Rapid population estimation in emergencies

for field personnel working in camps or sites
and wishing to rapidly draw maps
and estimate population figures

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Rapid population estimation in emergencies

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Foreword

We need population estimates, with an acceptable level of precision, to plan relief operations for refugees or displaced populations.

This guide addresses the principles and basic steps to follow to rapidly obtain a population estimate. We present two methods used and tested in the field.

This guide is intended for personnel wishing to obtain population figures while carrying out a rapid population assessment of refugees or internally displaced populations.

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To remain operational and adapted to field reality, users should feel free to send their comments and remarks to:

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1. Background

1.1 - Rapid population assessment in emergencies

As populations gather in camps or sites, a major issue of any initial assessment is to estimate the size of the displaced population and to determine age and sex distribution of «at risk» groups. Important population movements concern refugees crossing a border, or the flight of internally displaced populations (IDPs[1]) within a country. In such situations, excess mortality is commonly reported [1]. Population data is also necessary to calculate rates and compare the current situation to prior estimates or other contexts.

During the acute phase of any major emergency, working conditions rarely allow for a soundly planned population census. Therefore, population estimates obtained by rapid assessment methods are recommended as a priority [2]. During emergencies, the population estimate represents an essential public health tool for planning any community assistance program.

Rapid population estimation by area sampling or "mapping" is a simple way to obtain reliable demographic data (and denominators), and to draw camp or site maps[2]. This guide focuses on the quadrat and T-Square methods, but other rapid population assessment methods are briefly presented in Part 5.

1.2 - The place of rapid population assessment

There are an estimated 40 million refugees or IDPs throughout the world, with a great number registered in camps [3]. Field experience has shown that successful relief operations were related to the adequate camp organisation [4,5].

In the past two decades, the «mapping technique» has been used in numerous rapid assessments [6-11] where it was shown to be useful to estimate population size and provided useful information about the nature of the problems faced by the displaced. It has played a key role for the planning and implementation of sanitation and public health related activities. The method provides both an estimate of total population and average household size, both of which are needed to organise relief operations in emergencies.

Over the course of decades of extensive field experience, an empirical method for population estimation by mapping was refined [12]. Combining extensive field experience and further research, we refined the standard method, which is presented here, and we also provide an alternative [13].

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1 Refugees or IDPs: referred to as "displaced" in the following text.

2 Camps or sites: referred to as "camps" in the following text.

1.3 - Objectives of mapping (area sampling)

Main objectives

– To evaluate the total number of persons living in a camp.

– To provide decision makers and relief workers with adequate population data for planning and program implementation, thereby limiting speculations on population figures.

– To draw a map of the camp with its external limits

Specific objectives

– To provide denominators for the calculation and analysis of indicators used in emergencies (mortality and morbidity rates, program coverage, etc.) and in public health in general.

– To determine the population structure of a camp (age/sex pyramid, at risk groups).

– To determine the total camp surface (m^2).

– To evaluate the population density of a camp in number of persons/square meter (m^2).

2. First stage: Drawing the camp map

Before we estimate the population of a given camp, first we need to draw a map of the camp including geographic coordinates (1st stage).

Once the map is drawn, either the quadrat or the T-Square method is used to estimate the total population (2nd stage), presented in Part 3.

The perimeter of the site is delineated, usually by walking or driving along the border. To draw the camp map with all its external limits, camp dimensions are collected first at field level.
This can be accomplished either using a compass, or using a Geographical Positioning System (GPS). Although using a compass is always feasible, use of a GPS requires permission from local authorities and good satellite coverage.

Using either a compass or GPS, two measures need to be recorded:
– The camp sides between two landmarks are measured in metres; and
– The position of a landmark.

Summary of steps to follow and result expected

Activity	Steps	Results expected
Camp map	Collect all map coordinates: – Measure camp sides (metres) – GPS (Latitude, Longitude) in decimal degrees or – Compass (degrees)	– Detailed camp map with external limits (with E-Pop software, or drawn on paper) – Camp surface (m^2) – Population density in m^2/person – Camp perimeter (m)

2.1 - Camp perimeter

A starting-point or landmark is chosen on one side of the camp (any point is fine). Walking or driving around the perimeter, each time a new direction is taken, the distance between landmarks is measured (see *Camp map coordinates*, Appendix 1). Examples of landmarks are trees, ponds, water tanks, etc.

Several tools exist to measure the length in metres of each side of the camp:

– *Footstep measure*: while walking, no equipment is needed when using footsteps as a measure. Be sure to walk "normally", not taking larger or smaller steps than usual. The total number of steps to cover each side is counted separately and recorded (use a hand clicker to facilitate the counting of steps). Knowing one's precise footstep measure, camp dimensions are worked out in metres (1 footstep = 0.85 m, 100 feet steps = 85 m). You can estimate your step size by counting the number of steps needed to cover 50 metres for instance.

– *Odometer*: for large camps, side dimensions can also be obtained by driving around by car (check to make sure the vehicle is equipped), the odometer informing with a precision of «+/- 100 metres» the distance covered. Walking odometers also exist: distances are measured with a measuring wheel in "metres and cm".

– *Decametre*: a practical device that allows for the measurement of distances of at least 25 metres. Decametres are more accurate, but may be either not available or too time consuming. A simple rope of known length can also be used (25 m, 50 m, or rarely 100 m).

