

Notes on the design of a simple spatial sampling method (S3M) for assessing coverage of health and nutrition programmes in Liberia

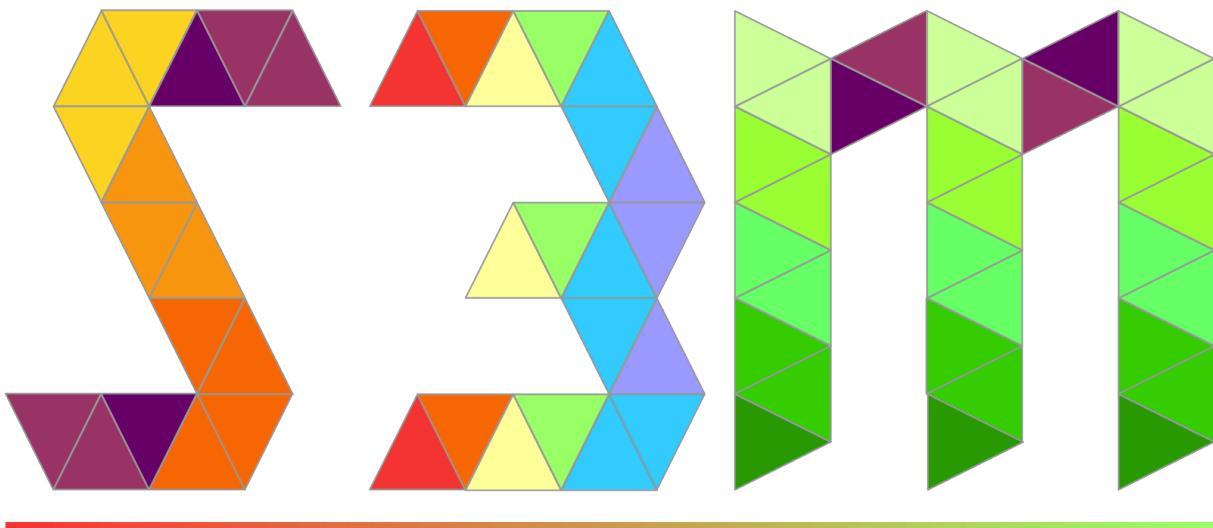
Valid International

2018-08-23

Contents

Simple Spatial Sampling Method (S3M)	5
1 Introduction	7
2 The survey sample	9
2.1 The first stage sample	9
2.2 The second stage sample	36
2.3 Sample size considerations	39
2.4 Urban and rural sample considerations	41
2.5 Overall sampling frame	41
2.6 Estimated time to complete full survey	71
3 Indicators	73
3.1 CMAM coverage	73
3.2 Vitamin A supplementation	79
3.3 Iron-folic acid (IFA) supplementation for pregnant women	80
3.4 Micronutrient powder supplementation	80
3.5 IYCF counselling	81
4 Questionnaire	83
4.1 CMAM coverage survey instruments	83
4.2 Survey for children 6-59 months and their mothers	86
4.3 Using Open Data Kit	89
5 Data management and analysis	93
5.1 Analytical approach for estimating coverage indicators	94
5.2 Analytical approach for mapping coverage indicators	97
6 Anthropometric measurement standardisation test	99
6.1 Objectives	99
6.2 Mechanics	99

Simple Spatial Sampling Method (S3M)



Chapter 1

Introduction

The Simple Spatial Survey Method (S3M) was developed from the CSAS coverage survey method as a response to the widespread adoption of community management of acute malnutrition (CMAM) by ministries of health. Large-scale programs need a large-scale survey method and S3M was developed to meet that need.

S3M was designed to :

- Be simple enough for MoH, NGO, and UNO personnel without specialist statistical training to perform.
- Provide a general survey method. S3M can be used to survey and map :
 - Need for and coverage of selective-entry programs such as CMAM and TSFP as well as universal programs such as EPI, GMP, GFD (general ration), and “blanket” SFP over wide areas.
 - Levels of indicators such as those for IYCF, WASH, and period prevalence / cumulative prevalence of ARI, fever, and diarrhoea over wide areas.

This document concentrates on using S3M to assess the need for and coverage of:

- Treatment of SAM in children aged between 6 and 59 months;
- Vitamin A supplementation;
- Micronutrient powder supplementation;
- Ferrous sulphate-folic acid supplementation; and,
- Infant and young child feeding counselling.

Chapter 2

The survey sample

The survey method described here uses a two-stage sample:

- **First-stage:** We take an even (or near-even) spatial sample of communities from all of the communities in the survey area.
- **Second-stage:** We take a sample of eligible individuals from each of the communities identified in the first stage of sampling.

Two-stage sampling is used in many survey methods. A typical example of a survey method that uses a two-stage sample is the SMART method that is commonly used for nutritional anthropometry surveys.

The main difference between the sample taken in S3M based surveys and in SMART type surveys is that S3M based samples use a spatial sample in the first stage whereas SMART type surveys use a proportional to population size (PPS) sample.

The advantages of using a spatial first stage sample is that such a sample allows us to identify where (and why) coverage is good, and where (and why) coverage is poor. This information is essential to improving program coverage and ensuring equitable access to services.

A spatial sample can be used to produce equivalent results to a traditional proportional to population size (PPS) sample as is used in (e.g.) SMART type surveys using a weighted analysis. This means that a spatial sample can be made to act as a PPS sample. A PPS type sample cannot, however, be made to act as a spatial sample.

2.1 The first stage sample

2.1.1 Step 1: Find a map

The first step in a S3M survey is to find a map of the survey area. A map showing the locations of all towns and villages in the survey area is essential. Try to find a map showing the locations

of all towns and villages in the survey area. You may need to update the map to take into account migration and displacement.

For the coverage survey of 2 counties in Liberia, it will be practical and useful to have:

- A small scale-map (a wide area map but with poor detail) of the entire survey area for each of the 2 counties. If the counties are contiguous (i.e., share borders with each other), the small scale map can be of the two counties together. This map does not need to show the location of all towns and villages in the survey area but it gives a general idea of where the 2 counties are located and main towns and locations and roads. Figure 2.1 is a small scale map of Liberia showing counties, roads and main towns and locations. Figure 2.2 is a small scale map of two counties showing all the districts within the county, roads and main towns and locations.



Figure 2.1: Small scale map of Liberia showing counties, roads and points of interest

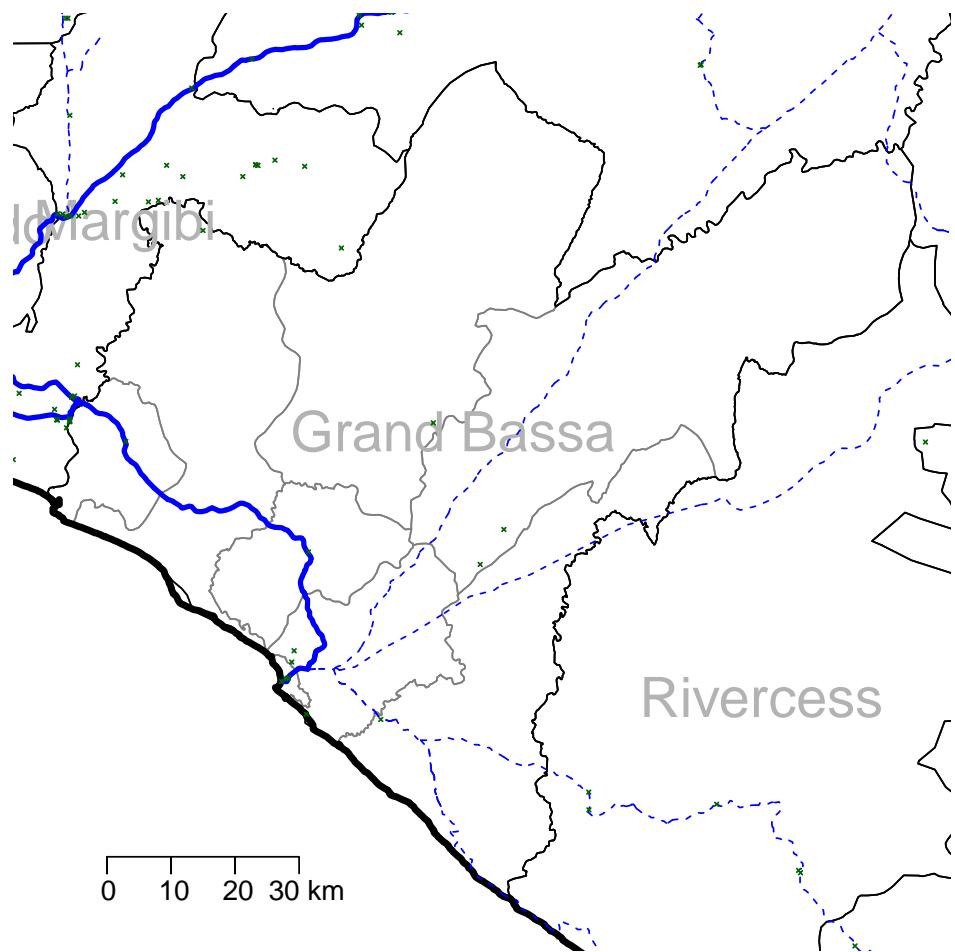


Figure 2.2: Small scale map of Montserrado and Grand Bassa in Liberia showing all districts, roads and points of interest

- A collection of larger scale maps (a small area map but with good detail) of each of the selected counties and each of the districts within those counties in Liberia. Figure 2.3 is a large scale map of Montserrado county showing all districts, roads and all settlements. Figure 2.4 is a collection of large scale maps of each of the districts of Montserrado country showing all roads and all settlements.

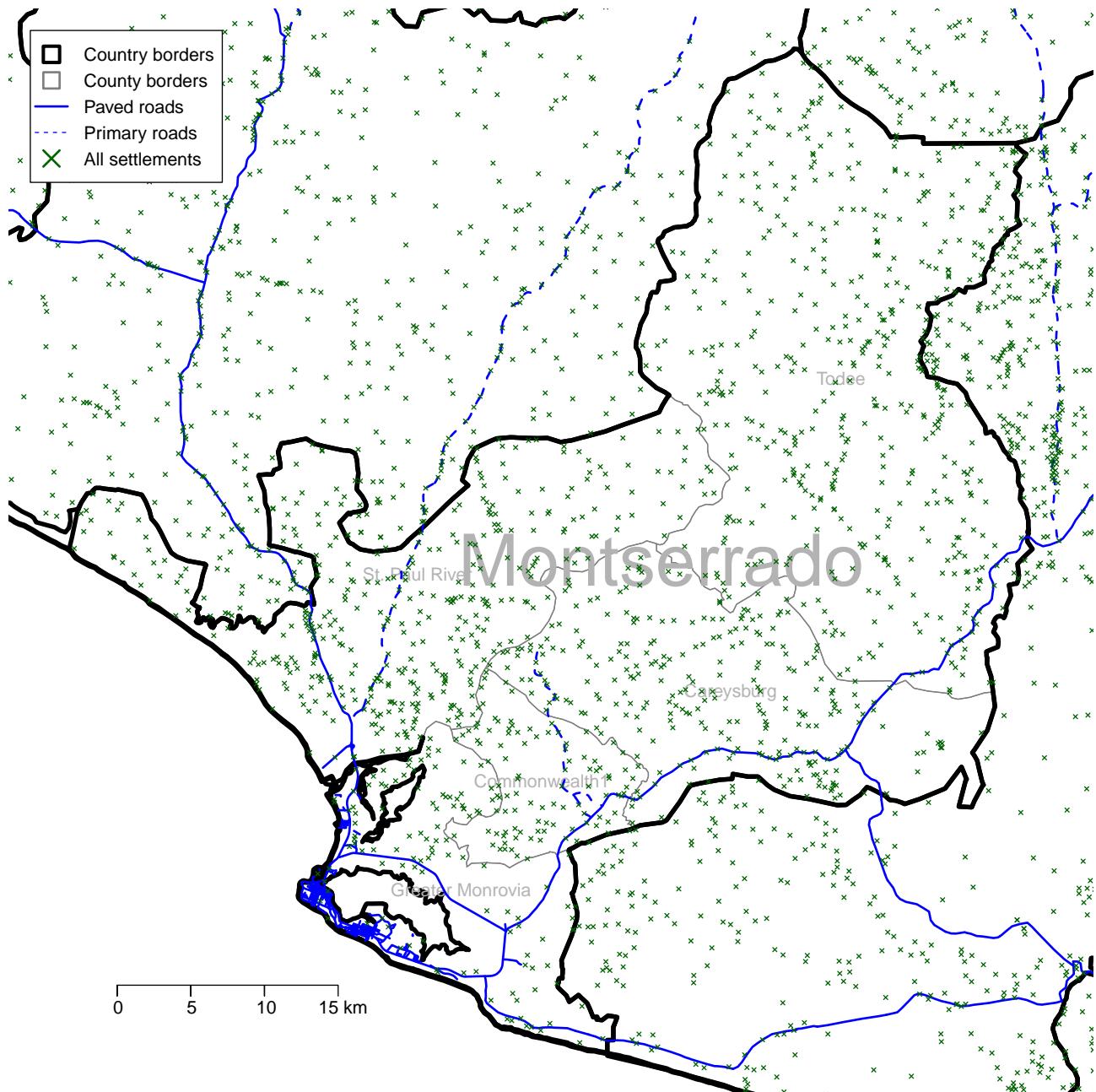


Figure 2.3: Large scale map of Montserrado county in Liberia showing all districts, roads and all settlements (towns, villages)



Figure 2.4: Large scale maps of 5 districts of Montserrado county in Liberia showing roads and all settlements (towns, villages)



Figure 2.5: Large scale map of Grand Bassa county in Liberia showing all districts, roads and all settlements (towns, villages)



Figure 2.6: Large scale maps of 8 districts of Grand Bassa county in Liberia showing roads and all settlements (towns, villages)



Figure 2.7: Large scale maps of 8 districts of Grand Bassa county in Liberia showing roads and all settlements (towns, villages) continued

The small-scale maps in Figures 2.1 and 2.2 will be useful for identifying initial sampling locations.

The large-scale maps in Figures 2.3, 2.5, 2.4, 2.6 and 2.7 will be useful for identifying the precise location of sampling points and for selecting the communities to be sampled.

2.1.2 Step 2: Decide the area to represent each sampling point

The easiest way of thinking about this is as a function of the intended maximum distance (d) of any community from the nearest sampling point (see Figure 2.8).

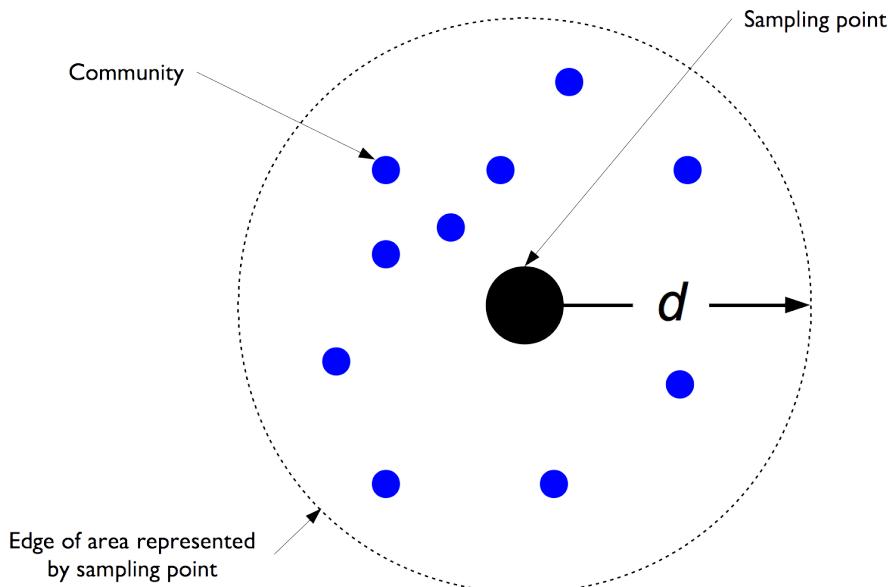


Figure 2.8: Conceptual presentation of the area represented by each sampling point

There are other ways of thinking about d . These are:

1. **The area of each triangular tile:** This can be calculated using the formula:

$$A = \tan 30^\circ \times \frac{9}{4} d^2$$

For $d = 10$ km the area of each triangular tile will be about:

$$A = \tan 30^\circ \times \frac{9}{4} d^2 \approx 1.3 \times 100 = 130 \text{ km}^2$$

2. **Practicability:** Most of the time spent in the field when doing a survey will be in travelling to and from sampling points. Having many sampling points can make for an expensive and / or lengthy survey. If you know how many sampling points that you can afford to take (m) then you can make a **very approximate** estimate of a suitable value for d using the following *rule-of-thumb* formula:

$$d \approx \sqrt{\frac{\text{Program Area}}{m}}$$

The value of d calculated using this formula is approximate and should be used as a starting point for a number of trial samples using the procedure outlined below.

Pair	Distance	Pair	Distance
1	21 km	13	13 km
2	14 km	14	11 km
3	13 km	15	12 km
4	17 km	16	15 km
5	11 km	17	13 km
6	14 km	18	16 km
7	12 km	19	18 km
8	15 km	20	13 km
9	16 km	21	8 km
10	12 km	22	16 km
11	17 km	23	18 km
12	14 km	24	14 km



Figure 2.9: Distances of communities to the nearest substantial markets

Calculations

 Following are steps to estimate value of d based on distances that carers are willing or able to walk to access services.

Using the information from the distance table, add the distances together:

$$\sum \text{Distance} = 343 \text{ km}$$

Divide the result by the number of paired distances:

$$\frac{\sum \text{Distance}}{\text{Number of paired distances}} = \frac{343}{24} = 14.29 \text{ km}$$

Divide the result by two:

$$d = \frac{14.29}{2} = 7.15 \approx 7 \text{ km}$$

This is an estimate of the distance that carers are willing or able to walk to access services. Only distances between towns and villages with markets are used in this calculation.

A way of deciding a value for d that is based on the economic geography of the survey area is to set d to one half of the mean distance between neighbouring pairs of communities with substantial markets.

S3M surveys have been done using a wide range (i.e. from $d = 8$ km to $d = 33$ km) of values for d . A value for d of 10 km or 12 km will probably be small enough in most circumstances.

2.1.3 Step 3: Draw a grid over the map

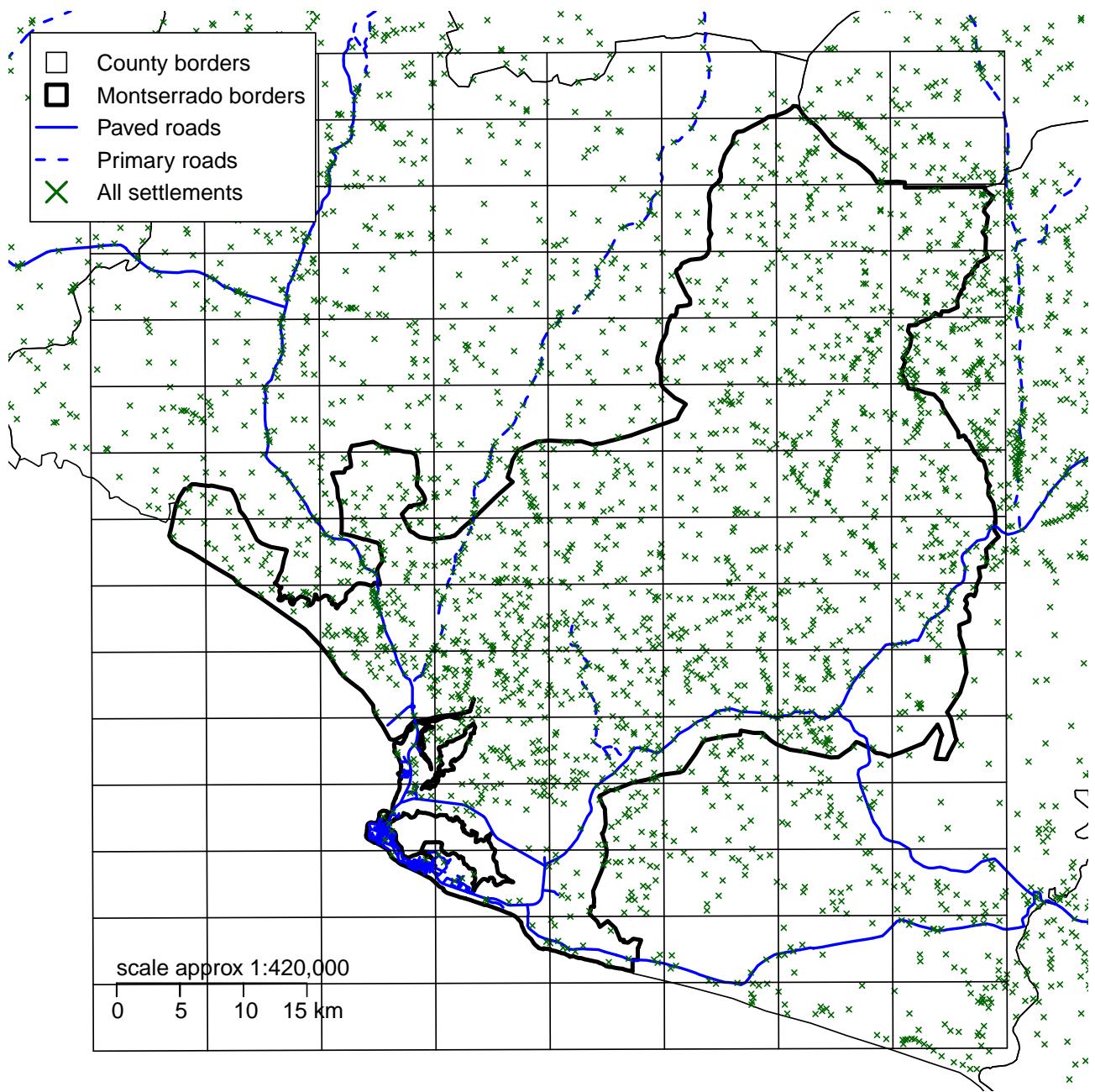


Figure 2.10: Montserrado county with a rectangular grid defined by d of 6 km



Figure 2.11: Grand Bassa county with a rectangular grid defined by d of 10 km

The next step is to draw a grid over the map.

