applied to total population estimates to obtain an estimate of male-female ratios, children under-five, or school-age children (CIEDRS 2003).
- Estimates of birth rates, death rates, and migration rates derived from the survey could be used to make projections of population figures for future programme planning (CIEDRS 2003).
- Interviews may detect specific protection challenges to individuals and/or groups of people (OCHA and IDMC 2008).
- Can ‘uncover’ difficult to locate IDPs who may be living in host families but have not been previously identified, and/or lower-status groups living in worse conditions (OCHA and IDMC 2008).
- Good level of detail likely to be obtained of population, displaced and host, as well as in-depth appreciation of their general condition and condition of community (OCHA and IDMC 2008).
- Useful for updating other sectoral indicators and planning changes to existing protection/assistance strategies (OCHA and IDMC 2008).
- Good indications can be obtained as to people’s intentions (e.g. return, resettlement) and how safe and sustainable return would be, if it were to take place to this location (OCHA and IDMC 2008).
- Surveys are cheaper than censuses and can be conducted much more frequently and on a more regular basis. They often provide more up-to-date information on the population than censuses (UNFPA 2010).

- Survey data provides more detailed information on behavioral aspects, aspirations and motivations for specific actions by the population and could therefore enhance anticipation, which is primordial in contingency planning (UNFPA 2010).
- Some surveys focus on specific vulnerable categories of the population and could thus make it possible for special attention to be given to such sub-populations (UNFPA 2010).
- Some survey data could also provide early warning signals of potential outbreaks of humanitarian situations (UNFPA 2010).

2.7.7 Limitations

- Difficult and can produce protection problems (people do not want to be singled out by being part of the sample) (OCHA and IDMC 2008).
- Intrusive on people's privacy (OCHA and IDMC 2008).
- Methodology can be difficult to plan and implement correctly, giving false estimates (OCHA and IDMC 2008).
- Time needed likely to equate to considerable resource outlay (OCHA and IDMC 2008).
- May lead to expectations of additional aid in sample group (OCHA and IDMC 2008).
- For surveys that directly ask about extremely high risk behaviours for estimating the size of most-at-risk populations, it is likely that population avoids answering such questions truthfully (WHO 2010).
- Surveys are less useful when behaviour is rare because it may not be reflected in the sample selected. A very large sample size would be required from a survey to establish the prevalence of such behaviours within a population (WHO 2010).
- It is difficult to create a population size estimate based on direct questioning about highly stigmatized behaviours within a household-based survey (WHO 2010).
- Not all survey data can be generalized and it depends largely on the method of sample selection to what level of disaggregation the results are considered valid. Survey results are often only valid down to the second level of the geographical administrative hierarchy (region, province) and rarely can be valid at the third level (the division or district) (UNFPA 2010).
- Not all surveys are sample surveys, thus not all survey results can be generalized (UNFPA 2010).
- Surveys are usually conducted by different ministerial departments and development partners, at various periods and in different parts of the country. Often, there is no central coordination and the terminology and approaches used differ. This renders the results difficult to compare across space and over time (UNFPA 2010).
- Most executing agencies tend to keep the datasets, and it is difficult to have access to the datasets for purposes of harmonization and study of trends (UNFPA 2010).

2.7.8 Case studies / validation studies

- Hurricanes Katrina and Rita crippled the ability of the local public health community to provide healthcare services to the population of New Orleans. Lack of information about the city's population size and health needs and the absence of an adequate communications system posed considerable obstacles to the coordination of local, state, and federal public health assets. The Health and Human Services Branch of

the city of New Orleans Emergency Operations Centre designed a project to collect population-based data through field surveys. With technical assistance from the Centres for Disease Control and Prevention, the Health Branch conducted surveys between October 2005 and January 2006, the results of which were widely used throughout the recovery process (Stone 2007).

3 Site estimation methods

3.1 'Guesstimates' and community estimates

3.1.1 Method reported in

RNN (1997), CIEDRS (2003), UNICEF (2010)

3.1.2 About the method

Many organisations make very rough estimates ('guesstimates') based on visual assessments. This educated guess can only be done with some kind of visual picture of what, for example, 1,000 people looks like (UNICEF 2010).

Key informants' estimates (people and community leaders from the area, village elders, service providers, local authorities) can be important sources of information on population figures, family composition, household size, settlement patterns, and arrival and departure rates (CIEDRS 2003, UNICEF 2010).

3.1.3 When appropriate?

- At the initial stages of an emergency, until conventional wisdom becomes challenged (UNICEF 2010).

3.1.4 Prerequisites

- Select more than one informant and triangulate the information provided by each to determine its reliability (RNN 1997, UNICEF 2010).

3.1.5 Strengths

- Can be an important source of alternative or complementary data used to compare results thrown up from other methods (RNN 1997, UNICEF 2010).

3.1.6 Limitations

- Different sources often come up with figures that differ by 100% or more (UNICEF 2010).
- Should only be used in the absence of other data (UNICEF 2010).
- Often a degree of mistrust of such sources among the staff of many international aid agencies (CIEDRS 2003).

3.2 Visual habitation count

3.2.1 Method reported in

RNN (1997)

3.2.2 About the method

Although called visual habitation count, this is an estimation method. A very approximate estimation of a population can be achieved rapidly by visiting and measuring an area considered representative of the population density of the settlement in question, and then

observing the total settlement from a high vantage point (hill, building, tower, aircraft) (RNN 1997).

3.2.3 When appropriate?

- Where speed is of the essence (a situation where a population is in urgent need of food and healthcare) (RNN 1997).

3.2.4 Prerequisites

- If the total settlement cannot be observed as one large unit (too dispersed, parts blocked from view by mountains), it will be necessary to estimate by observing the settlement sub-unit by sub-unit, or area by area (RNN 1997).

3.2.5 Population estimation steps

1. Estimate average household size (RNN 1997).

2. Estimate average population density of site (RNN 1997).

3. Estimate total area of the relevant site with the help of the beneficiaries, locals, or experts. This can be facilitated with aerial surveillance or a high vantage point (RNN 1997).

4. A very rough calculation will be obtained by dividing the estimated total area of the site by the estimate average number of m^2 per person. This needs to be compared with the results of other techniques (e.g. screening, sampling) (RNN 1997).

3.3 Static crowd estimation method

3.3.1 Method reported in

Watson and Yip (2011)

3.3.2 About the method

Shows similarities to the quadrat method, and has originally developed in 1967 by Jacobs to estimate the size of the Berkeley riots. The plaza where students gathered was marked into grid squares. A simple way to estimate the crowd was to count the number of squares and estimate how many students were in each square on average (Watson and Yip 2011).

Jacob's density rule is still used today: in a loose crowd the density is about 1 person per square metre, a solid crowd has about 2 persons per square metre and very dense crowds have about 4 per square metre (Watson and Yip 2011).

3.3.3 When appropriate?

- Static event (celebration, inauguration, commemoration) (Watson and Yip 2011).
- Static demonstration (rally, sit-in) (Watson and Yip 2011).

3.3.4 Prerequisites

- Photography is the best basis for estimation of density and for estimation of an area. This can be done by pixel-based approaches (depends on the quality of the images) or feature-based approaches (texture, edge-points, shape or head-counting) (Watson and Yip 2011).

3.3.5 Population estimation steps

- A very quick estimate can be obtained by observation (Watson and Yip 2011).
- A better estimate could be obtained by counting a sample of grid squares in real time or, better, from photos. Such sampling would lead to a standard error as well as an estimate (Watson and Yip 2011).
- If the crowd area is regular, clearly delineated and visible to the camera, then multiplying by the average density will produce a crowd estimate (Watson and Yip 2011).

3.3.6 Limitations

- Often the area occupied by the crowd will not be regular, and parts of it will remain invisible to the camera: trees, buildings or darkness may hide parts of the crowd. This adds to the uncertainty of the estimate (Watson and Yip 2011).
- Is not well suited to a mobile demonstration such as a march. Even if good photographs are available the area is generally more difficult to specify, and while the crowd density is less it tends to be much more variable: a march may have a disciplined, well-formed head and a ragged, spread-out tail, and then gather more compactly at the destination to hear the speeches (Watson and Yip 2011).

3.4 Participatory mapping

3.4.1 Method reported in

(IFRC 2007)

3.4.2 About the method

Participatory mapping of the catchment area may be done by inviting a group of the affected population to sketch a map of the entire community on the ground or on a large paper. The catchment area is the geographical area from which all the people attending a particular health facility come (IFRC 2007).

3.4.3 When appropriate?

- At the initial stages of an emergency, when time is limited. Helps direct fuller needs assessments if the situation warrants.

3.4.4 Population estimation steps

1. Ask affected group to define the physical boundaries of the affected location and the location of all key landmarks (e.g. rivers or lakes, roads, health facilities/services, water pumps, cemeteries). Distances should be shown as accurately as possible (IFRC 2007).

2. Ask affected group to identify where different ethnic communities and the most vulnerable group(s) (e.g. the poorest or most malnourished) are located in the map of the catchment area (IFRC 2007).

3.5 Focus group discussions

3.5.1 Method reported in

OCHA and IDMC (2008)

3.5.2 About the method

A focus group discussion entails organizing and conducting a group discussion while ensuring that the group is 'representative' of all segments of the (IDP) community (e.g. women, men, community elders, adolescents, IDP leaders). This method is useful in obtaining additional data and should be triangulated with at least one other source, such as good baseline data or a quantitative source. Useful data elements that can be collected are perceived size of the (IDP) population and perceived sex and age breakdown (OCHA and IDMC 2008).

3.5.3 When appropriate?

- When (additional) information is needed at the group/community level (OCHA and IDMC 2008).
- At the initial stage of an emergency, as time is limited. Helps direct fuller needs assessments if the situation warrants (OCHA and IDMC 2008).

3.5.4 Prerequisites

- It is essential that age, gender and diversity is taken into consideration when forming the focus groups. Each group will have specific information, problems or concerns and this needs to be reflected and carefully recorded (OCHA and IDMC 2008).
- In order to ensure effective participation, the group should not exceed 10 – 15 people (OCHA and IDMC 2008).

3.5.5 Strengths

- Group discussions can be a good way of obtaining (IDP) situations, reasons for displacement, particular protection challenges, immediate humanitarian needs and vulnerabilities (OCHA and IDMC 2008).
- Group discussions can give a more aggregate picture of, for example, what whole communities or villages experienced, estimates on people killed and wounded and those who fled (OCHA and IDMC 2008).

3.5.6 Limitations

- Group discussions may not achieve great accuracy (OCHA and IDMC 2008).

3.6 Drive through / walk through

3.6.1 Method reported in

CIEDRS (2003)

3.6.2 About the method

A drive through involves driving through a disaster-affected area to assess the situation. Things to look for could include settlement patterns, quality of shelters, physical signs of

distress (death, illness, conflict), household property (cooking facilities, livestock) and community resources (clinics, schools, wells) (CIEDRS 2003).

A walk-through puts the observer on the ground, and offers the opportunity for closer insights into the conditions of daily life for disaster-affected populations (CIEDRS 2003).

3.6.3 When appropriate?

- At the initial stages of an emergency, when time is limited. Helps direct fuller needs assessments if the situation warrants.

3.6.4 Strengths

- A drive-through is low-cost (assuming vehicles are available and roads are passable), easy to implement, covers a wide area quickly, and puts one close to the scene (CIEDRS 2003).
- Drive-through and walk-through offer the benefit of direct observation and enable cross-checking of maps and other data with "ground-truth." The emphasis should be on triangulating information from various sources and perspectives, in order to avoid bias and misinterpretation (CIEDRS 2003).

3.6.5 Limitations

- A drive-through limits observation to what can be seen from a passable road. In many emergency situations, areas and populations that are more remote and inaccessible may be the most vulnerable (CIEDRS 2003).
- A drive-through offers little more than a passing glimpse, and may lead to misinterpretations: an empty field in the morning may be crowded with people that afternoon (CIEDRS 2003).
- A drive-through provides limited opportunity for interaction with local populations, whose perspectives are vital to an understanding of the situation (CIEDRS 2003).
- A walk-through is more time-consuming and covers a smaller area (CIEDRS 2003).
- A walk-through is open to route-bias: populations and conditions off the beaten track may be quite different from those closer to the roads and pathways (CIEDRS 2003).

3.7 Transect walk

3.7.1 Method reported in

CIEDRS (2003)

3.7.2 About the method

In order to correct for the route-bias of established roads and pathways, a transect walk uses a compass and a (hand-drawn) map to trace a straight line through an affected area, which the assessment team then follows as closely as possible from end to end, noting observations of settlement patterns, quality of shelters, landmarks, facilities (CIEDRS 2003).

3.7.3 When appropriate?

- When established roads and pathways are expected to lead to route-bias and perspectives on both central and peripheral areas are needed.

3.7.4 Prerequisites

- A compass and a (hand-drawn) map (CIEDRS 2003).

Strengths

- By following a line rather than a path, the transect walk takes observers through a cross-section of terrain that is more likely to offer perspectives on both central and peripheral areas (CIEDRS 2003).

Limitations

- Can be more time-consuming than one that follows existing routes (CIEDRS 2003).
- Can present hazards and impediments both natural (e.g. swamps, rivers, mountains) and non-natural (e.g. land mines, insecure areas) (CIEDRS 2003).