2.2 - Landmark positions

For each new direction taken, the specific coordinates of points (landmarks) between two camp sides are recorded. We present two possible ways to take these measurements, using a compass or a GPS. Using a GPS is preferred.

2.2.1 - With a compass

The angles between each two sequential camp sides around the entire camp perimeter are measured at each specific landmark (external limits).
When going from one specific camp landmark to another, the direction in degrees is obtained by aiming the compass arrow in that direction.
With a compass, angles are defined by distance in degrees with the North, situated at 0° or at 360° (for beginners simple training may be needed before using a compass).

Thus, for each side of the camp two measures are obtained:
1) The direction in degrees
and
2) The dimension in metres
Angles and side measures can then be entered in E-Pop software (on CD ROM).
An example of the data recorded for camp «C» is presented in Table 1, and the corresponding map of camp C (Figure 1).

Without a computer, camp coordinates can also be recorded and then the map drawn on paper Remember to use a suitable scale.

Table 1
Area sampling coordinates using a compass, Camp C

Point n°	Degrees	Metres
1	135°	100
2	180°	100
3	225°	120
4	310°	70
5	250°	50
6	295°	150
7	75°	100
8	25°	100

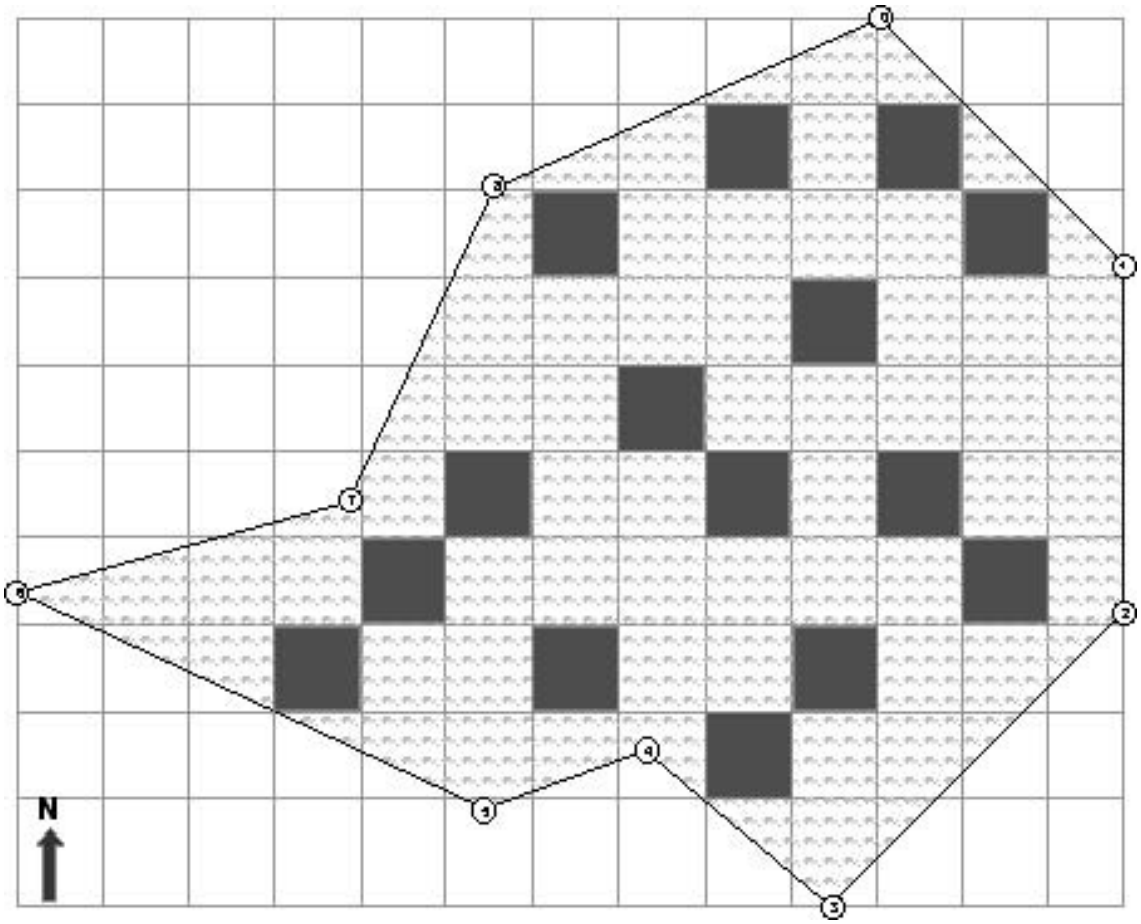


Figure 1
Map of Camp C (with coordinates in table 1)

2.2.2 - With a GPS

When tracing the perimeter of the camp from landmark to landmark, their position is recorded using a GPS. Point measures for each landmark are expressed in latitude and longitude. With a handhold GPS, verify before hand that the unit is set to decimal degrees (e.g. 39.4567 with 4 decimal place precision). The position is given with a few metres' precision, and each measurement is made at the nearest 1/1000 of second.

Each time you change direction, and a new landmark is identified, the measures are recorded.

For beginners, specific training is needed. This can be done with an experienced person in the field. Count 2 hours for basic data collection (see GPS functioning page 11), and more time for being able to reach *waypoints* (see below with the function 'GO TO' of the GPS).