The size of the grid is determined by the distance (d) that you decided in **Step 2**.

The grid is rectangular rather than square. This allows us to place sampling points at the centres of hexagons in a hexagonal grid without the need to draw a hexagonal grid (see **Step 4**).

The width of the grid in the east-west (x) direction is different from the height of the grid in the north-south (y) direction.

The width of the grid in the east-west (x) direction is calculated using:

$$x = \frac{3d}{2}$$

where d is the distance (d) that you decided in **Step 2**.

The height of the grid in the north-south (y) direction can be calculated using:

$$y = \frac{\sqrt{3}d}{2}$$

where d is the distance (d) that you decided in **Step 2**.

For example, in Figure 2.10, we used $d = 6$ km. This value of d creates a rectangular grid with the following dimensions:

$$x = \frac{3d}{2} = \frac{3 \times 6}{2} = \frac{18}{2} = 9 \text{ km}$$

and:

$$y = \frac{\sqrt{3}d}{2} \approx \frac{1.73 \times 6}{2} \approx \frac{10.38}{2} \approx 5.2 \text{ km}$$

So, the grid in Figure 2.10 is 9 km long on the east-west direction and 5.2 km on the north and south direction.

The table below shows the grid sizes for different values of d :

d	x	y	d	x	y
5	7.5	4.3	13	19.5	11.3
6	9.0	5.2	14	21.0	12.1
7	10.5	6.1	15	22.5	13.0
8	12.0	6.9	16	24.0	13.9
9	13.5	7.8	17	25.5	14.7
10	15.0	8.7	18	27.0	15.6
11	16.5	19.5	19	28.5	16.5
12	18.0	10.4	20	30.0	17.3

When drawing the grid make sure that it covers the entire survey area.

It is usually best to draw a grid that covers an area that is a little larger than the entire survey area. This helps to ensure that the survey will sample from the entire survey area.

The grid can be drawn using marker pens onto plastic film overlaying the map. This protects the map and allows you to reposition the grid to improve the coverage of the sample should this be needed.

If you are drawing the grid directly onto the map then use a soft pencil (e.g. a 2B or #1 pencil). A soft pencil will not damage the surface of the map and is easy to erase using a soft rubber eraser should you make a mistake or need to draw a different grid.

2.1.4 Step 4: Create an even spread of sampling points



Figure 2.12: Montserrado county with a rectangular grid defined by d of 6 km and alternating intersections of the grid used to identify sampling points

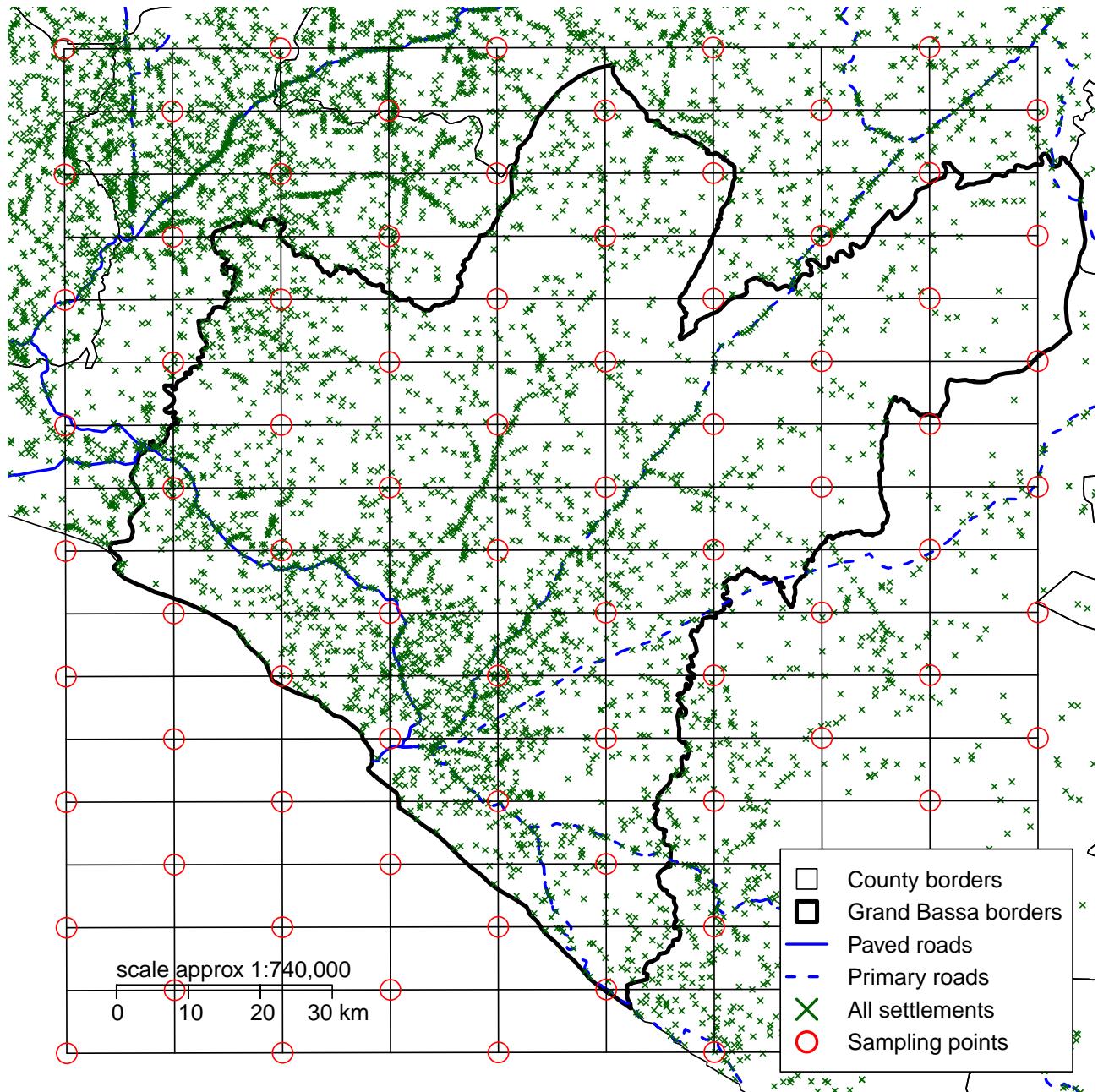


Figure 2.13: Grand Bassa county with a rectangular grid defined by d of 10 km and alternating intersections of the grid used to identify sampling points

Sampling points are located at the intersections of the rectangular grid in a staggered fashion. Alternate intersections of the grid in the x (east-west) and y (north-south) directions are used:



Figure 2.14: Selecting alternating intersections of the grid in the x and y directions to spread sampling points evenly

Note how this process places sampling points at the centres of hexagons in a hexagonal grid without the need to draw a hexagonal grid.

Make sure that your sample points go right to the edge (or even over the edge) of the survey area. This helps to ensure that the survey will sample from the entire survey area.

2.1.5 Step 5: Select the communities to sample

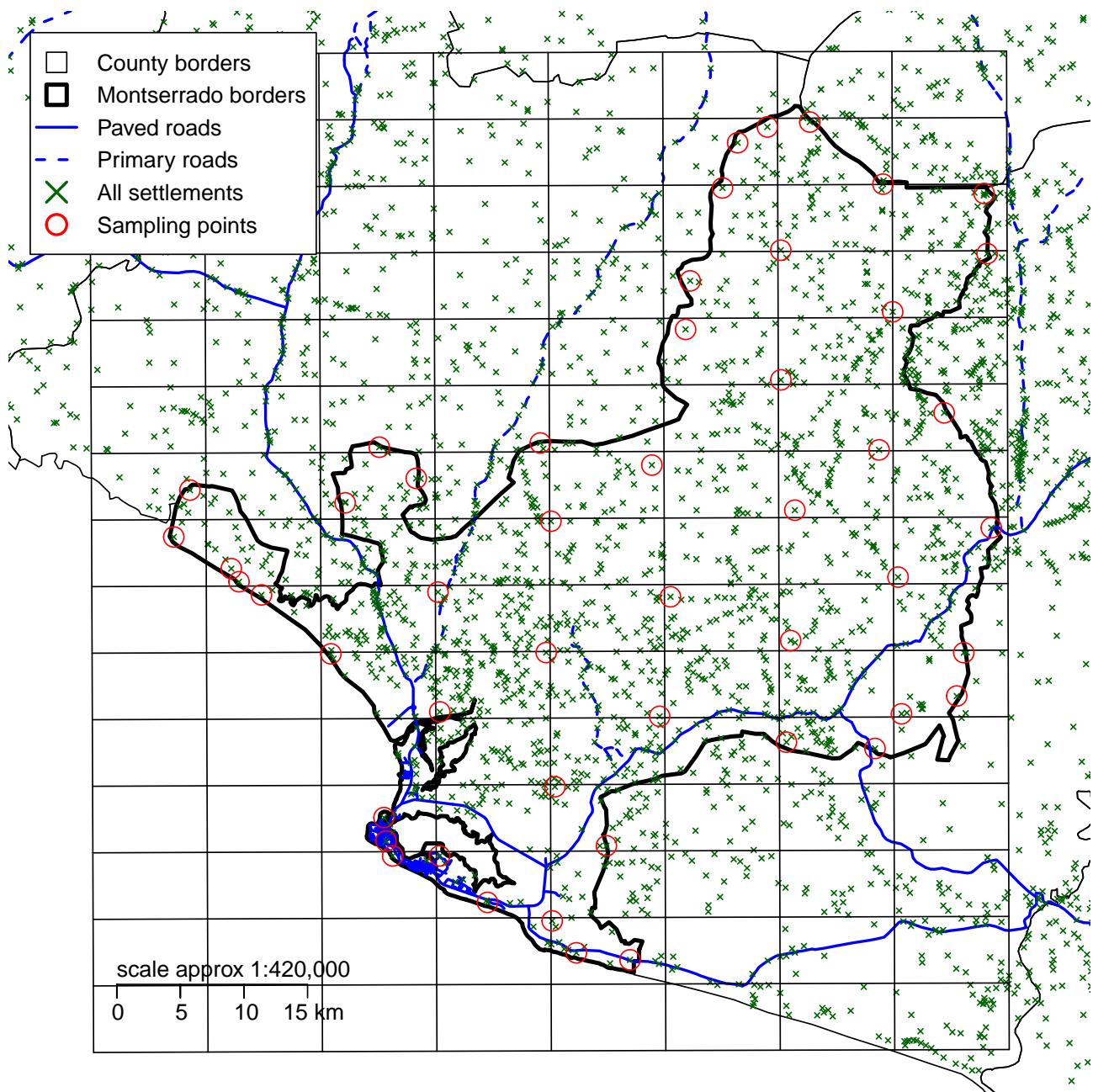


Figure 2.15: Montserrado county with a rectangular grid defined by d of 6 km and sampling points moved to the nearest communities



Figure 2.16: Grand Bassa county with a rectangular grid defined by d of 10 km and sampling points moved to the nearest communities

Select the community (or communities) closest to the sampling points identified in **Step 4**.

The position of the sampling point is moved to the position of the selected community. This is shown in the diagram above.

You may drop sampling points if you find that many sampling points are clustered closely together.

You may move or add sampling points if you find that there are populated areas that do not contain sampling points.

The aim is to create a roughly even spread of sampling points over the entire survey area.

Caution

⚠ The S3M sample is defined using a systematic sampling method. Like any systematic sampling method, an S3M sample can produce biased estimates if there is periodic variation in prevalence and / or coverage and the sampling points tend to coincide with this periodicity. This is difficult to control for without prior knowledge of the periodic variation, although simple checks such as ensuring that sampling points are not all in valleys or all on hilltops, and adjusting the grid position accordingly, should help to minimise this problem.



Figure 2.17: Montserrado county with a rectangular grid defined by d of 6 km and sampling points moved to the nearest communities showing test triangulation

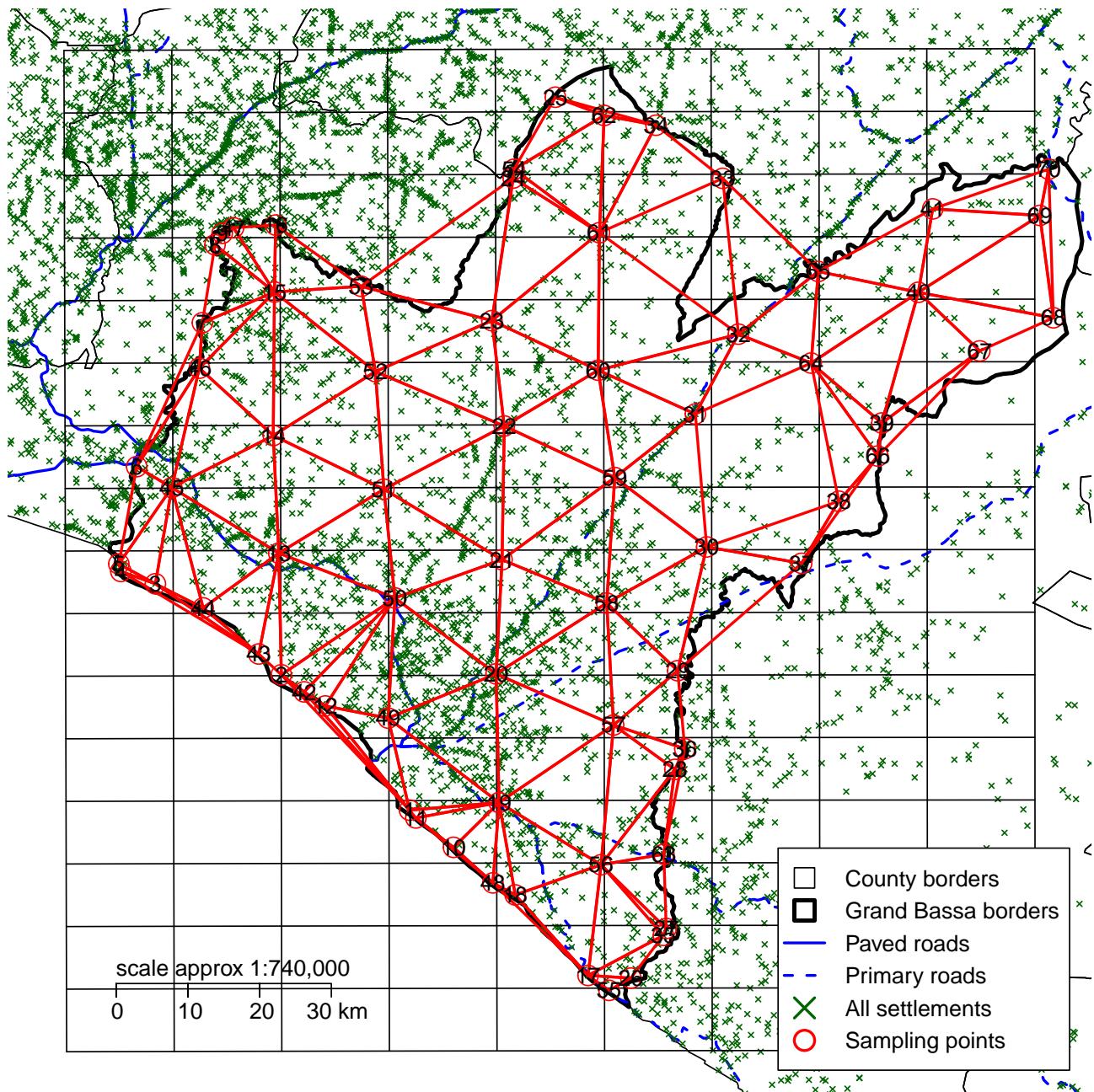


Figure 2.18: Grand Bassa county with a rectangular grid defined by d of 10 km and sampling points moved to the nearest communities showing test triangulation

A good way to check if you have an even spread of sampling points over the entire survey area is to do a trial *triangulation* of the selected sampling points. This involves dividing up the survey area into non-overlapping triangles with a sampling point at each vertex.

There will usually be many ways to divide the survey area into triangles. The best triangulation is one that results in small equilateral triangles (i.e. triangles with all sides of equal length) or small and nearly equilateral triangles. Avoid long and narrow triangles. Avoid large triangles.



Figure 2.19: Selecting alternating intersections of the grid in the x and y directions to spread sampling points evenly

You can triangulate “by eye” or automatically (i.e. using a computer). If you use a computer to do this then you should use software that produces a *Delaunay triangulation*.

You may drop sampling points if you find that many sampling points are clustered closely together.

You may move or add sampling points if you find that there are populated areas that do not contain sampling points.

The aim is to create a roughly even spread of sampling points over the entire survey area.



Figure 2.20: Montserrado county with a rectangular grid defined by d of 6 km and sampling points moved to the nearest communities showing updated triangulation

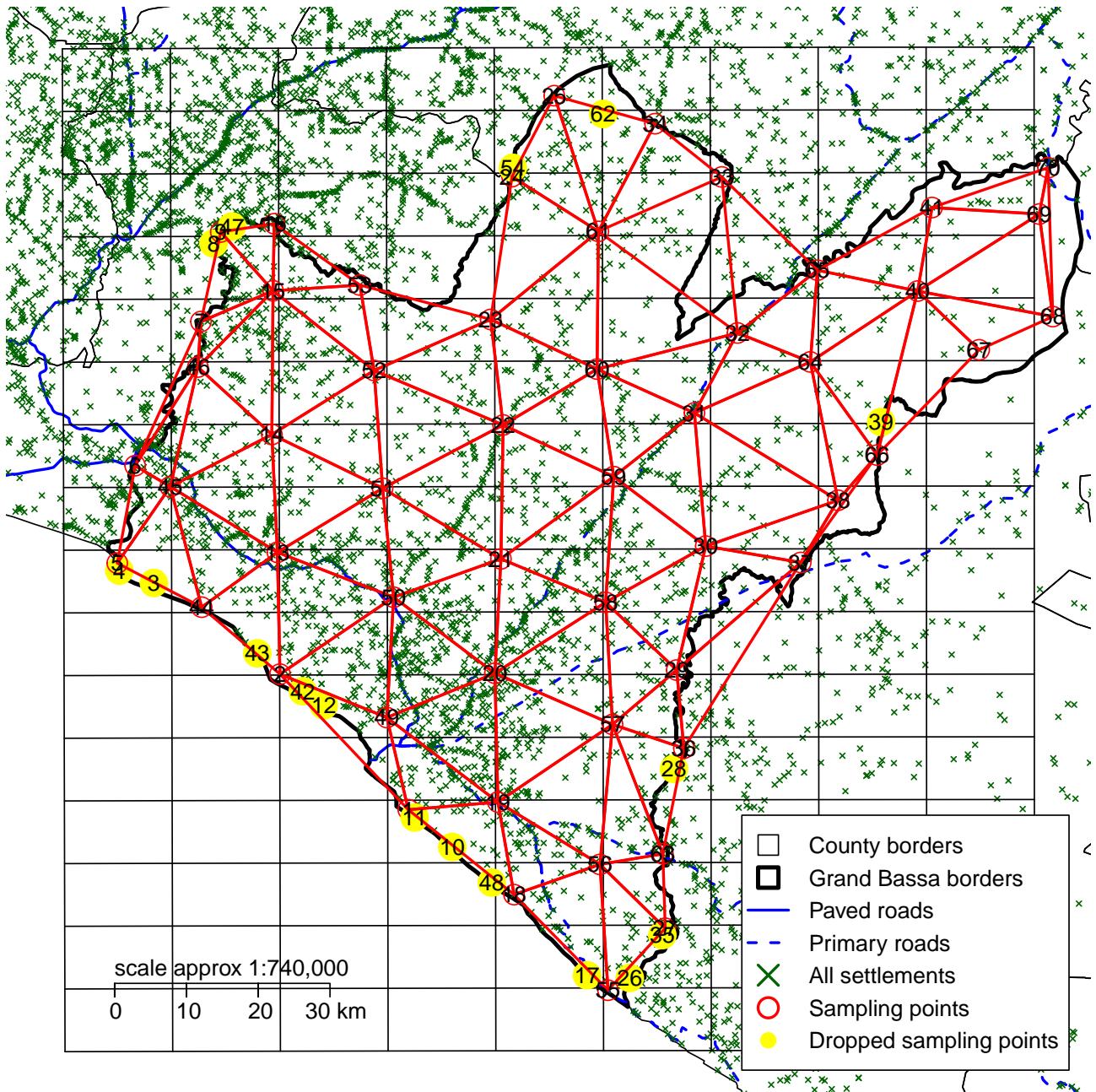


Figure 2.21: Grand Bassa county with a rectangular grid defined by d of 10 km and sampling points moved to the nearest communities showing updated triangulation

Figure 2.20 above show a trial triangulation for Montserrado county with only a few long and narrow triangles. Five sampling points (labelled 2, 25, 32, 33, 39) have been dropped to ensure that there are few long and narrow triangles.

Figure 2.21 above show a trial triangulation for Grand Bassa county with only a few long and narrow triangles. Seventeen sampling points (labelled 3, 4, 8, 10, 11, 12, 17, 26, 28, 35, 39, 42, 43, 47, 48, 54, 62) have been dropped to ensure that there are a few long and narrow triangles.

The sample will, to some extent, be dictated by the distribution of communities in the survey area. It is usual to find that you have some large triangles and some long and narrow triangles in your final triangulation. You should try to keep the number of these “problem” triangles to a minimum.

