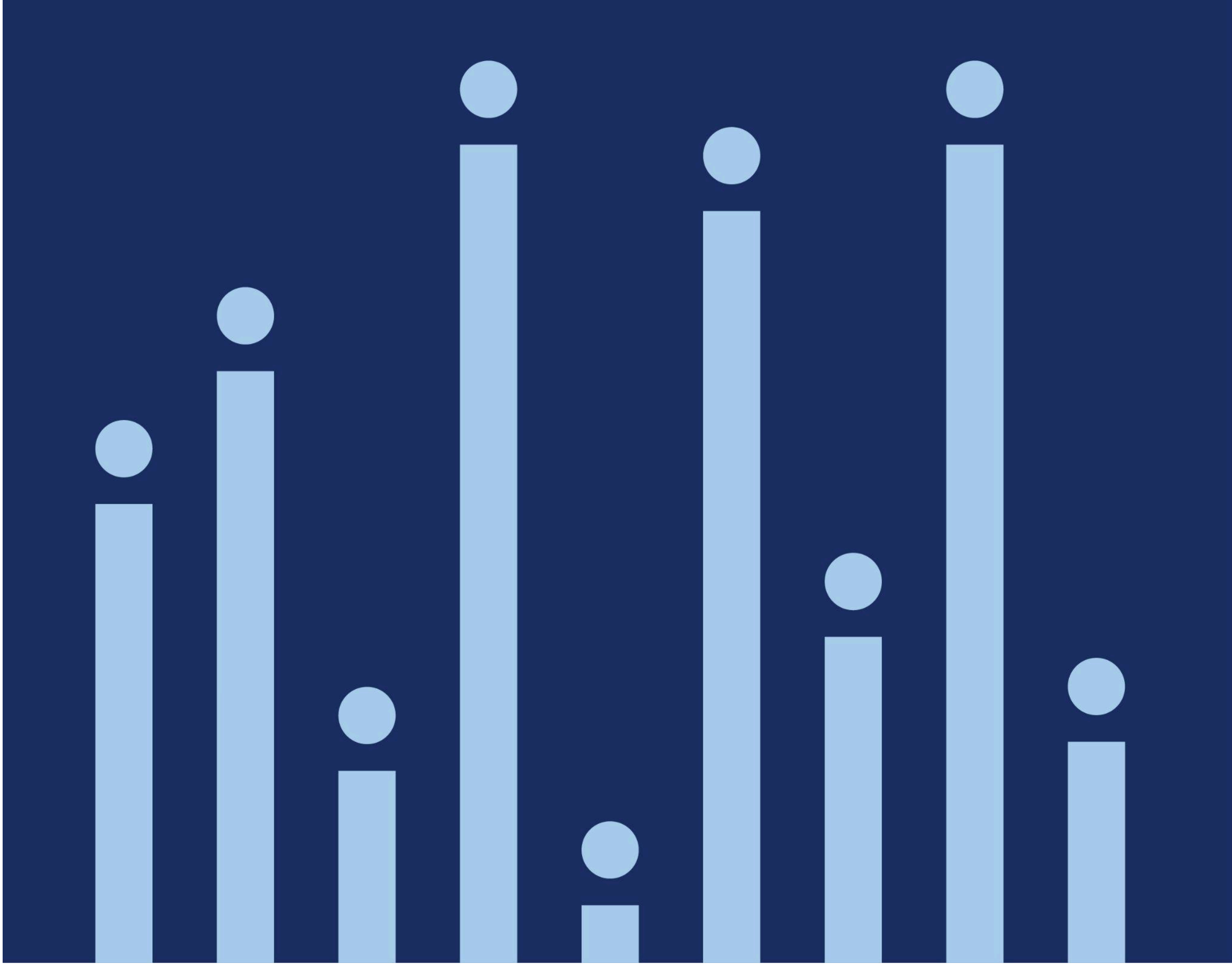


Estimating Populations

IDinsight’s summary & recommendations to GiveWell

7th February 2023

IDinsight

Table of Contents

Acronyms

AIS	Aids Indicator Surveys
CIESIN	Centre for International Earth Science Information Network
CRVS	Civil Registration & Vital Statistics
DG REGIO	Directorate General for Regional and Urban Policy
DHS	Demographic Household Survey
GHSL	Global Human Settlement Layer
GRID3	Geo-Referenced Infrastructure and Demographic Data for Development
HDX	Humanitarian Data Exchange
HKI	Helen Keller International
HRSL	High Resolution Settlement Layer
IDI	In-Depth-Interview
IPUMSI	Integrated Public Use Microdata Series International
JRC	Joint Research Centre
LGA	Local Government Area
LMIC	Lower & Middle Income Countries
LSMS	Living Standards Measurement Study
MICS	Multiple Indicator Cluster Surveys
MIS	Malaria Indicators Surveys
SIS	Social Indicators Surveys
SMC	Seasonal Malaria Chemoprevention
SSA	Sub-Saharan Africa
UNHCR	United Nations High Commissioner for Refugees
UNPD	United Nations Population Division
UNSD	United Nations Statistics Division
WHO	World Health Organisation
WPP	World Population Prospects

Executive Summary

PURPOSE OF THE REPORT

GiveWell is committed to identifying highly cost-effective giving opportunities through the use of data and evidence. One of the four criteria used to inform GiveWell's grantmaking is cost-effectiveness. In order to assess cost-effectiveness, GiveWell requires an estimate of how many people the charities' programs reach. This can be obtained in a number of ways, but for mass distribution charities, one way to obtain this is through a combination of coverage surveys and target population estimates.[1] GiveWell commissioned this study to provide recommendations to GiveWell for how they can provide alternative population estimates and mitigate this potential limitation of their cost-effectiveness model.

In this report, we compile information and expertise from existing literature, interviews with charities, and interviews with population estimate experts to inform a recommendation to GiveWell.

SUMMARY OF MAIN FINDINGS

Population estimates are generated from a combination of census data, civil registration and vital statistics, population surveys, and administrative data, such as health facility attendance. While censuses are seen as the gold standard of population estimation, they are only conducted every ten years or more. Therefore, accurate estimation requires more data.

The most prominent innovation in the field of population statistics is geospatial population modeling, which uses satellite imagery and other spatial information to improve on population estimates. This is done in two ways: 1) top-down modeling; and 2) bottom-up modeling. Top-down modeling is a census-dependent method that takes estimates such as the UN Population Division (UNPD) estimates and disaggregates it into population estimates for cells that can be as small as 30mx30m. Bottom-up estimates are not census-dependent. Instead,they rely on smaller population surveys and a large amount of modeling to estimate populations. This is generally done in countries where there has not been a recent census conducted.

There are a number of different platforms that produce estimates using geospatial population methods. This study provides an overview of the most relevant platforms, including WorldPop, LandScan, Meta High Resolution Settlement Layer, and the European Commission's Global Human Settlement Layer.

The other main source of population estimates is from the government itself. These estimates may incorporate the methods described above or may include other adjustments to the last census. These estimates are typically the ones provided by GiveWell's recommended charities ("charities" going forward) as the charities operate in close partnership with governments.

This study includes example data which shows that there can be meaningful variation in population estimates provided by different data sources. Further, the most accurate source is highly dependent on country context. Assessing the reliability of these sources therefore requires significant expertise. Simply replacing official estimates with estimates from a single alternative source is therefore unlikely the best solution across the contexts in which the charities work.

[1] For other types of charities and programs, reach data is reported as count data.

CORE RECOMMENDATION

IDinsight recommends that GiveWell should engage with a population estimation organization to provide an annual assessment of which data source to use for population estimates for each country in which charities are working.

This organization should:

- Be able to assess the reliability and accuracy of population data
- Have experience working with governments in Sub-Saharan Africa and/or South Asia
- Have experience working with a range of projects and clients
- Be able to work with GiveWell-supported charities to map geospatial boundaries
- Have significant experience in bottom-up population estimation

The following 5 points detail the rationale of this recommendation and how it improves the status quo:

1. **Official government estimates are not necessarily unreliable**
    - A partnership with an organization that has detailed knowledge of how governments estimate populations will help to understand if and how estimations can be improved
2. **Understanding the reliability of official government estimates is a complex matter and requires specific expertise**
    - A partnership with an organization that contains demographers and other experience of assessing reliability of censuses and other mechanisms of government population estimation is the best way to understand reliability
3. **The reliability of population estimates (official and other) is dynamic**
    - A partnership with a population estimation organization will allow GiveWell to leverage the institutional knowledge of the organization about the latest developments in official or modeled population estimations
4. **The data submitted by charities may not always match the official administrative boundaries**
    - A partnership with an organization that can work with charities to map boundaries and estimate populations will facilitate efficient resolution of mismatched boundaries
5. **There may be some countries where population estimates are low quality and the only way to improve is a bottom-up estimation.**
    - A relationship between GiveWell, their charities, and an organization that has experience with bottom-up estimation in Sub-Saharan Africa or South Asia will facilitate progress and contribution to bottom-up modeling.