2.3 - Camp surface

E-Pop software allows for the automatic calculation of the surface area, the total population and population density (see Part 3). The software can be found on the CD-ROM accompanying this guide.

Without a computer: an approximate surface can be obtained by drawing a grid over your paper map and count the number of squares of known surface within the map limits. For example, in Figure 1, 70 squares of 25 m x 25 m (625 m^2) were counted, amounting to an estimated surface of 43,750 m^2.

GPS functioning

In certain contexts (war zones/conflicts), it is recommended to check with the authorities before using a GPS.

Epicentre uses the Garmin 12 XL. MSF sections may use different GPS models. The type of model used should be verified. All GPS should also be tested before use. All necessary GPS parameters should be initialized before entering the data (make sure the projection is correct as well).

As a reminder, hereafter are a few steps to follow (a specific GPS booklet for the Garmin 12 XL and other models provided by manufacturers is available for more information):

1. Initialize the GPS: go to the "Satellite page": indicates how well the GPS monitors satellites' reception. The heights of dark bars indicate the strength. One page checks the position of satellites in the sky above you. At least 3 to 4 satellites are needed to have a good reception. Check your battery level: E = empty to F = full
   (a set of sufficient batteries is needed: Remember to change them every couple of hours).
2. Switch to the «Position page» by pressing 'PAGE' (to leave or come back to the first page, press 'QUIT'). GPS point coordinates appear for latitude (N) and longitude (E) in decimal degrees. The function 'AVERAGE' provides the average point position. Press 'MARK' to enter the present position in the waypoint list.
3. For each point collected, coordinates (Lat-Long) are kept automatically in the waypoint list of the GPS. In case of a mistake, it is easy to retrieve points from the waypoint list. A GPS has the capacity to store 400 to 500 waypoints. Also, record on paper the number or name given by the GPS to the first and last waypoints you recorded (i.e. from 024 to 098) as a back up.
4. 'GO TO': this function allows you to reach the points you need to go to (*way points*). This function is not needed here for the 1st stage (drawing the camp map). It is explained further in the 2nd stage (see Part 3) for the selection of points "to go to" (with quadrat to locate squares, and with T-Square for P_i points).

3. Second stage: Calculating the total camp population

Two methods can be used: the quadrat method or the T-Square.

First, we present the quadrat method, which is the most commonly used until now and is considered the reference method. It can be implemented in as little as 1 day (if proper equipment needed, see Appendix 2).

3.1 - Quadrat (or classical) method

In emergencies, the quadrat method is considered the reference method for estimating populations with area sampling. The quadrat method provides a means to estimate the total population by extrapolating the average population size living in square blocks (quadrats) of known area to the total camp surface.

The principle is to count the population living in a random sample of AT LEAST 15 inhabited squares (i.e., where the population is living) of 25 m x 25 m (625 m^2). The average population per square (AP/Sq) is calculated. The total population is then obtained by extrapolating the average population per square to the total camp surface[3] [13].

Summary of steps to follow and result expected

Activity	Steps	Results expected
Quadrat method	– Select at least 15 random square blocks of 25 m x 25 m (625 m^2) with E-Pop software, or on paper map – Count total population in 15 blocks – Calculate average pop/ square (AP/Sq) – Extrapolate figures to total camp surface	– Estimated population figure with lower and upper limits (based on results of 95% CI) – Number of persons per household – % children < 5

[3] Camp surface: see Part 2

In order to count the population, the 4 following steps need to be followed:

1st step *- Select a random sample of at least 15 squares:* E-Pop can select each square using either simple random or systematic sampling. Squares are identified with their GPS coordinates. These coordinates are entered in the GPS. Each GPS coordinate represents the lower left corner of each square. The spatial definition of a square with its 4 sides is presented in Appendix 3.

At least 10 squares must be inhabited to be representative. Otherwise, it means that your camp perimeter is too inaccurate, and/or you have empty fields inside your camp. The area of these fields must be estimated with the method explained here before and subtracts from the total surface.

To find the GPS coordinate of each square, use the function 'GO TO' of the GPS. 'GO TO' allows the surveyor to physically reach any way point selected in a waypoint list. In this case, the list of random generated points given by E-Pop software is downloaded from E-Pop software (GPS points in decimal degrees can be entered by hand if the hardware for downloading is not available. To download, a cable is required connecting the GPS to the computer.). On the GPS screen, the arrow indicates the direction to follow. The arrow is an electronic compass. It is activated after walking a few metres "in any direction" (a couple of minutes). The distance to cover: when getting closer, it decreases progressively down to 0 metre. When reaching this point, this is your GPS point.

Without a computer, each block can be selected from a paper map. Give each block a different number. A sample of at least 15 blocks is then obtained by simple random sampling, using for instance a random number table.

2nd step *- Collect population data in each block*: for each square (25 m x 25 m) selected, population data are collected directly at field level. All households (HH) are surveyed and the head of household is asked about the number of persons living together, their age and sex.

It is important to use a clear definition of a household to avoid under or over counting of the population. The HH should be defined: for instance as, "those persons who have slept here last night," or "all persons who usually sleep and eat under the same roof ". This provides a total number of families and persons living in the selected squares.