The process of selecting communities to sample is:

1. Start by defining the sample using the grid based approach outlined above.
2. Use a trial triangulation. This can be done “by eye” or using a computer. Check for an even spatial sample:
 - Most triangles should be short and wide.
 - Very few triangles should be long and narrow.
 - The triangles should be of roughly equal size.
 - The complete set of triangles should cover all (or almost all) of the survey area.
3. Move or add sampling points to improve the sample (i.e. to avoid long and narrow triangles, to avoid large triangles, to make triangles roughly equal in size, and to ensure the sample covers all or almost all of the survey area). Triangulate again. Repeat this process until you are happy with the sample.

2.2 The second stage sample

The second stage sample is also called *within-community sampling*. The sampling process that you use to select a sample from a community will depend on what the survey is investigating.

If you are investigating multiple indicators which apply to different groups of individuals then you may find it easier to use different sampling methods for different indicators. You can think of this as having different surveys for different indicators sampled from the same set of communities at the same time. For the Liberia S3M, this is the approach that will be used in which there will be 2 concurrent surveys. There will be a survey for CMAM coverage which will be specific for SAM children and a survey for children aged 6 - 59 months and their mothers.

2.2.1 Stage 2 sampling for CMAM coverage survey

For the survey for CMAM coverage, an active and adaptive (snowball) case-finding method can be used in stage 2 sampling to find all or nearly all SAM cases by MUAC in the stage 1 sample ([Myatt et al., 2012](#)). However, given that the Liberia CMAM programme uses both MUAC and weight-for-height as independent criteria for SAM, it is uncertain whether the use of active and adaptive case finding using weight-for-height will find all or nearly all SAM cases

by weight-for-height¹. It is therefore recommended that a full census of children aged 6-59 months in the selected villages in the stage 1 sample be conducted to ensure exhaustivity. This will also be the approach to use in urban areas given that active and adaptive case finding has been known to fail in finding all SAM cases when implemented in urban areas ([Myatt et al., 2012](#)). As an example, the only other known coverage survey conducted in Liberia is that which was conducted by Accion contra la faim in 2011 to assess coverage of CMAM in Greater Monrovia ([Accion Contra la Faim, 2011](#)). In this survey, it was unclear as to whether both MUAC and weight-for-height was used to identify SAM but both active adaptive case finding and mass screening was used to ensure that all or nearly all CAM cases are found. Doing both approaches will be too resource-intensive. A good census sample taken house-to-house or door-to-door should be sufficient.

2.2.2 Stage 2 sampling for children 6-59 months and their mothers

Given that the stage 2 sample for the CMAM coverage survey will utilise a house-to-house or door-to-door of the villages, the stage 2 sample for the survey of children 6-59 months old and their mothers can be done via door/house counting with systematic selection in the first village selected per sampling point.

Generally, in rural villages/communities, the village leader will know how many houses/households are in the village so they can be asked for this information. In urban locations/communities/blocks, this information isn't usually known. So, door counting of the urban location or block will be necessary to know the total number of doors/houses in that particular urban area/location.

Once the number of houses or number of doors has been established, a sampling interval will need to be calculated as follows:

$$n_{\text{Sampling interval}} = \frac{\text{Total number of houses/doors}}{\text{Target sample of children 6-59 months old in village}}$$

The house-to-house/door-to-door sampling to look for SAM children can start and then for every *nth* house/door, the survey for children 6-59 months old will be conducted as well.

Remember that this will be done in the first village selected per sampling point.

¹Capture and re-capture studies done to test the sensitivity of active and adaptive case-finding as a sampling approach to find all or nearly all SAM cases were all implemented using MUAC as the indicator for SAM (see [Wegerdt et al. \(2006\)](#)).

2.2.3 Special considerations for large villages

If a sampling point is located in a large village or town then the village or town can be divided into a set of segments and the entire population of only a sample of these segments are then fully enumerated for the SAM coverage survey. If this village is the first village of the sampling point, then the door/house counting with systematic selection will be applied only in the sample of segments selected.

Segmentation involves dividing a community into several parts and taking part of the within-community sample from each **segment**. With simple communities, segmentation is not required and we take a single sample from the entire community using the appropriate sampling method.

2.2.3.1 Segmentation

For more complicated communities we divide the community into several parts or segments, such as a community made up of several clusters:

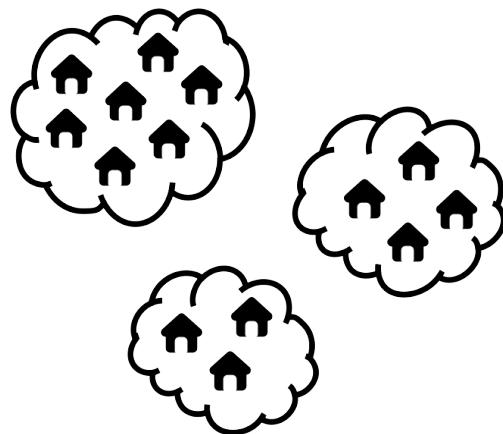


Figure 2.22: Example of a set of clusters of dwellings

or a community made up of several ribbons:



Figure 2.23: Dwellings arranged in several lines

or a mixed community:

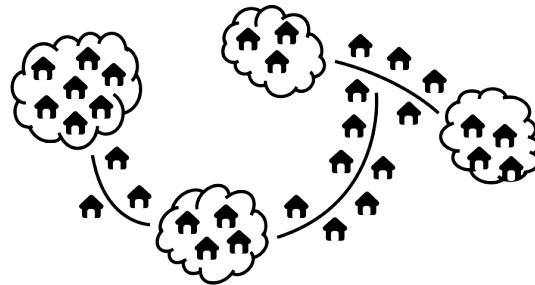


Figure 2.24: Mixture of clusters and ribbons

Segments should be either ribbons or clusters but should **never** contain both a ribbon and a cluster. This is because clusters and ribbons are sampled in different ways.

To select which segments to sample in a very large village or in urban locations/blocks, draw a rough map of the village and number each segment. Then depending on how many segments have been decided to sample (or are able to be sampled), select randomly the numbered segments. The selected segments are then sampled house-to-house/door-to-door. If this village is the first village of the sampling point, then the door/house counting with systematic selection will be applied only in these selected segments.

2.3 Sample size considerations

In general, the sample size needed for proportion-type indicators such as those to reported for this survey can be calculated using the following equation.

$$n = Z^2 \times \frac{p(1 - p)}{c^2}$$

where :

Z = z-value for preferred confidence interval

p = expected indicator proportion/prevalence

c = level of precision

The Z value is usually 1.96 for a 95% confidence interval. The p should usually be based on previous coverage results if available. If not, it is usually appropriate to set p at 50% (0.5) as this results in the highest sample size estimate. The precision (c) for coverage surveys is usually set at $\pm 10\%$ based on standard precision used for immunisation coverage.

Using these values, the typical sample size needed for coverage surveys is about 96.

$$n = 1.96^2 \times \frac{0.5(1 - 0.5)}{0.10^2} \approx 96$$

However, the survey design needs to be taken into account. A cluster survey such as the one that is proposed for the Liberia S3M will need to inflate sample sizes to account for the loss of variance due to the cluster design. This inflation factor is called the *design effect (DEFF)* which is based on the *intraclass correlation coefficient (ICC)*.

Generally, a *DEFF* of 2 is used to multiply the sample size with to account for the loss of variance. This would mean that a sample size of 192 would be the target sample size.

The sample size required will also depend on the indicators being assessed. Following is a further discussion of sample size requirements for the CMAM coverage survey and for the survey for children 6-59 months and their mothers.

2.3.1 Sample size for the CMAM coverage survey

SAM treatment coverage can be demonstrated in the following equation:

$$\text{SAM treatment coverage} = \frac{\text{SAM cases in treatment}}{\text{Total SAM cases}}$$

This indicator requires a sample of under 5 children who have SAM. SAM children are rare (at most 3% of the general population of children under 5). This means that the universe population of SAM children is small hence a finite population correction can be applied to sample size calculations. At the same time, given the active adaptive case finding approach that will be applied to finding SAM cases is known to be exhaustive, *DEFF* would generally be close to 1. Therefore, a sample size of about 96 is generally big enough to estimate SAM treatment coverage with a $\pm 10\%$ precision.

2.3.2 Survey for children aged 6-59 months and their mothers

For vitamin A supplementation, micronutrient powder supplementation, IYCF counselling and ferrous sulphate-folic acid supplementation the sample size of 192 would be the target sample size for each of these indicators.

However, given that this is a compound sample such that the MNP supplementation indicator is only for children 6-23 months old, the 192 sample will need to be inflated for the sample of children 6-59 months old big enough to ensure that at least 192 children aged 6-23 months will be included in the sample. The factor by which to inflate the sample size for children 6-59 months old can be estimated as follows:

$$\frac{\text{Age range in months for 6-59 month old children}}{\text{Age range in months for 6-23 month old children}} = \frac{59 - 6}{23 - 6} = \frac{53}{7} \approx 3$$

The sample size for children aged 6-59 months old will need to be inflated 3 times to ensure that a minimum sample size of 192 children aged 6-23 months will be sampled.

So, our sample size for the survey for children 6-59 months old and their mothers will be 576.

2.4 Urban and rural sample considerations

Currently, the requirements for the survey is to provide coverage estimates for Montserrado rural districts and the whole Grand Bassa county. Urban areas have been specifically excluded.

Given that urban areas would most likely have different characteristics than rural areas, it is more reasonable to treat urban areas as a separate survey area. If urban areas are to be sampled, then urban areas should have its own sample with the same minimum sample size as described above. The implication of this would be an extra survey for each and every urban area to be assessed.

2.5 Overall sampling frame

Given the stage 1 sampling, stage 2 sampling and sample size considerations described above, following are the overall sampling frames for each of two surveys that will be conducted.

2.5.1 Sampling frame for the CMAM coverage survey

Using an S3M approach to stage 1 sampling, thirty (30) stage 1 sampling points will be identified. This is an adaptation of S3M such that instead of first specifying a d value, a minimum number of stage 1 samples is specified based on which the hexagonal grid across each county will be drawn. This would mean that each county will be divided into 30 hexagonal, non-overlapping grids to identify 30 sampling points as the stage 1 sample. If estimates for urban areas will be required, then the urban areas of each county will be separated and a separate grid of 30 hexagons will be drawn on the map of the urban areas.

UNICEF has selected Greater Monrovia District and Grand Bassa County as the areas for the Liberia survey.

The Liberia Institute of Statistics and Geo-Informatic Services (LISGIS) has provided PDF maps of Greater Monrovia District and Grand Bassa County shown below.



Figure 2.25: Map of Greater Monrovia

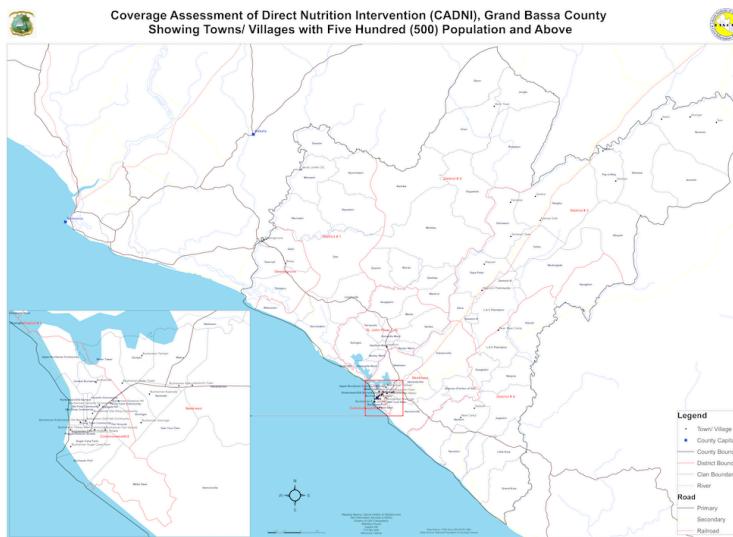


Figure 2.26: Map of Grand Bassa

Thirty hexagonal grids are then laid on top of these maps.

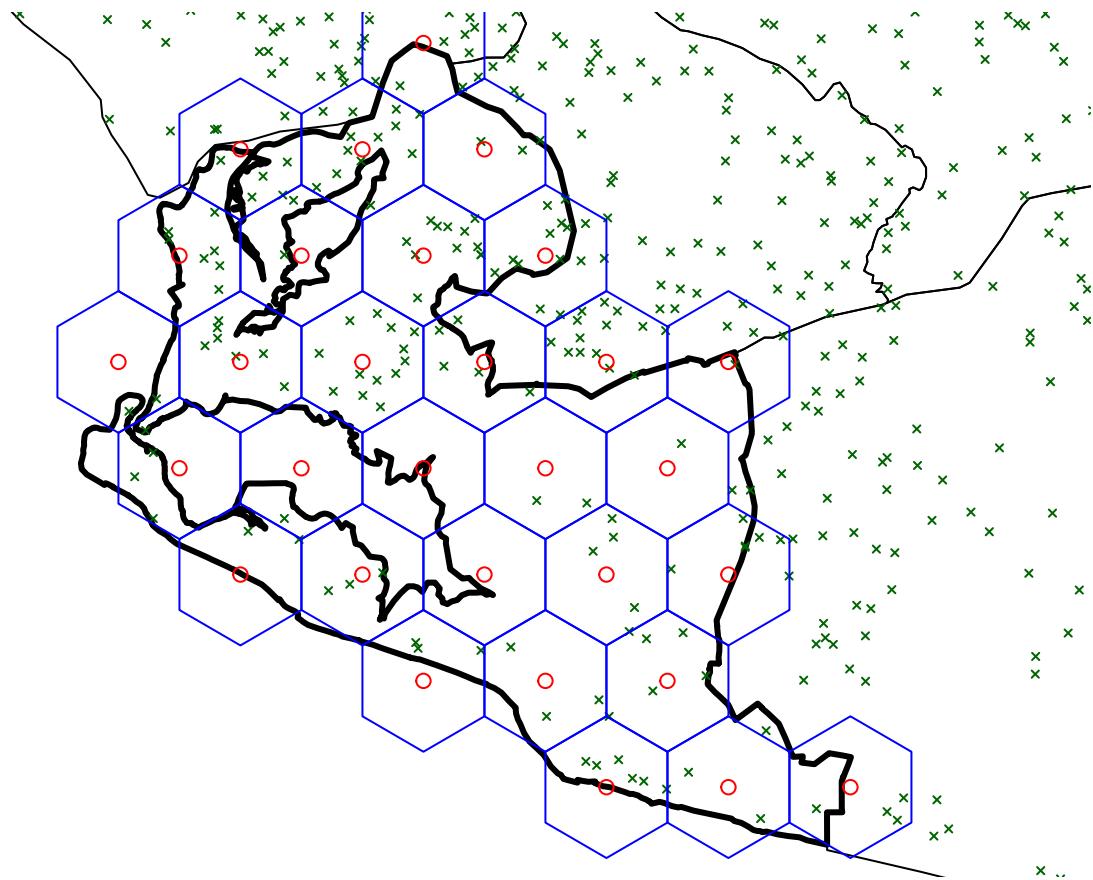


Figure 2.27: Thirty hexagonal grids laid on the map of Greater Monrovia District

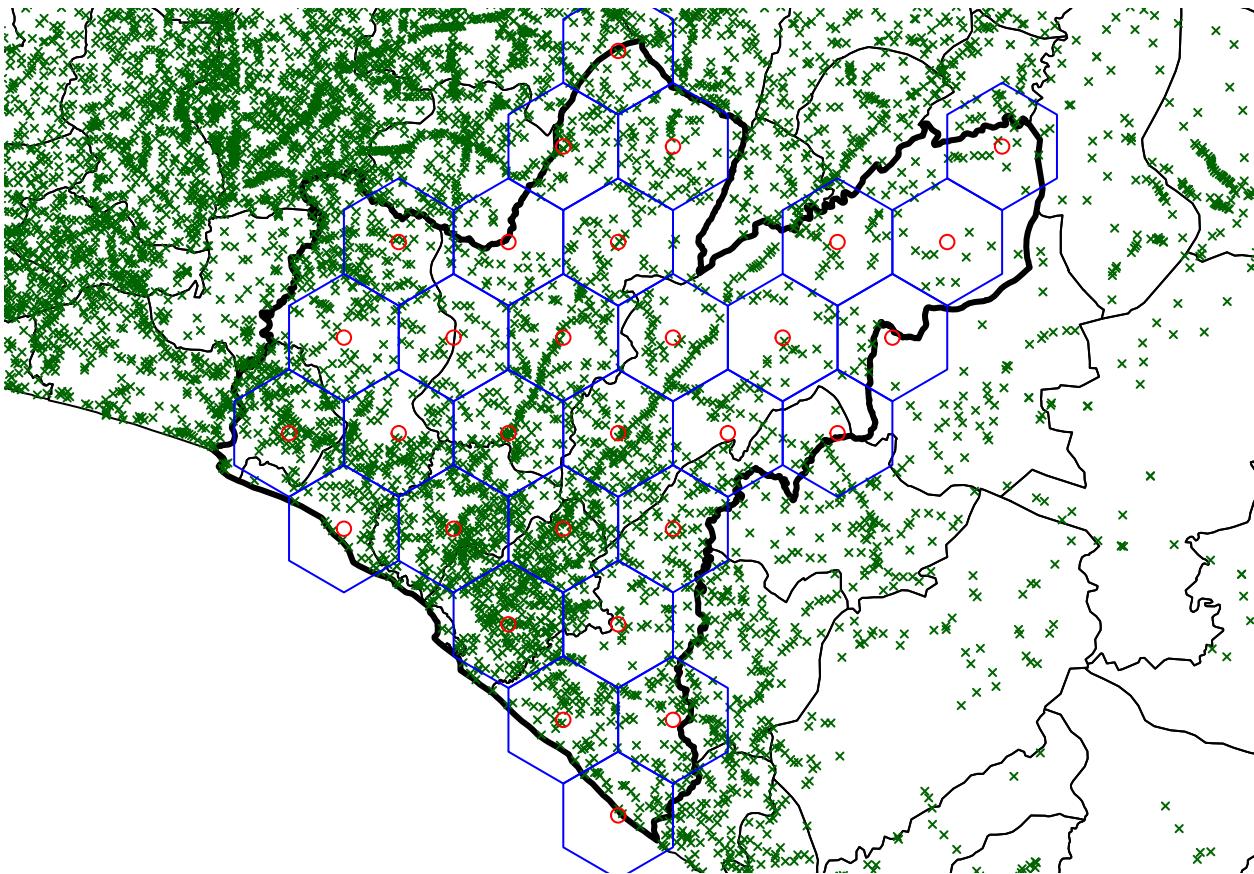


Figure 2.28: Thirty hexagonal grids laid on the map of Grand Bassa County

To determine how many villages near the 30 sampling points to select for the stage 1 sample, it would require estimating how many villages/localities/communities/enumeration areas will need to be sampled to obtain the target sample size of 96 SAM children in each county and urban areas. This can be estimated as follows:

$$n_{villages} = \frac{\text{Target sample size}}{n_{\text{average village population all ages}} \times \% \text{ under 5 children} \times \text{SAM prevalence}}$$

The average village population can be estimated using per village/locality/community/enumeration area population in Grand Bassa county and Greater Monrovia provided by the Liberia Institute of Statistics and Geo-information Services to UNICEF.

For Greater Monrovia, the average enumeration area population is 5200. For Grand Bassa (including urban areas) is 521 population per enumeration area and 100 population per locality/village/community.

The proportion of children under 5 can be estimated using data from the [US Census Bureau](#)

on estimated population for single years. Using this data, the estimated proportion of under five children is about 17%.

The SAM prevalence can be estimated as 3% (based on communication with UNICEF). This is most likely a high estimate considering that this is the estimate for the whole country and not specific to the counties. Also, seasonality of SAM prevalence will need to be taken into account. If the period in which the survey is to be conducted is a season for low prevalence of SAM, this should be considered in the estimation. So, it might be good to use a lower estimate for SAM to ensure there is enough villages sampled to get the target. An estimate of 1.5% (or even lower) is recommended.

Using these values, the number of villages needed to sample in each county (and urban areas if included) can be calculated for each county as follows:

$$n_{\text{Grand Bassa EA}} = \left\lceil \frac{\text{Target sample size}}{n_{\text{average EA population all ages}} \times \% \text{ under 5 children} \times \text{SAM prevalence}} \right\rceil$$

$$= \left\lceil \frac{96}{521 \times 0.17 \times 0.015} \right\rceil$$

$$= \left\lceil \frac{96}{1.32855} \right\rceil$$

$$\approx 73$$

$$n_{\text{Grand Bassa villages}} = \left\lceil \frac{\text{Target sample size}}{n_{\text{average village population all ages}} \times \% \text{ under 5 children} \times \text{SAM prevalence}} \right\rceil$$

$$= \left\lceil \frac{96}{100 \times 0.17 \times 0.015} \right\rceil$$

$$= \left\lceil \frac{96}{0.255} \right\rceil$$

$$\approx 377$$

$$\begin{aligned}
n_{\text{Greater Monrovia District EA}} &= \left\lceil \frac{\text{Target sample size}}{n_{\text{average EA population all ages}} \times \% \text{ under 5 children} \times \text{SAM prevalence}} \right\rceil \\
&= \left\lceil \frac{96}{5848 \times 0.17 \times 0.015} \right\rceil \\
&= \left\lceil \frac{96}{14.9124} \right\rceil \\
&\approx 7
\end{aligned}$$

A total of 73 enumeration areas (about 377 villages) will need to be sampled for Grand Bassa county. So, a total of 3 enumeration areas (or about 13 villages) for each of the 30 sampling points should be selected for the stage 1 sample for Grand Bassa. Given the huge populations of the enumeration areas in Greater Monrovia District, only a total of 7 enumeration areas will need to be sampled to make the sample size target. However, because this is a cluster survey, 7 clusters will produce a sample with very low sampling variance which will impact on the resulting precision of the indicator results. Hence, it would be recommended to maintain the number of sampling clusters to 30 enumeration areas (one enumeration area per sampling point).