3.8 Screening under fives

3.8.1 Method reported in

RNN (1997), IFRC (2007)

3.8.2 About the method

Relies upon the assumption that the number of children under five within a population represents a given percentage (15 to 20%) of the total. By counting or estimating the number of under-fives, it should be possible to estimate the total population. A method used for estimating the under-fives is to assume that they will not measure more than a maximum height (110 cm) (RNN 1997).

3.8.3 When appropriate?

- In emergencies where the ratio of under-fives to adults does not change.

3.8.4 Prerequisites

- Access to all children within the community.

3.8.5 Population estimation steps

1. A horizontal cross-bar can be mounted on two vertical posts (in the shape of a set of low goal posts) (RNN 1997).

2. All children in the population are asked to walk upright underneath (RNN 1997).

3. Those who pass under without touching their heads on the cross-bar are assumed to be under five years of age (RNN 1997).

Alternative: A more accurate alternative is to actually measure each child (RNN 1997).

4. The total population is then estimated by multiplying the under-five population figure by the required multiple (i.e. the accepted ratio of under-fives to the total population is 5 or 6) (RNN 1997).

3.8.6 Strengths

- Its relative simplicity (RNN 1997).

3.8.7 Limitations

- Screening or sampling all under-fives is not easy, and error through omission is frequent (RNN 1997).
- A direct fixed relationship between the number of under-fives and the total population is open to question in certain populations that are in emergency (e.g. a higher or lower ratio of under-fives to adults due to war, serious illness) (RNN 1997).
- Significant error may occur in the identification and measurement of the children (RNN 1997).

3.9 Water usage data

3.9.1 Method reported in

IFRC (2007)

3.9.2 About the method

Relies upon the assumption that the population number in a camp can be estimated by the average amount of water used by each individual.

3.9.3 When appropriate?

- In camp settings.

3.9.4 Prerequisites

- Access to water collection points, information on water consumption.

3.9.5 Population estimation steps

1. Determine the total amount of water the whole population in the camp consumes in one day (IFRC 2007).

2. Interview a sample of people at their household or water collecting point to estimate the average amount of water used by each individual (IFRC 2007).

3. If 200,000 litres of water are consumed in one day and individual water usage is estimated as 20 L/person/day, the total population in the camp should be $\frac{200{,}000}{20} = 10{,}000$ people (IFRC 2007).

Alternative: The total food distributed and individual food baskets may be used to estimate the total population in the same way as water usage. However, inaccuracy occurs when food rations are collected for sale or families may collect more than one ration (IFRC 2007).

3.10 Immunization coverage or programme activity data

3.10.1 Method reported in

MSF (1997), MSF (2006), UNICEF (2010)

3.10.2 About the method

This method uses the results of an immunization coverage survey or the number of vaccines administered during a mass immunization campaign, for a specific age group (e.g. 6 to 59 months). By using the known reference age group distribution, the total population can be deduced (UNICEF 2010).

3.10.3 When appropriate?

- When a mass campaign and a coverage survey have already been conducted in the early days of an intervention (MSF 1997).

3.10.4 Prerequisites

- Available results of an immunization coverage survey or the number of vaccines administered during a mass immunization campaign (UNICEF 2010).

3.10.5 Population estimation steps

1. E.g. suppose the immunization coverage rate among children (6 to 59 months) was 80 percent and that 10,000 children in this age group were immunized (UNICEF 2010).

2. The total children in this age group is therefore $\frac{10{,}000}{0.80} = 12{,}500$ (UNICEF 2010).

3. If children in this age group represent about 16 percent of the total population, the total population can be estimated: $\frac{12{,}500}{0.16} = 78{,}000$ (UNICEF 2010).

3.10.6 Limitations

- Not very accurate (MSF 1997).
- It is in any case rare that a mass campaign and a coverage survey have already been conducted in the early days of an intervention (MSF 1997).

3.11 Network scale-up

3.11.1 Method reported in

WHO (2010)

3.11.2 About the method

Uses information collected in general population household surveys to estimate the size of 'hidden' or 'hard to reach' populations, e.g. populations at increased risk for HIV. Instead of asking about the respondent's own behaviour, this method asks about the behaviour of the respondent's acquaintances (WHO 2010).

Based on the average number of individuals that respondents know in hidden populations and the average personal network size, the proportion of people in the most at risk population is estimated (WHO 2010).

3.11.3 When appropriate?

- Is currently being considered for estimating the size of hard-to-reach populations (WHO 2010).

3.11.4 Population estimation steps

1. Determine personal network size. Factors characterizing a personal network are when someone who knows you, and you know them by sight and name, when you can contact them or they can contact you, and when you have talked to them within the last two years. The size of a personal network can be estimated by the summation method and the known population method (WHO 2010).

- In the summation method, respondents are asked for a direct estimate of their personal network size. The respondent counts his number of acquaintances in a set of mutually-exclusive, but exhaustive, categories, and the number of acquaintances in each category is summed up (WHO 2010).
- In the known population method, respondents are asked about the number of people they know in specific populations for which a true value is known. E.g. if census data show there are 3,200 adults named Michael in the country with 300,000 people. The mean number of acquaintances named Michael (calculated from the respondents) is 5.57. The estimated personal network size can be calculated as: $\frac{5.57}{3200} * 300{,}000 = 522$

2. Ask the general population how many people they know in the hidden population. Not always easy to insert in a survey given the common stigma and illegality of these behaviours. The wording and location of these questions in the survey are important aspects to consider (WHO 2010).

3. Calculate the estimated population size and adjust for known biases. Divide the average number of people in the known populations by the average network size and multiply by the total adult population (WHO 2010).

3.11.5 Strengths

- Does not require members of hidden populations to identify themselves to a survey team (WHO 2010).
- The questions can be incorporated into existing household surveys so estimates can be generated at the level of those surveys (e.g. national or provincial) (WHO 2010).
- Can create size estimations for multiple hidden populations in one survey (WHO 2010).

3.11.6 Limitations

- The size of a network may vary among individuals (WHO 2010).
- A respondent may be unaware that someone in their network is a member of the population of interest (WHO 2010).
- The position of a respondent may cause them to know fewer members of the population than would be expected (barrier effects) (WHO 2010).

- Some populations might not admit knowing individuals with the hidden behaviours (WHO 2010).

3.12 Capture-recapture method

3.12.1 Method reported in

Luan et al. (2005), WHO (2010)

3.12.2 About the method

Capture-recapture techniques were first used in 1662 to estimate the population of London. In the early 1900s, the method was adapted to study wildlife populations. It calculates the total size of a population based on two independent captures of population members. The number of members captured in both samples is used to derive an estimate of the total number in the population (WHO 2010).

3.12.3 When appropriate?

- Particularly adapted for hard to reach populations such as migrant workers, nomads and IDPs (WFP 2006).
- When the population is closed, and the population available to be captured in the second sampling (recapture) includes exactly the same set of individuals as it did for the first (WHO 2010).
- Ideal for experimental studies (WFP 2006).

3.12.4 Prerequisites

- Capture in the second sample is independent of sample in the first. People in the first sample are not more or less likely to be included in the second sample than people who were not included in the first sample. If being included in the first sample increases a person's chance of being included in the second sample, the total population will be underestimated (WHO 2010).
- Each person in the population should have an equal chance of being included in the sample (random sample) (WHO 2010).
- Estimates based on small samples or too few matched individuals can be misleading. It should be ensured that there are enough members in the samples to produce meaningful results (WHO 2010).

3.12.5 Population estimation steps

1. Map all the sites where the population can be found (WHO 2010).

2. Tag all of the members of the population at the site (card, memorable gift). Keep a count of the persons tagged. Return to the sites a week later and retag all of the persons encountered (WHO 2010).

3. In the second visit, count members who were counted in the first sample and members who are being counted for the first time in the second sample (WHO 2010).

4. Population size is estimated by multiplying the number captured in the first sample by the number captured in the second sample and dividing by the number captured in both samples (WHO 2010).

Alternative: In situations where it is not feasible to visit all of the sites or all of the sites are not known a variation of this method can be used (WHO 2010).

1. Select a (random) sample of individuals from the population (WHO 2010).

2. Note persons selected in some fashion (names, clinic patient identifier number, a card) (WHO 2010).

3. Collect a second sample at a later time, which should be independent of the first sample (a different clinic, institution or survey) (WHO 2010).

4. In the second sample, determine how many people were also counted in the first sample and how many people are being counted for the first time in the second sample. The number of individuals observed in each sample and the number in both samples is recorded (WHO 2010).

5. Population size is estimated by multiplying the number captured in the first sample by the number captured in the second sample and dividing by the number captured in both samples (WHO 2010).

3.12.6 Limitations

- The prerequisite of no in- or outmigration is easily violated in studies of persons who inject workers within the illegal circuit, where there is large turnover (people joining or leaving the population) and where there is lots of movement (WHO 2010).

3.12.7 Case studies / validation studies

- A study has been conducted to ascertain practical methods of estimating the population size of men who have sex with men by field application in Chengdu City, (P.R. China). Nine public places were selected, where men who have sex with men frequented. Capture–recapture method and multiplier method were used to count the number of men who have sex with men in the assigned places in 10 days (Luan et al. 2005).
- The multiplier method was easy and smooth in practice and produced highly reliable results, which yet was expensive. The application of capture–recapture method cost less in both time and funds, and the three results produced could verify each other, which was fit for the estimation (Luan et al. 2005).
- The simulated capture-recapture method of gave accurate, non-biased results irrespective of the changing spatial distribution of the population. The results also show the higher the number of shelters visited the narrower the dispersion of the confidence intervals (more accurate the estimation), which is to be expected. However, the capture-recapture method could not be used in the field trial for operational reasons. It required a large sample size (would need 10% of the population in each survey) which would be expensive, in both time and resources. If a small sample size is used, there is a high probability there will be situations where there is no overlap from the two samples, therefore a population estimation will be unobtainable. Finally, it is difficult to ensure the independence of the two teams needed to do the two samples. Operationally it would have been necessary for the first team to identify households to prevent overlap, therefore difficult to maintain the independence of the two teams (Treacy-Wong 2011).

3.13 Flow monitoring

3.13.1 Method reported in

RNN (1997), CIEDRS (2003), UNHCR/WFP (2004), UNHCR (2007), IDMC/OCHA (2008)

3.13.2 About the method

Flow monitoring (referred to by UNHCR (2007) as counting) is based on monitoring and quantification of populations moving into or away from certain locations. By establishing teams of quantifiers at key points of entry or exit to the emergency settlements (e.g. border crossing points, major road junctions, ports), an estimate of population flows per defined time-period can be established RNN (1997).

Comprehensive monitoring requires enumerators to be placed at all significant entry and exit points as quickly as possible and maintained on a round-the-clock basis until flows have stabilized. It allows counting most arrivals and departures and uses those numbers to make direct estimates of overall population numbers (IDMC/OCHA 2008).

Spot monitoring places enumerators at selected points at selected intervals (several hours per day, alternate days) to monitor movement trends. It allows for the estimation of arrival and departure rates, which can be used to adjust population estimates (IDMC/OCHA 2008).

Counting should be supplemented with a systematic sample of arrivals and departures, to identify household/family size, place of origin, destination, and reason for move (IDMC/OCHA 2008).

3.13.3 When appropriate?

- Most disasters cause population displacement. Understanding displacement patterns may be essential not only in estimating current populations but in forecasting future numbers (CIEDRS 2003).
- Suitable for data collection at the group/community level (IDMC/OCHA 2008).
- For situations that are, or may become, unstable, resulting in sudden population movements to an area or from an area of which the population profile is known (IDMC/OCHA 2008).
- Useful for estimating the changes in population size of a known IDP population within a well defined geographic area (IDMC/OCHA 2008).

3.13.4 Prerequisites

- Enough staff at all significant population movement times (populations may move at the dead of night) (RNN 1997).
- The teams should be sufficiently well trained and equipped (e.g. handheld counters) (IDMC/OCHA 2008).
- While monitoring, it is advisable to provide daily updates on the size and the composition of the flow (IDMC/OCHA 2008).

3.13.5 Strengths

- If established from the very beginning of an operation, flow monitoring may even give an estimate of the total population in an emergency settlement (RNN 1997).

- General flow monitoring methods provides information on vulnerabilities and risks (IDMC/OCHA 2008).
- Provides a snapshot of situation on the ground (IDMC/OCHA 2008).
- Good methodology to use for IDPs on the move.
- Opportunity for information about the situation from which people are fleeing (IDMC/OCHA 2008).
- Presence of staff allows to see what is happening and to react (interviews) (IDMC/OCHA 2008).
- Possible to provide assistance to population en route (IDMC/OCHA 2008).
- Comprehensive monitoring captures the characteristics of the population consistently (IDMC/OCHA 2008).
- Spot monitoring is slightly less resource intensive than flow monitoring(IDMC/OCHA 2008).

3.13.6 Limitations

- Confusion as who is counting whom and where (same populations may be counted twice if counting points are placed so that the same movement is monitored at two separate locations) (RNN 1997).
- Normal or seasonal population movements (migrant workers entering or leaving an area seeking harvest employment) should have been understood and factored in (RNN 1997).
- General flow monitoring methods are resource intensive (e.g. finding sufficient enumerators, training, time, expenses) (IDMC/OCHA 2008).
- Comprehensive monitoring is labour intensive in comparison to spot monitoring (IDMC/OCHA 2008).
- May not be possible to organise in time to collect accurate estimates of people fleeing (IDMC/OCHA 2008).
- Needs prior organization so all resources can be rapidly deployed (necessary to foresee in contingency plan) (IDMC/OCHA 2008).
- Risk for enumerators if IDPs are fleeing from a very close conflict (IDMC/OCHA 2008).