Note: If a selected HH overlaps the side of a square: only habitats for which at least 50% of its surface falls within the square should be included (see Appendix 3).

3rd step *- Calculate the average population per square (AP/Sq)*: this is obtained by dividing the total population counted in all squares by the total number of squares. For instance, in "camp C" (Figure 1), a total of 1,500 displaced is counted in 15 squares (625 m^2 each). This represents an average of 100 displaced persons per square.

***4th step** - Calculate the total camp population and population density*: this is done automatically within E-Pop

Without a computer, the total population = AP/Sq x total number of squares counted for the camp. In our example of camp C (Figure 1) (AP/Sq = 100), total estimated population = 100 displaced x 70 squares = 7,000 displaced. Population density can be obtained by dividing total camp surface by total camp population. In our example, 6.3 m^2/displaced person (43,750 m^2/7,000 persons), in camp C. It is important to remember to interpret this information as well. Camp C is much too densely populated. International standards recommend at least 30 m^2/person.

3.2 - T-Square method

The T-Square method uses information on the spacing and population living in shelters to obtain an estimate of population size. By dividing the total camp surface by the average shelter occupancy (m^2), the total number of shelters or HH in the camp is obtained. Knowing the average population per HH, the *camp* population can be then calculated.
Depending on heterogeneity tests, results are presented with or without confidence intervals.

Summary of steps to follow and result expected

Activity	Steps	Results expected
T-Square method	– Select 50 random points P_i (with E-Pop software, or without E-Pop): measure for each point, d1, and d2 (Figure 2). – Perform heterogeneity test – Count total population living in 100 HH (50 HH x 2) – Calculate average pop/HH	– Estimated total camp population – Number of persons per HH

To carry out this method, 50 systematically distributed GPS points[4] are identified in the camp using the E-Pop software (see GPS fonctionning page 16). Without a computer, 50 systematically random points in the camp can be defined by super-imposing a grid onto the camp map.

[4] 60 points were initially recommended [14], but recent research recommends 50 points [13].

3.2.1 - Measures starting from GPS points, and HH count

– From each GPS point (P_i), measure the distance (d1) to the nearest household (HH1) (Figure 2).
– The distance is measured from the GPS point to the centre of the household (using a tape measure or decametre), by projection, as shown in Figure 3.
– Count the number of persons living in HH1
– Next, measure the distance (d2) between HH1 and the nearest household (HH2) situated in the half-plane excluding P_i, i.e. on the other side of the "T" (Figure 2).
– Count the number of persons in HH2.
– Repeat this process for all 50 GPS points where the distances d1 and d2 were collected, along with household size, for a total of 100 households (50 HH1 and 50 HH2). The distances **d1** and **d2** are used to characterize the spatial pattern of households within the site and subsequently the site population (Figure 3).

Note: if two households are more or less the same distance from HH1, select one at random by flipping a coin.

3.2.2 - Estimation of total population

To estimate the total site population, one of two formulae to calculate average HH area are used depending on the results of statistical tests characterizing the distribution of shelters [15,18]. These statistical tests are contained within the E-Pop software for use in the field. **If E-Pop is not available**, the T-Square method is NOT recommended as estimating the site population requires the use of formulae, which are not easily interpreted.
The total site population using the T-Square method is calculated as:
[site area/average HH area] * [average HH population] = total population

GPS functioning

Steps to follow using a GPS:

1. Using E-Pop sample 50 random points «P_i»: the 50 points are listed in the software with their GPS coordinates, latitude and longitude (decimal degrees).

2. Enter the 50 random points P_i in the GPS "waypoint list" (waypoint = point to go to): the GPS function 'GO TO' allows the surveyors to physically reach any way point selected. Different sets of waypoints can be entered in several GPS devices if several surveyor teams.

'GO TO' (GPS): allows selection of the random point P_i to go to, press enter. On the compass screen, the arrow indicates the direction to follow (activated after a couple minutes' walk "in any direction"). The distance to cover is indicated in metres: when getting closer, it decreases progressively down to 0 meter.

3. Measure the distance (d1) between P_i and the nearest Household (HH1).

Measure the distance (d2) between HH1 and the nearest HH situated in the half plane excluding P_i (Figure 2). All measurements and HH data are entered in T-Square data collection sheet (see Appendix 5), and then in E-Pop software.