Based on this, stage 1 sample for Greater Monrovia District can be selected as follows:

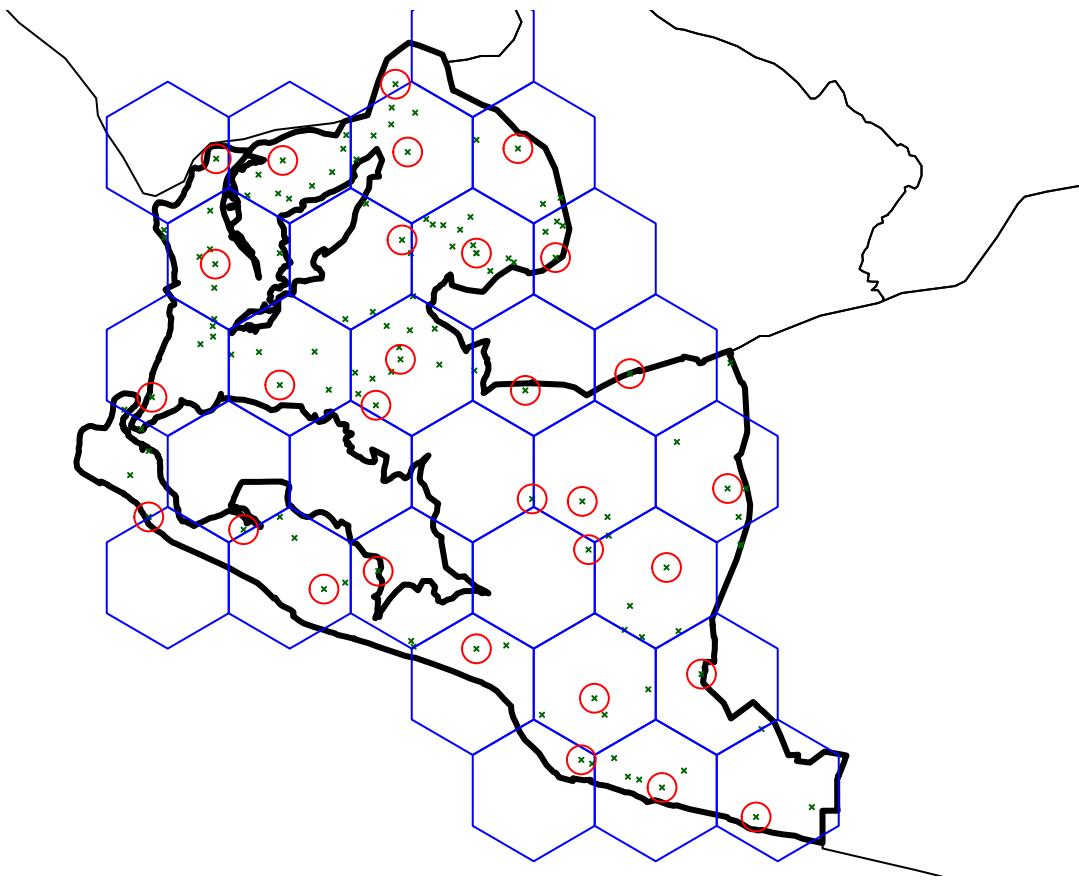


Figure 2.29: Selected sampling points in Greater Monrovia District

The list of selected enumeration areas in Greater Monrovia is below:

#>	spid	FNAME	COORD_X	COORD_Y	admin1Name
#>	3813	Elwa	-10.69000	6.23861	Montserrado
#>	3766	Foster Town	-10.66948	6.23162	Montserrado
#>	3721	Wamba Town	-10.64556	6.22417	Montserrado
#>	3947	Marcasville	-10.71667	6.26667	Montserrado
#>	3877	Sinda Town	-10.68667	6.25417	Montserrado
#>	3910	Duport	-10.65944	6.26028	Montserrado
#>	4133	Bassa Community	-10.80000	6.30000	Montserrado
#>	4039	Nipay Town	-10.75544	6.28176	Montserrado
#>	4059	Larkpase	-10.74166	6.28629	Montserrado
#>	4086	Parker Paint	-10.68816	6.29173	Montserrado
#>	4065	Kaiph Town	-10.66833	6.28722	Montserrado
#>	4115	Sinkor	-10.77588	6.29678	Montserrado

```

#> 4247    13           Supermarket -10.74223 6.32822 Montserrado
#> 4156    14           Nizohn -10.70250 6.30455 Montserrado
#> 4153    15           Morris Farm -10.68976 6.30392 Montserrado
#> 4166    16           Display -10.65281 6.30718 Montserrado
#> 4253    17           Clara Town -10.79919 6.33023 Montserrado
#> 4267    18           Topoe Village -10.76667 6.33333 Montserrado
#> 4304    19           Day Break Mouth Open -10.73599 6.33982 Montserrado
#> 4261    20 Lower Johnsonville (Hines Vill -10.70424 6.33198 Montserrado
#> 4283    21           Kpelle Town Johnsonville -10.67766 6.33621 Montserrado
#> 4448    22           Bong Mine Bridge -10.78309 6.36389 Montserrado
#> 4495    23           Zoiboi Town -10.73559 6.36999 Montserrado
#> 4471    24           Dandawailo (1) -10.71667 6.36667 Montserrado
#> 4462    25           Avenue -10.69655 6.36554 Montserrado
#> 4626    26           Twe Farm -10.78285 6.39052 Montserrado
#> 4622    27           Watchin Town -10.76592 6.39009 Montserrado
#> 4642    28           Caldwell -10.73417 6.39222 Montserrado
#> 4648    29           Kissi Kormah -10.70612 6.39309 Montserrado
#> 4753    30           Bassa Town Caldwell -10.73726 6.40936 Montserrado

#>      admin1Pcod      admin2Name admin2Pcod
#> 3813      LR11 Greater Monrovia      LR1103
#> 3766      LR11 Greater Monrovia      LR1103
#> 3721      LR11 Greater Monrovia      LR1103
#> 3947      LR11 Greater Monrovia      LR1103
#> 3877      LR11 Greater Monrovia      LR1103
#> 3910      LR11 Greater Monrovia      LR1103
#> 4133      LR11 Greater Monrovia      LR1103
#> 4039      LR11 Greater Monrovia      LR1103
#> 4059      LR11 Greater Monrovia      LR1103
#> 4086      LR11 Greater Monrovia      LR1103
#> 4065      LR11 Greater Monrovia      LR1103
#> 4115      LR11 Greater Monrovia      LR1103
#> 4247      LR11 Greater Monrovia      LR1103
#> 4156      LR11 Greater Monrovia      LR1103
#> 4153      LR11 Greater Monrovia      LR1103
#> 4166      LR11 Greater Monrovia      LR1103
#> 4253      LR11 Greater Monrovia      LR1103
#> 4267      LR11 Greater Monrovia      LR1103
#> 4304      LR11 Greater Monrovia      LR1103
#> 4261      LR11 Greater Monrovia      LR1103
#> 4283      LR11 Greater Monrovia      LR1103

```

```
#> 4448      LR11 Greater Monrovia    LR1103
#> 4495      LR11 Greater Monrovia    LR1103
#> 4471      LR11 Greater Monrovia    LR1103
#> 4462      LR11 Greater Monrovia    LR1103
#> 4626      LR11 Greater Monrovia    LR1103
#> 4622      LR11 Greater Monrovia    LR1103
#> 4642      LR11 Greater Monrovia    LR1103
#> 4648      LR11 Greater Monrovia    LR1103
#> 4753      LR11 Greater Monrovia    LR1103
```

Download

⬇ Download the list of selected enumeration areas in Greater Monrovia District [here](#).

The stage 1 sample for Grand Bassa can be selected as follows:

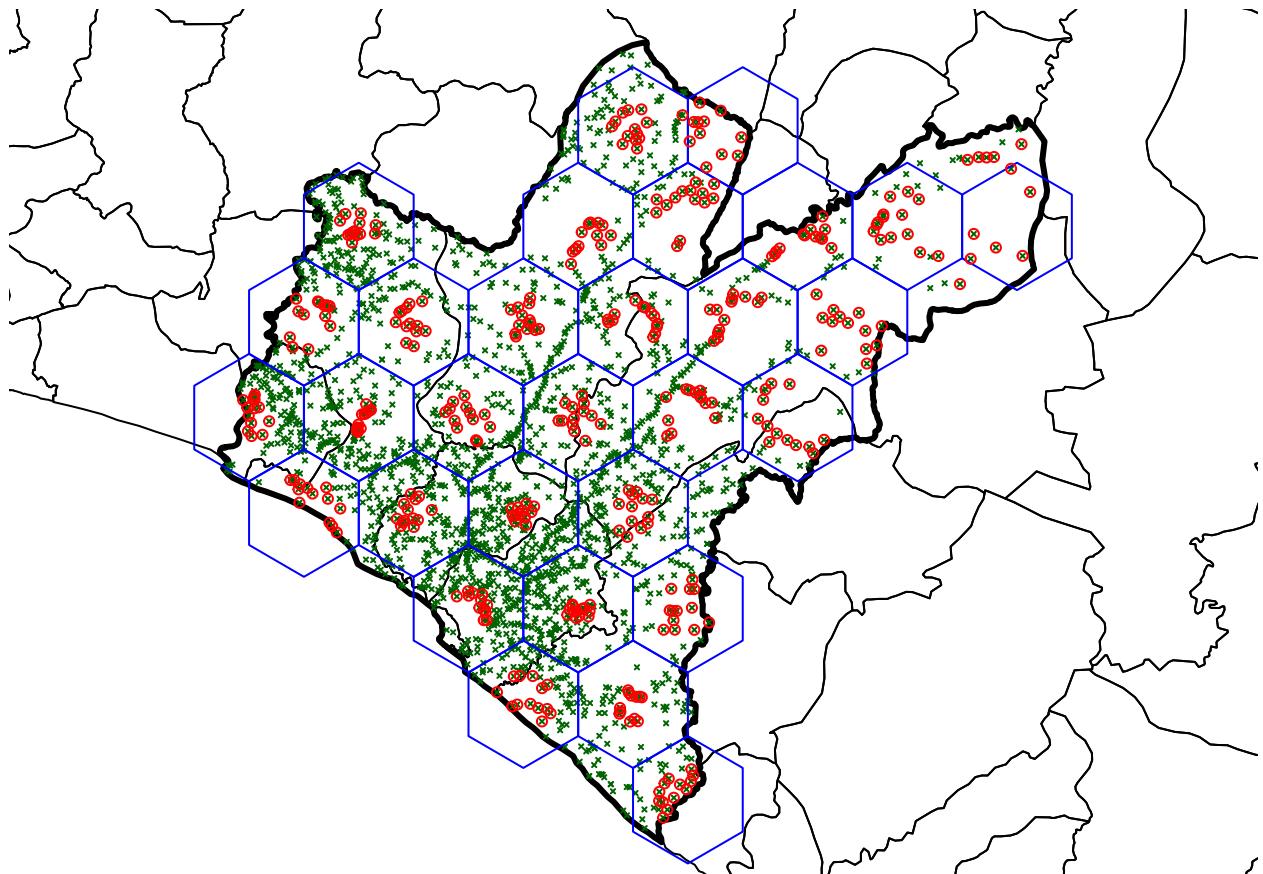


Figure 2.30: Selected sampling points in Grand Bassa County

The list of selected sampling points in Grand Bassa is below:

#>	spid	FNAME	COORD_X	COORD_Y	admin1Name	admin1Pcod
#> 1525	1	Pohkpa Village	-9.72628	5.60477	Grand Bassa	LR04
#> 1537	1	Gbueban Village	-9.72023	5.61651	Grand Bassa	LR04
#> 1560	1	Volugbo Village	-9.72694	5.62764	Grand Bassa	LR04
#> 1563	1	Chipay Village	-9.73227	5.62940	Grand Bassa	LR04
#> 1570	1	Karr Henry	-9.71053	5.63409	Grand Bassa	LR04
#> 1582	1	Dehyusaweh Village	-9.73194	5.64273	Grand Bassa	LR04
#> 1590	1	Jalaydaye	-9.69187	5.64664	Grand Bassa	LR04
#> 1598	1	Clayehyee	-9.70148	5.65351	Grand Bassa	LR04
#> 1604	1	David Villages	-9.72429	5.65512	Grand Bassa	LR04
#> 1608	1	Chadeh Village	-9.68530	5.65824	Grand Bassa	LR04
#> 1611	1	Peoland / Nemon	-9.71800	5.66208	Grand Bassa	LR04
#> 1622	1	Worwein Village	-9.68174	5.66689	Grand Bassa	LR04
#> 1633	1	Readygar Village	-9.68456	5.67593	Grand Bassa	LR04
#> 1756	2	Dugboryewh Village	-9.90565	5.74634	Grand Bassa	LR04
#> 1776	2	Goffa Village	-9.89284	5.75829	Grand Bassa	LR04
#> 1788	2	Konoe Village	-9.89783	5.76464	Grand Bassa	LR04
#> 1791	2	Naka	-9.91116	5.76609	Grand Bassa	LR04
#> 1799	2	Neeter	-9.94942	5.76839	Grand Bassa	LR04
#> 1802	2	Firestone Village	-9.94216	5.77114	Grand Bassa	LR04
#> 1806	2	Sweet Gaye	-9.92269	5.77225	Grand Bassa	LR04
#> 1848	2	Newcess	-9.97218	5.78926	Grand Bassa	LR04
#> 1857	2	Duah Village	-9.90553	5.79524	Grand Bassa	LR04
#> 1873	2	Garmondeh / Troyea Vi	-9.89779	5.80032	Grand Bassa	LR04
#> 1898	2	Gborgar Village	-9.94722	5.81269	Grand Bassa	LR04
#> 1899	2	Vaimah	-9.91928	5.81308	Grand Bassa	LR04
#> 1901	2	Zardah	-9.93857	5.81346	Grand Bassa	LR04
#> 1755	3	Whea Village	-9.77521	5.74610	Grand Bassa	LR04
#> 1757	3	Kodou Village	-9.76375	5.74661	Grand Bassa	LR04
#> 1766	3	Portroyah Village	-9.76868	5.75021	Grand Bassa	LR04
#> 1775	3	Sammie Village	-9.79094	5.75769	Grand Bassa	LR04
#> 1782	3	Zoepu Village	-9.78959	5.76082	Grand Bassa	LR04
#> 1792	3	Glaydor Village	-9.79015	5.76610	Grand Bassa	LR04
#> 1825	3	Gaye John	-9.75786	5.78181	Grand Bassa	LR04
#> 1829	3	Borbor	-9.76599	5.78251	Grand Bassa	LR04
#> 1830	3	Manneh	-9.76101	5.78272	Grand Bassa	LR04
#> 1836	3	Jubia	-9.77356	5.78435	Grand Bassa	LR04
#> 1846	3	Borbor's Village	-9.77693	5.78834	Grand Bassa	LR04

#> 1852	3	Wralakfa	-9.77814	5.79209	Grand Bassa	LR04
#> 2143	4	Prayer	-9.99176	5.89524	Grand Bassa	LR04
#> 2144	4	Kaksbahn	-9.98729	5.89536	Grand Bassa	LR04
#> 2171	4	Rubein Village	-9.98894	5.90618	Grand Bassa	LR04
#> 2184	4	Guah Village	-9.99118	5.91032	Grand Bassa	LR04
#> 2185	4	Guah	-9.99148	5.91039	Grand Bassa	LR04
#> 2194	4	Joe Farmer	-9.99826	5.91355	Grand Bassa	LR04
#> 2212	4	Whob Village	-9.98690	5.91737	Grand Bassa	LR04
#> 2239	4	Logan	-9.99574	5.92498	Grand Bassa	LR04
#> 2255	4	Kupue Village	-10.03163	5.93013	Grand Bassa	LR04
#> 2260	4	Floh	-10.01391	5.93129	Grand Bassa	LR04
#> 2267	4	Domah	-9.99385	5.93314	Grand Bassa	LR04
#> 2275	4	Jeremiah Harris	-10.00789	5.93501	Grand Bassa	LR04
#> 2288	4	Zoe	-10.01492	5.93780	Grand Bassa	LR04
#> 2152	5	Kpehyou	-9.85483	5.89830	Grand Bassa	LR04
#> 2161	5	Joynor Village	-9.83670	5.90075	Grand Bassa	LR04
#> 2163	5	Kpehpue	-9.85020	5.90178	Grand Bassa	LR04
#> 2166	5	Kporkon	-9.86820	5.90326	Grand Bassa	LR04
#> 2174	5	Kpelle Village	-9.83527	5.90840	Grand Bassa	LR04
#> 2175	5	Wheigo	-9.85375	5.90842	Grand Bassa	LR04
#> 2176	5	James Zonoe	-9.85867	5.90861	Grand Bassa	LR04
#> 2188	5	Maye Village	-9.86459	5.91136	Grand Bassa	LR04
#> 2190	5	Peter's Glay	-9.84655	5.91175	Grand Bassa	LR04
#> 2192	5	Kair's Village	-9.84354	5.91289	Grand Bassa	LR04
#> 2207	5	Memangar Village	-9.86007	5.91555	Grand Bassa	LR04
#> 2214	5	Zeogar	-9.83477	5.91787	Grand Bassa	LR04
#> 2215	5	Gboyah / Yeakai Villa	-9.86063	5.91817	Grand Bassa	LR04
#> 2087	6	Geezaye	-9.68018	5.88105	Grand Bassa	LR04
#> 2090	6	Qwrakpo	-9.72567	5.88122	Grand Bassa	LR04
#> 2091	6	Tarloe	-9.70901	5.88124	Grand Bassa	LR04
#> 2130	6	Deabozohn	-9.65834	5.89179	Grand Bassa	LR04
#> 2141	6	Gorzohn	-9.71094	5.89511	Grand Bassa	LR04
#> 2177	6	Compound	-9.71197	5.90886	Grand Bassa	LR04
#> 2178	6	Ben's	-9.70611	5.90887	Grand Bassa	LR04
#> 2179	6	Korzohn	-9.71659	5.90965	Grand Bassa	LR04
#> 2193	6	Margar Village	-9.68373	5.91353	Grand Bassa	LR04
#> 2300	6	Gbor Joe	-9.68678	5.94103	Grand Bassa	LR04
#> 2301	6	Wahn	-9.68036	5.94104	Grand Bassa	LR04
#> 2304	6	Burtroyah	-9.71424	5.94144	Grand Bassa	LR04
#> 2356	6	Tiah Village	-9.68309	5.95489	Grand Bassa	LR04

#> 2680	7	Malikor's	-10.20923	6.02428	Grand Bassa	LR04
#> 2726	7	Little Bassa	-10.21604	6.03350	Grand Bassa	LR04
#> 2752	7	Samuel Browne	-10.21985	6.03846	Grand Bassa	LR04
#> 2847	7	Barwain	-10.20392	6.05942	Grand Bassa	LR04
#> 2879	7	Duo Village	-10.26446	6.06801	Grand Bassa	LR04
#> 2902	7	Gor	-10.22238	6.07385	Grand Bassa	LR04
#> 2940	7	Beanan Village	-10.24509	6.08150	Grand Bassa	LR04
#> 2965	7	Gbargaye	-10.26581	6.08771	Grand Bassa	LR04
#> 2980	7	Jahway Village	-10.25267	6.08974	Grand Bassa	LR04
#> 2987	7	Kro	-10.22479	6.09043	Grand Bassa	LR04
#> 3013	7	Zuah Village	-10.26367	6.09509	Grand Bassa	LR04
#> 3036	7	Behzon Village	-10.27208	6.10135	Grand Bassa	LR04
#> 3037	7	Wesseh Village	-10.27778	6.10142	Grand Bassa	LR04
#> 2721	8	Bueh	-10.09518	6.03236	Grand Bassa	LR04
#> 2730	8	Kpah	-10.11435	6.03396	Grand Bassa	LR04
#> 2754	8	Gbarzee	-10.11144	6.03879	Grand Bassa	LR04
#> 2770	8	Gbarzee Mission	-10.10907	6.04138	Grand Bassa	LR04
#> 2774	8	Kollie	-10.08921	6.04267	Grand Bassa	LR04
#> 2780	8	Janjay	-10.11990	6.04437	Grand Bassa	LR04
#> 2784	8	Gbaquep	-10.09601	6.04492	Grand Bassa	LR04
#> 2838	8	Quegar	-10.06866	6.05732	Grand Bassa	LR04
#> 2841	8	Baa	-10.10409	6.05800	Grand Bassa	LR04
#> 2870	8	Tarpue	-10.10963	6.06595	Grand Bassa	LR04
#> 2897	8	Yeasay	-10.09258	6.07313	Grand Bassa	LR04
#> 2920	8	Karmour	-10.08749	6.07720	Grand Bassa	LR04
#> 2935	8	Lay's Village	-10.09961	6.08080	Grand Bassa	LR04
#> 2738	9	Gardea # 2	-9.92894	6.03541	Grand Bassa	LR04
#> 2766	9	Godgbarn	-9.94516	6.04063	Grand Bassa	LR04
#> 2793	9	Karyour	-9.93087	6.04667	Grand Bassa	LR04
#> 2794	9	Boegbah	-9.93088	6.04671	Grand Bassa	LR04
#> 2803	9	Laffiah	-9.94900	6.04889	Grand Bassa	LR04
#> 2805	9	Amos Cleon	-9.94422	6.04924	Grand Bassa	LR04
#> 2814	9	Pastor	-9.93877	6.05115	Grand Bassa	LR04
#> 2824	9	Boe	-9.92126	6.05434	Grand Bassa	LR04
#> 2831	9	Togar	-9.93373	6.05585	Grand Bassa	LR04
#> 2845	9	Gbewillie	-9.95048	6.05925	Grand Bassa	LR04
#> 2853	9	Juah	-9.94100	6.06108	Grand Bassa	LR04
#> 2857	9	Noway	-9.91721	6.06246	Grand Bassa	LR04
#> 2872	9	Leecoil	-9.92860	6.06647	Grand Bassa	LR04
#> 2647	10	Six New Camp	-9.77934	6.01778	Grand Bassa	LR04