3.14 Mobile crowd estimation

3.14.1 Method reported in

Watson and Yip (2008)

3.14.2 About the method

Shows similarities to the flow monitoring method. Estimates the size of a mobile population in which people may join or leave the march at various points. The number of participants, N, in the demonstration is defined to be the number of people who entered the demonstration route.

Two variations exist, the count and follow-up method, and the double counting and spot-checking method.

3.14.3 When appropriate?

- Mobile event (parade)
- Mobile demonstration (march)

3.14.4 Steps count and follow-up method

1. Choose an inspection point P, generally near to the focus, and to "count" the number of participants passing this point. This gives an initial estimate.

2. However, some participants may have left the route before the inspection point, or have joined the route after it, which would mean that the estimate is too low. One method used to overcome this is a subsequent random phone survey of the population. This involves first finding the participants, then asking them whether they passed the inspection point or not.

3.14.5 Limitations

- The crowd estimates are considerably more uncertain for a mobile crowd than for a static one.
- Even a big demonstration involves only a small proportion of the population, and so a large number of phone calls would need to be made.
- Other problems related to a phone survey include possible non-representativeness of the phone sample, the truthfulness of the responses, an allowance for clustering and household groups, dealing with non-response.
- In a tense and politically charged situation (demonstrations in Tunisia, Egypt), those who were present may have well-justified fears about admitting it, on the phone, to a stranger.

3.14.6 Steps double counting and spot-checking method

1. Another method, which avoids the use of a phone survey, is to choose not one but two inspection points, A and B, on the route of the march, not too close together and with one close to the end.

3.14.7 Strengths

- Avoids the time and cost of the phone survey.
- Avoids the phone response bias.
- Has the advantage of increased efficiency and immediacy.
- Gives a more accurate estimate than the single inspection point.
- It is also more immediate than the single inspection point method: a same-day estimate is obtained.

3.14.8 Limitations

- The crowd estimates are considerably more uncertain for a mobile crowd than for a static one.

- There will be participants who passed one but not both of the inspection points, and some who passed neither.
- Increases the counting cost and adds the cost of the spot-check survey.

4 Counting methods

4.1 Head count

4.1.1 Method reported in

CIEDRS (2003), UNHCR/WFP (2004), MSF (2006), IDMC/OCHA (2008), UNICEF (2010)

4.1.2 About the method

During head counts, enumerators are deployed to make a population count (CIEDRS 2003). It attempts to count each individual physically present in an area at a particular time. In effect, a head count is a census and may also be used to establish a registration system (CIEDRS 2003). Alternatively, a centralized headcount gathers the entire population to be counted in a central area (IDMC/OCHA 2008).

4.1.3 When appropriate?

- In settings where target populations are relatively small (under 10,000) and living in a camp, settlement or other location with discrete boundaries (CIEDRS 2003).

4.1.4 Population estimation steps

1. Obtain a map of the area within which the population is to be counted (satellite image, photo-mosaic made from aerial photography, digitized map created from GPS way-points, local political map, hand-drawn map created by community members) (CIEDRS 2003).

2. Identify non-overlapping segments or sections that cover the entire area on the map and assign enumerators to designated sections (CIEDRS 2003).

3. At a designated time (e.g. daybreak as people are waking up), enumerators move through their designated section of the population counting each habitation and counting the total number of people physically present. Unoccupied habitations should also be recorded (CIEDRS 2003).

4. The sum of all section or segment head counts equals the total population in that location. With information on total habitation numbers, it is possible to estimate an average household size as well (CIEDRS 2003).

4.1.5 Strengths

- No specific expertise necessary (IDMC/OCHA 2008).
- Gives direct access to people, allows for response and interventions (IDMC/OCHA 2008).
- Provides a snapshot of population (displaced and host) as well as an appreciation of their possible immediate protection problems and general condition (IDMC/OCHA 2008).
- In a centralised headcount, there is less likelihood than enumerator-based headcount of missing someone and less likelihood of double counting (IDMC/OCHA 2008).

4.1.6 Limitations

- In contexts of high IDP mobility the count should be updated regularly and as often as necessary, as a result of which 'counting fatigue' by the IDPs can occur (IDMC/OCHA 2008).
- The accuracy of headcount may be larger in comparison to the habitation count (IDMC/OCHA 2008).
- Is not appropriate when population is mobile (i.e. moving from one place to another) (IDMC/OCHA 2008).
- If cannot be concluded within a timeframe of 2 - 6 hours then the result will be distorted and unusable (e.g. wrong time of day may give false estimates of resident population) (IDMC/OCHA 2008).
- A centralised headcount is disadvantageous to the elderly, the disabled, single mothers and other groups with specific needs. Could lead to serious crowd control problems (IDMC/OCHA 2008).

4.2 Habitation count

4.2.1 Method reported in

CIEDRS (2003), UNHCR/WFP (2004), MSF (2006), IDMC/OCHA (2008), UNICEF (2010)

4.2.2 About the method

During habitation counts, enumerators are deployed to make a population count. It attempts to count each habitation in an area at a particular time, whether it is occupied or not. Head counts are taken in a (systematic) sample of habitations and the average household size is multiplied by the number of habitations to obtain a population estimate (CIEDRS 2003).

4.2.3 When appropriate?

- In settings where target populations are relatively small (under 10,000) and living in a camp, settlement or other location with discrete boundaries (CIEDRS 2003).

4.2.4 Prerequisites

- An exhaustive habitat count can be done while walking, driving in a car, or aerial photography. This assumes good quality and sufficient detail of the pictures taken (MSF 2006).

4.2.5 Population estimation steps

1. Obtain a map of the area within which the population is to be counted (satellite image, photo-mosaic made from aerial photography, digitized map created from GPS way-points, local political map, hand-drawn map created by community members) (CIEDRS 2003).

2. Identify non-overlapping segments or sections that cover the entire area on the map and assign enumerators to designated sections (CIEDRS 2003).

3. Enumerators go through their designated section of the population counting each habitation (CIEDRS 2003).

4. Using the total number of habitations per section, a sampling interval is calculated. At a designated time (often at daybreak as people are waking up), enumerators visit a systematic sample of habitations and count the number of people physically present (CIEDRS 2003).

5. The average number of people per habitation is multiplied by the number of habitations within the section to obtain an estimate of the section population. These sectional numbers are summed to obtain a total population estimate (CIEDRS 2003).

4.2.6 Strengths

- Habitation count is less labour intensive than head count (IDMC/OCHA 2008).
- Provides a rapid overview of the number and occupation rate of dwellings, the condition of people and their dwellings and possible immediate protection concerns (IDMC/OCHA 2008).
- Gives an indicator of how many people are still living there or appear to have left (IDMC/OCHA 2008).
- No specific expertise necessary (IDMC/OCHA 2008).

4.2.7 Limitations

- In contexts of high IDP mobility the count should be updated regularly and as often as necessary, as a result of which 'counting fatigue' by the IDPs can occur (IDMC/OCHA 2008).
- The accuracy of habitation count may be less in comparison to the headcount (IDMC/OCHA 2008).
- Can be labour intensive if the coverage area is large and requires more than one team to cover in one day (IDMC/OCHA 2008).
- Can give a false population estimate if not implemented correctly (IDMC/OCHA 2008).
- Not appropriate when population is mobile (i.e. moving from one place to another) (IDMC/OCHA 2008).
- Habitation count is intrusive (IDMC/OCHA 2008).

4.3 Census

4.3.1 Method reported in

MSF (1997), MSF (2006), IDMC/OCHA (2008), UNFPA (2010), UNICEF (2010)

4.3.2 About the method

While during sample surveys information is only obtained from a subset of a population, during a census every person is counted and registered individually (MSF 1997, MSF 2006). A census covers the entire population of a country and besides individual data, a set of relevant socio-economic information is gathered for every household (IDMC/OCHA 2008).

4.3.3 Prerequisites

- A census is done during the time of the day when most persons are at home (UNICEF 2010).

- Systematic registration of new persons can be done upon arrival at the site. This may be coupled to other aid activities, such as distribution of food cards, detection of malnutrition, measles vaccination etc (UNICEF 2010).
- In the census data, IDPs can only be identified through specific questions, which need to be established during the census planning. The opportunity should be used to have specific questions included in the census questionnaires that enable the identification of IDPs (IDMC/OCHA 2008).

4.3.4 Strengths

- Census data provide valuable baseline data for the sampling process in household surveys and for the design and planning of IDP registration activities (IDMC/OCHA 2008).
- Can provide essential background information for almost every other kind of profiling activity, even if outdated (IDMC/OCHA 2008).
- Provides data on the entire resident population in a country by administrative area and often by locality of residence at a given period (UNFPA 2010).
- Provides a detailed disaggregation of the population according to specific categories and by administrative area/locality (UNFPA 2010).
- Provides details on the key elements of population dynamics (fertility, mortality and migration) and lays the groundwork for future population projections (UNFPA 2010).
- Provides details on household and housing characteristics and therefore enables the study of its vulnerability (UNFPA 2010).
- Analyses of census data provide early warning signals of potential humanitarian crisis situations (e.g. very high densities where everyone depends on land, unconventional population structures) (UNFPA 2010).
- Census mapping enables the collection of valuable information on the location and characteristics of vital social infrastructure (e.g. health facilities, schools, churches, community halls, markets, roads) (UNFPA 2010).
- Census mapping culminates in the delimitation of the entire national territory into small enumeration areas. In the event of any disaster affecting only part of the territory, more realistic estimates of the population affected could be reconstituted using information on the enumeration areas affected (UNFPA 2010).
- Most of the surveys conducted in countries draw their samples from master sampling frames provided by the most recent census (UNFPA 2010).
- Census results are usually published and widely disseminated and used for development planning. They therefore constitute a recognized and official source of information (UNFPA 2010).

4.3.5 Limitations

- A census takes a long time and requires a lot of human resources, which is often lacking in emergencies (UNICEF 2010).
- Censuses are infrequent, as a result of which it is unlikely that data will provide an accurate and timely snapshot of a mobile sub-population such as an IDP group (IDMC/OCHA 2008). Most countries prone to humanitarian crisis situations, hardly ever respect the 10-year interval for census-taking and its figures may no longer reflect the actual situation on the ground (UNFPA 2010).

- Census data on IDPs will be useful for IDP profiling if it is less than two years old. For more dynamic IDP situations the census might only provide enough accuracy for one year (IDMC/OCHA 2008).
- A census as such is not necessarily the best IDP profiling tool since it is a costly, government driven and country wide exercise which in itself can be the cause of temporary movement of large population groups (IDMC/OCHA 2008).
- A census usually excludes 'sensitive' questions (IDMC/OCHA 2008).
- Some censuses are victims of incomplete coverage such that the results have to be adjusted before publication (UNFPA 2010).
- Census data does not provide all the information that may be needed for contingency planning for estimation of needs in terms of food (UNFPA 2010).
- Published reports from censuses provide in general only aggregate information, while the raw data files, which should enable breakdown of data to smaller units, are usually never easily accessible (UNFPA 2010).

4.4 Registration

4.4.1 Method reported in

UNHCR (1994), RNN (1997), CIEDRS (2003), IFRC (2007), UNHCR (2007), IDMC/OCHA (2008)

4.4.2 About the method

Registration involves recording information about individuals or families that will serve identification and programming purposes (CIEDRS 2003).

4.4.3 When appropriate?

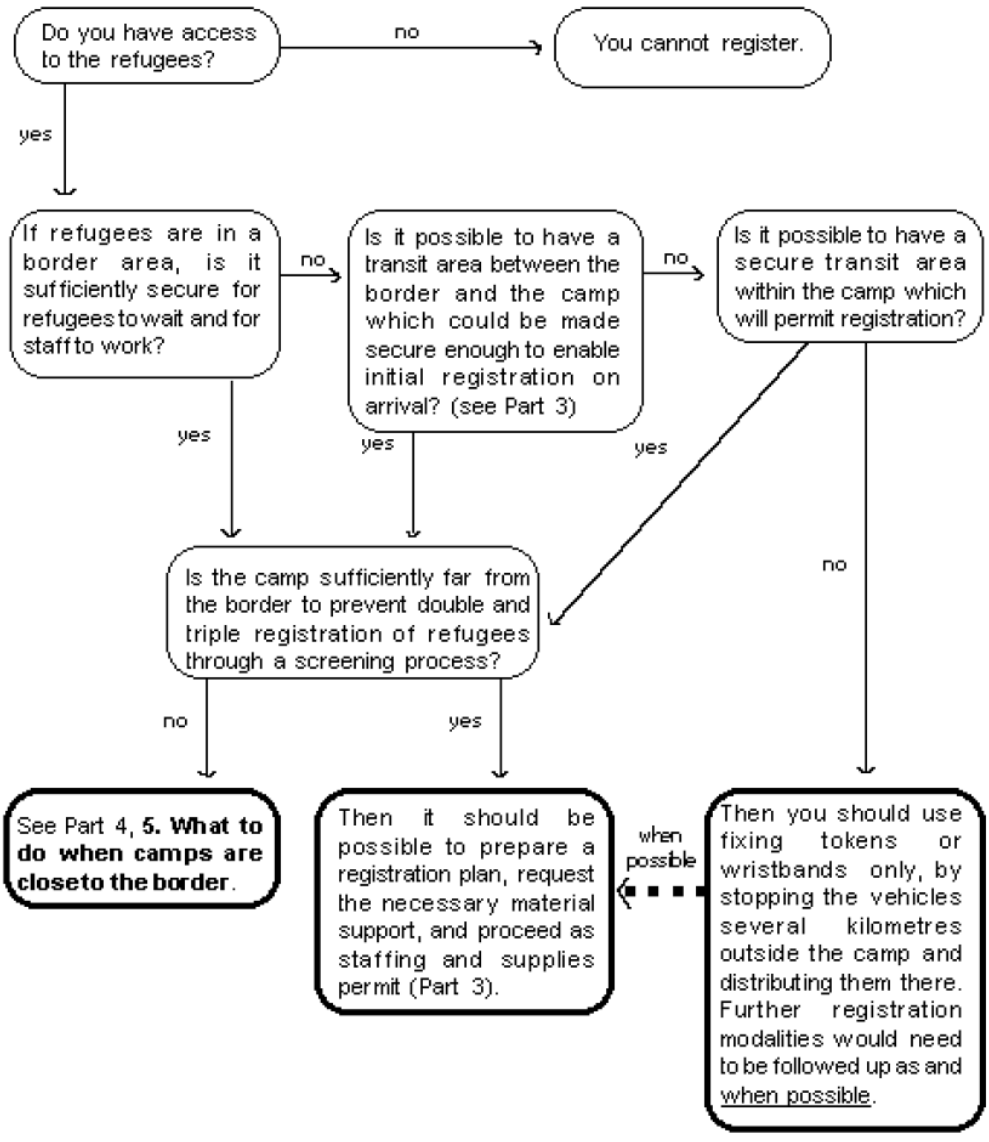
- If the information from the census or registration exercises is unreliable or more information is required as camp services are set up (IFRC 2007).
- When a programme lasts well beyond the acute emergency phase (RNN 1997).
- When the scale of the task is relatively small compared with the resources available, a small population in a large programme for instance (RNN 1997).
- When distribution arrives at a point at which it is direct, i.e. the last link in the distribution chain. This is especially so if assistance is targeted (RNN 1997).