4. Collect HH population information (same as for the quadrat) for each HH (= 50 HH x 2 = 100 HH).

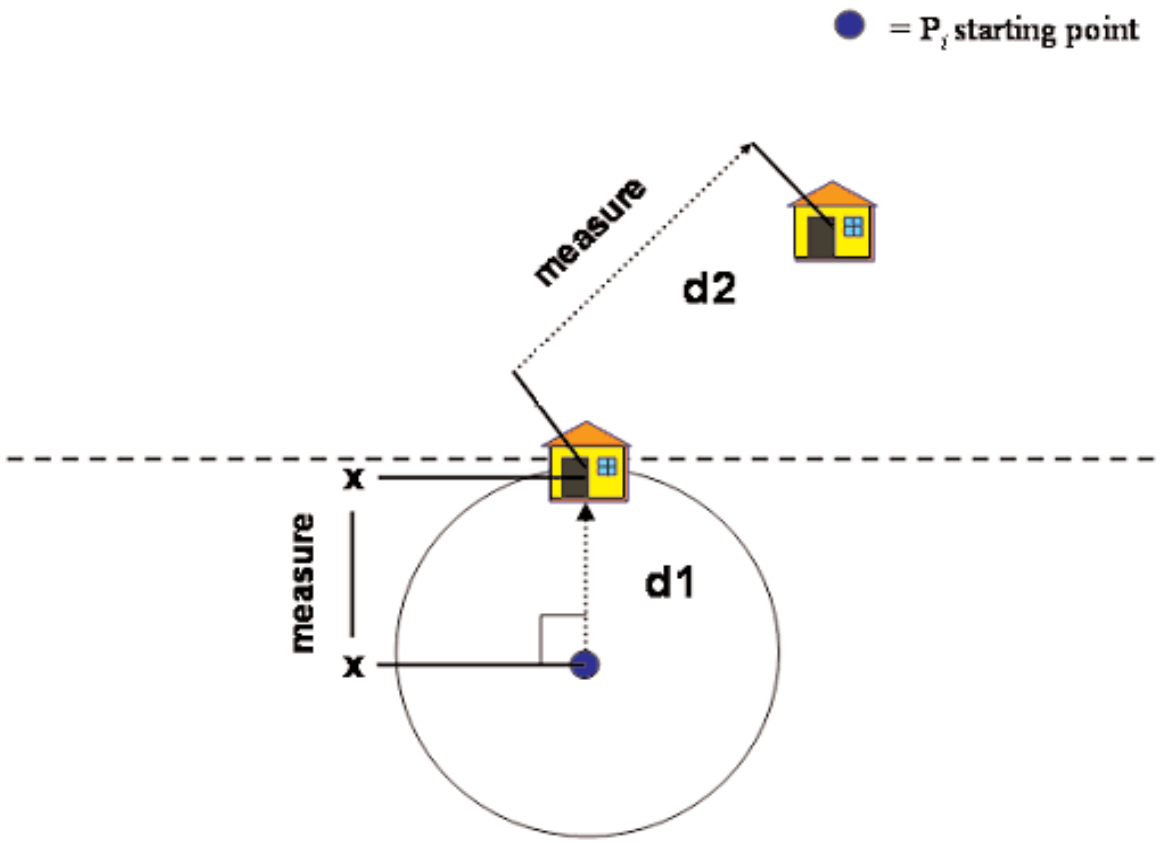


Figure 2

Precise measurements: shelter dimensions at ground level; without going inside the household (HH), survey teams project distances (trigonometry) to measure d1, d2.

