GRID3

GEO-REFERENCED INFRASTRUCTURE AND DEMOGRAPHIC DATA FOR DEVELOPMENT

Use of geospatial data to support LLIN distribution campaigns in DRC

Nairobi
May 8th 2023

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Overview on denominators and the GRID3 support to the PNLP implementation partners in DRC

Types of use of bottom up population estimates and geospatial data provided by GRID3 in DRC

Bottom up population estimate and geospatial data to help:

1. **Improve estimates of LLIN needs** (pre-campaign)
2. **Improve mapping for logistics readiness phase and micro-planning for field deployment** (pre-campaign)
3. **Increase LLIN distribution coverage** (during campaign)
4. **Increase accountability on the ground** (during the campaign)

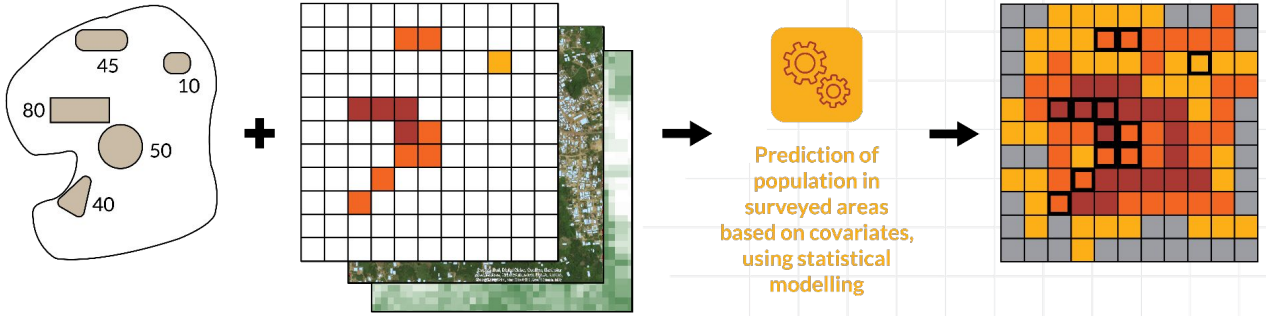
1/ Improve estimates of LLIN needs (before the campaign)

ISSUE

Problem of the validity of population estimates. Population projections, based on the last census carried out in 1984, are very uncertain. Local counts are often poorly documented and unreliable. There is a common acknowledgment that denominators used in the health sector are not exact/ always reliable

SOLUTION

Modeled population estimates, based on a bottom-up approach based on micro-censuses (dem t



Use cases / Impacts of High resolution bottom up population estimates

SUCCESS 1

Bottom up population estimates were used in the EPI routine planning in 2022
DRC EPI validated use of population estimates for planning purposes in 2022 where available. This contributed with many other factors to increase the immunization national coverage. Haut Lomami where this approach pioneered was leading in performance.

SUCCESS 1

Sample Cross surveys runned by the National Statistics Institute validated model prediction (The INS planned to use modeled population estimates where available to plan for the upcoming general census)

SUCCESS 1

Modeled population estimates add high resolution spatial distribution characteristic to aggregated health ward/health zones/ health areas population. Although its broader adoption is still under consideration its impact on settlement numbering hierarchy and anomalies detection remains very high **as** settlement are no more considered only as isolated point but spatially delimited settlements extents.

There are significant differences across population estimates depending on the sources

GRID3 bottom-up populations data are overall lower that other sources of data

PROVINCES	DHIS2 EXTRAPOLATED POPULATION	POPULATION EXTRAPOLATED FROM PREVIOUS PNLP COUNT	POPULATION EXTRAPOLATED ON THE BASIS OF HOUSEHOLDS SERVED PREVIOUS PNLP CAMPAIGN			POPULATION EXTRAPOLATED FROM THE EPI	POPULATION EXTRAPOLATED FROM GRID3
	2023	2023	Households size (MICS 2018)	Household count	2023	2023	2023
HAUT KATANGA	7,773,344	9,572,169	5.5	1,587,539	8,731,465	6,874,275	5,278,298
HAUT LOMAMI	4,666,455	4,988,506	6	836,242	5,017,451	4,058,550	2,883,545
ITURI	7,085,892	6,829,208	6.2	1,241,020	7,694,323	6,113,275	5,462,927
KINSHASA	11,783,290	13,682,294	5.4	2,026,753	10,944,466	9,802,425	7,467,300
KONGO CENTRAL	4,571,775	6,133,292	4.6	1,170,271	5,383,246	4,064,450	3,304,399
KWILU	6,210,983	6,735,615	4.6	1,185,232	5,452,067	5,424,400	4,675,115
LOMAMI	4,664,687	5,050,637	5.4	931,572	5,030,490	4,074,375	2,897,912
MAI NDOMBE	2,364,307	2,797,285	4.5	550,639	2,477,874	2,064,975	2,117,505
SUD KIVU	8,693,816	9,779,956	5.9	1,590,395	9,383,328	7,611,150	5,000,346
KWANGO	2,925,359	2,806,065	4.8	492,939	2,366,108	2,562,051	1,806,338
KASAI	5,877,285	5,647,333	5.2	1,032,729	5,370,189	5,106,050	3,122,168
KASAI ORIENTAL	5,854,705	5,844,655	4.8	1,145,961	5,500,615	5,088,925	2,376,736
TOTAL	**72,471,898**	**79,867,015**	**5.2**	**13,791,292**	**73,351,624**	**62,844,901**	**46,392,590**