4.4.4 Prerequisites

- Reviewing existing administrative records or interviewing key persons may help in designing the registers and in determining the target groups for emergency health services. Community health workers can be trained to visit all households and gather the required information (IFRC 2007).
- Household registers can later be used by health workers to locate vulnerable individuals who are most at risk of disease or death, and to target them for specific interventions (IFRC 2007).
- Planning for registration must be field driven and based on the situation on the ground. The possibility of increasing or decreasing registration activity depending on the situation should be included in the planning (UNHCR 1994).

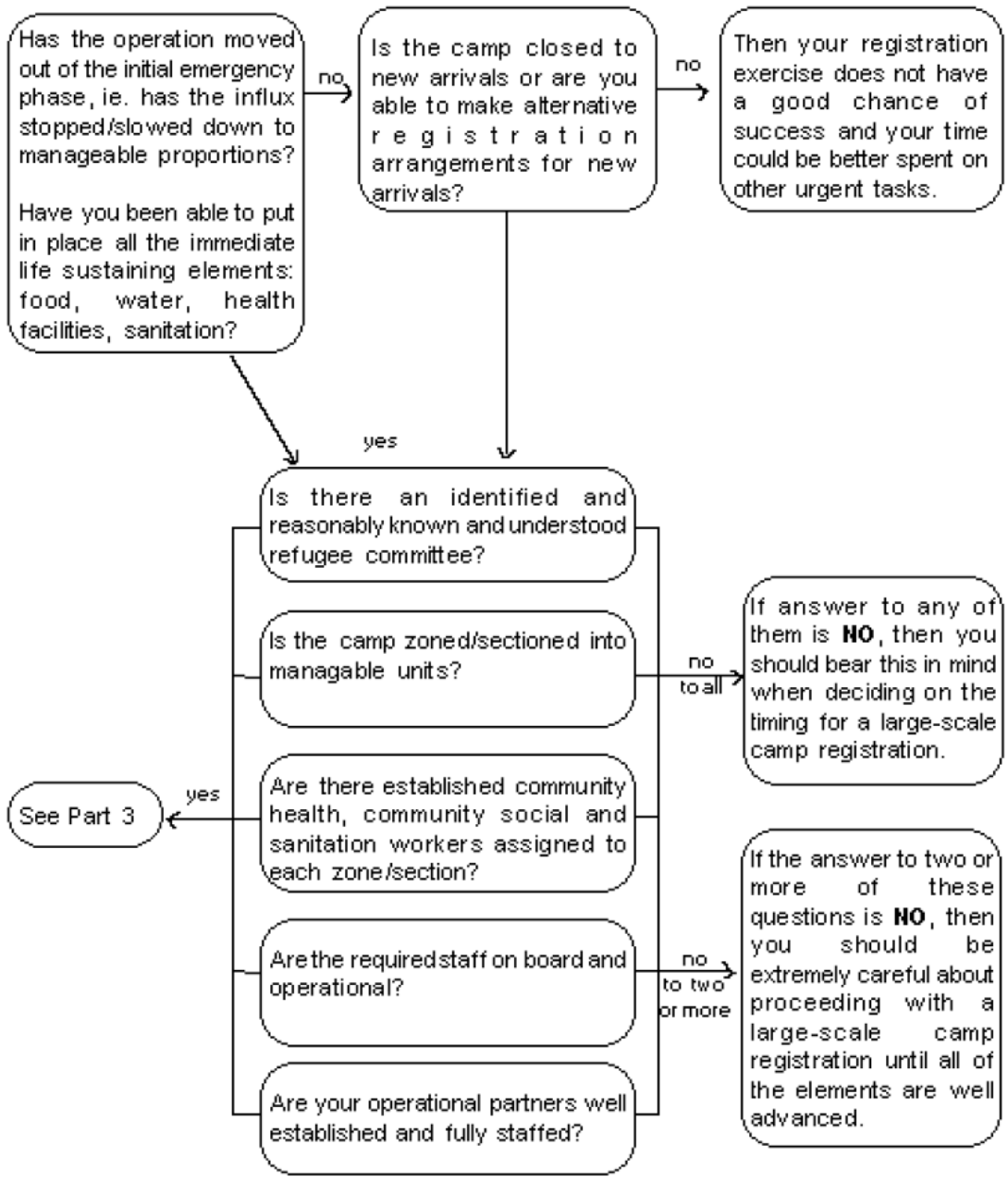
- There must be sufficient input of supplies and materials required for registration. Basic materials should be deployed with the initial emergency team and other needs, as identified, provided on request (UNHCR 1994).
- Refugee acquiescence, if not total cooperation, is a prerequisite. A refugee committee, accepted by the community, and known to aid workers, is important (UNHCR 1994).

Figure 3 Decision tree registration from a border or transit area to a camp



Source: UNHCR (1994)

Figure 4 Decision tree in-camp registration



Source: UNHCR (1994)

4.4.5 Population estimation steps

1. Planning and organization. Need to occur in advance of the date (or dates) of the actual registration. Clear objectives for the registration that are understood and agreed to by all major stake-holders in the exercise need to be established. It is vital that the affected population(s) understand why a registration is going to take place (CIEDRS 2003).

Staffing, equipment, supplies, security, telecommunications, vehicle and logistics support need to be available and appropriate training provided to all who will be helping to implement the registration (CIEDRS 2003).

Figure 3 and 4 show decision trees for registration from a border or transit area to a camp and in-camp registration.

2. "Fixing" the population. Establish or "fix" a number of program beneficiaries, whether they are targeted for assistance, protection, or both (CIEDRS 2003). A choice is offered Between a house to house system, which requires a certain level of calm and order, using wristbands; a registration point system, where there is a choice between using fixing tokens or wristbands; and an enclosure system, which should be applied only where circumstances are so unfavourable for registration that the process cannot be controlled in any other way (UNHCR 1994).

3. Collection of information/distribution of registration cards. People holding tokens, wristbands or other evidence of initial registration will be asked to present themselves to fill out a more complete registration form and to be presented with a registration card (CIEDRS 2003).

4. Verification. Establish a process for monitoring, updating and verifying registration (CIEDRS 2003).

4.4.6 Strengths

- Reasonably effective means of gathering other demographic information at the same time (CIEDRS 2003).
- In specific cases it is a right in itself, and closely linked to the protection of other rights, entitlements, or eligibility (e.g. recognition of refugee status, protection of POWs) (RNN 1997).
- Can allow a comprehensive protection response, follow-up and solutions (IDMC/OCHA 2008).
- Obtains base-line data if none exists or for solutions (return planning) (IDMC/OCHA 2008).
- Allows referral and follow-up on individual cases and potentially is the best source of protection information (IDMC/OCHA 2008).
- Effective tool for fair and equitable assistance (e.g. fraud prevention/avoiding double assistance) (IDMC/OCHA 2008).
- More effective than bulk monitoring (IDMC/OCHA 2008).

4.4.7 Limitations

- Even the most developed societies, acting under quite stable conditions, and with immense resources and sophisticated systems at their disposal have frequently failed to register adequately (RNN 1997).
- Governments are often either incapable of, or disinterested in registering sufficiently accurately or efficiently (RNN 1997).
- Technical problems such as wristbands that can be re-used and therefore allow multiple registrations (RNN 1997).
- If important groups or individuals are not registered when they should have been, were entitled to be, or inadequate information is collected on them, this may be a waste of resources (RNN 1997).
- Also under-registration is a voracious consumer of financial, physical and human resources (RNN 1997).

- It is usually a highly disruptive activity (RNN 1997).
- To be comprehensive and simultaneous (to limit the possibility of multiple registration) a cessation of most other assistance activities is required (RNN 1997).
- The population will most likely be requested to move to a central location. Queuing, frequently in sub-optimal conditions, is common (RNN 1997).
- Potential misuse of individual data, if confidentiality is not respected. Not appropriate in volatile situations (IDMC/OCHA 2008).
- Creates expectations and gives a 'promise' of assistance/ response (IDMC/OCHA 2008).
- Definitional issues as who is an IDP (may be political if assistance involved or 'status' conferred) (IDMC/OCHA 2008).
- Can exclude some groups or individuals depending on registration procedures/ administration of registration (IDMC/OCHA 2008).
- Resource intensive and lengthy process (IDMC/OCHA 2008).
- Intrusive: if all information is not used, raises issue of why collecting information (IDMC/OCHA 2008).
- Gives impression of substituting state responsibility (IDMC/OCHA 2008).

4.5 Initial report / D-forms

4.5.1 Method reported in

UNHCR (2007)

4.5.2 About the method

Initial report / D-forms are forms to determine the immediate needs. They are submitted by the assessor / community leader within 12-48 hours after occurrence of a disaster. The forms can be used to make an initial estimation of the affected population. With the forms assessors / community leaders estimate the total number of affected people within their community. Data entails figures of affected people, casualties, injuries, people in shelters etc. Local or national disaster management agencies collect these forms within the affected region to account for the total number of affected people within one region.

In a displacement context, lists of names can be compiled by refugee leaders and verified through a process agreed with the refugee community. Records compiled by refugee leaders may even eliminate the need for registration, provided they are checked and verified at random and updated regularly. The lists can also be useful in identifying vulnerable refugees who need special assistance (UNHCR 2007).

FORM-D: ASSESSMENT OF LOSS AND DAMAGE

1	2	3	4	5			6	7	8	9	10	
Name of Upazila	Total Union (nos)	Total areas (Sq. km)	Char Areas (if) (sq km)	Total population (No)			Total families/ households	Cost of house Tk/Unit	Repairing Cost of house Tk/Unit	Other information (housing materials used)	Total disaster shelter (under LGED, DRR and other institutes)	Information source
												Baseline data/ Basic statistics
Name of Upazila	Affected Union (No)	Affected Area (Sq. km)	Affected char areas (sq km)	Affected population (No)	No. of dead buried/ burnt	No. of injured	Number of affected families	No. of house Fully damaged	No. of houses partially damaged	No of pacca house damaged	Shelter used during disaster (if)	

11		12		13		14				15		16		17	
Sheep and goat Population (No)		Cattle and buffalo Population (No)		Poultry Population (Chicken and Duck) (No)		Total crop land				Other farms (Pond fisheries, shrimp and other farms)		Total Power lines and accessories (unit)		Other infrastructure (if any) telecom Towers	
Death/washed out sheep and goats		Death and washed out cattle and buffalo including farms		Death and washed out poultry including farms		Fully damaged		Partially damaged		Other farm (Pond fisheries, shrimp, *Gher, fish fingerlings*		Damaged Power lines and accessories		Damaged other infrastructure (if any)	
Number	Taka/unit	Number	Taka/unit	No.	Taka/unit	ha	Taka/ha	ha	Taka/ha	ha	Taka/ha	Fully (cost tk)	Partially (cost tk)	Fully (cost tk)	Partially (cost tk)

Source: Bangladesh Governement (2010)

5 Remote estimations

5.1 Delphi method

5.1.1 Method reported in

WFP (2009)

5.1.2 About the method

The Delphi method brings a group of experts together to reach a consensus opinion about a situation, like the numbers and locations of people affected by a crisis (WFP 2009).

It uses a structured process to systematically collect and distil opinions from a group of experts. The process consists of anonymous responses to several rounds of questions, with controlled and structured feedback on each round (WFP 2009).

Each expert provides anonymous responses to a questionnaire, which are then summarized and shared with the group. Question-and-answer rounds continue until the responses converge. A wide spread of responses generally occurs in the first round, with the range becoming progressively narrower, and converging within three or four rounds. Statistical analysis ensures that the summarizing and analysis of responses is impartial (WFP 2009).