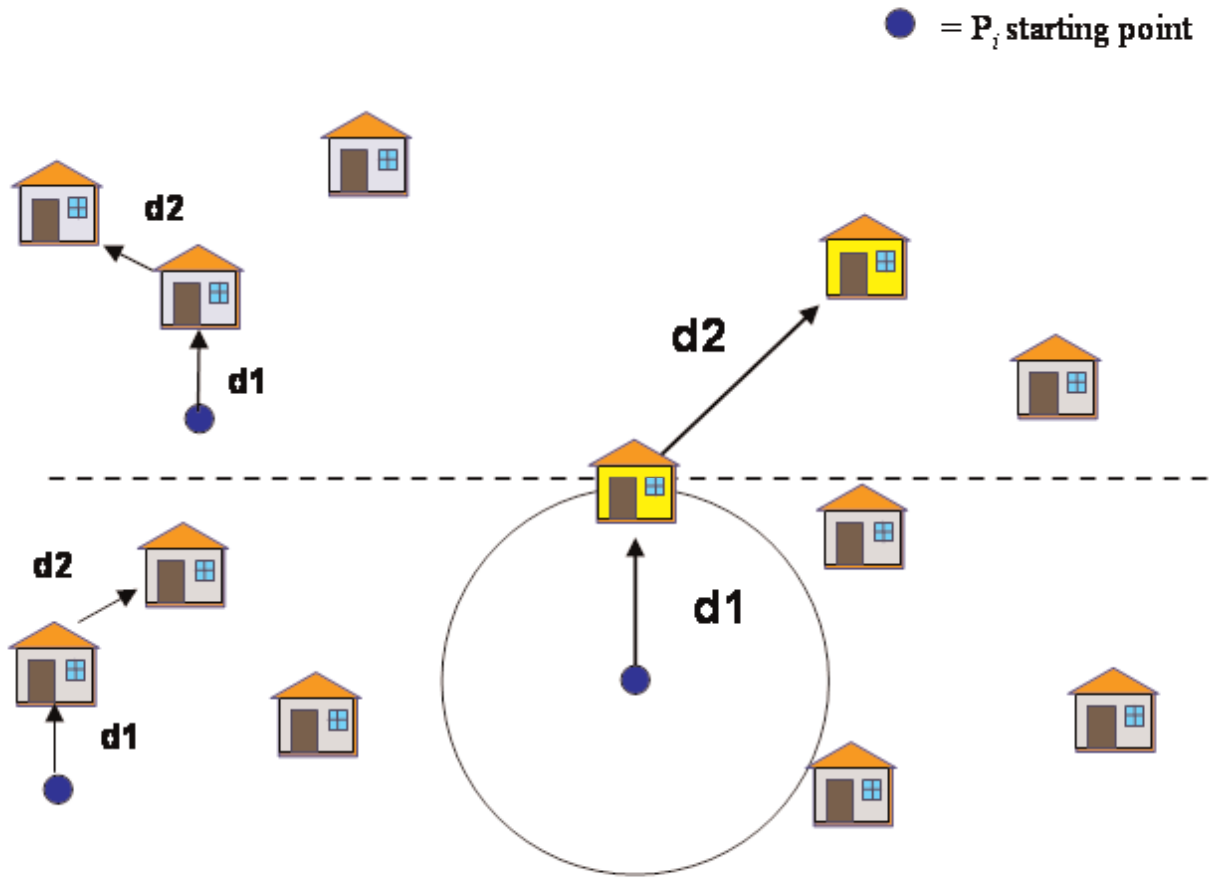


Figure 3

T-Square sampling: distances d1 and d2: used to characterize the spatial pattern of households within the camp and subsequently the camp population.

4. Special considerations

Implementation of either method can be tricky and we will attempt to provide some practical hints that may be useful in field practice. When in doubt, ask for help.

4.1 - Camp perimeter: how precise do I need to be?

When defining external limits of the camp, the goal is to define the inhabited areas of the camp. The best is to walk (or drive) along the sides at a few metres distance from the shelters, for instance 2 to 3 metres.

Although some amount of precision is required, one should look far ahead, in your line of sight (this may vary between 30 to 150 m distance); this is to avoid defining the perimeter of the camp too precisely. A good rule of thumb is to have "20-40" landmarks or points which are used to draw your camp perimeter avoiding to circle specifically each shelter (Figure 4). Being too precise would not be helpful in yielding better results. For small camps, distances to cover will be somehow smaller, but not much less.

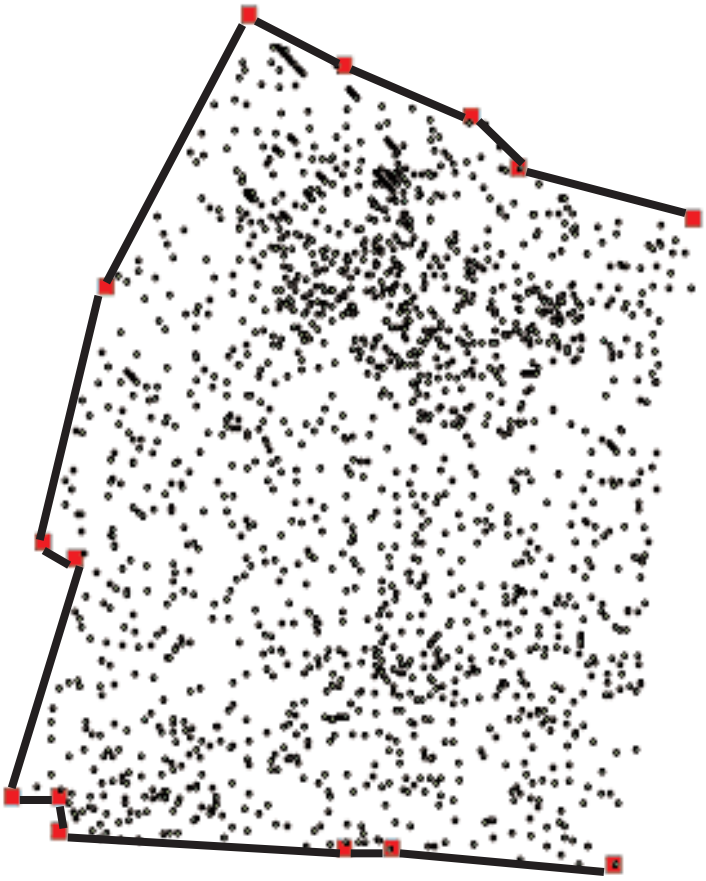


Figure 4
External camp limits

4.2 - Camps with very different population densities

In extreme situations, where population density in the camp varies greatly from one area to another, it may be necessary to control the amount of sampling bias that is likely to occur.

Camps should then be divided *de visu* (visually) into *high* and *low* density areas. Both population estimation techniques are conducted in the same way except two separate maps are drawn: a high density map and a low density map (Figure 5).

As a rule of thumb, if distances between households in a given sector of the camp become very different, then consider drawing separate maps. For example, if distances between households is at least twice smaller in high density areas than in low density areas.