ADDITIONAL RECOMMENDATIONS

GiveWell should also encourage charities to submit clear data information and details when submitting population estimates. In order to improve population estimates, it is critical to understand exactly where the data has come from. Some suggested information includes what exact data sources are used, what type of modeling, and which spatial boundaries the estimates represent.

Another recommendation is for GiveWell to leverage synergies between themselves, their charities, governments and the population experts to improve or expand bottom-up estimates. Accurate population estimates are useful to all stakeholders and each stakeholder can help contribute to improving them through bottom-up geospatial population methods. GiveWell should explore options to support this activity.

IDinsight

Introduction & Methodology

Context

Estimates of program reach for mass distribution charities in GiveWell's cost-effectiveness model are dependent on official government estimates of population, which may not always be accurate.

A key input to the GiveWell cost-effectiveness assessment is the number of people reached by the charity. This can be obtained in a number of ways, but for mass distribution charities, one way to obtain this is through a combination of coverage surveys and target population estimates. First, coverage surveys are conducted to give an estimate of the percentage of the target population that the charity has reached.[2] Second, this is converted to the number of people reached, by multiplying it by estimates of the target population (also known as "the denominator").

Accurate estimates of target populations can be difficult to obtain, particularly in remote areas of Lower & Middle Income Countries (LMICs). The mass distribution charities supported by GiveWell tend to work in large scale, multi-stakeholder programs that are typically led by national or state governments. As such, the target population estimates currently used for GiveWell's model may need to be endorsed by either national or state governments. These official estimates are not necessarily inaccurate but currently, the charities are not required to share the way in which they have been generated. As a result, there remains uncertainty about the accuracy of official estimates used by governments and consequently about a critical component of GiveWell's cost-effectiveness model.

As part of this project, we considered four organizations that GiveWell has supported for which GiveWell uses this method to calculate reach: Malaria Consortium's seasonal malaria chemoprevention program, Helen Keller International's vitamin A supplementation program, Sightsavers' deworming program and Evidence Action's Deworm the World. These four charities received $46.4 million dollars in GiveWell grants in 2022 (GiveWell, 2022[3]) and report to reach almost 12 million children (GiveWell, 2022[4]) .

Per GiveWell's model, improvements in the accuracy of population estimates will result in an improvement in the allocation of funds as a percentage of total funding allocated to relevant charities.

GiveWell commissioned IDinsight to support them to identify and assess existing methods to population estimation and to provide recommendations on how GiveWell can leverage these methods going forward.

---

[2]This report focuses on population estimates, and coverage surveys are out of scope. However, we note that coverage survey improvements are also an important way to get more accurate estimates of reach.
[3] https://www.givewell.org/top-charities-fund
[4] https://docs.google.com/spreadsheets/d/1tytvmV_32H8XGGRJlUzRDTKTHrdevPlYmb_uc6aLeas/edit#gid=472531943

Methodology

The goal of this study is to provide recommendations to GiveWell for how they can improve the population estimates they are using in their cost-effectiveness model. To achieve this, we sought to understand:

1. How charities are currently submitting estimates
2. The different approaches to population estimation
3. The best alternative population estimates
4. Who are the key stakeholders involved with estimating populations

We engaged in the following activities:

- In-depth-interviews (IDIs) with four relevant mass distribution charities recommended by GiveWell
- In-depth-interviews with population estimates
  - 6 IDIs with geospatial population modeling experts[5]
  - 3 IDIs with statistical population modeling experts
- Desk research

[5] Initially we looked at speaking with experts from organizations that innovate and civil registration & vital statistics, as well as people using telecommunications data for population estimates. However, none of these seemed like practical solutions to GiveWell's challenge and so we focused on geospatial (satellite) population experts & standard statistical population experts.

Population Data

Population data submitted by charities

Charities submit official government estimates for their target populations, which are either children under-5 or school-age children.

All of the mass distribution charities considered in this study work on programs relating to health outcomes of children. The exact target population varies between children aged 3-59 months and children of school age. This means that any improvement on population estimates needs to have estimates for age breakdowns at least as specific as 5-year age groups.

Further, the administrative level at which data is submitted depends on the country and the level at which the coverage surveys are conducted. GiveWell supports (or has recently supported) programs across 17 countries[6] for these four mass distribution charities (GiveWell, 2022[7]). The mass distribution charities' data is reported at various administrative levels across these 17 countries, meaning that improved population estimates will be needed at the same variety of administrative levels.

The IDIs with the mass distribution charities highlight two consistent messages: 1) the way in which governments estimate populations varies considerably across countries; and 2) since the charities' programs tend to be government-led, the charities rely on government-supported data sources for reporting. In order to improve population estimates, an assessment of how the current estimates are generated will need to be conducted.[8]

Data sources

The United Nations Statistics division identifies three main sources of demographic and social statistics data: censuses, surveys and administrative records (Suharto, 2001)[9]. For population estimation purposes, civil registration and vital statistics data (CRVS) are critical. Therefore, in this report, we consider CRVS and other administrative data sources as two separate administrative records. The four key data sources for estimating populations are:

1. Census
2. Civil registration & Vital Statistics (CRVS)
3. Population surveys / Micro-Census
4. Other administrative data

Censuses

Censuses are designed to capture data from the entire nation and are generally conducted every 10 years to provide governments with information on their population. When a census is conducted well, it is a real count of the entire population, broken down by demographics such as age and gender, so it is seen as the gold standard of population estimates. If a census has been conducted recently in a country, with high reliability, it is generally the only data source required for population estimates.

---

[6] Nigeria, Guinea, Burkina Faso, Cameroon, DRC, Guinea-Bissau, Kenya, Mali, Niger, Chad, Cote d'Ivoire, Ethiopia, India, Pakistan, The Gambia, Vietnam

[7] https://www.givewell.org/top-charities-fund

[8] A further consideration is that charities may receive information through more informal, local or contextual knowledge that they are exploring to use for decisions on a more micro- and planning level.

[9] https://unstats.un.org/unsd/demog/docs/symposium_03.htm

We heard from expert IDIs that there are a number of factors that determine if a census has been conducted well, including implementation of census, data collection accuracy, representativeness, political biases, and whether there are any limitations to data collection, such as active conflict. Accuracy can be measured using post-enumeration surveys that compare the same data collected via census for a sample of households. However, such surveys are not necessarily publicly available[10] in countries that the charities operate in. Further, there are a number of factors that determine whether a census conducted relatively recently is still a reliable data source, including the extent of internal migration, changes in birth or death rates, the degree of urbanization and other contextual factors that may have changed relative to the last census.

Civil Registration & Vital Statistics

Civil registration and vital statistics (CRVS) systems aim to register all births and deaths and compile vital statistics such as cause of death information. A well functioning CRVS system is essential for accurate population estimates as mortality and fertility are key components in population projection models. It is estimated that tens of millions of births are not registered each year and that up to two-thirds of deaths are never registered (WHO, 2022)[11] and many of these unregistered births and deaths are in LMICs.

Population surveys / microcensus

Population surveys, or microcensuses, are used either as a complement to census data, or as a replacement when the most recent survey is very old or deemed unreliable. There are a number of publicly available population surveys, such as the Demographic Household Survey, which are a consistent source of population data. These surveys are conducted on a smaller scale compared to a census but can be combined with other sources, such as satellite imagery, to scale up to give larger population estimates. They are also a useful source for triangulation with a census and therefore an indication of reliability.

Other administrative data

Administrative data can come from a number of sources, including voter rolls, health management information systems, schools and the education system, and other government institutions. Such administrative data is not routinely used in population estimates but it can provide an alternative source of information to the census to validate it. There can be issues with data availability and data quality of administrative data, depending on the country.

[10] We are unable to find out how many countries publish post-enumeration surveys for censuses conducted in their country
[11]https://www.who.int/data/data-collection-tools/civil-registration-and-vital-statistics-(crvs)

Statistical population estimation modeling

United Nations Population Division

The United Nations Population Division[12](UNPD) is a division of the UN Department of Economic and Social Affairs which is focused on population estimates and prospects. They combine multiple data sources to inform these estimates, with population census data being their principal source. The population estimate product they release is known as the World Population Prospects.

Approach

The full methodology can be found in the World Population Prospects Methodology report[13] (United Nations, 2022), and we provide a brief summary below using information from the report.

The core approach underlying population estimates conducted by UNPD is the cohort-component method for projecting population which relies on three key components - fertility, mortality, and international migration. CRVS systems, as described above, are used to estimate fertility and mortality, whereas international migration is measured using official government estimates, UNHCR estimations, or by the residual unaccounted for by other growth, depending on the context.