5.1.3 When appropriate?

- When mathematical methods are inappropriate (too costly, time-consuming, require considerable expertise, results are difficult to interpret) (WFP 2009).
- An appropriate number of experts are available (WFP 2009).
- The issue should be complex enough to need more experts than can interact effectively in face-to-face exchange (WFP 2009).
- There are few data, or time is limited (WFP 2009).
- Time, cost and distance make face-to-face group meetings unfeasible (WFP 2009).
- When social, psychological and political differences may hinder effective communication and behaviour (WFP 2009).
- When different perspectives, terminologies, frames of reference and approaches to working may hinder effective communication through conventional channels (WFP 2009).

5.1.4 Population estimation steps

1. Formulate the goal of the exercise (WFP 2009).

2. Convene the expert panel (WFP 2009).

3. Develop the first-round Delphi questionnaire (WFP 2009).

4. Pilot the questionnaire to check its wording is clear (WFP 2009).

5. Explain the process to the panellists, and send out the first questionnaire (WFP 2009).

6. Analyze the first round of responses (WFP 2009).

7. Gather and provide additional information to panellists, if requested (WFP 2009).

8. Prepare the second-round questionnaire**.** Send the second-round questionnaire, the first-round summary and additional information to panellists (WFP 2009).

9. Analyze the second-round responses (WFP 2009).

10. Steps 6 to 10 are repeated until there is agreement or stability in the responses, then the support group prepares a final report and sends the results to the panellists and decision-makers (WFP 2009).

5.1.5 Strengths

- Useful for answering one, specific, single-dimensional question, such as estimating population size and demographics after a crisis (WFP 2009).
- Offsets the problems of conventional meetings that pool opinions from group discussions, by avoiding the influence of dominant individuals, discussion on other topics and group pressure for conformity (WFP 2009).
- Anonymity decreases the effect of dominant personalities, individual and group interests, reduces group pressure to follow the majority opinion, reduces participants' unwillingness to abandon a position they have expressed in public, makes it easier to take a position on an issue before all the facts are known or a majority opinion has been formed, reduces their fear of publicly contradicting individuals in higher positions or bringing up an idea that might turn out to be unreasonable or be viewed as foolish (WFP 2009).
- Fewer obstacles to sharing, changing and formulating opinions (WFP 2009).

5.1.6 Limitations

- The facilitator can impose its views and preconceptions, and does not allow panellists to suggest alternative approaches for estimating population size and demographics (WFP 2009).
- Disagreements are ignored and not explored, leading discouraged dissenters to drop out and the result becomes biased (WFP 2009).
- The demands can be underestimated, making panellists fatigued or overwhelmed by the process (WFP 2009).
- There is a tendency to downplay future events (political, social or environmental changes) that affect their projections of the population size and demographics (WFP 2009).
- Some experts end up being unable to provide an estimate of population numbers, or have political motives for inflating or decreasing numbers (WFP 2009).
- When poorly executed, experts feel rushed to make projections (WFP 2009).
- The support group alters the responses to expedite convergence (WFP 2009).
- Low response rates lower the quality of the information (WFP 2009).
- Panellists are solicited for their expert judgments, rather than being surveyed about their limited knowledge (WFP 2009).
- The procedure for choosing experts for the panel (WFP 2009).
- Bias in the support group (WFP 2009).
- The unscientific and inaccurate nature of the method (WFP 2009).

5.2 Aerial survey

5.2.1 Method reported in

RNN (1997), CIEDRS (2003), UNHCR/WFP (2004), UNHCR (2007), IDMC/OCHA (2008)

5.2.2 About the method

Fixed-wing aircraft or a helicopter are ideal survey options (considering price, availability, ease of landing and take-off) to cover in one day by air what could take days or even weeks to do by land. Particularly when road access is impeded due to topography or conflict (RNN 1997).

Aerial views can provide perspectives on settlement patterns, migration routes or geographic contours that may not be readily detectable from the ground. Aerial photographs can be converted into digitized maps and/or help to establish “ground-truth” for satellite imagery (CIEDRS 2003).

5.2.3 When appropriate?

- When road access is impeded due to topography or conflict (RNN 1997).
- At the initial (and later) stages of an emergency, when time is limited.

5.2.4 Prerequisites

- Key is the photographic equipment and photographer, since it is not easy to photograph from the air. Ideally, an expert with access to a specially equipped aircraft would be used (RNN 1997).
- Video equipment would also be a plus, since it can be edited, manipulated, and allows for various options including scanning of large areas. Digital images can be printed and reproduced, or transmitted to permit expert analysis elsewhere (RNN 1997).

5.2.5 Population estimation steps

In situations involving displacement, UNHCR suggests a seven-step process for using aerial photography to prepare maps and help estimate population size (CIEDRS 2003):

1. Identification of the mapping coordinates of the site where the target population is located (CIEDRS 2003).

2. Overflying the site for photography (more than one run may be needed) (CIEDRS 2003).

3. Processing of the film (CIEDRS 2003).

4. Construction of photo-mosaics (composite pictures from photographs) (CIEDRS 2003).

5. On-the-ground sampling of households/shelters at the same time as the overflights to estimate average number of people per dwelling, proportion of empty dwellings, population movements, etc (CIEDRS 2003).

6. Compilation, processing, tabulation and analysis of sample data (CIEDRS 2003).

7. Photo interpretation combined with the results of on-the-ground sampling (CIEDRS 2003).

5.2.6 Strengths

- Relatively quick if an aeroplane is available (IDMC/OCHA 2008).

- Provides a 'snapshot' of the situation on the ground (IDMC/OCHA 2008).
- Useful methodology when access on the ground is difficult/impossible (IDMC/OCHA 2008).
- Identification of movement of all sizes of population groups, or to register coordinates of a stationary group (IDMC/OCHA 2008).
- Information about immediate dangers, shelter situation, proximity of surface water, etc. (IDMC/OCHA 2008).
- Rapid information about suitability of settlements/camp location (IDMC/OCHA 2008).
- Has the advantage of offering more localized control than satellite imagery (CIEDRS 2003).

5.2.7 Limitations

- Expensive to hire plane (IDMC/OCHA 2008).
- Risky if conducted in a conflict area (not advisable) (IDMC/OCHA 2008).
- Difficult to rapidly source all elements necessary (plane, pilot, fuel, mapping equipment) (IDMC/OCHA 2008).
- Provides limited information about risks/ capacities of people (IDMC/OCHA 2008).
- No physical presence, minimal protection to IDPs (IDMC/OCHA 2008).
- May be misleading (exact locations and contexts are not always clear from the air) and more sophisticated than effective (RNN 1997).

5.2.8 Best practices

- Used in DRC in 1994 during the huge influx of refugees from Rwanda. The presence of military aircraft at the disposal of the humanitarian operation was a major advantage (RNN 1997).
- Aerial observation and assessment was also used in Southern Turkey in 1991 (using military helicopters, which had the added advantage of allowing for associated ground assessments) (RNN 1997).
- During 1988 aerial assessment was also used when a large-scale voluntary repatriation operation from Honduras to El Salvador turned into an emergency. As a result of the confusion on the border, one of the only methods of assessing the situation was to charter a light-aircraft and over-fly the area (RNN 1997).
- Events in eastern DRC also illustrate the use of such a method, when US and UK military over flights (albeit relatively late in the day, despite calls by international aid agencies for recognition of the refugees' existence and the scale of the problem), confirmed fears that several thousand Hutu refugees were hiding in the forests (RNN 1997).

5.3 Satellite imagery / Remote sensing

5.3.1 Method reported in

Bjorgo (2000), CIEDRS (2003), UNHCR/WFP (2004), NRC (2007), IDMC/OCHA (2008)

5.3.2 About the method

For a long time the use of satellite imagery was only limited to the military and scientific communities. Since costs have come down, access and accuracy has increased, and field-based computer capabilities have improved, more humanitarian organizations are taking advantage of satellite imagery (CIEDRS 2003).

Satellite images can allow for detailed camp area estimates during an emergency or crisis, but can also provide baseline data for an area which is susceptible to a shock. Selected characteristics of populations may be extracted from fine to coarse scale fine-tuned resolution remotely sensed data based on:

- Counts of individual dwelling units.
- Measurement of urbanized land areas (settlement size).
- Estimates of land cover/or land use as proxies for the existence and type of residential units as a proxy for population density (NRC 2007).

5.3.3 Population estimation steps

Directly estimate population size
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 housing density coefficients are known. Landsat imagery can be used to define the urban extent of settlements and, through links to allometric growth principles, to estimate population size. Imagery can be combined with other data to estimate population size. For example census data can be 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 (NRC 2007).

Indirectly estimate population size
Imagery analysis is also effective in identifying and monitoring the distribution of land occupation and use, which can be used to make indirect estimates of population (NRC 2007). 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 (NRC 2007).

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. 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 (NRC 2007).

Transformations of environment: Humans generally transform their physical environment in ways that provide clues about their numbers, location, and overall well-being. These activities yield clear, aerially extensive signs of the human alteration of the physical environment. This transformation is even more intense in urban areas (buildings, transportation networks) (NRC 2007).

Land-use changes: focuses on which lands and ecosystems have been modified and transformed by human occupancy. Deforestation from selective logging and forest regrowth from slash-and-burn cultivation and moving settlement frontiers can be detected and added

to the occupational uses of forests. Burning and grazing patterns in savanna and open woodlands can be used to determine where people are located, and the changes in the intensity of livestock and cultivation activities (NRC 2007). Nighttime lights data and imagery have been used as proxies for level of development, and population change, extent, and location (NRC 2007).

5.3.4 Prerequisites

- Satellite imagery has some utility simply as an aerial picture (camp, flood plain), but is most effective when it is linked to GIS (CIEDRS 2003).
- Data must be geo-referenced and ideally available in a standardized format (CIEDRS 2003).

5.3.5 Strengths

- Allows for pictures without the risk of flying a small plane over a conflict area (IDMC/OCHA 2008).
- Provides a 'snapshot' of the situation on the ground (IDMC/OCHA 2008).
- Useful when access on the ground is difficult/impossible (IDMC/OCHA 2008).
- Information about immediate dangers, shelter situation, proximity of surface water, etc. (IDMC/OCHA 2008).
- Rapid information about suitability of settlements/camp location etc (IDMC/OCHA 2008).
- Useful for future GIS mapping (IDMC/OCHA 2008).
- Land-use changes tracks the presence of people and their activities in areas that often receive less attention from those sources that derive population information by other means (NRC 2007).
- Nighttime lights can be used as a good estimate of built-up area (NRC 2007).

5.3.6 Limitations

- Most satellites cannot photograph areas covered by clouds, which presents a particular problem in the tropics and temperate zones, where most humanitarian relief operations take place (CIEDRS 2003).
- The time between a satellite's visit and re-imaging of an area (repeat frequency) varies from one to more than twenty days. Can prove frustrating in a highly dynamic, emergency environment (CIEDRS 2003).
- Image resolution may not prove detailed enough for images of some refugee/IDP settlements (CIEDRS 2003).
- Delivery time can be slow as obstructing cloud cover and limited processing capabilities can impede the delivery of detailed, single-scene imagery (CIEDRS 2003).
- Costs of satellite imagery can be high and vary considerably, expense of analyst costs (IDMC/OCHA 2008).
- Governments can order restrictions on the distribution of satellite imagery. Usage may also be a sensitive issue for local governments and military groups (CIEDRS 2003).

- Provides limited information about risks/ capacities of people (IDMC/OCHA 2008).
- No physical presence, minimal protection to IDPs (IDMC/OCHA 2008).
- The blooming or overglow effect using nighttime lights as a proxy (lighted area extending beyond the area of settlement) raises the question of using the areal measurement to calculate settlement footprints (NRC 2007).
- Using nighttime lights as a proxy biases urban centres, since they are typically saturated by lighted roadways, shopping centres etc. This may indicate the existence of population, when in reality few people live there (NRC 2007).
- Land-use changes: caution to discern land use and land cover changes by extractive industries, such as the international timber trade, which rely on small pools of labour, even though the observed footprint may be large (NRC 2007).

5.3.7 Case studies / validation studies

- The relatively inexpensive 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 (CIEDRS 2003).
- A study to assess the potential of very high spatial resolution (VHSR) satellite sensors to provide geographic information by mapping refugee camps and their environment on an operational basis was conducted in six refugee camps in the Qala en Nahal settlement scheme in the Sudan. The VHSR satellite sensor image was found to be useful for mapping refugee camp environmental parameters, such as land use, roads, rivers, and water sources, as well as camp infrastructure, including geographic positioning of camps, housing, and street network. The image also allowed for detailed camp area estimates. In addition, a statistically significant relationship between camp area and population was revealed for refugee camps (Borgo 2000).

5.4 Tracking population movement with mobile phone network data

5.4.1 Method reported in

Bengtsson et al. (2011)

5.4.2 About the method

All mobile phones have a SIM card, which communicates with a mobile phone network through mobile phone towers. Every time a SIM calls, the mobile phone network database records which tower connects the call. This database allows each SIM card's position to be followed over time with the accuracy of the mobile phone towers' coverage areas. Coverage areas vary from approximately 1–100 km (Bengtsson et al. 2011).