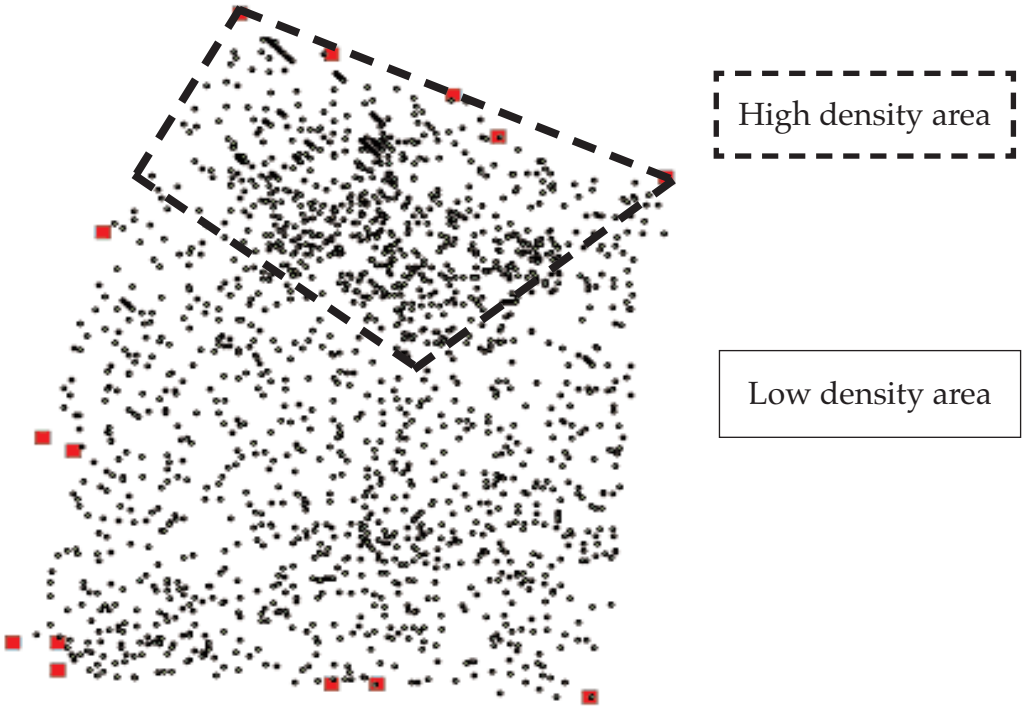


Figure 5
Map of Camp D showing high and low density areas

Calculation, example:
The total surface of Camp D (figure 5) is estimated at 150,000 m².
2 population density areas were defined, high and low:
– High density area (HDA) = 50,000 m² —> Average population/square = 120
– Low density area (LDA) = 100,000 m² —> Average population per square = 65
HDA and LDA average population/625 m², respectively 120 and 65
Total HDA population = (50,000/625) x 120 persons = 9,600
Total LDA population = (100,000/625) x 65 persons = 10,400
—> **Total camp population** = 9,600 + 10,400 = 20,000

4.3 - Aerial photographs

Other population estimation methods such as aerial view planes may be considered. Nevertheless, one needs to keep in mind it is usually difficult to obtain timely pictures in emergencies. They are costly and authorization problems may occur. In 1994, when the French military took pictures of Goma from airplanes, figures were under-estimated because it was not possible to identify refugees without shelters. Nevertheless, even if these photos will not help you to determine the site population directly given our available technology, an aerial photo would always be useful to draw a map of your camp.

5. Other rapid population assessment methods

The size of the population can also be estimated through other methods.

5.1 - Census and/or registration

During a census, every person is counted and registered individually.
This is the "ideal" method. However, a census takes a long time, and requires a lot of human resources - both of these often lack in emergencies.
A census is done during the time of the day when most persons are "at home".

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.

5.2 - Exhaustive counting of habitats (or households)

Habitats in the target area are counted one by one. This is often only feasible in small sites (small surface areas).

The average number of persons per household is obtained from a sample of households, selected at random or through systematic sampling.

The total population is then obtained by multiplying the total number of habitats by the average number of persons per household.

An exhaustive habitat count can be done while walking, or while driving in a car, and sometimes by aerial photography. This assumes good quality and sufficient detail of the pictures taken when flying over the target area.

5.3 - Vaccination coverage or programme activity data

This method uses the results of a vaccination coverage survey or the number of vaccines administered during a mass vaccination campaign, for a specific age group (e.g. 6 to 59 months). Using the reference age group distribution, the total population can be deduced (see example).

Example: Population estimate from vaccination coverage data

Assume that measles vaccination coverage among children between 6 and 59 months, was 80% (or 0.80) and that 10000 measles vaccines were administered in that age group.

With this information, the total number of children between 6 and 59 months can be estimated: 10000/0.80 = 12500.

Knowing that children of this age group generally represent around 16 to 20% of the total population[5], the total population is estimated to be 12500/0.16 or 0.20 = 78125 or 62500 persons.

5 The proportion of children under 5 years may vary according to the context [2].

Appendices

Appendix 1

Camp map coordinates

Nb of footsteps for 50 metres: _____

Foot step size: _____m

Name of surveyor: _____

Date: ___ / ___ / 200__

POINT	GPS coordinates		Compass (degrees:00.0000)	Number of foot steps	Odometer
	Latitude	Longitude			
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

Appendix 2

Equipment for one team

- GPS device
- A set of batteries for GPS
- 1 computer (and 1 printer to leave the map in the field)
- 1 decametre (or 25 m rope or measuring bands, also called boundary tape)
- 1 downloading device (GPS —> to computer)
- Several clipboards
- Several hand clickers to count footsteps
- Optional: walking odometer (wheel)
- Indelible pens
- Tent sticks + hammers
- House identifier (examples: spray paint, or coloured thread)
- Vehicle with odometer: for wide areas (> 5 km)
- Millimetre graph paper to draw paper map