The preferred source of data on fertility is counts of live births from a system of civil registration with national coverage and high level of completeness. Where this is lacking, fertility estimates are typically obtained through sample surveys, including Demographic and Health Surveys (DHS), Multiple Indicator Cluster Surveys (MICS). For most countries, recent direct or indirect information on fertility is available to inform the official 2022 estimates.

Estimating mortality relies on two different methods, depending on availability of data - “empirical” and “model-based”. The empirical approach is used for 113 countries with reliable[14] information to describe sex- and age-specific mortality rates from vital registration statistics. The model-based approach is used for 124 countries and requires one or more mortality indicators as inputs (e.g. under-five mortality rate or life expectancy at birth).

In order to estimate the current population, UNPD estimates population retrospectively using data from the last 70 years and compares estimates with the periodic censuses over the time period as the benchmark for population accuracy. At the global level, population data from censuses or registers referring to 2017 or later are available for 127 countries or areas, representing 54% of the 237 countries or areas included in this analysis. For 45 countries or areas, the most recent available population count is from the period 2012-2016, and for another 50 locations from the period 2007-2011. For the remaining 15 countries or areas, the most recent available census data are from before 2007. The most recent census in each country can be found here[15] (UNSD, 2022).

Importantly, UNPD data is not modeled nor reported at the subnational level. This means it cannot be used on its own to estimate populations within a country. However, it is regularly used in combination with other data sources on population distribution to provide accurate estimates on subnational levels.

---

[12] https://population.un.org/wpp/Methodology/
[13] https://population.un.org/wpp/Publications/Files/WPP2022_Methodology.pdf
[14]The methodology report does not provide specific details on what criteria define ‘reliable’ but it may include coverage rates or validation against other surveys, such as the Demographic Health Survey.
[15] https://unstats.un.org/unsd/demographic-social/census/censusdates/

US Census Bureau

The US Census bureau produces and compiles population estimates, including subnational population by sex, age and geographic area for a number of countries around the word, including many in Sub-Saharan Africa and South Asia. The methods used to calculate the subnational estimates depend on the country being estimated and, similar to UNPD estimates, are based on the most recent census. The main value added by the US Census Bureau compared with UNPD estimates is that it is modeled at the lowest administrative unit available in the data sources. Full details of the methodologies used in each country can be found here[16] (Leddy, 2016) and the list of countries where this data is available can be found here[17] (US Census Bureau, 2022).

WorldPop's Demographic Dataset

WorldPop have produced a global denominator dataset of populations by gender and 5-year age groups for every country in the world. This data has been assembled using various sources, prioritizing census data wherever available. The methodology is described briefly in this paper[18], and a summary is below (Carioli et al, 2019).

For those countries where recent full census data is not available, sources such as microdata from the Integrated Public Use Microdata Series International (IPUMSI) database[19] (Minnesota Population Center, 2020); Demographic Household Survey (DHS); Malaria Indicators Surveys (MIS); Aids Indicator Surveys (AIS); Social Indicators Surveys (SIS); and Multiple Indicator Cluster Surveys (MICS) are used, with priority given to household surveys from recent years and by sample size. For African and Asian countries, 30 of the 87 countries' data is derived from full censuses, 17 from IPUMSI microdata, 19 from traditional DHS, 4 from MIS/AIS/SIS and 8 from MICS. For the 9 countries where subnational data on population age and sex structures are not available, 2010 UNPD country level estimates are used.

It should be noted that for this dataset, since the priority is to construct age/sex proportions, datasets are chosen that could provide this information. This meant that more spatially detailed or recent datasets may not be used, and the efforts to adjust boundaries and do other corrections of population totals that are usually undertaken, are not prioritized.

Geospatial modeling

Satellite imagery can be used to improve on population estimates in two ways: 1) top-down modeling; and 2) bottom-up modeling (World Pop, 2022[20]). Top-down modeling takes pre-existing census data or UNPD population estimates, combines it with a set of geospatial datasets, and disaggregates the inputted population data into grid cells. Bottom-up modeling uses data from as many trustworthy and recent survey datasets as possible, combines it with detailed geospatial datasets to build a statistical model to estimate population numbers and age/sex breakdowns. It is most commonly done in countries where census data is deemed to be unreliable. Both top-down and bottom-up approaches typically use machine learning techniques.

[16] https://www2.census.gov/programs-surveys/international-programs/about/global-mapping/subntl-pop-est-methods-pgs-uscb-dec16.pdf
[17] https://www.census.gov/geographies/mapping-files/time-series/demo/international-programs/subnationalpopulation.html
[18] http://paa2019.populationassociation.org/uploads/192031
[19] https://international.ipums.org/international/citation.shtml
[20] https://www.worldpop.org/methods/populations/

There are three key factors that describe how a given gridded population product is produced:

- Input data (census data, administrative boundary data, geospatial correlates)
- Data adjustment (population estimates from UNPD, surveys or other)
- Modeling method (areal weighting, dasymetric mapping, random forest, etc)

Top-down

Top-down datasets start with census data based on administrative units and then use a set of geospatial datasets to disaggregate the census into grid cells. The geospatial datasets include things such as building footprints, land use such as forest cover, night time lights, or road coordinates. Grid cells can range from 1kmx1km to 30mx30m or even lower[21].

The main benefit of this approach is that it disaggregates datasets into grids, or more simply, much smaller units than the lowest administrative unit reported in the census. If population data is only available at administrative level 2 then the grids (which are disaggregated from administrative level 2) can be aggregated upwards to administrative level 3 if that is required for analysis. Further, if the area of interest is not an administrative unit, but a school catchment area for example, then population estimates can be obtained from that area provided that the boundaries are known. Other than the disaggregation and reaggregation to the correct level, top-down is not typically an improvement on census or other modeled estimates, and suffers from the same problems of reliability if census data is outdated.

Bottom-up

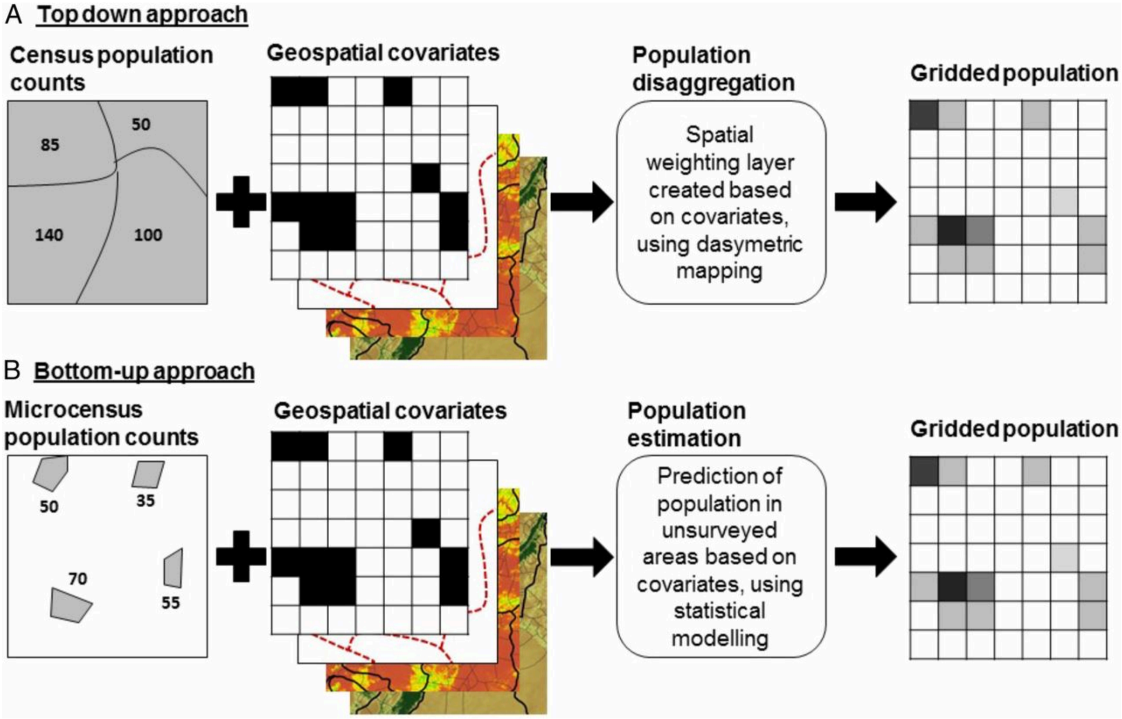
Bottom-up datasets start with data from as many trustworthy and recent survey datasets as possible, in some cases commissioning data collection efforts as a data input. Detailed geospatial datasets (the same types as in top-down) are then used to build a statistical model, based on the survey datasets, to estimate population numbers and age/sex breakdowns in unsampled locations. This geospatial data needs to be (i) strongly correlated to population density and (ii) available consistently across all areas where the population estimation is required.