Bengtsson et al. (2011) have investigated whether position data from mobile phone SIMs (subscriber identity modules) can be used to (1) estimate the magnitude and trends of population movements by retrospectively following the positions of SIMs in Haiti before and after the earthquake and (2) tracking SIMs during the first few days of the cholera outbreak. The results suggest that it is feasible to produce and disseminate accurate data on movements of SIM cards within hours of receiving the data (Bengtsson et al. 2011).

5.4.3 When appropriate?

- Suitable for data collection in a large area.
- For monitoring purposes of large population movements, during the acute phase of a disaster.
- When close to real time data on population movement is needed.

5.4.4 Prerequisites

- A high number of people with mobile subscription per country.
- Some mobile phone operators work in multiple countries. If the market shares of the companies operating in more than one of the countries for study are at an acceptable level in the concerned country, focusing on the data of that company would be highly beneficial.
- Access to mobile phone network data.
- Operating mobile phone towers after the disaster.
- Not too widely dispersed mobile phone towers.

5.4.5 Population estimation steps

1. Data Collection. For the earthquake displacement, data included the position of the mobile phone tower used by each SIM at the time of its first call each day.

Data for the cholera outbreak included the position of the mobile phone tower used by each SIM at the time of each call.

Also maps of the network's towers and coverage areas were used (Bengtsson et al. 2011).

2. Study Population and Inclusion Criteria. For study period one, all SIMs were included that made at least one call during the period prior to the earthquake and that also made at least one call during the last month of the study period. The former excluded the large numbers of relief workers arriving after the earthquake, while the latter excluded SIMs that were lost or destroyed in or after the earthquake.

For the cholera outbreak all SIMs were included that made at least one call within the outbreak area (Bengtsson et al. 2011).

The position of a SIM at any given date was defined by its latest registered position (Bengtsson et al. 2011).

3. Analyses. For each SIM a list was produced of its location on each day during the study period. This database was then used to summarize the number of SIMs located in the respective administrative areas in Haiti during the study period. Data were stored and managed in MS SQL server 2005. Analyses were performed in Microsoft Visual C# 2008, Matlab R2008c, and ArcGIS 9.2 (Bengtsson et al. 2011).

5.4.6 Strengths

- While large-scale surveys and censuses can give detailed information on people's movement history, they are not feasible to implement for monitoring purposes during the acute phase of a disaster. Tracking population movements with mobile phone data provides timely and accurate estimates of population movements (Bengtsson et al. 2011).
- With software development and in cooperation with network operators, the approach can provide data in close to real time (Bengtsson et al. 2011).

- Information on postdisaster population distributions can potentially enable improved distribution of water, food, shelter, and sanitation (Bengtsson et al. 2011).
- Needs assessment surveys can potentially be improved through increased validity of population estimates (constructing sampling frames for needs assessment surveys, generalizing survey data to overall population needs) (Bengtsson et al. 2011).
- Daily estimated changes in the number of displaced persons can be generated for specified areas, which can signal important on-going developments (Bengtsson et al. 2011).
- Estimates of mortality can potentially be derived from the number and geographic distribution of non-responding SIMs (Bengtsson et al. 2011).
- Estimation of buried but alive persons following an earthquake is a potential area for development (Bengtsson et al. 2011).
- Network data can provide even richer information when combined with information on the ground and potentially also with data from mobile phone surveys (Bengtsson et al. 2011).
- Approach may also be useful in non-disaster contexts. Human mobility is extremely important for the spread of communicable diseases, and early containment of epidemic outbreaks is often a key factor in preventing spread. Rapid data on population movements can potentially inform outbreak preparedness and response for infectious diseases (Bengtsson et al. 2011).
- Text messaging that targets specific areas is a potentially valuable use of mobile phone network data. If these refer to advice relating to population movements (e.g. evacuation, the localisation of relief supplies), results could be directly evaluated with the use of network data (Bengtsson et al. 2011).

5.4.7 Limitations

- May be less suitable in areas where mobile phone use and mobile radio coverage is low (Bengtsson et al. 2011).
- Geographic localisation is less precise in areas with low tower density (Bengtsson et al. 2011).
- When relying on call data, locations of infrequent callers are updated less often than those of frequent callers (Bengtsson et al. 2011).
- There are settings where many people have one SIM card from each company, which needs to be taken into account if data from more than one company is analyzed (Bengtsson et al. 2011).
- Although mobile phone networks are relatively resilient to external shocks, major disasters can affect power supply, destroy towers, and cause a complete loss of functionality. Limited possibilities for people to charge their mobile phones can cause bias (Bengtsson et al. 2011).

5.4.8 Case studies / validation studies

- The results of Bengtsson et al. (2011) agreed well with the results of a large retrospective population-based survey by UNFPA. The similarities can be due to a widespread use of mobile phones, that non-mobile phone users (e.g. children, elderly) moved together with mobile phone users, and also that users and nonusers of mobile phones had similar movement patterns (Bengtsson et al. 2011).

6 Population data sets

6.1 Administrative data

6.1.1 Method reported in

RNN (1997), NRC (2007), UNHCR (2007)

6.1.2 About the method

Administrative records provide data on the number of households in a given region. In combination with other estimates of household size, this information can be used to generate total population estimates for sub national areas (NRC 2007).

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 (NRC 2007).

Also community health, water and food consumption statistics can all be indicative of the overall size of the population to be assisted. While none alone will be sufficient to provide an overall picture of the size of the population, combined they can help in testing assumptions. Local staff working in such assistance facilities, local authorities, media, local religious or civic bodies are a good source of information and estimates (RNN 1997).

Digital databases, printed country profiles and year books, encyclopaedias, UN publications, university and specialised periodicals and journals, embassies and cultural centres, tourist authorities, and school text books, amongst others, can supply a wealth of information on particular groups, populations, and communities (RNN 1997).

6.1.3 Strengths

- Properly kept and updated administrative data can provide vital information for the appraisal of trends and for early warning and to monitor specific developments in various parts of the country (UNFPA 2010).
- Administrative information constitutes some of the groundwork for the development of other more robust sources of information, such as geographic information systems, censuses and household surveys (UNFPA 2010).
- Information on the number and state of various public infrastructure such as transportation and communication lines, lodging and storage facilities and infrastructure for delivery of various services is vital for determining the various possible response scenarios during preparedness and contingency planning (UNFPA 2010).

6.1.4 Limitations

- Few programmes have the resources necessary to sift and process these sources into usable information for contingency planning (RNN 1997).
- These sources of population estimates rarely provide data on the characteristics of the population or households (NRC 2007).
- Areas lacking censuses are equally likely to lack these sources of information (NRC 2007).
- In complex emergencies local records may be incomplete, out of-date, destroyed, or unavailable (CIEDRS 2003).

- In most developing countries, statistical data from administrative sources is usually incomplete, poorly managed and outdated. The coverage and quality varies per administrative unit and period, which makes it difficult to appraise the exact situation on the ground and trends over time (UNFPA 2010).
- Administrative sources mainly contain information on public (health, educational, communication, etc.) facilities and leave out prominent private facilities, which are equally vital for preparedness and contingency planning (UNFPA 2010).
- Access can be difficult, either because information is available at several locations without any central coordination or because of various other bottlenecks such as confidentiality, red tape, cost sharing, etc (UNFPA 2010).
- Administrative sources are usually in crude form and may require much processing (UNFPA 2010).

6.2 Survey data

6.2.1 Method reported in

NRC (2007)

6.2.2 About the method

Survey data is an essential, but often underestimated, source of information for vulnerability assessment and disaster response. In 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 (NRC 2007).

Local, national, and international development and humanitarian actors carry out surveys on a regular basis to scope interventions for health, nutrition, access to water, housing and eradication of poverty (NRC 2007). 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 (NRC 2007).

- The scientific sample surveys most likely to be available are either the Demographic and Health Surveys (DHSs) or the Multiple Indicator Cluster Surveys (MICS). These surveys almost always include at least one subnational administrative level and thus provide an important basis for modelling subnational populations (NRC 2007).
- Household surveys in developing countries have been conducted by the World Health Organization (WHO). They may overlap coverage with the DHS (NRC 2007).
- The World Bank, in conjunction with the UNDP, 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: http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTLSMS/0,,contentMDK:21610833~pagePK:64168427~piPK:64168435~theSitePK:3358997,00.html (NRC 2007).
- 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: http://www.ihsn.org/home/index.php? (NRC 2007).

- 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 NGOs or national statistical office heads. While the quality of these data is typically unknown Noji (2005) suggests that such data are preferable to no data at all (NRC 2007).

6.3 Global population data sets

Often data are place specific, relating to acquiring existing demographic data and digital geospatial data for a particular country for the most recent date. Important initiatives have been made to create global spatial databases of population that can be used to identify populations at risk (NRC 2007).

6.3.1 Gridded population of the world: population estimation service

Gridded Population of the World, version 3 (GPWv3) and the Global Rural-Urban Mapping Project, version 1 (GRUMPv1) are two gridded global population maps produced using different methods at different spatial resolutions: http://sedac.ciesin.columbia.edu/gpw/index.jsp.

GPW
GPW contains population datasets produced by the Centre for International Earth Science Information Network. The dataset contains 127,105 census estimates, a mean spatial resolution of 31 km and population figures for 253 countries. The data inputs are solely administrative boundary data and population estimates associated with the administrative units (WFP 2006, NRC 2007).

The GPW data include only total population numbers 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 or global environmental change assessments. There is also an extensive map collection that includes population density and sub-national administrative boundary maps (depicting the input units) at country, continental, and global levels (WFP 2006, NRC 2007).

GRUMP
The GRUMPv1 project builds on GPW to construct a common geo-referenced framework of urban and rural areas by combining census data with satellite data. GRUMPv1 comprises three data products: higher resolution gridded population data product for 1990, 1995, and 2000, a data set that delineates urban areas based on NOAA's nighttime lights and a points data set of all urban areas with populations of greater than 1,000 persons, which may be downloaded in Excel, CSV, and shapefile formats (WFP 2006, NRC 2007).

Population Estimation Service
The Population Estimation Service is a web-based service for estimating population totals and related statistics within a user-defined region. It enables users of a wide variety of map clients and tools to quickly obtain estimates of the number of people residing in specific areas without having to download and analyze large amounts of spatial data. The service accepts polygons that define areas of interest, then returns population totals, land area, quality measures, and basic parametric statistics for the requested polygons based on GPWv3: http://sedac.ciesin.columbia.edu/gpw/wps.jsp (WFP 2006, NRC 2007).

6.3.2 LandScan

GPWv3 and GRUMPv1 inspired the development of a similar database, LandScan, but with higher resolution, designed specifically to help globally identify populations at risk of disasters. That database is a project of Oak Ridge National Laboratory (ORNL): http://www.ornl.gov/sci/landscan/.

LandScan was developed in 1997 with the explicit intention of modelling populations at risk. 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. LandScan measures population across times of day, seasons, and likely localities (e.g. implicitly at work rather than at home). The advantage of LandScan is that it does not assume that individuals remain stationary and near their homes at all times (NRC 2007).

Limitations of LandScan are that the most common flows of individuals, daytime versus nighttime movements, are not incorporated. Also a set of seasonally specific population estimates would also enhance LandScan's utility, particular for hazard zones near coasts (NRC 2007).

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, LandScan has considerable utility and is used for a variety of purposes including emergency planning (NRC 2007).

6.3.3 The nighttime lights dataset

The Nighttime Lights dataset contains the first satellite-based global inventory of human settlements derived from nighttime data from the Defense Meteorological Satellite Programme (DMSP) Operational Linescan System (OLS). It has the unique ability to observe faint sources of visible near-infrared emissions present on the Earth's surface, including cities, towns, villages, gas flares and fires, by collecting low-light imagery through polar orbiting satellites: www.ngdc.noaa.gov/dmsp/global_composites_v2.html (WFP 2006).

6.3.4 AfriPop

The AfriPop project was initiated in 2009 with an aim of producing detailed and freely-available population distribution maps for the whole of Africa. It provides detailed gridded spatial population datasets showing age composition by 5-year groupings and gender: http://www.afripop.org/

For 2012 it is expected that full 100m resolution country datasets providing population distributions by 5-year age groupings and sex are available, together with total population distribution datasets with metadata and documentation. Similar datasets for Asia will be available on http://www.asiapop.org and will be started with the initiation of South/Central Americas mapping (AfriPop 2012).

6.3.5 United States Census Bureau

International Programs Center (IPC), United States Census Bureau contains a database of 228 countries and small areas. The International Data Base (IDB) is a computerized source of demographic and socioeconomic statistics for countries and areas of the world. The IDB combines data from country sources (especially censuses and surveys) with IPC's estimates and projections to provide information dating back as far as 1950 and as far ahead as 2050. The major types of data available in the IDB include population by age and sex, vital rates,

infant mortality and life expectancy, fertility, marital status and family planning: http://www.census.gov/ipc/www (WFP 2006).

Because the IDB is maintained at IPC as a research tool in response to sponsor requirements, the amount of information available for each country may vary.

6.3.6 United Nations Statistics Division

The United Nations Statistics Division collects, processes and disseminates statistical information on 208 countries and areas. The lowest resolution is country level but the population size of capital cities and cities of 100,000 or more people is also available. The datasets contain demographic information on births, deaths, migration and other characteristics: http://unstats.un.org/unsd/databases.htm (WFP 2006).

6.3.7 Measure DHS

MEASURE DHS (Monitoring and Evaluation to Assess and Use Results, Demographic and Health Surveys) has provided technical assistance to more than 200 surveys in 75 countries and advanced global understanding of health and population trends in developing countries: http://www.measuredhs.com (WFP 2006).