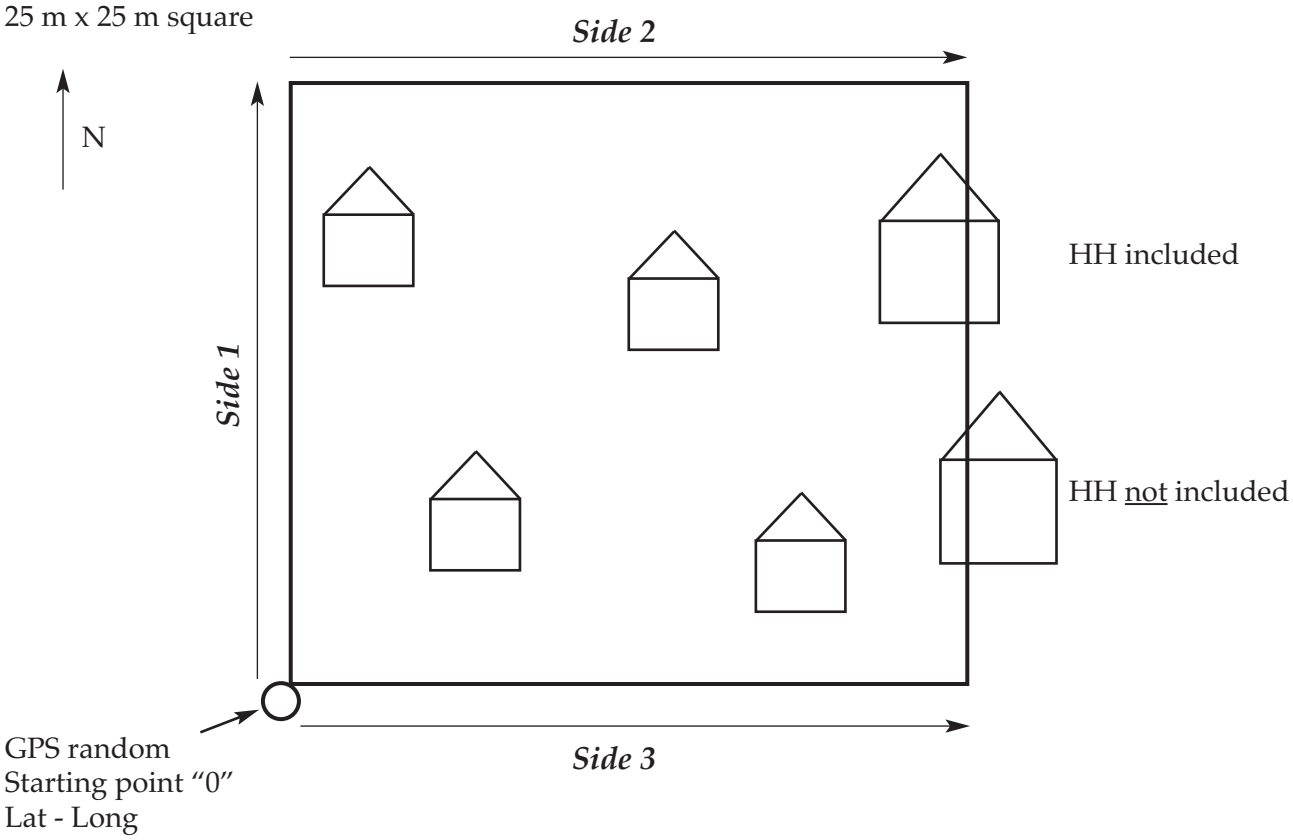
Appendix 3

Geographical definition of a 25 m x 25 m square

When the random GPS waypoint is reached, the next steps to follow are:

- Point "0" = exact GPS random point reached (given Lat. - Long. coordinates)
- Starting at point « 0 », measure 25 metres by walking (aiming) exactly to the North: this represents the left side (side 1) of the square to select (25 m x 25 m).
- Sides 2 and 3: 2 surveyors walk at 90° towards East (with compass) and measure 25 metres. When sides 2 and 3 are drawn, close the square. If necessary, a rope or measuring band (boundary tape) or decametre held with sticks gives the limits of the square obtained.
- The surveyor team(s) count(s) the number of houses in each 25 m x 25 m square block: a different square data collection sheet is filled for each new square. Each team counts the total number of persons per household and fills in the questionnaire (see Appendix 4).
- Proceed in the same manner for all 15 squares selected.
- Household (HH) included: if at least half of the HH surface falls within the selected square.

Spatial definition of a random square and households (HH) included or not



Appendix 4

Household (HH) data collection in 25m x 25m square blocks

Square block number: _____

Block coordinate (to start):

1. If using GPS
   - Latitude: _____
   - Longitude: _____
2. If using compass
   - Angle: _____
   - Distance: _____

Name of surveyor: _____

Date: ___ / ___ / 200__

N° HH	Total	< 5 years	≥ 5 years
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			

Appendix 5

T-Square data collection sheet

Points: _____ to _____

Nb of footsteps for 50 metres: _____

Name of surveyor: _____

Date: ___ / ___ / 200__

P_i	GPS coordinates in degrees (00.0000)		Decametre (in m, cm)		Number of foot steps	Odometer
	Latitude	Longitude	d1	d2		
P1			,	,		
P2			,	,		
P3			,	,		
P4			,	,		
P5			,	,		
P6			,	,		
P7			,	,		
P8			,	,		
P9			,	,		
P10			,	,		
P11			,	,		
P12			,	,		
P13			,	,		
P14			,	,		
P15			,	,		
…			,	,		
P50			,	,		

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