The benefit of this approach is that it can produce more accurate outputs than top-down estimation where census data is outdated and/or census projections are highly uncertain. Because the primary objective of bottom-up estimation is to predict in areas not covered by a census, validation or accuracy tests of the population estimates are rare. However, where accuracy tests have been done, results indicate a decent correlation between predicted and observed population estimates, particularly for larger administrative units (Wardrop et al, 2018[22]). Further, because the estimates are heavily modeled, uncertainty is measured and reported (through confidence intervals, or otherwise) at the administrative unit level, which can highlight where caution needs to be taken in trusting estimates. This can also be used as an indication of where further data collection could be prioritized (WorldPop website, 2022).

A big disadvantage is the level of effort required for this process, either from data collection or from modeling which is typically country or region specific. Further, estimates are tied to a single year and are likely only to be valid for a few years, depending on the country context) or until more data is collected.

[21] https://www.worldpop.org/methods/populations/
[22] https://www.pnas.org/doi/10.1073/pnas.1715305115#sec-4

Figure 2: Graphical representation of Top-Down vs. Bottom-up (Wardrop et al, 2018)



Geospatial Platforms

There are a number of geospatial organizations, platforms, and datasets available and choosing the correct one depends on a number of factors, discussed in the next section. We provide a brief overview of some of the most relevant geospatial platforms below. Full details of each platform can be found in the Designing and Implementing Gridded Population Surveys[23] (Thompson, 2022), up-to-date as of 2022, and in the Leaving No One Off The Map[24] document (PopGrid, 2020), which was released in 2020 but is already out of date on some aspects.

WorldPop

Summary: Focused in Sub-Saharan Africa, WorldPop uses top-down and bottom-up solutions in their work with governments and other stakeholders.

Main Products: As well as the Demographic Dataset mentioned above, WorldPop produces different types of gridded population count datasets, depending on the methods used and end application. WorldPop produces the WorldPop Global-Constrained & -Unconstrained datasets. The Constrained version distinguishes between unsettled and settled land and derives estimates from the total population divided by the settled area only in an administrative unit. Whereas, the Unconstrained dataset estimates are derived from total population divided by the entire land area in an administrative unit. This means that there shouldn't be a large difference at the administrative unit that the inputted population data is provided at, but there will be difference for any lower administrative unit or for the gridded population estimates

WorldPop also produces bottom-up estimates, some of which are publicly available through their woprVision[25] tool[26]. They often do this in partnership with governments, and some of their estimates are not publicly available. This means that in some cases, official government estimates may be prepared by WorldPop and be accurate and reliable.

For all products, data is available at gender and 5-year age breakdowns.

Organization Structure: WorldPop is also a core partner of the Geo-References Infrastructure and Demographic Data (GRID3[27]) , a program that works with countries to generate, validate and use geospatial data on population, settlements, infrastructure and boundaries. GRID3 combines top-down and bottom-up approaches, depending on country needs and is focused on Sub-Saharan Africa.

[23] http://gridpopsurvey.com/wp-content/uploads/2022/09/Designing_and_Implementing_Gridded_Population_Surveys_2022.pdf
[24] https://www.popgrid.org/sites/default/files/documents/Leaving_no_one_off_the_map.pdf
[25] https://apps.worldpop.org/woprVision/
[26]Burkina Faso, DRC, Ghana, Guinea, Mozambique, Niger, Nigeria, Senegal, South Sudan, Zambia
[27] https://grid3.org/solution/high-resolution-population-estimates

Oak Ridge National Laboratory

(LandScan)

Summary: OakRidge National Laboratory runs the LandScan Program, and has vast experience in population estimation, with particular strength in the humanitarian context with high quality maps in countries with ongoing, or previous, conflict.

Main Products: LandScan produces two relevant products: LandScan Global and LandScanHD. LandScan Global is a top-down product with resolution at approximately 1kmx1km. The population estimates represent ambient population (the 24-hour average) rather than where people live.

The LandsScanHD product, however, is a bottom-up model with a much more detailed resolution at 90mx90m. It is only available in a subset of countries[28]. LandScan HD modeling is tailored to the unique geography and data conditions of individual cities, countries, or regions. The countries are specifically chosen to be in parts of the world that regularly experience large changes in population distribution due to rapid growth, natural hazards or conflict[29].

Data is not publicly available for age and other demographic breakdowns.

Organization Structure: The LandScan Program is run by OakRidge National Laboratory and funded by the US government. It was initiated 1997 to address the need for improved estimates of population for consequence assessment. For example, natural and manmade disasters across the globe place vast populations at risk, often with little or no advance warning.

[28] Afghanistan, Bahrain, Cuba, Ethiopia, Egypt, Honduras, Iran, Iraq, Lebanon, Mali, Nigeria, North Korea, Pakistan, Russia, South Korea, South Sudan, Syria, Taiwan, Ukraine, Venezuela, West Bank,Yemen, Zambia
[29] https://landscan.ornl.gov/about

Meta

(High Resolution Settlement Layer)

Summary: Meta (previously Facebook) produces a population dataset for public consumption, the motivation for which is largely for their own internal purposes, with little government or other external engagement.

Main Products: Meta produces the High Resolution Settlement Layer (HRSL), a lightly modeled dataset that produces very detailed estimates available at 30mx30m grids**.**

Meta uses computer vision techniques to identify buildings from commercially available satellite images. Using this building information, Columbia University (CIESIN) use census data to generate population estimates, validates the result against other, more coarse-grained datasets and then the World Bank Living Standards Measurement Study (LSMS) program validates the final dataset against anonymized "ground-truth" household surveys[30].

Data is available at gender and five-year age breakdowns.

Organization Structure: The population datasets are a joint effort between Meta's "Data for Good" team, CIESIN, and the World Bank.

[30] https://engineering.fb.com/2016/11/15/core-data/open-population-datasets-and-open-challenges/

(Global Human Settlement Layer)

Summary: A lightly modeled top-down dataset, that is much improved in its 2022 version, but does not provide population estimates at age breakdowns.

Main Products: The Global Human Settlement Layer's GHS-POP, initially released in 2015 but with an improved version re-released in 2022 at much higher resolution (100mx100m) and an additional strong building footprints dataset, is a lightly-modeled dataset that uses UNPD estimates and projections. A strength of this dataset is the consistency of the model outputs over time, which makes population estimates comparable across years (Thompson, 2022[31]).

GHSL also produces a buildings footprint layer called the GHS BUILT-UP and a dataset for the degree of urbanization called the GHS-SMOL, as well as other products relating to buildings.

The GHS-POP dataset does not provide population estimates at 5 year age breakdowns.

Organization Structure: The GHSL is supported by the Joint Research Centre (JRC) and the Directorate General for Regional and Urban Policy (DG REGIO) of the European Commission, together with the international partnership GEO Human Planet Initiative.

[31] http://gridpopsurvey.com/wp-content/uploads/2022/09/Designing_and_Implementing_Gridded_Population_Surveys_2022.pdf

How do the geospatial platforms compare with each other

A study conducted in Bioko Island, Equatorial Guinea measured the accuracy of different gridded population estimates (Fries et al, 2021[32]). The study used census data from a bed-net mass distribution campaign as the gold standard to evaluate LandScan Global, WorldPop-Constrained, WorldPop-Unconstrained, and Meta HRSL.

They found that LandScan Global was the most accurate in higher density, urban areas, whereas HRSL and WorldPop-Constrained were the best in areas of lower population density and the best overall. The HRSL had the best performance overall and was very similar to the census in terms of percent urban, percent empty, and overall island population total. It did not match the census distribution at high population densities (above 1000 people per square kilometer) though. WorldPop-Constrained consistently under-reported populations in urban areas but overall was similar to HRSL. LandScan Global, whilst most accurate in urban areas, is limited by its inability to produce estimates at the 100mx100m level. This means it cannot provide specific estimates for smaller settled areas such as villages or small towns. WorldPop-Unconstrained performed poorly everywhere, because it does not rule out any areas as uninhabited (e.g. large forest reserves) unlike the other platforms. This has a particularly large impact on population estimates in this context.[33]

An article published in Earth System Science Data (Leyk et al, 2019) presents, compared and discussed a set of large-scale gridded datasets representing population counts or densities. It focused on data properties, methodological approaches and relative quality aspects through the lens of the "fitness for use" concept. The article described a number of aspects that need to be considered when selecting which model is the most appropriate for different uses:

- **The quality of the data**, including accuracy of census/population data, modeled population estimates and all the geospatial data used.
- **The processing- and model-related uncertainty**. Any data processing will create uncertainty where the more highly modeled datasets will have greater uncertainty. This will vary for each model across contexts and requires a specific assessment of the datasets in a given context.
- **Validation of population data** is a time-consuming and expensive process, which requires comprehensive data collection, as described above in the Fries et al (2021) paper, making it difficult to say with certainty which models are the best.