#> 2692	10	Estate 2 Bongolo	-9.79118	6.02717	Grand Bassa	LR04
#> 2712	10	Cattle Bahn Camp	-9.75896	6.03039	Grand Bassa	LR04
#> 2745	10	Division 4.1 Office	-9.74918	6.03762	Grand Bassa	LR04
#> 2767	10	Six Old Camp	-9.77280	6.04080	Grand Bassa	LR04
#> 2795	10	Bear -Bear Camp	-9.74817	6.04695	Grand Bassa	LR04
#> 2859	10	Djueh Camp	-9.77246	6.06260	Grand Bassa	LR04
#> 2871	10	Kpain Camp	-9.79174	6.06612	Grand Bassa	LR04
#> 2895	10	Division 1.1 Office	-9.74269	6.07268	Grand Bassa	LR04
#> 2904	10	Zeanweah Camp	-9.75661	6.07408	Grand Bassa	LR04
#> 2931	10	Division 2.3 Office	-9.77205	6.07996	Grand Bassa	LR04
#> 2949	10	David Gboh Camp	-9.76509	6.08376	Grand Bassa	LR04
#> 2958	10	3 Old Camp	-9.77718	6.08635	Grand Bassa	LR04
#> 3392	11	Barzon Village	-10.33534	6.16606	Grand Bassa	LR04
#> 3402	11	Palace Village	-10.31911	6.16790	Grand Bassa	LR04
#> 3438	11	Nycgweh	-10.34057	6.17319	Grand Bassa	LR04
#> 3488	11	Kugbeh Village	-10.33596	6.18527	Grand Bassa	LR04
#> 3501	11	Koezohn Village	-10.30929	6.18783	Grand Bassa	LR04
#> 3550	11	Cole's Village	-10.33951	6.19608	Grand Bassa	LR04
#> 3617	11	Garmah Village	-10.33068	6.20704	Grand Bassa	LR04
#> 3621	11	Dougbah	-10.34151	6.20776	Grand Bassa	LR04
#> 3627	11	Bar Village	-10.32437	6.20837	Grand Bassa	LR04
#> 3691	11	Bean's	-10.34756	6.21886	Grand Bassa	LR04
#> 3694	11	Troyahbarh village	-10.33073	6.21971	Grand Bassa	LR04
#> 3714	11	Sailama Village	-10.33153	6.22372	Grand Bassa	LR04
#> 3744	11	Borbor Village	-10.33046	6.22680	Grand Bassa	LR04
#> 3433	12	Wrue-Wah Village	-10.17805	6.17233	Grand Bassa	LR04
#> 3440	12	Peter Hata Village	-10.17955	6.17404	Grand Bassa	LR04
#> 3444	12	Zyne-Where Village	-10.17855	6.17446	Grand Bassa	LR04
#> 3451	12	Ruben Smith	-10.17931	6.17647	Grand Bassa	LR04
#> 3453	12	Johnny Garyah	-10.17377	6.17735	Grand Bassa	LR04
#> 3460	12	Beh	-10.17857	6.17853	Grand Bassa	LR04
#> 3475	12	Hard Time Village	-10.17721	6.18284	Grand Bassa	LR04
#> 3567	12	Goesuah	-10.17197	6.19803	Grand Bassa	LR04
#> 3571	12	John Clarke Village	-10.16806	6.19844	Grand Bassa	LR04
#> 3579	12	Tweah Zammes	-10.16514	6.20005	Grand Bassa	LR04
#> 3592	12	Woekpeh Juah	-10.16144	6.20317	Grand Bassa	LR04
#> 3602	12	Thomas Vonzih	-10.15873	6.20451	Grand Bassa	LR04
#> 3665	12	Sayli Village	-10.16567	6.21299	Grand Bassa	LR04
#> 3336	13	Worldwid Mission	-10.00147	6.15823	Grand Bassa	LR04
#> 3350	13	Trysee Village	-10.00325	6.15999	Grand Bassa	LR04

#> 3457	13	Kolako Village	-10.03119	6.17832	Grand Bassa	LR04
#> 3462	13	Glebah / Worfour Vill	-9.98246	6.17952	Grand Bassa	LR04
#> 3508	13	Karyou Village	-10.03489	6.18874	Grand Bassa	LR04
#> 3517	13	Charley Gio / Kpakpel	-10.00772	6.19080	Grand Bassa	LR04
#> 3565	13	Krankie Village	-9.99039	6.19781	Grand Bassa	LR04
#> 3577	13	Weamorgar	-10.01200	6.19991	Grand Bassa	LR04
#> 3584	13	Jacob Village	-10.04834	6.20139	Grand Bassa	LR04
#> 3612	13	Dee Village	-10.04202	6.20634	Grand Bassa	LR04
#> 3629	13	Gurtor Village	-10.01742	6.20865	Grand Bassa	LR04
#> 3680	13	Payone Village	-10.03697	6.21661	Grand Bassa	LR04
#> 3732	13	Matada Village	-10.02023	6.22564	Grand Bassa	LR04
#> 3346	14	Bethlehem Village	-9.84148	6.15909	Grand Bassa	LR04
#> 3439	14	Kpalimue	-9.85787	6.17341	Grand Bassa	LR04
#> 3474	14	Tokpah Village	-9.86017	6.18265	Grand Bassa	LR04
#> 3483	14	Bozohn	-9.81866	6.18381	Grand Bassa	LR04
#> 3507	14	Lolayah Village	-9.88110	6.18869	Grand Bassa	LR04
#> 3509	14	Bigboy Village	-9.87564	6.18878	Grand Bassa	LR04
#> 3524	14	Gorworh Village	-9.85845	6.19172	Grand Bassa	LR04
#> 3553	14	Wrehyou	-9.83208	6.19616	Grand Bassa	LR04
#> 3589	14	Zuagar	-9.84368	6.20243	Grand Bassa	LR04
#> 3632	14	Samuel Village	-9.86067	6.20885	Grand Bassa	LR04
#> 3668	14	Painyoucom Village	-9.84361	6.21420	Grand Bassa	LR04
#> 3669	14	Sulonteh Village	-9.87098	6.21452	Grand Bassa	LR04
#> 3731	14	Noryougbah Village	-9.84670	6.22540	Grand Bassa	LR04
#> 3396	15	Weebo / Zedrew	-9.72008	6.16632	Grand Bassa	LR04
#> 3420	15	George Briggs / Tuku	-9.71402	6.16998	Grand Bassa	LR04
#> 3512	15	Wredyu	-9.71876	6.18913	Grand Bassa	LR04
#> 3533	15	Kargar / Yard	-9.64907	6.19257	Grand Bassa	LR04
#> 3670	15	Gud	-9.66366	6.21464	Grand Bassa	LR04
#> 3672	15	Manideh / Dowher	-9.65440	6.21528	Grand Bassa	LR04
#> 3708	15	Zlowein	-9.67045	6.22261	Grand Bassa	LR04
#> 3713	15	Dahn / Flanke	-9.72194	6.22350	Grand Bassa	LR04
#> 3723	15	Zorwein	-9.67137	6.22441	Grand Bassa	LR04
#> 3758	15	Borbor's	-9.67788	6.22985	Grand Bassa	LR04
#> 3774	15	Garmana Village	-9.67148	6.23278	Grand Bassa	LR04
#> 3780	15	Kofa Gborgar	-9.68753	6.23347	Grand Bassa	LR04
#> 3792	15	Kona	-9.69182	6.23501	Grand Bassa	LR04
#> 3235	16	Baye	-9.50432	6.14081	Grand Bassa	LR04
#> 3287	16	Benzohn	-9.51006	6.15019	Grand Bassa	LR04
#> 3304	16	Gueh	-9.52977	6.15280	Grand Bassa	LR04

#> 3329	16	Mannah Whea Village	-9.56908	6.15733	Grand Bassa	LR04
#> 3353	16	Refaco Camp	-9.54247	6.16029	Grand Bassa	LR04
#> 3355	16	Kahyah	-9.48831	6.16060	Grand Bassa	LR04
#> 3419	16	Bold Dollar	-9.55812	6.16995	Grand Bassa	LR04
#> 3470	16	Farr	-9.57202	6.18068	Grand Bassa	LR04
#> 3523	16	Morris Gbehgbeh	-9.58608	6.19161	Grand Bassa	LR04
#> 3693	16	Willie	-9.57828	6.21942	Grand Bassa	LR04
#> 3791	16	Boue Village	-9.57472	6.23488	Grand Bassa	LR04
#> 3827	16	Juah's	-9.53927	6.24239	Grand Bassa	LR04
#> 3831	16	Wodorgbah / Nimely Vi	-9.56627	6.24339	Grand Bassa	LR04
#> 4098	17	Buegbo	-10.25129	6.29394	Grand Bassa	LR04
#> 4116	17	Kiray Town/Buegba Vil	-10.27449	6.29680	Grand Bassa	LR04
#> 4176	17	Gio Village	-10.27862	6.31131	Grand Bassa	LR04
#> 4244	17	Nyuda	-10.21874	6.32795	Grand Bassa	LR04
#> 4321	17	Yanmoh	-10.22632	6.34267	Grand Bassa	LR04
#> 4333	17	Kpaliyelah	-10.25792	6.34487	Grand Bassa	LR04
#> 4357	17	Zinc Kitchen	-10.26585	6.34956	Grand Bassa	LR04
#> 4409	17	Kpannah/David	-10.21987	6.35725	Grand Bassa	LR04
#> 4418	17	Varney	-10.22772	6.35830	Grand Bassa	LR04
#> 4420	17	Robert Cebal	-10.22370	6.35841	Grand Bassa	LR04
#> 4442	17	David	-10.23535	6.36287	Grand Bassa	LR04
#> 4452	17	Bono/Daklhore Village	-10.23713	6.36411	Grand Bassa	LR04
#> 4481	17	Douweh/Wheeto Town	-10.26923	6.36805	Grand Bassa	LR04
#> 4121	18	Fred	-10.09515	6.29821	Grand Bassa	LR04
#> 4149	18	Whemyou	-10.10639	6.30312	Grand Bassa	LR04
#> 4215	18	Gber	-10.09143	6.32006	Grand Bassa	LR04
#> 4217	18	New Gbanga	-10.07776	6.32055	Grand Bassa	LR04
#> 4240	18	Isaac	-10.10600	6.32750	Grand Bassa	LR04
#> 4246	18	Old Gbanga	-10.08982	6.32814	Grand Bassa	LR04
#> 4259	18	Fuafua-Weon	-10.10114	6.33161	Grand Bassa	LR04
#> 4269	18	Gerneo	-10.12192	6.33353	Grand Bassa	LR04
#> 4351	18	Bai	-10.11640	6.34792	Grand Bassa	LR04
#> 4362	18	Bai mission	-10.11313	6.35010	Grand Bassa	LR04
#> 4396	18	Nado	-10.10587	6.35486	Grand Bassa	LR04
#> 4427	18	Worhn	-10.10168	6.36061	Grand Bassa	LR04
#> 4453	18	Duayou	-10.08280	6.36428	Grand Bassa	LR04
#> 4181	19	Goegar Village	-9.94417	6.31249	Grand Bassa	LR04
#> 4197	19	Ballah Village	-9.94497	6.31667	Grand Bassa	LR04
#> 4221	19	Gargar's Village	-9.91556	6.32207	Grand Bassa	LR04
#> 4228	19	Dolo	-9.92753	6.32355	Grand Bassa	LR04

#> 4229	19	Zeon	-9.91002	6.32358	Grand Bassa	LR04
#> 4251	19	Nyakpah Village	-9.93952	6.32911	Grand Bassa	LR04
#> 4260	19	Budu	-9.92256	6.33168	Grand Bassa	LR04
#> 4287	19	Gaye Flomo	-9.92382	6.33652	Grand Bassa	LR04
#> 4326	19	Gbiahgaye	-9.93500	6.34370	Grand Bassa	LR04
#> 4376	19	Glabo Village #1	-9.95157	6.35191	Grand Bassa	LR04
#> 4400	19	Waygron Village	-9.94089	6.35534	Grand Bassa	LR04
#> 4432	19	Kpu-Jimmy	-9.92438	6.36126	Grand Bassa	LR04
#> 4489	19	Zahn	-9.92307	6.36905	Grand Bassa	LR04
#> 4178	20	Karr's / Gbah Tumah	-9.74091	6.31177	Grand Bassa	LR04
#> 4199	20	Yarkpah	-9.73815	6.31679	Grand Bassa	LR04
#> 4236	20	Logan Village # 1	-9.73553	6.32680	Grand Bassa	LR04
#> 4254	20	Logan	-9.73473	6.33099	Grand Bassa	LR04
#> 4268	20	Gonoe / Garvah	-9.80713	6.33337	Grand Bassa	LR04
#> 4284	20	Kaykay / Kpawoe / Bua	-9.80105	6.33637	Grand Bassa	LR04
#> 4293	20	Juah's	-9.80806	6.33726	Grand Bassa	LR04
#> 4320	20	Joemlue	-9.73951	6.34237	Grand Bassa	LR04
#> 4335	20	Two Cent	-9.79818	6.34507	Grand Bassa	LR04
#> 4342	20	Teewaygar Village	-9.74363	6.34664	Grand Bassa	LR04
#> 4398	20	Gbenyan Town # 1	-9.75305	6.35509	Grand Bassa	LR04
#> 4407	20	Gbenyan Town # 2	-9.75615	6.35637	Grand Bassa	LR04
#> 4461	20	Bahn / Peter G.Sahn	-9.76738	6.36549	Grand Bassa	LR04
#> 4163	21	John Kianue / Wee Zeo	-9.65114	6.30607	Grand Bassa	LR04
#> 4174	21	Jah Fair	-9.64500	6.31070	Grand Bassa	LR04
#> 4201	21	Kiamue Giah	-9.64519	6.31767	Grand Bassa	LR04
#> 4223	21	Goweh / John Nover	-9.64333	6.32229	Grand Bassa	LR04
#> 4290	21	Barseegiah	-9.63572	6.33694	Grand Bassa	LR04
#> 4375	21	Sawkpah	-9.64701	6.35185	Grand Bassa	LR04
#> 4377	21	Winshue	-9.65695	6.35216	Grand Bassa	LR04
#> 4443	21	James Pue	-9.58627	6.36309	Grand Bassa	LR04
#> 4444	21	Jallah	-9.62522	6.36371	Grand Bassa	LR04
#> 4480	21	Kassian Village	-9.62428	6.36790	Grand Bassa	LR04
#> 4493	21	Momo	-9.58068	6.36983	Grand Bassa	LR04
#> 4499	21	Garkpee	-9.60483	6.37101	Grand Bassa	LR04
#> 4524	21	Manawon	-9.62273	6.37447	Grand Bassa	LR04
#> 3992	22	Jackson	-9.42494	6.27273	Grand Bassa	LR04
#> 4085	22	Larway / James Zoko	-9.49237	6.29170	Grand Bassa	LR04
#> 4099	22	Dahn- Jimmy	-9.42615	6.29407	Grand Bassa	LR04
#> 4129	22	Suah / Dolo	-9.41038	6.29946	Grand Bassa	LR04
#> 4218	22	Geedyu	-9.42705	6.32084	Grand Bassa	LR04

#> 4241	22	Kpohn	-9.40288	6.32781	Grand Bassa	LR04
#> 4264	22	Boe-Wee	-9.45290	6.33242	Grand Bassa	LR04
#> 4273	22	Zeh Village	-9.47584	6.33451	Grand Bassa	LR04
#> 4305	22	Zohn	-9.49052	6.34016	Grand Bassa	LR04
#> 4312	22	Charlie's / Morflemh	-9.46496	6.34163	Grand Bassa	LR04
#> 4347	22	Wheazohn / Doun	-9.43678	6.34739	Grand Bassa	LR04
#> 4372	22	Karpee	-9.47426	6.35158	Grand Bassa	LR04
#> 4525	22	Gbodoe/ Goeh Village	-9.49931	6.37448	Grand Bassa	LR04
#> 5115	23	Raccoon Village	-10.18663	6.45065	Grand Bassa	LR04
#> 5220	23	Matie / Sumo Village	-10.17936	6.46161	Grand Bassa	LR04
#> 5224	23	Yeah	-10.19224	6.46186	Grand Bassa	LR04
#> 5238	23	Gearge Ploms Village	-10.18897	6.46327	Grand Bassa	LR04
#> 5239	23	Heneny Smith Village	-10.17472	6.46334	Grand Bassa	LR04
#> 5246	23	Blo-Wheon	-10.15271	6.46396	Grand Bassa	LR04
#> 5260	23	Dolemue	-10.18592	6.46558	Grand Bassa	LR04
#> 5280	23	Bindaghoh/Mobay Villa	-10.18303	6.46735	Grand Bassa	LR04
#> 5341	23	Paye Village	-10.15170	6.47636	Grand Bassa	LR04
#> 5372	23	Paye Town/Framk Moeba	-10.17552	6.47971	Grand Bassa	LR04
#> 5406	23	Bondo/Dukuly Village	-10.20425	6.48286	Grand Bassa	LR04
#> 5505	23	Femah	-10.19637	6.49271	Grand Bassa	LR04
#> 5518	23	Kolleh Jimmy/Congo	-10.17362	6.49374	Grand Bassa	LR04
#> 4840	24	Nahndoe	-9.86265	6.41910	Grand Bassa	LR04
#> 4996	24	Gbeahgaveazohn	-9.86000	6.43739	Grand Bassa	LR04
#> 5023	24	Mudeh	-9.85623	6.44044	Grand Bassa	LR04
#> 5034	24	Yahwea / Galawolo	-9.85520	6.44133	Grand Bassa	LR04
#> 5073	24	David Crawford	-9.85154	6.44532	Grand Bassa	LR04
#> 5087	24	Vlekpah	-9.81794	6.44684	Grand Bassa	LR04
#> 5214	24	Garva	-9.82405	6.46120	Grand Bassa	LR04
#> 5215	24	Bonnie Part	-9.80364	6.46132	Grand Bassa	LR04
#> 5263	24	Gbogar / Daryou / Moo	-9.84679	6.46596	Grand Bassa	LR04
#> 5337	24	Whenzohn	-9.81606	6.47618	Grand Bassa	LR04
#> 5362	24	Doeneah Garway	-9.83624	6.47811	Grand Bassa	LR04
#> 5373	24	Kpoe Village	-9.82235	6.47974	Grand Bassa	LR04
#> 5378	24	Mamadee / Gbar Villag	-9.83387	6.48014	Grand Bassa	LR04
#> 5077	25	Kemoweh's Village	-9.70556	6.44547	Grand Bassa	LR04
#> 5137	25	Gbango Village	-9.70123	6.45323	Grand Bassa	LR04
#> 5530	25	Vionless's Village	-9.73628	6.49478	Grand Bassa	LR04
#> 5616	25	Geezon	-9.72102	6.50590	Grand Bassa	LR04
#> 5656	25	Gweh	-9.66498	6.50953	Grand Bassa	LR04
#> 5708	25	Kyne's	-9.73589	6.51411	Grand Bassa	LR04