6.3.8 The world Gazetteer

The World Gazetteer provides a comprehensive set of population data and related statistics. Data is available by country, largest cities, towns and places as well as metropolitan areas: http://www.world-gazetteer.com/ (WFP 2006).

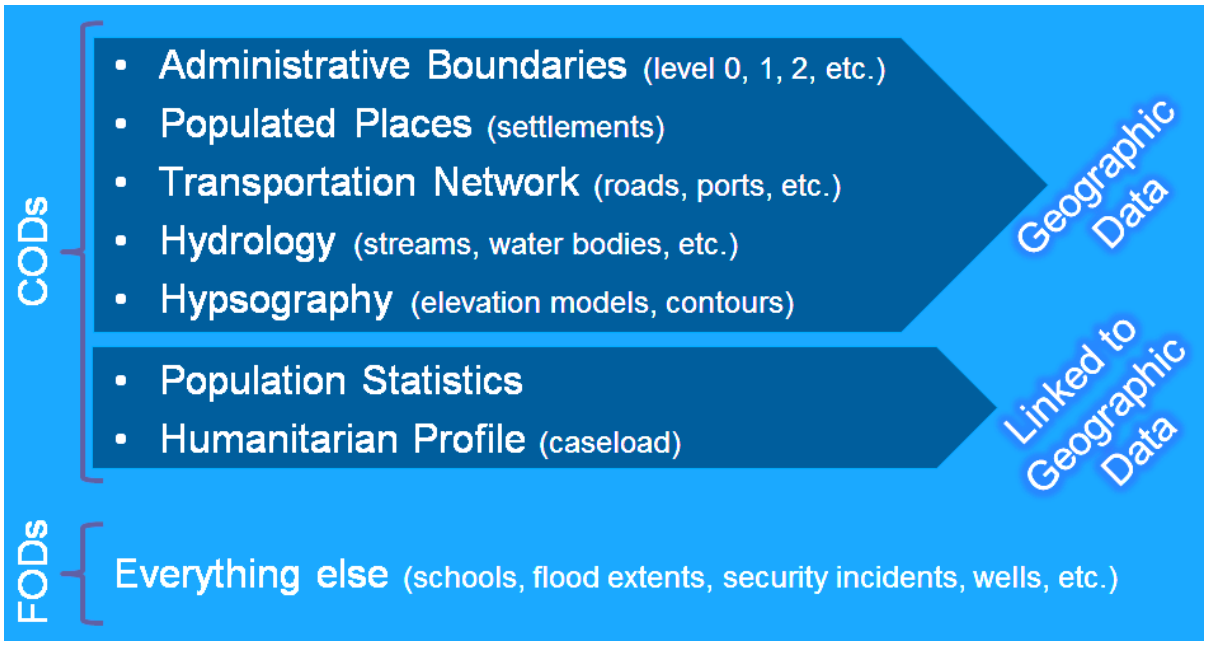
6.3.9 Common Operational Datasets

The Common Operational Datasets (CODs) are critical datasets that are used to support the work of humanitarian actors across multiple sectors. They are considered as de facto standard for the humanitarian community and should represent the best-available datasets for each theme: http://cod.humanitarianresponse.info/ (Bredin 2011; IASC 2011).

The IASC Guidelines on Common Operational Datasets in Disaster Preparedness and Response were developed to help national authorities and humanitarian organizations exchange data thereby improving the effectiveness of humanitarian response. OCHA is the guardian of the agreed upon datasets and will facilitate the distribution of the best available common operational and fundamental datasets in emergencies while managing forums for updates and distribution communication. Each dataset has a designated sponsor who is responsible for identifying and liaising with relevant sources to analyse, collate, clean and achieve consensus around a specific operational dataset. The designated source or owner of the dataset (e.g. national authority/agency, cluster, NGO, UN agency, International Organization, International Red Cross/Red Crescent) agrees to be fully responsible for the development, maintenance and metadata associated with a dataset and controls distribution restrictions (Bredin 2011; IASC 2011).

There are seven CODs defined (see figure 5), of which five have a geographical representation (e.g. transportation network or hydrography). The two remaining datasets concern the population and are linked to administrative units or populated places. The Fundamental Operational Datasets (FODs) are datasets that are relevant to a humanitarian operation, but are more specific to a particular sector or otherwise do not fit into one of the seven COD themes (Bredin 2011; IASC 2011).

Figure 5 Grouping of CODs according to their geographical aspect



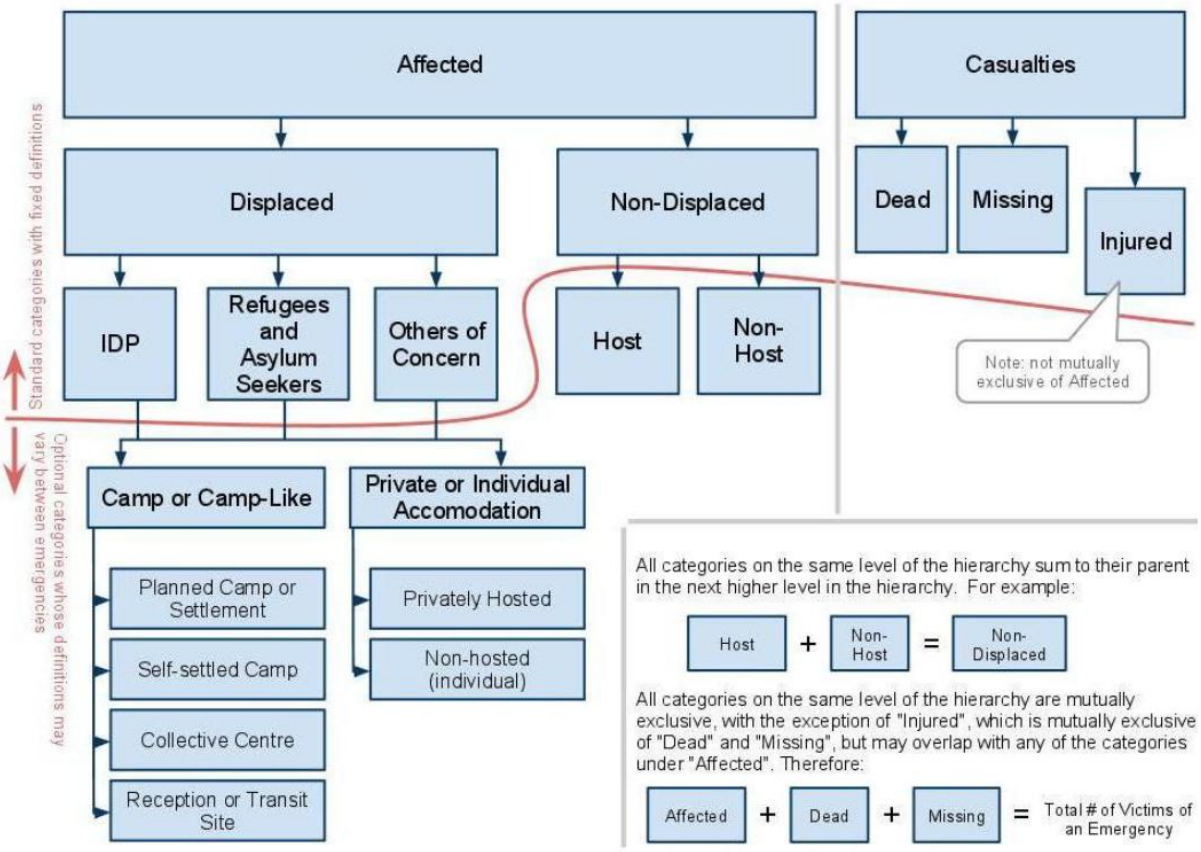
Source: Bredin (2011)

Humanitarian profile

The humanitarian profile is an attempt to account for, on an ongoing basis, the number of people having humanitarian needs arising from an emergency. It is a count of the number of affected people in the emergency (Bredin 2011; IASC 2011).

The humanitarian profile dataset is unique among the common operational datasets in its operational importance to the humanitarian community, the dynamic nature of its data and the way its composition may vary according to the operational context and priorities of a particular emergency. The humanitarian profile includes the numbers of affected, missing, dead, and injured persons, where the affected category has sub-groups of importance for humanitarian response (see figure 6). The purpose is to provide, in a predictable way, numbers that can facilitate humanitarian planning and needs assessment (Bredin 2011; IASC 2011).

Figure 6 Humanitarian Profile Classification System



Source: IASC (2011)

6.4 PARK Database

The Profiling and Assessment Resource Kit (PARK) is an online database which makes it easy to access and share documents, presentations, tools and guidelines on profiling and assessment activities. It aims to offer a helping hand to both operational decision-makers and implementation teams by providing access to a range of information about what, when and how to successfully embark on a profiling or assessment activity.

The website contains easily accessible and practical tools that serve to improve planning, implementation, and dissemination of information that articulates the needs of displacement-affected populations. The website contains a range of tools and resources on rapid population estimations: http://parkdatabase.org/.

6.5 Population projections

6.5.1 General population projections

6.5.1 Method reported in

WFP (2006), NRC (2007), UNFPA (2010)

6.5.2 About the method

Population projections provide an estimate of the expected population at various periods in the future (and even in the past) depending on a certain number of assumptions (UNFPA 2010).

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. 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 (NRC 2007).

Organizations that regularly provide estimates and projections of subnational populations for different countries of the world include the UNFPA and the Population Division of the U.S. Census Bureau (NRC 2007).

6.5.3 When appropriate?

- 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 to estimate their current populations (UNFPA 2010).
- Since contingency planning has to do with the expected situation in the future, they must unavoidably depend on projected population figures to arrive at their estimates of needs (UNFPA 2010).

6.5.4 Prerequisites

- Good vital statistics data or indirect estimates of mortality (NRC 2007).
- Additional information (e.g. age-specific birth rates) may be drawn from DHS or similar reproductive surveys (NRC 2007).
- 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) (NRC 2007).
- Factors influencing strategy choice include the availability of detailed and up-to-date census data or population projections; unforeseen demographic changes that might render such projections invalid; and the time elapsed since the most recent census. The greater the time elapsed since the last census, the greater the number of necessary estimate assumptions and uncertainties regarding the validity of the projections (ECLAC 2006).

6.5.5 Strengths

- Projected figures provide the base from which future estimates of needs can be made during contingency planning (UNFPA 2010).
- Several sources of population projections exist and some of them can be accessible on-line, unlike most census data. Some sources provide detailed data by year of projection and disaggregated by single ages and by sex, thus rendering projected needs for sub-populations much easier (UNFPA 2010).

6.5.6 Limitations

- The further away from the census date, the more unreliable population projections are likely to be, irrespective of the robustness of the underlying assumptions and/or of the methods used (UNFPA 2010).
- Most available sources of population projections do not provide information on the methods used and on the underlying assumptions employed for the projections. This makes it impossible to assess their quality (UNFPA 2010).
- Most projected population figures are available for five-year intervals and publish data in five-year age groups. However, contingency planning is best done on yearly bases and needs are usually estimated based on information on sub-populations, which may not always fit into five-year intervals (UNFPA 2010).
- Expertise in population projection is relatively scarce. But many kinds of software are readily available for making population projections. The tendency has been for most agencies to autonomously carry out their own projections without sufficient regard to the constraints that underlie the use of the methods in the software (UNFPA 2010).
- The ease of access to projected population figures or the ease with which some of them can be produced has greatly contributed to the decline in funding for the conduct of regular census operations in most developing countries (UNFPA 2010).

6.5.2 Exponential growth formula

6.5.7 Method reported in

NRC (2007)

6.5.8 Prerequisites

- Annual population projections at a detailed (e.g. municipal) level are available (NRC 2007).
- The disaster has occurred no more than five years after the most recent census (NRC 2007).
- There have been no important demographic changes in the affected area since the most recent census (NRC 2007).

6.5.9 Population projection steps

After identification of the affected area, the projected population for the year can be taken directly, or it can be estimated for the date of the disaster using the following exponential growth formula:

$$Pd = Po^{*}\ er^{t}$$

Pd = the population on the day of the disaster;
Po = the most recent official estimate of the population;
r = the annual exponential growth rate for the year or period in which the disaster occurs; and
t = the length of time in years between the initial projection date used to calculate r and the time of the disaster.

Alternative: The disaster has occurred five or more years after the most recent census, and the projections at a disaggregated level may not be updated or do not exist. Either a projection of the population should be done or the available estimates should be analysed to determine whether there is any evidence of municipalities whose population has increased or declined to a greater degree than that observed in the preceding inter-census period (NRC 2007).

If there is no disaggregate population projection or if the existing one is out of date, it will be necessary to make a projection of the population in the affected area (NRC 2007).

It is possible that projected information is available for a larger geographical area. In this case, the population of the affected area should be projected by applying the growth rate for the population of the department, province or state in which the area is located for the year or period that includes the date of the disaster (NRC 2007).

6.5.3 Component II

6.5.10 Method reported in

WFP (2006)

6.5.11 About the method

Uses vital statistics data (birth and death data) to measure the natural increase from the last census (WFP 2006).

6.5.12 Population projection steps

The following formula is use to estimate the population size:

$$P_{i,t} = P_{i,0} + (B_i - D_i + I_i - E_i) + u_i P_{i,0}$$

$P_{i,t}$ = population estimate for area i at time t,
$P_{i,0}$ = population in area i at beginning of period,
B_i = births in area i since beginning of period,
D_i = deaths in area i since beginning of period,
I_i = international immigrants to i,
E_i = international emigrants from i and
u_i = estimator of rate of net internal migration to i.