[32] https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0248646
[33] There do not appear to be (public) direct comparisons of population estimates from different platforms based on how they perform at estimating sub-populations such as age and gender.

A summary of key population estimate data sources

Table 1: Summary of key population platforms, their coverage, level available at and other comments

Platform	Coverage	Level available at	Comments	Subgroup (e.g. age)	Subnational
Statistically Modeled Datasets					
UNPD / WPP	Global	National	Generally perceived by experts to be the 'gold standard' of national population estimates and is used in many other datasets to constrain estimates to the UNPD national totals. Can be combined with proportions from the most recent census to provide subnational estimates, but it is uncertain whether this is an improvement on official estimates.	✓	✗
US Census Bureau	~40 Selected Countries (Link)	Administrative level 1-2 depending on country	Although the modeling techniques used are good and the estimates reliable, the lack of global coverage makes consistency across countries difficult. The 40 countries mentioned here are the ones that have subgroup and subnational data available.	✓	✓
WorldPop Demographic Dataset	Global	Administrative level 1-2 depending on country	Selects the most accurate inputted data source on a country-by-country basis and uses a variety of modeling techniques to produce population estimates at varying administrative levels for age and gender demographics.	✓	✓
Top-Down Geospatial Datasets					
Meta HRSL	Global	Gridded ~30mx30m	The data validation conducted by Fries et al (2021) indicated that this was overall the most accurate geospatial dataset, particularly in rural areas. Note this is only one study in one country context. Further, the next version, expected in 2023, is prioritizing improvements to urban estimates.	✓	✓
GHS-POP	Global	Gridded ~100mx100m	Lightly modeled dataset which had a new version released in 2022 which has not yet been publicly assessed for accuracy and reliability.	✗	✓
WPG-Constrained	Global	Gridded ~100mx100m	The data validation conducted by Fries et al (2021) suggested that this was one of the more accurate datasets overall, particularly in rural contexts. Note this is only one study in one country context.	✓	✓
LandScan Global	Global	Gridded ~1kmx1km	The data validation conducted by Fries et al (2021) suggested that this was the most accurate at predicting urban environments. Note this is only one study in one country context.	✗	✓
Bottom Up Geospatial Datasets					
LandScanHD	23 Selected Countries[34], particularly those with conflict	Gridded ~100mx100m		✗	✓
WorldPop Bottom-up	10 Selected Countries[35] in Sub-Saharan Africa	Gridded ~100mx100m	Can be viewed and population estimates extracted using the WoprVision online tool	✓	✓

[34] Afghanistan, Bahrain, Cuba, Ethiopia, Egypt, Honduras, Iran, Iraq, Lebanon, Mali, Nigeria, North Korea, Pakistan, Russia, South Korea, South Sudan, Syria, Taiwan, Ukraine, Venezuela, West Bank,Yemen, Zambia

[35] Burkina Faso, DRC, Ghana, Guinea, Mozambique, Niger, Nigeria, Senegal, South Sudan, Zambia

Sample dataset comparisons

This section compares some of the data sources listed above for three different charity/country contexts. These example comparisons show the different data sources that would need to be compared for each charity's country submissions. In order to select the most accurate denominator estimate, each data source would need to be assessed in the specific country context.

The objective of these examples is not to make a definite recommendation of one data source over another, but to illustrate the potential disparities occurring between country contexts and data sources. In the below, we illustrate findings from a relatively light analysis of three case studies[36]:

1. Malaria Consortium in Zamfara State, Nigeria
2. Malaria Consortium in Burkina Faso
3. Helen Keller International in Guinea

A more comprehensive and systematic exercise across charities and country contexts - coupled with additional, contextual information - would be required to provide a more thorough analysis of the trade-offs involved in deciding which estimates to use.

Depending on the country, the tables compare a combination of: the data submitted by charities; data from the WorldPop Demographic Dataset; data from the WorldPop-Constrained model; data from Meta HRSL; data from WorldPop's bottom-up WoprVision tool; data from an official government census. We chose these data sources because they are the only data sources available that provide estimates at the same age breakdowns as the submitted charity data. We provide all data sources at the end of the Comparing Datasets section.[37]

The critical finding here from these example datasets is that **there is significant variation across countries, in terms of both the difference between submitted charity data and other estimates; and the difference between estimation platforms.** There is also a suggestion that the data submitted by charities may not match the official administrative boundaries

[36] Note that the population estimates are not reported by the charities themselves but by the overall programs that they are working in which have multiple stakeholders

[37] We present WorldPop Demographic database, WorldPop-Constrained and Meta HRSL for all countries as these are the most comparable. WorldPop's bottom-up estimation is presented in Nigeria to show how it differs from other estimates. Official Statistics office data is presented for Burkina Faso to emphasize the point that the submitted data is different from official estimates and therefore represents something other than an accuracy issue.

Example 1: Malaria Consortium in Zamfara State, Nigeria

Key findings:

- The total population data submitted by Malaria Consortium is relatively similar to that of WorldPop-Constrained and Meta HRSL, however there are fairly substantial differences at the LGA level, for example in Maradun LGA, where WorldPop-Constrained and Meta HRSL both report populations over 30% higher.
- All total population estimates are higher than those submitted by Malaria Consortium, but this could be due to population growth due to the difference in time that the data refer to[38].
- The bottom-up estimation of WoprVision is substantially different from other estimates in some LGAs, for example, in Gusau, WoprVision reports population of children aged 3-59 months to be 160,696, whereas in in Meta HRSL and WorldPop Constrained it is only 97,219 & 98,087, respectively.
- WorldPop-Constrained and Meta HRSL estimates are relatively similar.
- Direct feedback from the WorldPop team is that in Nigeria, the bottom-up WoprVision data is the most reliable.

Table 2: Population estimate comparison for Malaria Consortium submitted data in Zamfara State, Nigeria

LGA	Malaria Consortium SMC 2017 Target Population (3-59 months)	Population according to WorldPop Demographic database 2019		Population according to WorldPop-Constrained model (Top-Down)		Population according to Meta HRSL (Top-Down)		Population according to WoprVision (Bottom-up)	
Anka	**37,023**	38,691	4.5%	47,344	27.9%	46,072	24.4%	41,028	10.8%
Bakura	**48,634**	46,448	-4.5%	33,271	-31.6%	34,306	-29.5%	44,270	-9.0%
Brinin Magaji	**46,478**	52,389	12.7%	59,322	27.6%	62,439	34.3%	42,423	-8.7%
Bukkuyum	**55,069**	71,345	29.6%	65,946	19.8%	66,955	21.6%	69,450	26.1%
Bungudu	**67,112**	56,342	-16.0%	68,694	2.4%	70,041	4.4%	94,802	41.3%
Gunmi	**53,223**	55,198	3.7%	49,020	-7.9%	48,272	-9.3%	63,611	19.5%
Gusau	**99,702**	88,048	-11.7%	98,087	-1.6%	97,219	-2.5%	160,696	61.2%
Kara Namoda	**73,214**	81,295	11.0%	86,039	17.5%	87,599	19.6%	76,499	4.5%
Maradun	**54,866**	54,955	0.2%	72,737	32.6%	74,893	36.5%	52,284	-4.7%
Maru	**75,955**	80,469	5.9%	77,318	1.8%	75,654	-0.4%	116,760	53.7%
Shinkafi	**35,297**	35,043	-0.7%	32,429	-8.1%	32,090	-9.1%	43,242	22.5%
Talata Mafara	**55,991**	54,822	-2.1%	68,384	22.1%	72,645	29.7%	66,175	18.2%
Tsafe	**69,218**	72,142	4.2%	54,919	-20.7%	56,264	-18.7%	69,930	1.0%
Zurmi	**76,055**	79,396	4.4%	77,515	1.9%	76,854	1.1%	75,070	-1.3%
Total	**847,837**	**866,583**	**2.2%**	**891,025**	**5.1%**	**901,303**	**6.3%**	**1,016,242**	**19.9%**

[38] Data from the same year is not used due to data availability reasons

Example 2: Malaria Consortium Burkina Faso

The detailed district comparison for this example is included in Appendix 1 due to its size.

Key findings:

- There are vast differences between the data submitted by Malaria Consortium and all other population estimates.
- These huge differences can be explained by the fact that the data submitted by Malaria Consortium is not matched with official administrative boundaries despite the names matching.
- Specifically, Malaria Consortium have explained that health districts, the unit at which SMC target population data is compiled, are only a recognised unit within the health system. Whereas, for general administrative purposes, the administrative units are village, commune, province, and region. Each health district comprises several communes and it is common for health districts to be named after the largest commune in the district.