#> 5709	25	Daydeah	-9.67926	6.51417	Grand Bassa	LR04
#> 5734	25	Kwatoe	-9.65206	6.51569	Grand Bassa	LR04
#> 5746	25	Jacob's / Gaye Moore	-9.70830	6.51693	Grand Bassa	LR04
#> 5807	25	Gozohn	-9.66771	6.52317	Grand Bassa	LR04
#> 5829	25	Gaye	-9.69784	6.52617	Grand Bassa	LR04
#> 5849	25	Buebee	-9.68583	6.52750	Grand Bassa	LR04
#> 5971	25	Gone	-9.67813	6.53909	Grand Bassa	LR04
#> 4936	26	Jeremiah	-9.56512	6.43054	Grand Bassa	LR04
#> 4969	26	Fiamah Village	-9.56079	6.43382	Grand Bassa	LR04
#> 4995	26	Philips Vah	-9.55907	6.43736	Grand Bassa	LR04
#> 5039	26	Whoeyoko	-9.55392	6.44207	Grand Bassa	LR04
#> 5044	26	Nagbo	-9.47723	6.44269	Grand Bassa	LR04
#> 5171	26	Sakpayah	-9.49124	6.45613	Grand Bassa	LR04
#> 5185	26	Watchee	-9.49356	6.45811	Grand Bassa	LR04
#> 5201	26	Kpelle-Toe	-9.50077	6.45951	Grand Bassa	LR04
#> 5213	26	Gonn	-9.51696	6.46117	Grand Bassa	LR04
#> 5232	26	Gardea	-9.51862	6.46274	Grand Bassa	LR04
#> 5292	26	Tarr Town / Gbardyu	-9.50809	6.46962	Grand Bassa	LR04
#> 5300	26	Paw-Paw	-9.48670	6.47012	Grand Bassa	LR04
#> 5466	26	Kpokon	-9.49038	6.48909	Grand Bassa	LR04
#> 4989	27	Sammy Piso	-9.34639	6.43638	Grand Bassa	LR04
#> 5154	27	New Zardyu	-9.40421	6.45469	Grand Bassa	LR04
#> 5188	27	Gbogar	-9.38923	6.45825	Grand Bassa	LR04
#> 5235	27	Kaka-Gbain / Vaingbon	-9.36446	6.46302	Grand Bassa	LR04
#> 5279	27	Taylue	-9.41484	6.46724	Grand Bassa	LR04
#> 5350	27	Gormah	-9.41022	6.47709	Grand Bassa	LR04
#> 5382	27	Wee	-9.40851	6.48038	Grand Bassa	LR04
#> 5458	27	Duo	-9.40067	6.48852	Grand Bassa	LR04
#> 5494	27	Ceein	-9.37274	6.49147	Grand Bassa	LR04
#> 5497	27	Garmondah Village	-9.40044	6.49194	Grand Bassa	LR04
#> 5712	27	Ceezohn	-9.34804	6.51437	Grand Bassa	LR04
#> 5762	27	Desoe	-9.39043	6.51822	Grand Bassa	LR04
#> 5825	27	Saylor	-9.36392	6.52548	Grand Bassa	LR04
#> 4617	28	Wroyonwon Diasaw	-9.28712	6.38963	Grand Bassa	LR04
#> 4904	28	Moore Goffa Village /	-9.27136	6.42680	Grand Bassa	LR04
#> 4943	28	George Solo	-9.31907	6.43089	Grand Bassa	LR04
#> 4945	28	Deabaseh / Tompoe	-9.19451	6.43112	Grand Bassa	LR04
#> 5054	28	Gbor-Larsaw / Jackson	-9.23406	6.44333	Grand Bassa	LR04
#> 5241	28	Kondour	-9.26673	6.46337	Grand Bassa	LR04
#> 5822	28	Yarpoe / Robert / Zeo	-9.18332	6.52509	Grand Bassa	LR04

```

#> 6208 28           Sue -9.21158 6.55922 Grand Bassa LR04
#> 6352 28           Zeongar -9.27589 6.57229 Grand Bassa LR04
#> 6391 28           Karr's -9.24777 6.57581 Grand Bassa LR04
#> 6399 28           Boe Wesseh -9.25951 6.57631 Grand Bassa LR04
#> 6403 28           Wehgar -9.23679 6.57655 Grand Bassa LR04
#> 6635 28           Kangba -9.19614 6.59540 Grand Bassa LR04
#> 6566 29           Gblelawra -9.76488 6.58894 Grand Bassa LR04
#> 6636 29           Tar -9.78628 6.59544 Grand Bassa LR04
#> 6711 29           Memyo -9.76697 6.60181 Grand Bassa LR04
#> 6741 29           Mepol -9.76174 6.60424 Grand Bassa LR04
#> 6785 29           Gayezun / Gaylor's -9.77874 6.60748 Grand Bassa LR04
#> 6818 29           Gargbo Village -9.76481 6.61064 Grand Bassa LR04
#> 6895 29           Kayar's -9.76813 6.61748 Grand Bassa LR04
#> 6944 29           Willie -9.80179 6.62171 Grand Bassa LR04
#> 6999 29           Garneo Town -9.75054 6.62724 Grand Bassa LR04
#> 7015 29           Sawzohn -9.79687 6.62881 Grand Bassa LR04
#> 7162 29           Juejay -9.78579 6.64178 Grand Bassa LR04
#> 7208 29           Peablah/Peayanblah -9.77796 6.64536 Grand Bassa LR04
#> 7219 29           Yeanay's -9.75851 6.64664 Grand Bassa LR04
#> 5943 30           Kaikayoh -9.65093 6.53674 Grand Bassa LR04
#> 6225 30           Borbawein -9.66237 6.56140 Grand Bassa LR04
#> 6425 30           Taye -9.61582 6.57858 Grand Bassa LR04
#> 6451 30           Wehngbo -9.63959 6.58047 Grand Bassa LR04
#> 6681 30           Dennis -9.68700 6.59934 Grand Bassa LR04
#> 6752 30           Yokpo -9.61056 6.60559 Grand Bassa LR04
#> 6825 30           Whankai's -9.67189 6.61159 Grand Bassa LR04
#> 7007 30           James Naloo Village -9.67494 6.62781 Grand Bassa LR04
#> 7010 30           Whinee Village -9.68086 6.62811 Grand Bassa LR04
#> 7017 30           Weasay -9.66576 6.62887 Grand Bassa LR04
#> 7117 30           Daniel / Marborle -9.69757 6.63799 Grand Bassa LR04
#> 7201 30           Jumoe Town / Gomu Vil -9.64104 6.64462 Grand Bassa LR04
#> 7349 30           Malomkai's -9.67230 6.65638 Grand Bassa LR04

#>           admin2Name admin2Pcod
#> 1525      District # 4     LR0405
#> 1537      District # 4     LR0405
#> 1560      District # 4     LR0405
#> 1563      District # 4     LR0405
#> 1570      District # 4     LR0405
#> 1582      District # 4     LR0405
#> 1590      District # 4     LR0405

```

#> 1598	District # 4	LR0405
#> 1604	District # 4	LR0405
#> 1608	District # 4	LR0405
#> 1611	District # 4	LR0405
#> 1622	District # 4	LR0405
#> 1633	District # 4	LR0405
#> 1756	District # 4	LR0405
#> 1776	District # 4	LR0405
#> 1788	District # 4	LR0405
#> 1791	District # 4	LR0405
#> 1799	District # 4	LR0405
#> 1802	District # 4	LR0405
#> 1806	District # 4	LR0405
#> 1848	Neekreen	LR0406
#> 1857	District # 4	LR0405
#> 1873	District # 4	LR0405
#> 1898	Neekreen	LR0406
#> 1899	District # 4	LR0405
#> 1901	Neekreen	LR0406
#> 1755	District # 4	LR0405
#> 1757	District # 4	LR0405
#> 1766	District # 4	LR0405
#> 1775	District # 4	LR0405
#> 1782	District # 4	LR0405
#> 1792	District # 4	LR0405
#> 1825	District # 4	LR0405
#> 1829	District # 4	LR0405
#> 1830	District # 4	LR0405
#> 1836	District # 4	LR0405
#> 1846	District # 4	LR0405
#> 1852	District # 4	LR0405
#> 2143	Neekreen	LR0406
#> 2144	Neekreen	LR0406
#> 2171	Neekreen	LR0406
#> 2184	Neekreen	LR0406
#> 2185	Neekreen	LR0406
#> 2194	Neekreen	LR0406
#> 2212	Neekreen	LR0406
#> 2239	Neekreen	LR0406
#> 2255	Neekreen	LR0406

```
#> 2260           Neekreen    LR0406
#> 2267           Neekreen    LR0406
#> 2275           Neekreen    LR0406
#> 2288           Neekreen    LR0406
#> 2152           Neekreen    LR0406
#> 2161           Neekreen    LR0406
#> 2163           Neekreen    LR0406
#> 2166           Neekreen    LR0406
#> 2174           Neekreen    LR0406
#> 2175           Neekreen    LR0406
#> 2176           Neekreen    LR0406
#> 2188           Neekreen    LR0406
#> 2190           Neekreen    LR0406
#> 2192           Neekreen    LR0406
#> 2207           Neekreen    LR0406
#> 2214           Neekreen    LR0406
#> 2215           Neekreen    LR0406
#> 2087           District # 4 LR0405
#> 2090           District # 4 LR0405
#> 2091           District # 4 LR0405
#> 2130           District # 4 LR0405
#> 2141           District # 4 LR0405
#> 2177           District # 4 LR0405
#> 2178           District # 4 LR0405
#> 2179           District # 4 LR0405
#> 2193           District # 4 LR0405
#> 2300           District # 4 LR0405
#> 2301           District # 4 LR0405
#> 2304           District # 4 LR0405
#> 2356           District # 4 LR0405
#> 2680           District # 1 LR0402
#> 2726           District # 1 LR0402
#> 2752           District # 1 LR0402
#> 2847           District # 1 LR0402
#> 2879           District # 1 LR0402
#> 2902           District # 1 LR0402
#> 2940           District # 1 LR0402
#> 2965           District # 1 LR0402
#> 2980           District # 1 LR0402
#> 2987           District # 1 LR0402
```

#> 3013	Owensgrove	LR0407
#> 3036	Owensgrove	LR0407
#> 3037	District # 1	LR0402
#> 2721	St. John River City	LR0408
#> 2730	St. John River City	LR0408
#> 2754	St. John River City	LR0408
#> 2770	St. John River City	LR0408
#> 2774	St. John River City	LR0408
#> 2780	St. John River City	LR0408
#> 2784	St. John River City	LR0408
#> 2838	St. John River City	LR0408
#> 2841	St. John River City	LR0408
#> 2870	St. John River City	LR0408
#> 2897	St. John River City	LR0408
#> 2920	St. John River City	LR0408
#> 2935	District # 1	LR0402
#> 2738	St. John River City	LR0408
#> 2766	St. John River City	LR0408
#> 2793	St. John River City	LR0408
#> 2794	St. John River City	LR0408
#> 2803	St. John River City	LR0408
#> 2805	St. John River City	LR0408
#> 2814	St. John River City	LR0408
#> 2824	St. John River City	LR0408
#> 2831	St. John River City	LR0408
#> 2845	St. John River City	LR0408
#> 2853	St. John River City	LR0408
#> 2857	St. John River City	LR0408
#> 2872	St. John River City	LR0408
#> 2647	District # 4	LR0405
#> 2692	District # 3	LR0404
#> 2712	District # 4	LR0405
#> 2745	District # 4	LR0405
#> 2767	District # 3	LR0404
#> 2795	District # 4	LR0405
#> 2859	District # 3	LR0404
#> 2871	District # 3	LR0404
#> 2895	District # 3	LR0404
#> 2904	District # 3	LR0404
#> 2931	District # 3	LR0404

```
#> 2949      District # 3      LR0404
#> 2958      District # 3      LR0404
#> 3392      Owensgrove       LR0407
#> 3402      Owensgrove       LR0407
#> 3438      Owensgrove       LR0407
#> 3488      Owensgrove       LR0407
#> 3501      Owensgrove       LR0407
#> 3550      Owensgrove       LR0407
#> 3617      Owensgrove       LR0407
#> 3621      Owensgrove       LR0407
#> 3627      Owensgrove       LR0407
#> 3691      Owensgrove       LR0407
#> 3694      Owensgrove       LR0407
#> 3714      Owensgrove       LR0407
#> 3744      Owensgrove       LR0407
#> 3433      District # 1     LR0402
#> 3440      District # 1     LR0402
#> 3444      District # 1     LR0402
#> 3451      District # 1     LR0402
#> 3453      District # 1     LR0402
#> 3460      District # 1     LR0402
#> 3475      District # 1     LR0402
#> 3567      District # 1     LR0402
#> 3571      District # 1     LR0402
#> 3579      District # 1     LR0402
#> 3592      District # 1     LR0402
#> 3602      District # 1     LR0402
#> 3665      District # 1     LR0402
#> 3336      District # 2     LR0403
#> 3350      District # 2     LR0403
#> 3457      District # 2     LR0403
#> 3462      District # 2     LR0403
#> 3508      District # 2     LR0403
#> 3517      District # 2     LR0403
#> 3565      District # 2     LR0403
#> 3577      District # 2     LR0403
#> 3584      District # 2     LR0403
#> 3612      District # 2     LR0403
#> 3629      District # 2     LR0403
#> 3680      District # 2     LR0403
```

#> 3732	District # 2	LR0403
#> 3346	District # 3	LR0404
#> 3439	District # 2	LR0403
#> 3474	District # 2	LR0403
#> 3483	District # 3	LR0404
#> 3507	District # 2	LR0403
#> 3509	District # 2	LR0403
#> 3524	District # 2	LR0403
#> 3553	District # 3	LR0404
#> 3589	District # 3	LR0404
#> 3632	District # 2	LR0403
#> 3668	District # 2	LR0403
#> 3669	District # 2	LR0403
#> 3731	District # 2	LR0403
#> 3396	District # 3	LR0404
#> 3420	District # 3	LR0404
#> 3512	District # 3	LR0404
#> 3533	District # 3	LR0404
#> 3670	District # 3	LR0404
#> 3672	District # 3	LR0404
#> 3708	District # 3	LR0404
#> 3713	District # 3	LR0404
#> 3723	District # 3	LR0404
#> 3758	District # 3	LR0404
#> 3774	District # 3	LR0404
#> 3780	District # 3	LR0404
#> 3792	District # 3	LR0404
#> 3235	District # 4	LR0405
#> 3287	District # 4	LR0405
#> 3304	District # 4	LR0405
#> 3329	District # 4	LR0405
#> 3353	District # 4	LR0405
#> 3355	District # 4	LR0405
#> 3419	District # 4	LR0405
#> 3470	District # 4	LR0405
#> 3523	District # 3	LR0404
#> 3693	District # 3	LR0404
#> 3791	District # 3	LR0404
#> 3827	District # 3	LR0404
#> 3831	District # 3	LR0404

```
#> 4098      District # 1      LR0402
#> 4116      District # 1      LR0402
#> 4176      District # 1      LR0402
#> 4244      District # 1      LR0402
#> 4321      District # 1      LR0402
#> 4333      District # 1      LR0402
#> 4357      District # 1      LR0402
#> 4409      District # 1      LR0402
#> 4418      District # 1      LR0402
#> 4420      District # 1      LR0402
#> 4442      District # 1      LR0402
#> 4452      District # 1      LR0402
#> 4481      District # 1      LR0402
#> 4121      District # 1      LR0402
#> 4149      District # 1      LR0402
#> 4215      District # 1      LR0402
#> 4217      District # 1      LR0402
#> 4240      District # 1      LR0402
#> 4246      District # 1      LR0402
#> 4259      District # 1      LR0402
#> 4269      District # 1      LR0402
#> 4351      District # 1      LR0402
#> 4362      District # 1      LR0402
#> 4396      District # 1      LR0402
#> 4427      District # 1      LR0402
#> 4453      District # 1      LR0402
#> 4181      District # 2      LR0403
#> 4197      District # 2      LR0403
#> 4221      District # 2      LR0403
#> 4228      District # 2      LR0403
#> 4229      District # 2      LR0403
#> 4251      District # 2      LR0403
#> 4260      District # 2      LR0403
#> 4287      District # 2      LR0403
#> 4326      District # 2      LR0403
#> 4376      District # 2      LR0403
#> 4400      District # 2      LR0403
#> 4432      District # 2      LR0403
#> 4489      District # 2      LR0403
#> 4178      District # 3      LR0404
```

#> 4199	District # 3	LR0404
#> 4236	District # 3	LR0404
#> 4254	District # 3	LR0404
#> 4268	District # 2	LR0403
#> 4284	District # 2	LR0403
#> 4293	District # 2	LR0403
#> 4320	District # 3	LR0404
#> 4335	District # 2	LR0403
#> 4342	District # 3	LR0404
#> 4398	District # 3	LR0404
#> 4407	District # 3	LR0404
#> 4461	District # 2	LR0403
#> 4163	District # 3	LR0404
#> 4174	District # 3	LR0404
#> 4201	District # 3	LR0404
#> 4223	District # 3	LR0404
#> 4290	District # 3	LR0404
#> 4375	District # 3	LR0404
#> 4377	District # 3	LR0404
#> 4443	District # 3	LR0404
#> 4444	District # 3	LR0404
#> 4480	District # 3	LR0404
#> 4493	District # 3	LR0404
#> 4499	District # 3	LR0404
#> 4524	District # 3	LR0404
#> 3992	District # 3	LR0404
#> 4085	District # 3	LR0404
#> 4099	District # 3	LR0404
#> 4129	District # 3	LR0404
#> 4218	District # 3	LR0404
#> 4241	District # 3	LR0404
#> 4264	District # 3	LR0404
#> 4273	District # 3	LR0404
#> 4305	District # 3	LR0404
#> 4312	District # 3	LR0404
#> 4347	District # 3	LR0404
#> 4372	District # 3	LR0404
#> 4525	District # 3	LR0404
#> 5115	District # 1	LR0402
#> 5220	District # 1	LR0402

```
#> 5224      District # 1      LR0402
#> 5238      District # 1      LR0402
#> 5239      District # 1      LR0402
#> 5246      District # 1      LR0402
#> 5260      District # 1      LR0402
#> 5280      District # 1      LR0402
#> 5341      District # 1      LR0402
#> 5372      District # 1      LR0402
#> 5406      District # 1      LR0402
#> 5505      District # 1      LR0402
#> 5518      District # 1      LR0402
#> 4840      District # 2      LR0403
#> 4996      District # 2      LR0403
#> 5023      District # 2      LR0403
#> 5034      District # 2      LR0403
#> 5073      District # 2      LR0403
#> 5087      District # 2      LR0403
#> 5214      District # 2      LR0403
#> 5215      District # 2      LR0403
#> 5263      District # 2      LR0403
#> 5337      District # 2      LR0403
#> 5362      District # 2      LR0403
#> 5373      District # 2      LR0403
#> 5378      District # 2      LR0403
#> 5077      District # 2      LR0403
#> 5137      District # 2      LR0403
#> 5530      District # 2      LR0403
#> 5616      District # 2      LR0403
#> 5656      District # 2      LR0403
#> 5708      District # 2      LR0403
#> 5709      District # 2      LR0403
#> 5734      District # 2      LR0403
#> 5746      District # 2      LR0403
#> 5807      District # 2      LR0403
#> 5829      District # 2      LR0403
#> 5849      District # 2      LR0403
#> 5971      District # 2      LR0403
#> 4936      District # 3      LR0404
#> 4969      District # 3      LR0404
#> 4995      District # 3      LR0404
```

#> 5039	District # 3	LR0404
#> 5044	District # 3	LR0404
#> 5171	District # 3	LR0404
#> 5185	District # 3	LR0404
#> 5201	District # 3	LR0404
#> 5213	District # 3	LR0404
#> 5232	District # 3	LR0404
#> 5292	District # 3	LR0404
#> 5300	District # 3	LR0404
#> 5466	District # 3	LR0404
#> 4989	District # 3	LR0404
#> 5154	District # 3	LR0404
#> 5188	District # 3	LR0404
#> 5235	District # 3	LR0404
#> 5279	District # 3	LR0404
#> 5350	District # 3	LR0404
#> 5382	District # 3	LR0404
#> 5458	District # 3	LR0404
#> 5494	District # 3	LR0404
#> 5497	District # 3	LR0404
#> 5712	District # 3	LR0404
#> 5762	District # 3	LR0404
#> 5825	District # 3	LR0404
#> 4617	District # 3	LR0404
#> 4904	District # 3	LR0404
#> 4943	District # 3	LR0404
#> 4945	District # 3	LR0404
#> 5054	District # 3	LR0404
#> 5241	District # 3	LR0404
#> 5822	District # 3	LR0404
#> 6208	District # 3	LR0404
#> 6352	District # 3	LR0404
#> 6391	District # 3	LR0404
#> 6399	District # 3	LR0404
#> 6403	District # 3	LR0404
#> 6635	District # 3	LR0404
#> 6566	District # 2	LR0403
#> 6636	District # 2	LR0403
#> 6711	District # 2	LR0403
#> 6741	District # 2	LR0403

#> 6785	District # 2	LR0403
#> 6818	District # 2	LR0403
#> 6895	District # 2	LR0403
#> 6944	District # 2	LR0403
#> 6999	District # 2	LR0403
#> 7015	District # 2	LR0403
#> 7162	District # 2	LR0403
#> 7208	District # 2	LR0403
#> 7219	District # 2	LR0403
#> 5943	District # 2	LR0403
#> 6225	District # 2	LR0403
#> 6425	District # 2	LR0403
#> 6451	District # 2	LR0403
#> 6681	District # 2	LR0403
#> 6752	District # 2	LR0403
#> 6825	District # 2	LR0403
#> 7007	District # 2	LR0403
#> 7010	District # 2	LR0403
#> 7017	District # 2	LR0403
#> 7117	District # 2	LR0403
#> 7201	District # 2	LR0403
#> 7349	District # 2	LR0403

Download

↳ Download the list of selected enumeration areas in Grand Bassa County [here](#).

2.5.2 Sampling frame for survey of children aged 6-59 months and their mothers

Given a target sample size of 576 and using a stage 1 sample of 30 grids as described above, a single nearest village to each of the 30 sampling points identified in the stage 1 sample will be selected. In each of these villages, the number of children 6-59 months and their mothers can be estimated as follows:

$$\begin{aligned}
 n_{\text{children 6-59 months and mothers}} &= \left\lceil \frac{\text{Target sample size}}{\text{Number of villages}} \right\rceil \\
 &= \frac{576}{30} \approx 20
 \end{aligned}$$

Twenty children 6-59 months and their mothers will need to be sampled from each of the first villages of the 30 sampling points for each county (and urban areas if included).

This will mean that the sampling interval to use for the door/house counting with systematic selection for the stage 2 sampling of the survey for children 6-59 months and their mothers can be calculated as follows:

$$\begin{aligned}
 n_{\text{Sampling interval}} &= \frac{\text{Total number of houses/doors}}{\text{Target sample of children 6-59 months old in village}} \\
 &= \frac{\text{Total number of houses/doors}}{20}
 \end{aligned}$$

2.6 Estimated time to complete full survey

Given the overall sampling frame for SAM coverage survey and survey for children 6-59 months and their mothers, the estimated time to complete the whole survey will be based on the total number of villages to sample and based on an assumed/estimated rate of completion of a single village by single survey team.

A total of 90 villages will need to be sampled per county (and per urban area if included). Assuming that a single survey team can enumerate one village in a day, then the following lent of survey in days can be considered based on number of survey teams:

Table 2.3: Estimated length of full survey in days given number of survey teams and number of areas to survey

Number of survey teams	Length of survey (per county/area)	Length of survey (2 counties)	Length of survey (2 rural, 1 urban)
5 survey teams	18 days	36 days	54 days
10 survey teams	10 days	20 days	30 days
15 survey teams	6 days	12 days	18 days

Chapter 3

Indicators

3.1 CMAM coverage

CMAM coverage usually pertains to coverage of SAM treatment. Historically, there have been two coverage estimators in common use: **point** and **period** coverage.

Point coverage is the number of current SAM cases in a treatment programme divided by the total number of current SAM cases.

Point coverage uses data for current cases only. It is calculated using the following formula:

$$\text{Point coverage} = \frac{C_{in}}{C_{in} + C_{out}}$$

where :

C_{in} = current SAM cases in the programme

C_{out} = current SAM cases out of the programme

Point coverage provides a snapshot of programme performance, putting a strong emphasis on the effectiveness and timeliness of case-finding and recruitment ([Myatt et al., 2012](#)).