Modeled “bottom-up” vs. PNLP vs. demographic survey (“microcensus)

Good alignment between PNLP and modeled data

Données	Population total	Nombre de ménage
PNLP	309	59
Micro-recensement	387	96
Estimations carroyées “bottom-up “	340.9 (95% CI: 253-462)	-

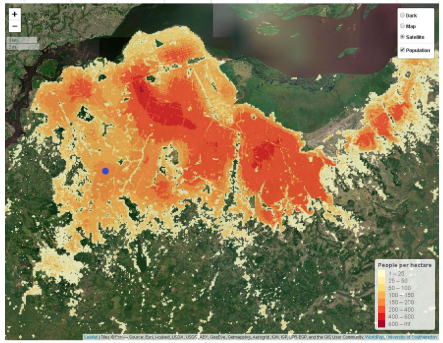
Figure 11: Example (kabongo_2 - 25.6483332°E 7.4058331°S) of a microcensus cluster in Kabongo, Haut-Lomami, with PNLP data points shown as yellow dots and GRID3 modelled estimates as the red/pink raster, overlaid on satellite imagery.

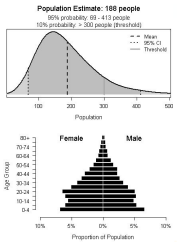
Lag linked to a cluster / concentration of points

Données	Population total	Nombre de ménage
PNLP	1623	293
Micro-recensement	184	45
Estimations carroyées “bottom-up “	261.1 (95% CI: 141-466)	-

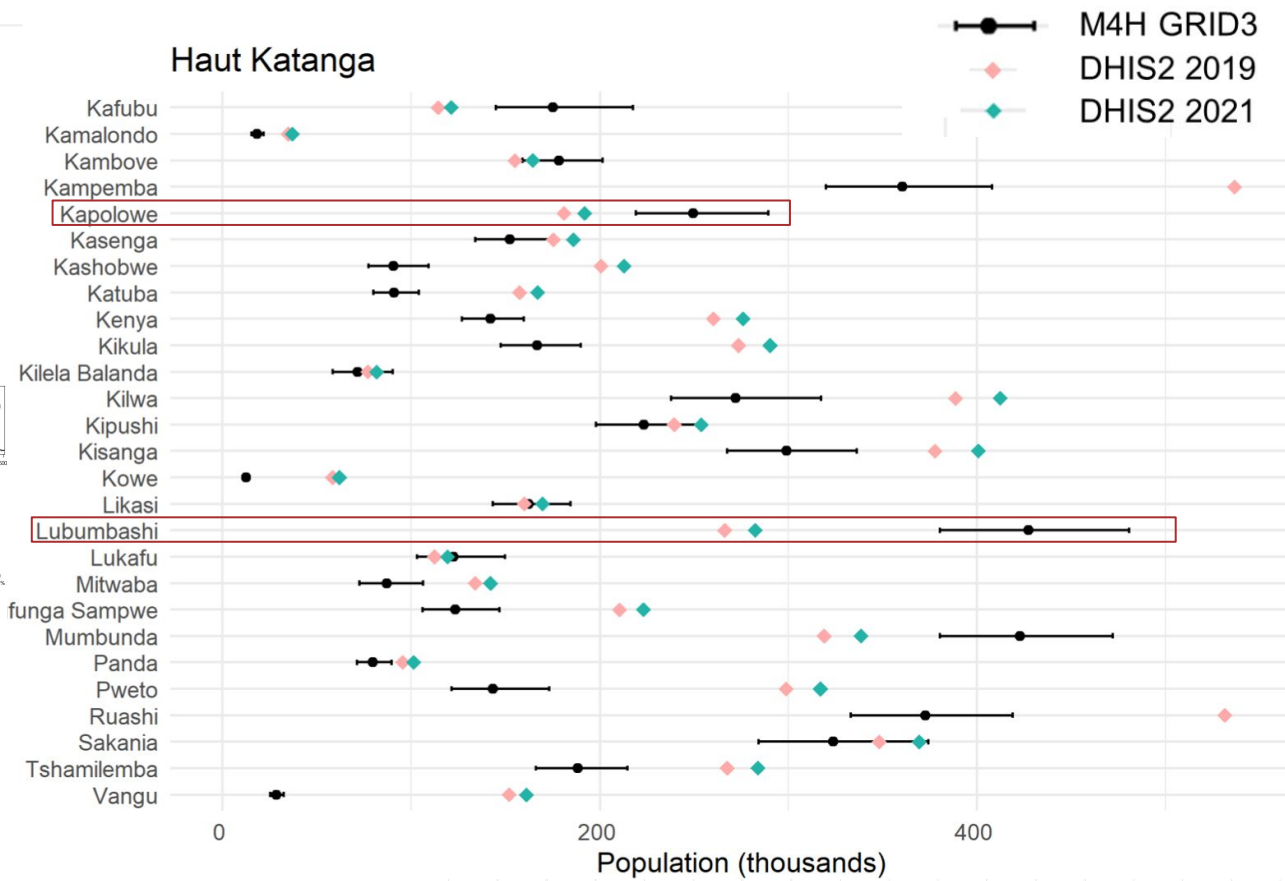
Figure 12: Example (katshimpwa_1 - 26.5504166°E, 7.6045831°S) of a microcensus cluster in Malemba-Nkulu, Haut-Lomami, with PNLP data points shown as yellow dots and GRID3 modelled estimates as the red/pink raster, overlaid on satellite imagery.