Table 3: Population estimate comparison for Malaria Consortium submitted data in Burkina Faso

	Malaria Consortium SMC 2017 Target Population (3-59 months)[39]	Population according to online available official government statistics 2019		Population according to WorldPop Demographic Data 2019	*Population according to WorldPop-Constrained model* (Top-Down)		*Population according to Meta HRSL* (Top-Down)	
Total	**1,737,814**	648,149	-62.7%	Not available	587,980	-66.2%	618,537	-64.4%

Example 3: Helen Keller International, Guinea

Key findings:

- Estimated populations are all substantially lower than the data submitted by HKI
- The differences between WorldPop-Constrained and Meta HRSL are larger here, particularly in Conakry - the largest urban area.

Table 4: Population estimate comparison for Helen Keller International data in Guinea

District	HKI 2019 Target Population (aged 6-59 months)	Population according to WorldPop Demographic Data 2019		*Population according to WorldPop-Constrained model* (Top-Down) 2019		*Population according to Meta HRSL* (Top-Down)	
Conakry	366,859	274,072	-25.3%	221,473	-39.6%	317,170	-13.5%
Kindia	379,219	268,042	-29.3%	318,376	-16.0%	356,461	-6.0%
Mamou	161,425	109,767	-32.0%	115,376	-28.5%	131,800	-18.4%
Labe	219,615	115,630	-47.3%	165,677	-24.6%	182,342	-17.0%
Yomou District, Nzerekore	25,218	NA	NA	16,877	-33.1%	18245	-27.7%

[39] Data from the same year is not used due to data availability reasons

Data sources for tables

- Malaria Consortium: Malaria Consortium SMC 2017 coverage[40] [41]
- Helen Keller International: HKI Annual Report Guinea[42]
- Administrative boundaries:
    - Nigeria / Zamfara State: HDX Admin Boundaries Nigeria[43]
    - Burkina Faso: HDX Admin Boundaries Burkina Faso[44]
    - Guinea: HDX Admin Boundaries Guinea[45]
- WorldPop Demographic Dataset: WorldPop Demographic Data Zip File[46]
- WorldPop-Constrained model: WorldPop-Constrained download data[47]
- Meta HRSL: HRSL download data[48]
- WoprVision: Online Tool[49]
- Burkina Faso Official Government Statistics: Institut Geographique National de la Statistique[50]
    - Note that this is included for Burkina Faso only to illustrate that the differences between submitted data and population estimates is not due to poor government estimates

We extracted specific estimates from the geospatial datasets for the estimates and administrative boundaries to specify the estimation areas. We did this by building a Python script (available on request) that is able to ingest both the shapefiles and the population density maps, perform the spatial summation, produce a basic map visualization and output the results to CSV. Importantly, it can be easily replicated from country to country, provided that the administrative boundaries are available.

[40] https://docs.google.com/spreadsheets/d/1i80mUD4ojT1qgeO9uy95tvGHmclooD5mloEyqfTjhPQ/edit#gid=766537929
[41] Note that the data submitted by Malaria Consortium is not owned by them
[42] https://files.givewell.org/files/DWDA%202009/Helen_Keller_International/HKI_annual_report_Guinea_2019.pdf
[43] https://data.humdata.org/dataset/cod-ab-nga
[44] https://data.humdata.org/dataset/cod-ab-bfa
[45] https://data.humdata.org/dataset/cod-ab-gin
[46] https://www.portal.worldpop.org/demographics/data/global_agesex_proportions_totals_2020.zip
[47] https://hub.worldpop.org/project/categories?id=3
[48] https://research.facebook.com/downloads/high-resolution-settlement-layer-hrsl/
[49] https://apps.worldpop.org/woprVision/
[50] https://data.humdata.org/dataset/cod-ps-bfa

Recommendation

We recommend that GiveWell engages with a population estimation organization to provide an annual assessment of which data source to use for population estimates for each country in which charities are working.

This organization should:

- Have a good understanding of the **reliability and accuracy of population data** from different sources and be able to assess the reliability efficiently
- Have experience working with and detailed knowledge of **government statistics offices in Sub-Saharan Africa**
- Be **experienced working in a project-based manner**, able to work to tight deadlines, produce output that is appropriate to the resources available, and quickly respond to changes in scope of work
- Be able to work with charities to **efficiently map catchment areas that do not follow administrative boundaries** and estimate populations from these areas, if necessary
- Have significant experience and expertise in **bottom-up population estimation**

Suggested format of the engagement

Structure: An ongoing relationship between GiveWell and an appropriate organization where approximately 2-3 weeks of more substantial work is conducted annually. This timing is based on an estimation that it will take about 1 day of time for each of the 17 countries that require population estimates, although this is expected to get quicker over time.

Primary output: During those 2-3 weeks, the organization will indicate to GiveWell which dataset would be the most accurate for each country/state that the relevant charities are working in. The recommendation could be delivered similar to the example comparisons above, or in any other way deemed appropriate by GiveWell and the expert organization.

Additional optional output: Once the best dataset has been indicated, the organization would also be able to efficiently extract the population estimates to match what has been submitted by the charities. This data extraction could also be done in-house by GiveWell, as all of the datasets are publicly available. We can provide the script used and would be able to provide additional guidance, if necessary, for how this can be conducted[51].

[51]A staff of IDinsight's Data Science, Engineering and Machine Learning team spent about 1.5 days developing and implementing a script to automate the data extraction from the pre-set administrative boundaries.

Rationale for core recommendation

KEY RATIONALE 1

Official government estimates are not necessarily inaccurate.

We heard from experts that the way in which governments produce their official population estimates varies greatly by context, with some using cutting-edge technology and others using simple multipliers or deliberate misrepresentation. Additionally, some expert organizations work directly with approximately half the governments in Sub-Saharan Africa and, therefore, their estimations are likely to be reliable.

A partnership with an organization that has **detailed knowledge of how governments currently, and will continue to, estimate populations** is necessary in order to understand if and how estimations can be improved.

KEY RATIONALE 2

Understanding the reliability of official government estimates is a complex matter and requires specific and contextual expertise.

Almost all experts we spoke to reported that there is no framework or guidelines for assessing the reliability of a census and other contributing factors to official government estimates that will hold across a variety of contexts, especially in Sub-Saharan Africa. Factors such as the recency of census, the level of active conflict, or the reliability of mortality & fertility statistics can be considered a starting point. However, all experts emphasized the importance of country-specific contextual knowledge and genuine census or population expertise to robustly assess reliability.

IDinsight attempted to create a holistic framework (See Appendix 2) to identify the best source of data to use in a given country. Through our interviews, we found that at each critical node, a sufficiently accurate answer would require more specific contextual expertise.

A partnership with an **organization that contains demographers and other knowledge and experience of assessing reliability of censuses, CRVS systems** and other mechanisms of government population estimation in GiveWell recommended charities areas of operation.

KEY RATIONALE 3

The reliability of population estimates (official and other) is dynamic.

Both the government official estimates and estimates from satellite imagery or otherwise get periodically updated. For example, Meta HRSL is updating its dataset in 2023 which is likely to have significant improvements in its urban estimations. Similarly, population estimates can be updated based on unofficial surveys or administrative data. It is important to keep on top of such developments, which is built into population estimation organizations day-to-day work.

A partnership with a population estimation organization will allow GiveWell to **leverage the institutional knowledge of the organization about the latest developments** in official or modeled population estimations.

KEY RATIONALE 4

The data submitted by charities may not always match the official administrative boundaries.

The difference between the data submitted by charities and all other population estimates in Burkina Faso (Example 3) was so large (approximately 3 times larger) that it seems unlikely the difference can be explained with an accuracy issue. One hypothesis is that the administrative boundaries used by the charities are different to the official district boundaries.

A partnership with an **organization that can quickly and accurately work with charities to map new boundaries and extract population estimates** will facilitate efficient resolution of mismatched boundaries.

KEY RATIONALE 5	
	There may be some countries for which existing population estimates are very unreliable and the only way to improve is a bottom-up estimation.
	When a reliable census hasn't been conducted for an extended period of time of 10 years or more, or there has been substantial internal migration since the most recent census, all population estimates that rely on the census might be inaccurate. In this situation, the most cost-effective way to generate accurate population estimates may be to use a bottom-up model.
	A relationship between GiveWell, their charities, and an organization that has experience on bottom-up estimation in Sub-Saharan Africa or South Asia **will facilitate progress and contribution to bottom-up modeling** is the best way to understand reliability**.** *Note: We are not suggesting that GW fund a bottom-up estimation but that an additional benefit of this partnership will mean that the barriers to expanding bottom-up modeling in certain countries will be lower for all parties. See section below for more details.*

Additional Recommendations

ADDITIONAL RECOMMENDATION 1: Provide clear data information requirements to charities.