Period coverage, on the other hand, uses data for both current and recovering cases. It is calculated using the following formula:

$$\text{Period coverage} = \frac{C_{in} + R_{in}}{C_{in} + C_{out} + R_{in}}$$

where :

R_{in} = recovering SAM cases in the programme

Period coverage is the number of current and recovering cases in a treatment programme divided by all current SAM cases and recovering cases. It approximates treatment coverage much better (albeit with limitations) as it accounts for children who are no longer cases but are in the programme.

Point and period coverage both have their limitations.

Point coverage of a programme with good case-finding and recruitment and short lengths of stay can be misleadingly low because there are too few current cases. For example, a coverage survey found:

Table 3.1: Scenario 1 - coverage survey results from a programme with good case-finding and recruitment and short lengths of stay

Number of current cases	2
Number of current cases in the programme	0
Number of current cases not in the programme	2
Number of recovering cases in the programme	34

In this scenario, the point coverage estimator returns:

$$\text{Point coverage} = \frac{C_{in}}{C_{out}} = \frac{0}{2} = 0 = 0\%$$

but the period estimator returns:

$$\text{Period coverage} = \frac{0 + 34}{0 + 34 + 2} = 0.944 = 94.4\%$$

In this regard, the point coverage estimate penalises good performance and the period coverage most likely better depicts the coverage of the programme.

On the other hand, a programme with poor case-finding and recruitment and long lengths of stay due to late presentation and/or late admission may have a period coverage that is misleadingly high because of high number of recovering cases. In such a scenario, the two estimators will yield very different results. For example:

Table 3.2: Scenario 2 - coverage survey results from a programme with good case-finding and recruitment and short lengths of stay

Number of current cases	12
Number of current cases in the programme	3
Number of current cases not in the programme	9
Number of recovering cases in the programme	22

$$\text{Point coverage} = \frac{C_{in}}{C_{out}} = \frac{3}{12} = 0.250 = 25.0\%$$

but the period estimator returns:

$$\text{Period coverage} = \frac{3 + 22}{3 + 22 + 9} = 0.735 = 73.5\%$$

In this example, point coverage is the more reflective coverage of the programme.

It should be noted also that period coverage has a tendency to an overestimation bias. This is because the current period coverage estimator does not take into account cases of acute malnutrition who have recovered spontaneously but were never enrolled in any treatment programme.

An estimator of coverage that does include both recovering cases that are in the programme and recovering cases that are not in the programme and, thus, provides an unbiased estimator of overall programme performance is:

$$\text{Single coverage} = \frac{C_{in} + R_{in}}{C_{in} + R_{in} + C_{out} + R_{out}}$$

where :

R_{out} = Recovering SAM cases not in the programme

It is for these reasons that the coverage assessment technical guide ([Myatt et al., 2012](#)) recommends that only one of these estimators be reported and the choice of estimator to report should be guided by specific programme features and characteristics (such as lengths of stay in the programme) that would justify the choice of reported estimator. In a recent Epicentre review ([Epicentre, 2015](#)) this has been highlighted as a source of confusion and issues given the possibility of period coverage being chosen more as a coverage estimator rather than point coverage because of it being a higher estimate even if the programme characteristics do not merit its use. The review suggests that both coverage indicators could be reported, with sufficient context (e.g. on length of stay, timeliness of admissions, etc.) to allow for their interpretation.

In response to the review and to address the limitations of the coverage estimators, development work has been conducted on further developing and improving the coverage estimators to address this confusion and the issues around them ([Balegamire et al., 2015](#)). This work focused primarily on improving the period coverage estimator to address the overestimation bias described earlier and to make it more closely approximate the treatment coverage estimator formula shown above.

The problem with this estimator is that R_{out} (i.e. the number of recovering cases that are not in the programme) is unknown and may be difficult to collect accurately. This problem of estimating the number of recovering cases not in the programme (R_{out}) may be addressed using a simple mathematical model¹ proposed by [Balegamire et al. \(2015\)](#).

¹This model assumes that incidence of acute malnutrition and programme coverage do not vary rapidly over time.

$$\frac{C_{in} + C_{out}}{C_{in}} \approx \frac{R_{in} + k \times R_{out}}{R_{in}}$$

where :

k = a correction factor

R_{out} can then be expressed in terms of the known variables:

$$R_{out} \approx \left\lfloor \frac{1}{k} \times \left(R_{in} \times \frac{C_{in} + C_{out}}{C_{in}} - R_{in} \right) \right\rfloor$$

Given the possibility that no cases in the programme (C_{in}) are found, the calculation is adjusted by adding 1 to C_{in} . To arrive at a whole number value for R_{out} , the calculation is rounded off towards zero.

$$R_{out} \approx \left\lfloor \frac{1}{k} \times \left(R_{in} \times \frac{C_{in} + 1 + C_{out}}{C_{in} + 1} - R_{in} \right) \right\rfloor$$

This leaves the problem of deciding a suitable value for the correction factor (k). A reasonable candidate for k is the ratio of the mean length of an untreated episode to the mean length of a CMAM treatment episode.

$$k = \frac{\text{Mean length of untreated episode}}{\text{Mean length of a treatment episode}}$$

Possible value for mean length of untreated episode is 7.5 months (Garenne et al., 2009) which is the common value used when estimating programme case-loads from prevalence estimates (Myatt, 2012). Mean length of a treatment episode can be estimated by calculating the mean length of stay in the CMAM programme using routine monitoring data. In general, A value of

2.5 months could be used in the absence of better information or when the validity of routine programme monitoring data is suspect. Using these values, k is:

$$k = \frac{\text{Mean length of untreated episode}}{\text{Mean length of a treatment episode}} = \frac{7.5}{2.5} = 3$$

The inclusion of recovering cases means that the single coverage estimate is mathematically constrained to return a coverage estimate that is greater than or equal to the point coverage estimate. The underestimation present in the point coverage estimate has, to some extent, been corrected. The inclusion of recovering cases that are not in the programme means that the single coverage estimator is mathematically constrained to return a coverage estimate that is less than or equal to the period coverage estimate. The overestimation present in the period coverage estimate has, to some extent, been corrected.

Given this single coverage estimator, a shift in terminology is proposed that is more descriptive and specific with regard to what the estimator is actually measuring, allowing both measures to be reported together without confusion. **Point coverage** is now named *case-finding effectiveness* to more precisely reflect it as a measure of the programme's ability to find and recruit current cases. This indicator assesses how good the treatment programme is in finding cases of SAM and then getting them to treatment. **Period coverage** that has been improved into the single coverage metric is now named *treatment coverage* as this is the estimator that approximates this coverage indicator the closest.

3.1.1 Requirements

This indicator will require additional programmatic information to be operationalised specific for Liberia.

It would be ideal that a Liberia-specific value for mean length of a treatment episode be estimated using routine programme data from a selection of cured cases from a selection of health centres providing CMAM services in the two counties in which the survey is to be implemented. This data should be collected from the beneficiary cards of cured cases. For each county, a total of 30 health centres from the full list of health centres in the county can be selected systematically. Of these 30 health centres, a sample of 30 records of discharged cured cases should be selected. From these records, data on date of admission and date of discharge should be extracted collated into a data format (ideally a comma-separated value or CSV file) with each of these values in a separate column.

This data will allow the calculation of the mean length of stay in the CMAM programme of discharge cured cases.

$$\text{Mean length of stay} = \frac{\text{Length of stay in programme (days)}}{\text{Number of records}}$$

For data collection, enumerators will require:

1. A height board;
2. A digital weighing scale; and,
3. A MUAC tape.

Traditionally, if data collection is done using pen and paper, enumerators are provided with z-score tables for weight-for-height so that they can determine if child is SAM. Since this survey will utilise digital data collection (see Section 5), the digital form will determine whether the child is SAM by MUAC and/or weight-for-height and/or oedema and will instruct the enumerators on what to do next if the child is a SAM case.

Referral slips will also be needed so that children who are identified as SAM but not in the programme can be referred.

3.2 Vitamin A supplementation

The standard estimator for vitamin A supplementation is the proportion of children aged 6-59 months who received two age-appropriate doses of vitamin A in the past 12 months.

In standard surveys such as the DHS and MICS, this indicator is adjusted to a recall of 6 months for a single age-appropriate dose of vitamin A.

In order to determine whether supplementation with vitamin A is age appropriate, vitamin A supplementation should first be assessed on the child's health card. Provision of vitamin A card is usually recorded on the child's health card with the corresponding does given. If health card not available or if health card is lost or if the child doesn't have a health card at all, then the mother/caregiver will have to be asked whether their child has received vitamin A in the past 6 months and respond by recall. If the mother/caregiver says yes, then the next question to ask will be which type of gel capsule was provided. The blue vitamin A gel capsule containing 100,000 IU of vitamin A is given to children 6-11 months. The red vitamin A gel capsule containing 200,000 IU of vitamin A is given to children 12 - 59 months. A sample of the blue and the red gel capsule (or a photo of the capsules) can be used to aid the mother/caregiver in answering this question.

Given this, two indicators can be reported on vitamin A supplementation.

1. Any vitamin A supplementation in the past 6 months.
2. Age-appropriate vitamin A supplementation in the past 6 months.

3.2.1 Requirements

Either samples and/or photos of both the blue and red gel vitamin A capsules will be needed per enumerator to use in aiding the mother to answer which type of vitamin A gel capsule has been provided to the child.

3.3 Iron-folic acid (IFA) supplementation for pregnant women

Population-based surveys typically report the percentage of women with a live birth in the two to five years before the survey who received and took IFA supplementation during their most recent pregnancy. Because antenatal care (ANC) is typically the main platform for IFA supplement distribution for pregnant women, survey questions on antenatal care attendance and timing of the first antenatal care visit can provide information on the use of this platform to deliver IFA supplementation. [Sununtnasuk et al. \(2015\)](#) propose a falter point framework² that utilises four indicators that proxy the four critical points at which the ANC approach to IFA distribution might falter in IFA supplementation coverage to pregnant women. These indicators are:

1. At least one ANC visit during most recent pregnancy
2. Receipt or purchase of IFA tablet/s
3. IFA consumption
4. Adherence to 180 days of supplementation

3.3.1 Requirements

It would be ideal for each enumerator to have a sample/s and/or photos of an IFA tablet to show the respondent as an recall aid or prompt. Given that some mothers may have to recall as far back as 5 years and that they might not be able to remember that the tablet is called, showing them a sample of the tablet might help them remember if they have taken it.

²Similar to a bottleneck framework and consistent with [Tanahashi \(1978\)](#) hierarchical model of coverage.

3.4 Micronutrient powder supplementation

The indicator for coverage of micronutrient powder supplementation is the proportion of children aged 6-23 months who consume micronutrient powder supplements. Depending on the programme protocol on mechanism of distribution and effective intake of MNP, a full indicator set on MNP supplementation can be devised that will be similar to the IFA supplementation falter point or bottleneck framework. For example, if MNPs were being provided through the health centres or health posts, then the following indicators can be assessed hierarchically:

1. Health centre / health post attendance in the past month
2. Awareness of MNP
3. Consumption of MNP

3.4.1 Requirement

It would be ideal to provide enumerators with sample/s and/or photo/s of MNP sachets used in Liberia. If there are various brands of MNP distributed, it would be good to have sample/s and/or photo/s of each one. These sample/s and/or photo/s can be used to help mothers or caregivers recall or know what an MNP is and be able to ascertain whether they do know it or have heard of it and whether their child has consumed it.

3.5 IYCF counselling

There are no standard indicators for IYCF counselling. Any indicator developed for this programme will depend on the mechanics of how the IYCF counselling is delivered and who the target beneficiaries are. In terms of mechanism, what is known so far is that these sessions are delivered via the health clinic/health post and that the target beneficiaries are pregnant women. Given this, similar approach to the IFA supplementation coverage of falter points/bottle necks can be used with the following indicators:

1. At least one ANC visit during most recent pregnancy
2. Awareness of IYCF counselling (have they been advised IYCF counselling when they attended ANC)
3. Attendance to IYCF counselling

3.5.1 Requirement

It would be ideal to have the training materials used for IYCF counselling and the materials used when conducting IYCF counselling. These materials can be used as a recall aid for mothers/caregivers who are being asked about whether they know or have heard about IYCF counselling and whether they have attended.

Chapter 4

Questionnaire

The following are sample/template questionnaires used for the two types of surveys that will be implemented.

4.1 CMAM coverage survey instruments

CMAM coverage surveys use primarily use two forms. The first form is used to collect coverage data from SAM children found during the survey. Given that this survey will use house-to-house/door-to-door sampling for stage 2, then it would be necessary to record all data from all children that are measured with MUAC, weight-for-height and oedema. The following tabular form can be used for this purpose:

SAM Coverage Data Collection Form

Figure 4.1: SAM coverage survey sample/template form

The data collected using the tabular forms will allow estimation of coverage. They do not, however, allow you to know the reasons for coverage failure. To collect this data we apply a “barriers” questionnaire to the mothers/carers of uncovered SAM cases. Here is an example of a barriers questionnaire:

SAM Coverage Barriers Data Collection Form

PSU ID	ID
__ __	__ __

B1: Do you know that your child is malnourished or thinner than he/she should be? YES NO**B2:** Do you know that there is a programme that can treat malnourished children? YES NOIf **NO**, thank mother/carer and terminate interview.**B3:** What do you call this programme? _____**B4:** Where is this programme? _____**B5:** Why is this child not attending this programme?*Do not prompt. Probe "Any other reasons?"*

- Programme site is too far away
- No time/too busy to attend the programme
- Carer/mother cannot travel with more than one child
- Woman cannot travel alone
- Carer is ashamed to attend programme
- Difficulty with childcare
- Child has been rejected by the programme

Record all other reasons given:

B6: Has this child ever been to the program site or examined by program staff? YES NOIf **NO**, thank mother/carer and terminate interview.**B7:** Why is this child not in the programme now?

- Previously rejected
- Defaulted
- Discharged as cured
- Discharged as not cured

Thank mother/carer. Issue a referral slip. Inform mother/carer of site and date to attend.

Figure 4.2: SAM coverage barriers survey sample/template form

4.2 Survey for children 6-59 months and their mothers

For the survey for children 6-59 months, following is a sample/template questionnaire.

Children 6-59 months Data Collection Form		
PSU ID	County	Village Name
<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> 1 = Grand Bassa 2 = Rural Montserrado	<input type="text"/>
Administrative Data		
ad1	Date of data collection	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>
ad2	Team number	<input type="text"/> <input type="text"/> <input type="text"/>
ad3	Name of enumerator	<input type="text"/>
ad4	Consent?	1 = YES 2 = NO
<i>If consent is not given then stop the interview and move to next respondent.</i>		
Identifying Data		
psu	PSU (cluster) number	<input type="text"/> <input type="text"/> <input type="text"/>
hh	Household identifier	<input type="text"/> <input type="text"/> <input type="text"/>
Mother Information		
m1	Mother's identifier	<input type="text"/> <input type="text"/> <input type="text"/>
m2	Mother's age (in full years)	<input type="text"/> <input type="text"/> <input type="text"/>
m3	How many children 6-59 months do you have?	<input type="text"/> <input type="text"/> <input type="text"/>
Iron-Folic Acid (IFA) Supplementation		
ifa1	During your pregnancy for your youngest child, did you see anyone for antenatal care?	1 = YES 2 = NO 99 = Don't know/not sure <input type="text"/> <input type="text"/> <input type="text"/>
ifa2	During your pregnancy for your youngest child, did you receive any information about taking iron-folic acid tablets (show sample/photo)?	1 = YES 2 = NO 99 = Don't know/not sure <input type="text"/> <input type="text"/> <input type="text"/>
ifa3	During your pregnancy for your youngest child, did you receive and/or purchase iron-folic acid tablets (show sample/photo)?	1 = YES 2 = NO 99 = Don't know/not sure <input type="text"/> <input type="text"/> <input type="text"/>
	<i>If NO, go to ifa3a; If DON'T KNOW/NOT SURE, skip to ifc1; If YES, go to ifa4</i>	
ifa3a	Why did you not receive or purchase iron-folic acid tablets? <i>Do not prompt. Probe "Any other reasons?"</i>	<input type="checkbox"/> Health centre ran out <input type="checkbox"/> Took too long to get tablets <input type="checkbox"/> Too expensive Other reasons: <input type="text"/> <input type="text"/>

Figure 4.3: Children 6-59 months old and their mothers survey sample/template form

ifa4	During your pregnancy for your youngest child, did you take iron-folic acid tablets (show sample/photo)?	1 = YES 2 = NO 99 = Don't know/not sure	__ __
<i>If NO, go to ifa4a; If DON'T KNOW/NOT SURE, skip to icf1; If YES, go to ifa5</i>			
ifa4a	Why did you not take iron-folic acid tablets? <i>Do not prompt. Probe "Any other reasons?"</i>	__ Concerns about side effects __ Don't need it __ I was told not to take it __ I don't think it helps Other reasons: _____ _____	__ __ __
ifa5	During the whole duration of your pregnancy for your youngest child, how many days did you take the iron-folic acid tablets (show sample/photo)?	__ __ __	

IYCF Counselling			
icf1	During your pregnancy for your youngest child, did you receive any information or hear about any service that provided counselling for pregnant women on infant and young child feeding?	1 = YES 2 = NO 99 = Don't know/not sure	__ __
icf2	During your pregnancy for your youngest child, did you attend any counselling session for pregnant women on infant and young child feeding?	1 = YES 2 = NO 99 = Don't know/not sure	__ __
If NO, go to icf2a; If DON'T KNOW/NOT SURE, skip to ; If YES, go to icf3.			
icf2a	Why did you not attend the counselling sessions? <i>Do not prompt. Probe "Any other reasons?"</i>	__ Timing was not convenient __ Not interested __ Do not trust counsellor __ Don't think I need it Other reasons: _____ _____	__ __
icf3	How many counselling sessions did you attend?	__ __	

Figure 4.4: Children 6-59 months old and their mothers survey sample/template form

Child Information			
	<i>If m3 > 1, randomly select one child from the mother's children.</i>		
c1	Age in months of respondent child	<input type="text"/> <input type="text"/>	
	<i>If c1 ≥ 23, go to mnp1; If c2 > 23, go to vit1</i>		
Micronutrient Powder (MNP) Supplementation			
mnp1	Have you heard about [LOCAL NAME OF MNP] or seen [show sample/photo of MNP]?	1 = YES 2 = NO 99 = Don't know/not sure	<input type="text"/> <input type="text"/>
mnp2	Have you received or bought [LOCAL NAME of MNP] (show sample/photo of MNP) for your child aged 6-23 months?	1 = YES 2 = NO 99 = Don't know/not sure	<input type="text"/> <input type="text"/>
	<i>If NO, go to mnp2a; If DON'T KNOW/NOT SURE, go to vit1; IF YES, go to mnp3</i>		
mnp2a	Why did you not receive/buy [LOCAL NAME of MNP] (show sample/photo of MNP) for your child aged 6-23 months? <i>Do not prompt. Probe "Any other reasons?"</i>	<input type="checkbox"/> Health centre ran out <input type="checkbox"/> Took too long to get MNP <input type="checkbox"/> Too expensive <input type="checkbox"/> Child doesn't need it <input type="checkbox"/> Heard it doesn't work/help Other reasons: <hr/> <hr/>	
mnp3	Did you give your child aged 6-23 months the [LOCAL NAME OF MNP] to eat?	1 = YES 2 = NO 99 = Don't know/not sure	<input type="text"/> <input type="text"/>
	<i>If NO, go to mnp3a; If DON'T KNOW/NOT SURE, go to vit1; IF YES, go to mnp4</i>		
mnp3a	Why did you not give the [LOCAL NAME OF MNP] to your child aged 6-23 months to eat? <i>Do not prompt. Probe "Any other reasons?"</i>	<input type="checkbox"/> Too expensive <input type="checkbox"/> Not available in the market <input type="checkbox"/> Do not need MNP <input type="checkbox"/> Heard other's bad experience <input type="checkbox"/> Advised not to use it <input type="checkbox"/> Not seen other mothers use it <input type="checkbox"/> Don't trust the product <input type="checkbox"/> Using another product <input type="checkbox"/> Haven't seen it Other reasons: <hr/> <hr/>	
mnp4	In the last week, how many times did your child aged 6-23 months old eat [LOCAL NAME OF MNP]?	<input type="text"/> <input type="text"/>	

Figure 4.5: Children 6-59 months old and their mothers survey sample/template form

Vitamin A Supplementation			
vit1	In the past 6 months, has your child received drops from a capsule like this one (show vitamin A sample or photo)?	1 = YES 2 = NO 99 = Don't know/not sure	<input type="checkbox"/> <input type="checkbox"/>
	<i>If NO, go to vit1a; If DON'T KNOW/NOT SURE, thank mother and end interview; If YES, go to vit2.</i>		
vit1a	Why did your child not receive (show vitamin A capsule sample or photo)? <i>Do not prompt. Probe "Any other reasons?"</i>	<input type="checkbox"/> Health centre ran out <input type="checkbox"/> Took too long to get drops <input type="checkbox"/> Child doesn't need it <input type="checkbox"/> Heard it doesn't work/help Other reasons: <hr/> <hr/> <hr/>	
vit2	What type of capsule (show sample or photo of blue and red capsule) did your child get drops from?	1 = blue capsule 2 = red capsule 99 = Don't know/not sure	<input type="checkbox"/> <input type="checkbox"/>
vit3	How many months ago did your child receive drops from (show vitamin A sample or photo)?		<input type="checkbox"/>

Figure 4.6: Children 6-59 months old and their mothers survey sample/template form

4.3 Using Open Data Kit

Based on the template forms described in the previous sections, a digital data collection system using Open Data Kit (ODK) has been developed. These forms are available as a [Github repository](#). The system is composed of two forms.