6.5.4 Ratio-correlation

6.5.13 Method reported in

WFP (2006)

6.5.14 About the method

Ratio-correlation is a regression method in which changes in population are related to changes in indicators of population change, such as school enrolment, the number of voters, the number of passenger car registrations, and occupied housing units (WFP 2006).

A multiple-regression equation is used to relate changes in the distribution of births, deaths and housing units to changes in the population distribution among municipalities. For both the development of the regression equation and the computation of the population size, ratios of percentage shares in the later year to corresponding percentage shares in the earlier year are calculated (WFP 2006).

6.5.5 Administrative record

6.5.15 Method reported in

WFP (2006)

6.5.16 About the method

Uses births, deaths, school enrolment, social insurance, building permits, driver licenses, voter registration and tax returns to estimate population size. Each record reflects a facet of population structure and change that may be useful for constructing estimates and projections, or for tracking demographic trends. These records can deal with employment, tax, voter, property ownership, professional licenses, housing, or schooling.

6.5.6 Cohort component method

6.5.17 Method reported in

WFP (2006), NRC (2007), UNFPA (2010)

6.5.18 About the method

A majority of population projections today use the cohort-component method, which traces people born in a given year through their lives. As each year passes, cohorts change due to mortality and migration assumptions. Applying fertility assumptions to women of childbearing age forms new cohorts. The projection is based on age in the population by five-year blocks, subjecting each group to age- and sex-specific mortality, fertility and net migration regimes (WFP 2006).

6.5.19 Prerequisites

- 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 (NRC 2007).

- 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 (NRC 2007).

6.5.20 Population projection steps

The principle of the method is to calculate the survival rate in the population with the age-specific mortality schedule and then add in age-specific migration to complete the estimates for each age group. This method makes separate and independent projections of fertility, mortality and migration. The results of these three projections are then combined into the equation (WFP 2006):

$$P_t = P_{t-1} + B_{t-1,\,t,} - D_{t-1,\,t} + NM$$

P_t	population at time t
P_{t-1}	population at time t-1
$B_{t-1,\,t}$	births in the interval from time t-1 to time t
$D_{t-1,\,t}$	deaths in the interval from time t-1 to time t
NM	net migration, in the interval from time t-1 to time t

6.5.21 Strengths

- Produces more detailed and disaggregated results (UNFPA 2010).

6.5.7 Redatam software

6.5.22 Method reported in

WFP (2006)

6.5.23 About the method

The Latin American Demographics Center (CELADE) has developed and offers free of charge a programme called Redatam that can process population information from censuses and/or household surveys. Redatam G4 and its interface applications, such as R+G4xPlan, are designed to help generate population indicators from a variety of data sources. This facilitates decision-making at different geographical levels, from a country down to a municipality. The programme's features make it ideal for estimating the population and its characteristics in user-defined disaggregated areas, such as a set of districts added to another group of city blocks or rural sectors. Such a user-defined selection in combination with basic census or survey information can serve as a starting point for estimating the characteristics of the population and housing in these areas. These findings can be used to project population size: http://www.eclac.cl/redatam/default.asp?idioma=IN.

7 References and further reading

ACAPS (2012) *Methodology* [online]. Available on: http://www.acaps.org/en/pages/methodology

Bengtsson, L. X. Lu, A. Thorson, R. Garfield, J. von Schreeb (2011) Improved Response to Disasters and Outbreaks by Tracking Population Movements with Mobile Phone Network Data: A Post-Earthquake Geospatial Study in Haiti. *PLoS Medicine* 8 (8): 1-9. Available on: http://www.plosmedicine.org/article/info%3Adoi%2F10.1371%2Fjournal.pmed.1001083

Bjorgo, E. (2000) Using very high spatial resolution multispectral satellite sensor imagery to monitor refugee camps. *International Journal of Remote Sensing* 21(3): 79-88. Available on: http://www.geocarto.com.hk/cgi-bin/pages1/june00/refugee.pdf

Bostoen, K., Z. Chalabi, and R.F. Grais (2007) Optimisation of the T-square sampling method to estimate population sizes. *Emerging Themes in Epidemiology* 4(7)

Bredin, J. (2011) *COD consultancy report*. UNHCR, 2011-09-09

Brown, V., D. Coulombier, F. Belanger, J. Jacquier, S. Balandine, D. Legros (2001). Rapid assessment of population size by area sampling in disaster situations. *Disasters* 25 (2): 164-171

CIEDRS (2003) *Demographic Methods In Emergency Assessment - A Guide For Practitioners*. Johns Hopkins University Bloomberg School of Public Health Baltimore, Maryland. Available on: http://parkdatabase.org/files/documents/2003_Demographic-Methods-In-Emergency-Assessment_A-Guide-for-Practitioners_CIEDRS_Johns-Hopkins-Univ.pdf

Doocy, S., A. Rofi, G. Burnham, C. Robinson. *Tsunami mortality in Aceh province, Indonesia*. Johns Hopkins Bloomberg School of Public Health. Available on: http://parkdatabase.org/files/documents/2005_Tsunami-Mortality-in-Aceh-Province-Indonesia_Johns-Hopkins-Univ_S-Doocy-et-al.pdf

ECLAC (2003) *Handbook for Estimating the Socio-economic and Environmental Effects of Disasters*. Available on: http://parkdatabase.org/files/documents/2003_Handbok-for-Estimating-the-Socio-economic-and-Environmental-Effects-of-Disasters_ECLAC.pdf

Garb, J.L., R.G. Cromley and R.B. Wait (2007) Estimating Populations at Risk for Disaster Preparedness and Response. *Journal of Homeland Security and Emergency Management* 4 (1). Available on: http://parkdatabase.org/files/documents/2007_Estimating-Populations-at-Risk-for-Disaster-Preparedness-and-Response_Journal-of-Homeland-Security-and-Emergency-Mangement_JL-Garb-et-al.pdf

Gorokhovich, Y. and S. Doocy (2008) *Estimating population risk for coastal disasters using spatial models with global data*. Solutions to Coastal Disasters Congress 2008. Available on: http://parkdatabase.org/files/documents/2007_Estimating-Population-Risk-for-Coastal-Disasters-Using-Spatial-Models-with-Global-Data-_Y-Gorokhovich_S-Doocy.pdf

Grais, R.F., D. Coulombier, J. Ampuero, M.E.S. Lucas, A. T. Barretto, G. Jacquier, F. Diaz, S. Balandine, C. Mahoudeau and V. Brown (2006) Are rapid population estimates accurate? A field trial of two different assessment methods. *Disasters* 30 (3): 364-376. Available on: http://parkdatabase.org/files/documents/2005_Are-Rapid-Population-Estimates-Accurate_A-Field-Trial-of-Two-Different-Assessment-Methods_ODI_RF-Grais-et-al.pdf

Higgs, G. and M. Langford (2009) GIScience, environmental justice, & estimating populations at risk: The case of landfills in Wales. *Applied Geography* 29: 63–76. Available on: http://www.dpi.inpe.br/sil/cst310/Aula13_M%C3%A9todoDasimetrico/Langford_Pop_Wales.pdf

HPN (2007) *Public health in crisis affected populations. A practical guide for decision-makers*. Available on: http://www.odihpn.org/documents/networkpaper061.pdf

IASC (2011) *IASC Guidelines on the Humanitarian Profile Common Operational Dataset*. IASC IM Task Force 20-Jun-2011

IASC (2010) *IASC Guidelines Common Operational Datasets (CODs) in Disaster Preparedness and Response*. As requested by the 77th IASC Working Group meeting. IASC Endorsed November 1 2010. Available on: http://parkdatabase.org/files/documents/2010_Guidelines-on-Common-Operational-Datasets-in-Disaster-Preparedness-and-Response-June_IASC.doc

IDMC and OCHA (2008) *Guidance on profiling internally displaced persons*. April 2008 edition. Available on: http://parkdatabase.org/files/documents/2008_Guidance-on-Profiling-Internally-Displaced-Persons_NRC-IDMC_OCHA.pdf

IFRC (2007) *The Johns Hopkins and IFRC Public Health Guide for Emergencies.* Available on: http://parkdatabase.org/files/documents/2007_Disaster-Epidemiology_Public-Health-Guide-for-Emergencies_Johns-Hopkins-Univ_IFRC.pdf

Luan R., G. Zeng, D. Zhang, L. Luo, P. Yuan, B. Liang (2005) A study on methods of estimating the population size of men who have sex with men in Southwest China. *European journal of epidemiology* 20(7): 581-585. Available on: https://www.globalhivmeinfo.org/Gamet/pdf/598_Size%20Estimation%20MSM%20in%20China.pdf

MSF (2006) *Rapid health assessment of refugee or displaced populations*. Third edition. Available on: http://www.refbooks.msf.org/MSF_Docs/En/Rapid_health/RAPID_HEALTH_en.pdf

MSF (1997) *Refugee Health - An approach to emergency situations*. Available on: http://www.refbooks.msf.org/MSF_Docs/En/Refugee_Health/RH.pdf

Nepali, A. (2010) *County level population estimation using knowledge-based image classification and regression models*. Master thesis university of North Texas August 2010. Available on: http://digital.library.unt.edu/ark:/67531/metadc30498/m2/1/high_res_d/thesis.pdf

Noji, E.K. (2005) Estimating population size in emergencies. *Bulletin of the World Health Organization* 83 (3). Available on: http://parkdatabase.org/files/documents/2005_Estimating-Population-Size-in-Emergencies_EK-Noji_WHO.pdf

NRC (2002) *Demographic Assessment Techniques in Complex Humanitarian Emergencies-Summary of a workshop*. National Academy Press, Washington DC

NRC (2007) *Tools and Methods for Estimating Populations at Risk from Natural Disasters and Complex Humanitarian Crises*. The National Academies Press, Washington DC

NRC (2007) *Successful Response Starts with a Map: Improving Geospatial Support for Disaster Management*. The National Academies Press, Washington DC. Available on: http://parkdatabase.org/files/documents/2007_Successful-Response-Starts-with-a-Map_Improving-Geospatial-Support-for-Disaster-Management_CPC_National-Academies.pdf

RNN (1997) *Counting and identification of beneficiary populations in emergency operations: registration and its alternatives*. Available on: http://parkdatabase.org/files/documents/1997_Counting-and-Identification-of-Beneficiary-Populations-in-Emergency-Operations_Registration-and-Its-Alternatives_RRN-ODI_J-Telford.pdf

Stone, G., A. Lekht, N. Burris and C. Williams (2007) Data Collection and Communications in the Public Health Response to a Disaster: Rapid Population Estimate Surveys and the

Daily Dashboard in Post-Katrina New Orleans. *Journal of Public Health Management Practice* 13 (5): 453–460. Available on: http://www.lphi.org/LPHIadmin/uploads/Stone_2007_Data%20collection%20and%20communications-14436.pdf

Treacy-Wong, V. (2011) *Population Estimation Methods used in Complex Emergency Settings*. Master thesis London school of hygiene & tropical medicine

UNFPA (2010) *Guidelines on Data Issues in Humanitarian Crisis Situations*. June 2010. Available on: http://parkdatabase.org/files/documents/2010_Guidelines-on-Data-Issues-in-Humanitarian-Crisis-Situations_UNFPA.pdf

UNHCR (1994) *Registration: A Practical Guide for Field Staff*. Geneva: May 1994.

UNHCR (2007) *Handbook for Emergencies* - Second edition. Available on: http://parkdatabase.org/files/documents/2010_-UNHCR-Handbook-for-Emergencies-2001_ProCap.pdf

UNHCR/WFP (2004) *Joint Assessment Guidelines.* Available on: http://documents.wfp.org/stellent/groups/public/documents/ena/wfp038210.pdf

UNICEF (2010) Rapid *Assessment Sampling in Emergency Situations*. Available on: http://parkdatabase.org/files/documents/2010_Rapid-assessment-sampling-in-emergencies_UNICEF.pdf

Watson, R. and P. Yip (2011) How many were there when it mattered? Estimating the sizes of crowds. *Significance* September 2011. Available on: http://onlinelibrary.wiley.com/doi/10.1111/j.1740-9713.2011.00502.x/abstract

WFP (2006) *Desk Review: Estimating Population Size in Emergencies.*

WFP (2007) *Area method to estimate population size and demographics in emergency food security assessments*. Technical guidance sheet 7.

WFP (2009) *Using the Delphi method to estimate population size and demographics in emergency food security assessments*. Technical guidance sheet 10.

WFP (2009) *Using the T-square sampling method to estimate population size, demographics and other characteristics in emergency food security assessments*. Technical guidance sheet 11.

WFP (2010) *Pakistan flood impact assessment*. September 2010. Available on: http://parkdatabase.org/files/documents/2010_Pakistan_Pakistan-Floods-Impact-Assessment_WFP.pdf

WHO (1996) A modified cluster-sampling method for post-disaster rapid assessment of needs. *Bulletin of the World Health Organization* 74 (4): 399-405. Available on: http://parkdatabase.org/files/documents/1996_A-Modified-Cluster-sampling-Method-for-Post-disaster-Rapid-Assessment-of-Needs_WHO-Bulletin.pdf

WHO (2010) *Guidelines on Estimating the Size of Populations Most at Risk to HIV*. Available online: http://parkdatabase.org/files/documents/2010_Guidelines-on-Estimating-the-Size-of-Populations-Most-at-Risk-to-HIV_UNAIDS_WHO.pdf