The example data presented above suggests that alternative data sources and the data submitted by charities may not be using the same administrative boundaries. The charities themselves will have the best knowledge and understanding of how the population estimates that they use for reporting are generated, or at least the closest connection with the government to clarify with them directly. Therefore, asking for more detailed information on the submitted target population estimates should facilitate quicker resolution of any data disparities.

A potential barrier to this is that governments may not communicate how their estimates are generated to the charities. This might mean that the charities are unable to provide the clear data requirements.

Below, we list some suggestions for what information could be provided by charities to help understand where the submitted population estimates come from. An initial list of suggested questions for GiveWell to ask as part of the submission process could include:

- Are the estimates directly from the government[52] or from another source?
- Do the estimates depend on census data, administrative data or another source of data?
- To the best of your knowledge, what type of modeling is used on the population estimates, if any?
- Do the estimates strictly follow official administrative boundaries or other geographic boundaries, such as school or clinic catchment areas?
    - If not official administrative boundaries, can you provide details of the boundaries used?
- Please provide details of any known partnerships between official government statistics offices and external population organizations.

[52] It should be noted that since charities are committed to operating mass distribution programs in a "government-led" way, the data reported by them may need to be endorsed by the governments that they are working with.

ADDITIONAL RECOMMENDATION 2: Leverage synergies to further improve upon existing bottom-up population estimates.

In some countries, particularly those with heavy migration, conflict or political instability, conventional, census-based population estimates might be highly inaccurate. The widespread primary data collection capabilities of GiveWell supported charities (or government-led programs) could be leveraged to provide additional, complementary data to inform existing bottom-up estimation models. Exploring such synergies could increase both the accuracy of population estimates for the GiveWell cost-effectiveness model, while also amplifying the broader social impact of building up population estimates in data poor areas.

The main challenge to this recommendation is that informing bottom-up estimation models may require expertise which is expensive. Further, the data collection and sampling methodology used in post-coverage surveys is very specific and the required adaptations may interrupt the charities (and/or government-led) program's workflow.

In our conversations, population experts provided a brief overview of the requirements to generate population estimates from bottom-up estimation models. The models required are relatively complex and require adapting to country contexts[53]. For the data collection efforts, this could either be specifically funded or the existing data collection efforts of the charities could be used to add-on a population survey estimate. The requirements for this are:

- Every household within a **clearly defined geographic area** must be surveyed
- An accurate **household roster** and basic characteristics for each household must be collected
- Access to **good, up to date satellite imagery**

If a charity is already conducting data collection efforts where they interview everyone in a given village, then they may already collect household rosters. In these cases, the only additional effort that needs to be put in is assurances that every household is interviewed within the clearly defined spatial boundaries. However, in other cases it may require a significant amount of effort for the charities. Further exploration is needed to understand how feasible it is for charities to contribute to this bottom-up data collection. One suggested way forward is to pick a single country and charity context, and to see how feasible it is to build a bottom-up estimate in this context.

[53]In order to build bottom-up estimates you need to combine specific population surveys with geospatial population modeling techniques. The population modeling would need to be done by an expert organization (WorldPop and Landscan both have experience with this). If the country is a relatively unique context then a new model may need to be developed, which would take a lot of time and resources. However, if the country is relatively similar to existing bottom-up modeling which has been done, then the data could be inputted into this model at a relatively low level of effort.

IDinsight

Appendix

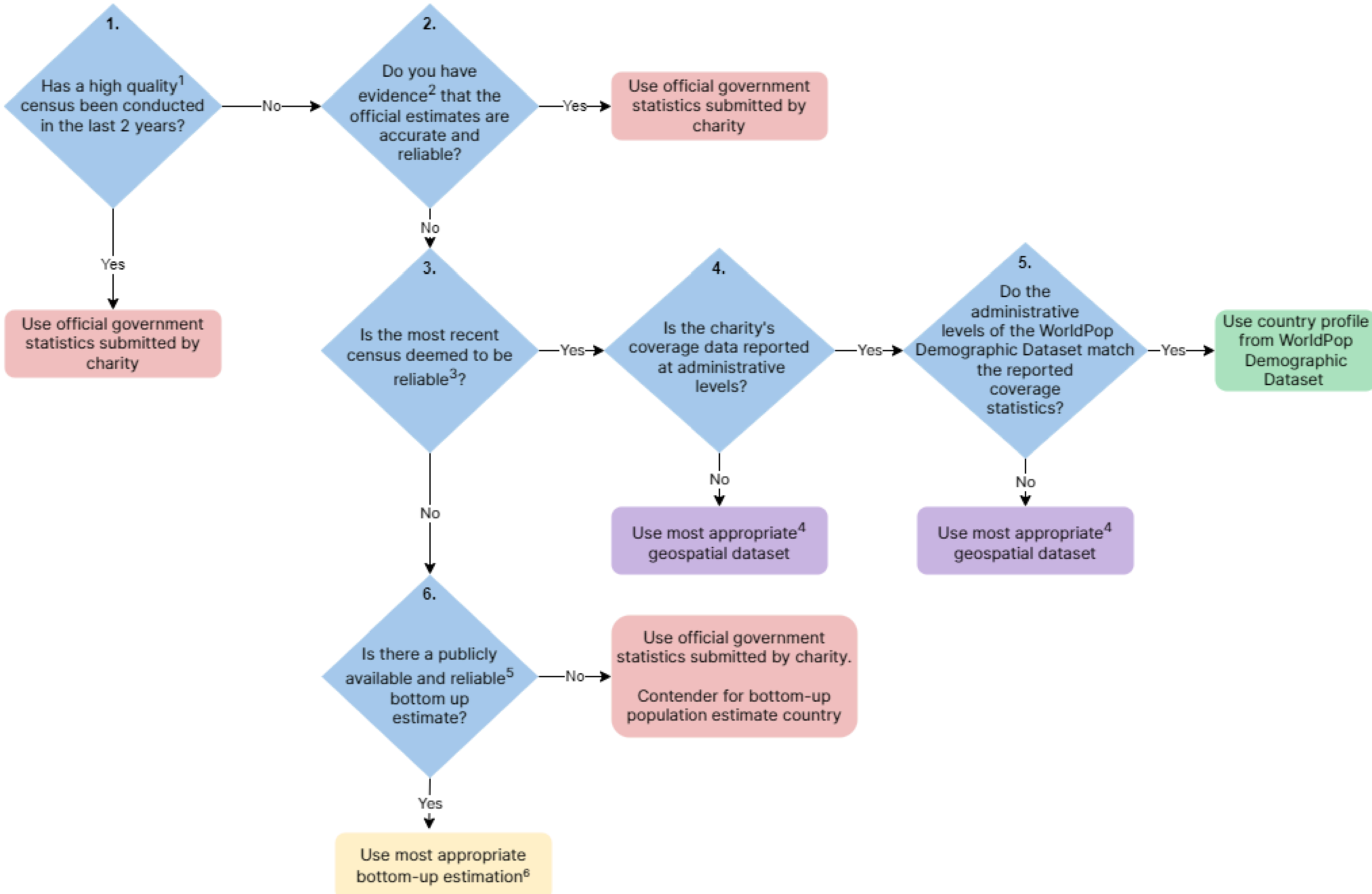
Appendix 1: Malaria Consortium in Burkina Faso