4.3.1 Village form

This form (`liberiaCoverageVillageForm.xlsx` and `liberiaCoverageVillageForm.xml`) collects information on the villages or primary sampling units (PSU) selected for the Liberia Coverage Survey. This information includes:

1. County name (and identifier)
2. Village name (and identifier)
3. Village population size
4. Village geocoordinates

4.3.2 Coverage form

This form (`liberiaCoverage.xlsx` and `liberiaCoverage.xml`) collects information on the various coverage indicators assessed in the Liberia Coverage Survey:

1. CMAM coverage
2. Iron-folic acid supplementation coverage
3. IYCF counselling coverage
4. Micronutrient powder supplementation coverage
5. Vitamin A supplementation coverage

The coverage form has been developed in such a way that it implements the survey as per survey design such that the modules for IFA coverage, IYCF counselling coverage, MNP supplementation coverage and vitamin A supplementation coverage are only shown based on the sampling interval for a particular primary sampling unit (PSU) and based on the different eligibility requirements for each coverage survey module.

4.3.3 Usage

For those wanting to test out the forms on their own Android mobile devices, the following applications need to be downloaded and installed from the Google Play Store:

- ODK Collect ([link](#))
- ODK Counter ([link](#))

Once these applications are installed, there are two options for getting the Liberia Coverage Survey forms onto mobile devices.

4.3.4 1. Using ODK Aggregator or other similar ODK servers

The XLSForm can be uploaded to a remote server-based ODK Aggregator or other ODK servers such as ONA, SurveyCTO, KoBoToolbox and the like. The form is validated and then converted into XML format which can then be retrieved from the server into mobile devices as blank forms.

For the purposes of viewing and testing the Liberia Coverage Survey forms, a test server has been setup. To view and/or test the Liberia Coverage Survey forms, ODK Collect in the mobile devices will need to be connected to the server. This is described [here](#). The following ODK Aggregate server settings should be used:

url: <https://odk.ona.io>

username: validtrial

password: zEF-STN-5ze-qom

Once ODK Collect has been connected to the test server, it will now be possible to pull the Liberia Coverage Survey forms into ODK Collect in the mobile device using the instructions found [here](#).

Once the Liberia Coverage Survey forms have been pulled into the ODK Collect in the mobile device, the forms can be viewed and tested by following the instructions [here](#).

4.3.5 2. Convert to XML and transfer to mobile devices via USB cable connection

The XML version of this form can then be transferred to the mobile devices (into the device's `odk` folder) via local USB connection. This can be done by following the instructions [here](#). The associated media files for the forms (found in the folder called `media` in this repository) will also need to be transferred to the mobile device. This can be done by following the instructions [here](#).

Chapter 5

Data management and analysis

Data will be collected using an electronic data entry system based on the **Open Data Kit (ODK)** standard that runs on the Android® operating software (OS) platform for mobile devices. The study instrument (see Section 4) will be encoded into the electronic data entry system platform and will be served out of either a local computer server or a remote/cloud-based server¹. Each study team will be provided with mobile devices running on Android® OS that have been configured with an application that will receive the electronic data form. All measurements and answers by respondents will then be recorded on the mobile devices and will then be transmitted to the local server or the remote server whenever there is a mobile phone and / or WiFi signal.

Appropriate data check mechanisms will be put in place using the data check systems available with the ODK system. Spot checks by study supervisor/s will be done in the field to ensure that enumerators are performing the measurements correctly, administering the study instrument correctly and entering all data accordingly. Further checks will be performed by the survey manager on the data as needed as they are received by the local server or remote server.

The digital data collection forms based on the Open Data Kit (ODK) standard using XLS-form and XML is available at <https://github.com/validmeasures/liberiaS3Mforms>. The form faithfully replicates the paper-based forms described in Section 4. The form also faithfully replicates the sampling design described by the survey design such that proposed sampling interval within a primary sampling unit (PSU) is implemented as the survey team goes house-to-house finding SAM cases. The modules on IFA supplementation, IYCF counselling, vitamin A supplementation and MNP supplementation coverage appear appropriately on the digital forms when the correct household based on the sampling interval is being interviewed. The forms also appear appropriately based on eligibility of the child/mother as respnodents to the specific survey modules.

These forms can be viewed and tested using an Android-based mobile device. Instructions for

¹This will depend on what resources are available to the Liberia Institute of Statistics and Geo-Information Services. Valid International has resources to implement either a local server or a remote server solution.

usage can be found at <https://github.com/validmeasures/liberiaS3Mforms>.

Data analysis will be done using R language for statistical computing ([R Core Team, 2018](#)) through bespoke analytic scripts put together into application-based workflow which can be used by non-R users. The application that will be created for this study will be designed such that an automatic reporting format is produced including maps, figures and tables of results.

5.1 Analytical approach for estimating coverage indicators

It is important to note that data analysis procedures need to account for the sample design. All major statistical analysis software can do this (details vary). There are two things to note:

- This survey is a two-stage sample. Subjects are sampled from a small number of primary sampling units (PSUs).
- This survey is **not** prior weighted. This means that per-PSU sampling weights will be needed. These are usually the populations of the PSU.

This sample design will need to be specified to your statistical analysis software. Failing this, the analysis may produce estimates that place undue weight to observations from smaller communities with confidence intervals with lower than nominal coverage (i.e. they will be too narrow).

For this survey, the *blocked weighted bootstrap* estimation approach will be used:

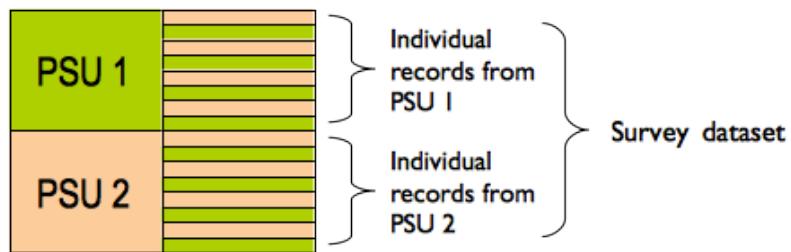
- **Blocked** : The block corresponds to the PSU or cluster.
- **Weighted** : The sampling procedure for this survey does not use population proportional sampling to weight the sample prior to data collection as is done with SMART type surveys. This means that a posterior weighting procedure is required. The “roulette wheel” algorithm to weight (i.e. by population) the selection probability of PSUs in bootstrap replicates will be utilised.

A total of m PSUs are sampled *with-replacement* from the survey dataset where m is the number of PSUs in the survey sample. Individual records within each PSU are then sampled *with-replacement*. A total of n' records are sampled *with-replacement* from each of the selected PSUs where n is the number of individual records in a selected PSU. The resulting collection of records replicates the original survey in terms of both sample design and sample size. A large number of replicate surveys are taken (minimum of $r = 399$ replicate surveys but this can be changed). The required statistic (e.g. the mean of an indicator value) is applied to each replicate survey. The reported estimate consists of the 50th (point estimate), 2.5th (lower 95% confidence limit), and the 97.5th (upper 95% confidence limit) percentiles of the distribution of the statistic observed across all replicate surveys. The blocked weighted bootstrap procedure is outlined in Figure 5.1.

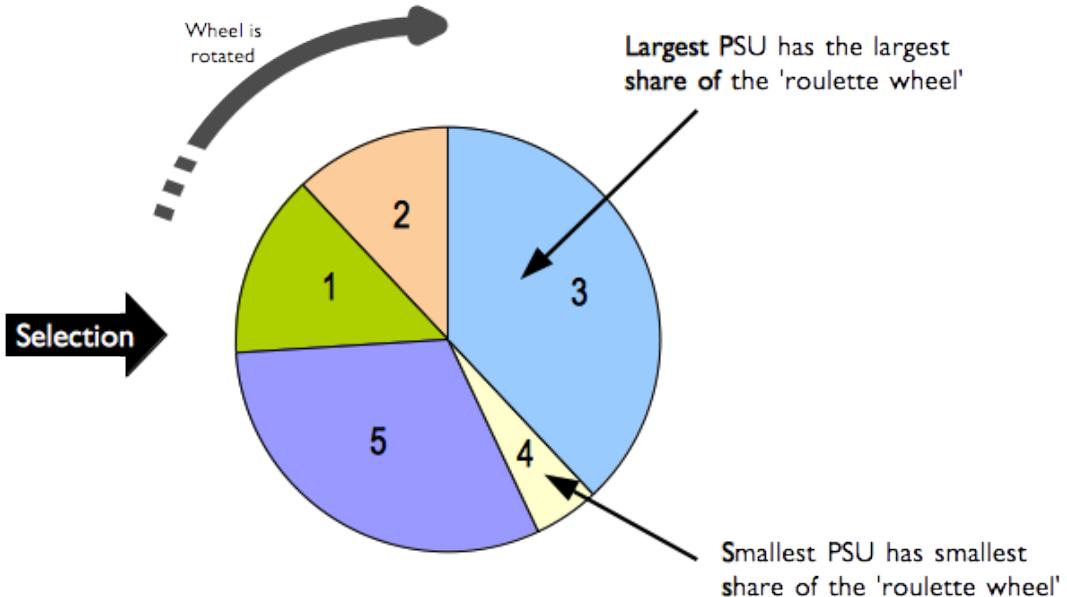
The principal advantages of using a bootstrap estimator are:

- Bootstrap estimators work well with small sample sizes.
- The method is *non-parametric* and uses empirical rather than theoretical distributions. There are no assumptions of things like normality to worry about.
- The method allows estimation of the sampling distribution of almost any statistic using only simple computational methods.

Data are collected using a two-stage cluster design:



PSUs are selected from the survey dataset *with-replacement* and with probability proportional to population size (PPS) using a *roulette wheel* algorithm :



PSUs are selected *with-replacement* and proportional to population size (PPS) :



Individual records are selected *with-replacement* from within each PSU to create a *replicate survey*. The estimator is applied to the replicate survey and the result recorded. This process is repeated many times. The estimate of the indicator value is made from the distribution of the results from each replicate survey which is the *empirical sampling distribution* of the indicator :

Estimate and 95% confidence interval from 50th, 2.5th, and 97.5th percentiles of the empirical (i.e. observed) sampling distribution of the indicator

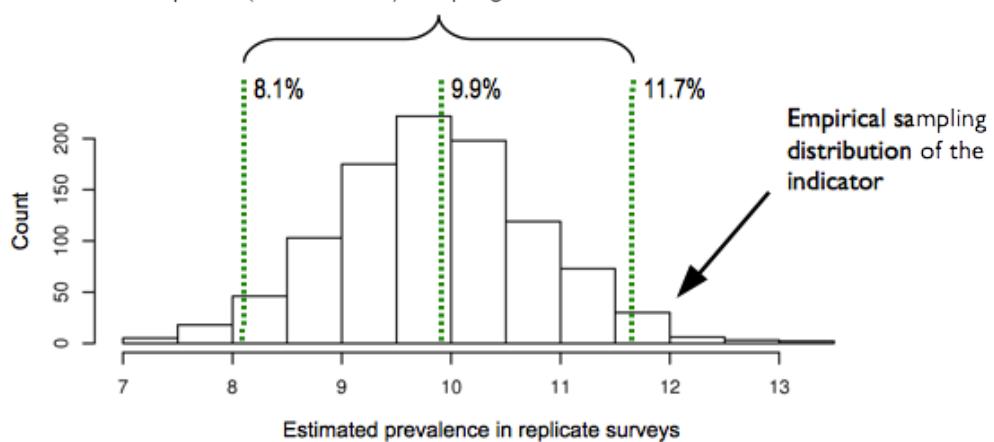


Figure 5.1: The blocked weighted bootstrap

5.2 Analytical approach for mapping coverage indicators

The indicator mapping will create a surface map of indicator values using spatial interpolation. There are various approaches and methods of spatial interpolation, the main differences are determined by the weights applied to the point dataset to estimate values at each of the unknown points of the surface map. For the Liberia coverage survey, spatial interpolation will be performed using the inverse distance weighting (IDW) method. As the name implies, the IDW method uses weights that are inversely proportional to the distance of a point being estimated from the sampling point locations ([Isaaks and Srivastava, 1989](#); [Diggle and Ribeiro, 2007](#); [Diggle, 2013](#)). This can be mathematically demonstrated as follows:

$$\hat{v} = \frac{\sum_{i=1}^n \frac{1}{d_i^p} v_i}{\sum_{i=1}^n \frac{1}{d_i^p}}$$

where :

$d_1 \dots d_n$ = distances from each n sampling points to estimation point

p = power of the distance

$v_1 \dots v_n$ = sample values

The power of the distance p is an important aspect of the IDW method for point estimation. The influence of p to the weights applied to the point estimation is such that as p approaches 0, the weights become more similar, thereby giving more weight to the nearest sample values. As p approaches ∞ , the weights become more different from each other, thereby giving more weight to the closest sample. The power of the distance p has been traditionally set at 2 for convenience and ease of calculations. In theory, given a set p , IDW calculations can be performed using manual calculations aided by a spreadsheet and / or a calculator as it requires fewer calculations. For the Liberia Coverage Survey, p will be initially set at 2 and then cross-validation (see below) will be applied to optimise p to a value that minimises the estimation errors at each of the sampling point locations.

Cross-validation is a technique applied to validate predictive models. It assesses how accurately the predictive model performs in practice. IDW is one of the simplest model-based interpolation methods available, but ideally would still require a form of cross-validation to determine the optimal value of the distance power p (described above).

A two-fold cross validation ([Bivand et al., 2013](#)) in which data points are randomly split into

two sets of equal size, with one set assigned as the validation data for testing the model, and the other set as the training data. The validation data is then interpolated using the IDW method with an initial p of 2 and the resulting predictions were compared with the training data. Comparison is made using the sum of the squared residuals between the predicted values and the observed values to report errors. Optimisation is then performed by replicating the two-fold cross validation process 100 times using randomly generated values for p . Out of these replicates, the value of p that provided prediction results with the minimum errors is selected as the distance power for the eventual interpolation performed.

Chapter 6

Anthropometric measurement standardisation test

The survey personnel should go through theoretical discussions and demonstrations on how to perform the anthropometric measurements. This should then be followed by practical demonstration of the measurement techniques, measurement readings and recording ideally with a large number of children particularly if there is a large number of survey personnel. Once all personnel have had the opportunity to adequately practice their measurement and recording techniques, a standardisation test or exercise must be carried out. Chapter 6 provides detailed instructions on how to carry out an anthropometric measurement standardisation test as part of a training process in preparation for a nutrition survey.

6.1 Objectives

The standardisation test evaluates the **precision** and the **accuracy** of the measurements taken by each survey personnel.

The **accuracy** of measurements taken by survey personnel is determined by how close they are to the true value with repeated measurements. On the other hand, the **precision** of measurements taken by survey personnel is determined by how similar the values are of repeated measurements made. In preparation for a nutrition survey while the survey personnel are in training, the aim is for survey personnel to be *highly accurate* and *highly precise* with their anthropometric measurements.

6.2 Mechanics

The general process of the standardisation test is for each survey personnel to take measurements of at least 10 children 6-59 months, twice, with an interval of time between the 1st and

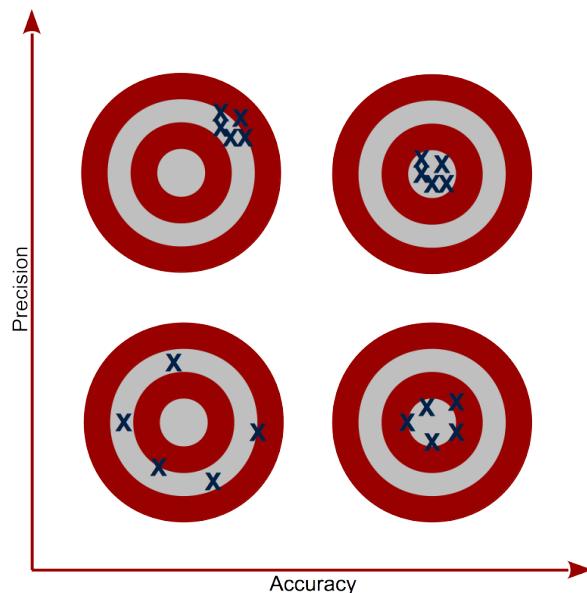


Figure 6.1: Relationship between accuracy and precision

2nd measurements.

6.2.1 Test parameters

The following test parameters need to be followed when conducting an anthropometric standardisation test:

1. The same type of equipment must be used both during the standardisation test and the survey
2. Each child is measured with the same equipment
3. The supervisor must observe how measurements are being taken
4. Survey personnel measurements are compared to the reference (supervisor) values
5. Survey personnel measurements are compared to the repeated measures taken (intra-observer)

6.2.2 Test organisation and requirements

The following test organisation and requirements need to be met in order to conduct a credible standardisation test:

1. Spacious and shady area
2. Healthy children between 6 and 59 months or according to the age group targeted by the survey

3. Incentives provided for the mother and children
4. Survey personnel are grouped into pairs, but each personnel will carry out the measurements in turn
5. There should only be one pair of survey personnel per child at any time during the test
6. Each survey personnel is given a unique ID. For example if there are 20 survey personnel, a unique ID from 1 to 20 is given to each survey personnel. The supervisor's ID is always 0
7. Each measurement station should have a height board, weighing scale and a MUAC tape
8. Each child must remain with their mother in a fixed station with a unique ID number. For example if there are 10 mother and children pairs, a unique ID from 1 to 10 is given to each pair
9. It is not allowed for pairs of survey personnel to speak with other pairs during the test

6.2.3 Timeframe

In order to follow the test parameters specified above and organise the test appropriately, a considerable amount of time needs to be set aside for conducting the test.

For a survey team of about 20 survey personnel, the test can be carried out in 2 half-days such that half of the survey personnel (first half of each team) measures 10 children in the morning and the other half (second half of each team) measures the same 10 children in the afternoon.

It would be possible to have a different set of 10 children for the afternoon session. However, the results of the first half who took the test in the morning cannot be combined with the results of the second half who took the test in the afternoon.

For larger scale surveys with survey personnel more than 20, more days will be required to conduct the test to appropriately and to correct specifications.

6.2.4 Steps in carrying out the standardisation test

1. The supervisor carefully performs the measurements on each child without allowing the teams to see the values. The supervisor records his/her measurements on the standardisation test form for the first round of measurements.

Standardisation Test Form - Measurement Round 1

Enumerator ID: _____ Enumerator Name: _____

Child ID	Weight (kg)	Height (cm)	MUAC (mm)	Oedema (yes/no)
01				
02				
03				
04				
05				
06				
07				
08				
09				
10				

Download

⤳ Download the standardisation test form [here](#).

2. Each team starts with a different child, and the first half of the team measures the child once and records the results in a standard form for the 1st measurement (as above). The current measurer should make sure that he/she is entering data in the row corresponding to the child ID of the child he/she is currently measuring.
3. When the first half of the team has done the measurements for the current child, they should move on to the next child. After the first half of all the teams has measured 10 children once, the first measurement round forms are handed in. The teams and the children then take a break. Appropriate incentives including food and drinks to snack on during the break should be provided to the mothers and children.
4. After the break, the first half of the team repeats the whole process and measures each child for the second time and records his/her measurements onto the standardisation test form for the second round of measurements. After the the first half of all the teams has measured 10 children twice, the second measurement round forms are handed in. The teams and the children then take a break for lunch (end of first half of the day/first half of the test). Appropriate lunch arrangements should be prepared for the mothers and children.
5. After the lunch break or on a new day altogether, the whole process is done all over again but this time, the second half of the teams will be performing the measurements. Ideally, the same set of mother and child pairs should be utilised for the second half day of testing. However, it may be that some of the mothers will be unable to come back to help. If for the second half day of testing the mother and child pairs are different from the first half day, then measurements made in the second half day cannot be mixed with the data

from the first half day when reporting on the performance in the standardisation test of the survey personnel.

Bibliography

- Accion Contra la Faim (2011). Semi-Quantitative Evaluation of Access & Coverage (SQUEAC) Greater Monrovia Liberia. Technical report, Accion Contra la Faim, London.
- Balegamire, S., Siling, K., Alvarez, J. L., Guevarra, E., Woodhead, S., Norris, A., Fieschi, L., Binns, P., and Myatt, M. (2015). A single coverage estimator for use in SQUEAC, SLEAC, and other CMAM coverage assessments. *Field Exchange*.
- Bivand, R., Pebesma, E., and Gómez-Rubio, V. (2013). *Applied Spatial Data Analysis with R*. Use R! Springer New York.
- Diggle, P. (2013). *Statistical Analysis of Spatial and Spatio-Temporal Point Patterns, Third Edition*. Chapman & Hall/CRC Monographs on Statistics & Applied Probability. Taylor & Francis.
- Diggle, P. and Ribeiro, P. (2007). *Model-based Geostatistics*. Springer Series in Statistics. Springer.
- Epicentre (2015). Open review of coverage methodologies: Questions, comments and ways forward. Technical report, Epicentre.
- Garenne, M., Willie, D., Maire, B., Fontaine, O., Eeckels, R., Briand, A., and Van den Broeck, J. (2009). Incidence and duration of severe wasting in two African populations. *Public Health Nutrition*, 12(11):1974–1982.
- Isaaks, E. and Srivastava, R. (1989). *Applied Geostatistics*. Oxford University Press.
- Myatt, M. (2012). How do we estimate case load for SAM and / or MAM in children 6 – 59 months in a given time period ? CMAM Forum.
- Myatt, M., Guevarra, E., Fieschi, L., Norris, A., Guerrero, S., Schofield, L., Jones, D., Emru, E., and Sadler, K. (2012). *Semi-Quantitative Evaluation of Access and Coverage (SQUEAC)/ Simplified Lot Quality Assurance Sampling Evaluation of Access and Coverage (SLEAC) Technical Reference*. FHI 360/FANTA, Washington, DC.
- R Core Team (2018). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria.

- Sununtnasuk, C., D'Agostino, A., and Fiedler, J. L. (2015). Iron+folic acid distribution and consumption through antenatal care: identifying barriers across countries. *Public Health Nutrition*, 19(04):732–742.
- Tanahashi, T. (1978). Health service coverage and its evaluation. *Bulletin of the World Health Organization*, 56(2):295–303.
- Wegerdt, J., Zanchettin, M., and Myatt, M. (2006). Assessing sensitivity of case-finding using capture-recapture techniques. *Field Exchange*, (27):2.