District	Malaria Consortium SMC 2017 Target Population (3-59 months)	Population according to online available official government statistics 2019		Population according to WorldPop Demographic Data 2019	*Population according to WorldPop -Constrained model (Top-Down)*		Population according to Meta HRSL (Top-Down)	
Barsalogo	**38,737**	23,802	-38.6%	Not available at this level	20166	-47.9%	21113	-45.5%
Bittou	**25,141**	21,278	-15.4%	Not available at this level	17369	-30.9%	18511	-26.4%
Bogandé	**69,583**	23,936	-65.6%	Not available at this level	21333	-69.3%	23298	-66.5%
Boulsa	**38,562**	21,098	-45.3%	Not available at this level	17319	-55.1%	17409	-54.9%
Boussé	**31,812**	11,182	-64.8%	Not available at this level	8695	-72.7%	9219	-71.0%
Boussouma	**38,697**	7,301	-81.1%	Not available at this level	4386	-88.7%	4256	-89.0%
Dafra	**47,532**	NA	NA	Not available at this level	18072	-62.0%	19508	-59.0%
Diapaga	**91,332**	22,224	-75.7%	Not available at this level	9106	-90.0%	9910	-89.1%
Fada	**79,956**	9,014	-88.7%	Not available at this level	37206	-53.5%	39586	-50.5%
Garango	**36,265**	35,276	-2.7%	Not available at this level	16135	-55.5%	17283	-52.3%
Gayeri	**21,951**	18,086	-17.6%	Not available at this level	14554	-33.7%	15384	-29.9%
Gourcy	**40,791**	15,830	-61.2%	Not available at this level	17968	-56.0%	18854	-53.8%
Kaya	**69,053**	21,549	-68.8%	Not available at this level	26809	-61.2%	27838	-59.7%
Kombissiri	**33,971**	28,379	-16.5%	Not available at this level	11922	-64.9%	13083	-61.5%
Koudougou	**64,402**	16,804	-73.9%	Not available at this level	26976	-58.1%	28508	-55.7%
Koungoussi	**67,685**	29,444	-56.5%	Not available at this level	16247	-76.0%	17164	-74.6%
Koupéla	**42,469**	14,651	-65.5%	Not available at this level	13484	-68.2%	13937	-67.2%
Lena	**13,574**	4,769	-64.9%	Not available at this level	3988	-70.6%	3822	-71.8%
Léo	**50,289**	12,816	-74.5%	Not available at this level	12992	-74.2%	13452	-73.3%
Manga	**56,419**	7,495	-86.7%	Not available at this level	6419	-88.6%	7323	-87.0%
Mangodara	**41,286**	15,660	-62.1%	Not available at this level	14890	-63.9%	15718	-61.9%
Manni	**35,156**	20,123	-42.8%	Not available at this level	21982	-37.5%	23239	-33.9%
Nanoro	**31,223**	8,686	-72.2%	Not available at this level	5903	-81.1%	6205	-80.1%
Ouargaye	**64,331**	8,383	-87.0%	Not available at this level	8710	-86.5%	8754	-86.4%
Pama	**22,530**	12,791	-43.2%	Not available at this level	19586	-13.1%	19443	-13.7%
Pô	**36,835**	12,810	-65.2%	Not available at this level	11305	-69.3%	11936	-67.6%
Pouytenga	**37,914**	20,040	-47.1%	Not available at this level	19218	-49.3%	20600	-45.7%
Réo	**34,897**	14,836	-57.5%	Not available at this level	11042	-68.4%	11548	-66.9%
Sabou	**19,788**	12,116	-38.8%	Not available at this level	9148	-53.8%	9519	-51.9%

Saponé	**18,084**	8,474	-53.1%	Not available at this level	5798	-67.9%	6063	-66.5%
Sapouy	**44,017**	16,005	-63.6%	Not available at this level	19782	-55.1%	20473	-53.5%
Séguenega	**40,659**	17,682	-56.5%	Not available at this level	12212	-70.0%	12809	-68.5%
Tenado	**32,730**	11,365	-65.3%	Not available at this level	7064	-78.4%	7470	-77.2%
Tenkodogo	**41,838**	32,469	-22.4%	Not available at this level	26136	-37.5%	26748	-36.1%
Tougouri	**42,320**	21,989	-48.0%	Not available at this level	18099	-57.2%	19438	-54.1%
Yako	**75,987**	19,889	-73.8%	Not available at this level	14777	-80.6%	15454	-79.7%
Zabré	**28,782**	22,928	-20.3%	Not available at this level	17721	-38.4%	18409	-36.0%
Ziniaré	**55,759**	15,634	-72.0%	Not available at this level	13071	-76.6%	13679	-75.5%
Zorgho	**75,457**	11,335	-85.0%	Not available at this level	10388	-86.2%	11576	-84.7%
Total	**1,737,814**	**648,149**	**-62.7%**		**587,980**	**-66.2%**	**618,537**	**-64.4%**

IDinsight

Appendix 2: Flowchart framework



(footnotes below)

Flowchart Footnotes:

1. Determining whether a census has been conducted in a high quality manner is an extremely specialist subject. Factors that may affect it include census coverage, implementation quality, and political sensitivities / corruption index.

2. Obtaining evidence whether official estimates are accurate and reliable often requires inside knowledge of the government statistics office or other bodies responsible for population estimates. In some cases there may be publicly available information about how those estimates have been generated but often this is not well documented.

3. Determining if the most recent census is reliable involves a similar assessment to the quality of the census implementation as point 1, as well as additional points such as the recency of the census, the level of internal migration since census implementation, whether there is active conflict, degree of urbanization among others. There is no rule of thumb for how to do this but it requires a context specific analysis of these factors plus other unexpected factors.

4. Up-to-date knowledge of all the different platforms and in which context they are most accurate is required here. We have given a brief overview in this study but in order to make a decision about the most appropriate geospatial data platform with confidence will require significantly greater expertise and knowledge.

5. We have identified publicly available bottom-up estimations from LandScanHD, as well as WorldPop. There may be more that we have not found, as well as some which are not publicly available.

6. There doesn’t seem to be many countries with multiple bottom-up estimations in, but if there were, then selecting which to use would require very technical knowledge of the methods and data used to form the bottom-up estimations.

Bibliography

Bureau, U. (2022, November 28). Subnational population data by geographic area. Retrieved December 9, 2022, from https://www.census.gov/geographies/mapping-files/time-series/demo/international-programs/subnationalpopulation.html

Carioli, A., Pezzulo, C., Nielsen, K., & Tejefor-Garavito, N. (2019). *Adolescent fertility: A multi-temporal subnational perspective across low and middle-income countries.* (Rep.).

Dahmm, H., & Rabiee, M. (2020). *LEAVING NO ONE OFF THE MAP A GUIDE FOR GRIDDED POPULATION DATA FOR SUSTAINABLE DEVELOPMENT* (Rep.). TReNDS.

Fries, B., Guerra, C. A., García, G. A., Wu, S. L., Smith, J. M., Oyono, J. N., . . . Dolgert, A. J. (2021). Measuring the accuracy of gridded human population density surfaces: A case study in Bioko Island, Equatorial Guinea. *PLOS ONE, 16*(9). doi:10.1371/journal.pone.0248646

GiveWell. (2022, September). Top charities fund. Retrieved December 9, 2022, from https://www.givewell.org/top-charities-fund

GiveWell. (n.d.). 2022 GiveWell cost-effectiveness analysis - version 5. Retrieved December 09, 2022, from https://docs.google.com/spreadsheets/d/1tytvmV_32H8XGGRJlUzRDTKTHrdevPIYmb_uc6aLeas/edit#gid=472531943

GRID3. (2022). High-resolution population estimates - GRID3. Retrieved December 9, 2022, from https://grid3.org/solution/high-resolution-population-estimates

LandScan. (2022). Ornl LandScan viewer - oak ridge national laboratory. Retrieved December 9, 2022, from https://landscan.ornl.gov/

Leddy, R. (2016). *METHODS FOR CALCULATING 5-YEAR AGE GROUP POPULATION ESTIMATES BY SEX FOR SUBNATIONAL AREAS* (Rep.). US Census Bureau.

Leyk, S., Gaughan, A. E., Adamo, S. B., De Sherbinin, A., Balk, D., Freire, S., . . . Pesaresi, M. (2019). The spatial allocation of population: A review of large-scale gridded population data products and their fitness for use. Earth System Science Data, 11(3), 1385-1409. doi:10.5194/essd-11-1385-2019

Minnesota Population Center. Integrated Public Use Microdata Series, International: Version 7.3 [dataset]. Minneapolis, MN: IPUMS, 2020. https://doi.org/10.18128/D020.V7.3

Suharto, S. (2001). *Complementary Sources of Demographic and Social Statistics* (Rep.). New York: UNSD. doi:https://unstats.un.org/unsd/demog/docs/symposium_03.htm

Thomson, D.R. 2022. Designing and Implementing Gridded Population Surveys (D.A. Rhoda, Ed.). Dana Thomson Consulting.

Tiecke, T. (2016, November 15). Open population datasets and open challenges. Retrieved December 9, 2022, from https://engineering.fb.com/2016/11/15/core-data/open-population-datasets-and-open-challenges/

United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022: Methodology of the United Nations population estimates and projections. UN DESA/POP/2022/TR/NO. 4.

UNPD. (2022). World population prospects - population division. Retrieved December 9, 2022, from https://population.un.org/wpp/Methodology/

UNSD. (2020). UNSD - demographic and social statistics. Retrieved December 9, 2022, from https://unstats.un.org/unsd/demographic-social/census/censusdates/

Wardrop, N. A., Jochem, W. C., Bird, T. J., Chamberlain, H. R., Clarke, D., Kerr, D., . . . Tatem, A. J. (2018). Spatially disaggregated population estimates in the absence of national population and Housing Census Data. Proceedings of the National Academy of Sciences, 115(14), 3529-3537. doi:10.1073/pnas.1715305115

WHO. (2022). Civil Registration and Vital Statistics (crvs) - who. Retrieved December 9, 2022, from https://www.who.int/data/data-collection-tools/civil-registration-and-vital-statistics-(crvs)

WorldPop. (2022, October 15). Methods. Retrieved December 9, 2022, from https://www.worldpop.org/methods/