Use of high-resolution population data to estimate net need and identify potential outliers/outliers.





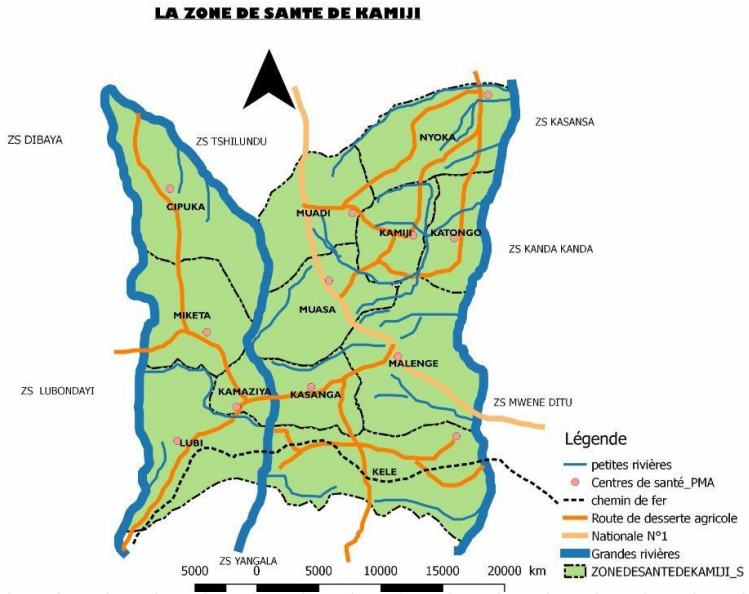
The population estimates for ZS Kapolowe and ZS Lubumbashi are lower than the population estimated by the GRID3 model - which makes it possible to identify areas that may not have enough LLINs.



2/ Improve maps for logistics and micro-planning (before the campaign)

ISSUE

In many health zones and areas, **only rough sketches are available for planning**. They are not to scale and do not identify where the built-up areas to visit are, or the exact boundaries with other health areas and do not list the



ZS KAMIJI, PROVINCE LOMAMI

SOLUTION

Creation of accurate maps from available geospatial data - in order to know:

- the area of the AS and the distances (km)
- the precise location of health facilities and villages / hamlets present in the microplans, as well as the built-up areas around them
- natural barriers
- population distribution can also be added

Maps of health zones with distances between BCZs and health facilities.

ZS MBULULA, PROVINCE TANGANYIKA

Aire de Santé	Centre de Santé	Distance du BCZ
Bigobo	CS Bigobo	22.9
Buyovu	CS Buyovu	68.8
Ilunga	CS Ilunga	21.6
Kabundi	CS Kabundi	49.1
Kahenga	CS Kahenga	34.7
Kasawa	CS Kasawa	47
Kateba	CS Kateba	65.2
Kayanza	CS Kayanza	11.5
Kayenge	CS Kayenge	29.1
Kilenge	CS Kilenge	28.7
Kundu	CS Kundu	11.9
Makutano		
Mbulula		
Mpala		
Mwana Ngoy		
Nkulula		
Nonge		
Nyanga		
Ponda		
Tambwe		
Yenga		

Limites

- Zone de bâti
- Aire de santé
- Zone de santé

Etablissements de santé

- Hôpital
- Clinique
- Centre de Santé
- Centre de Santé de Référence
- Poste de Santé
- Site de Soins Communautaire
- Dispensaire
- Autre

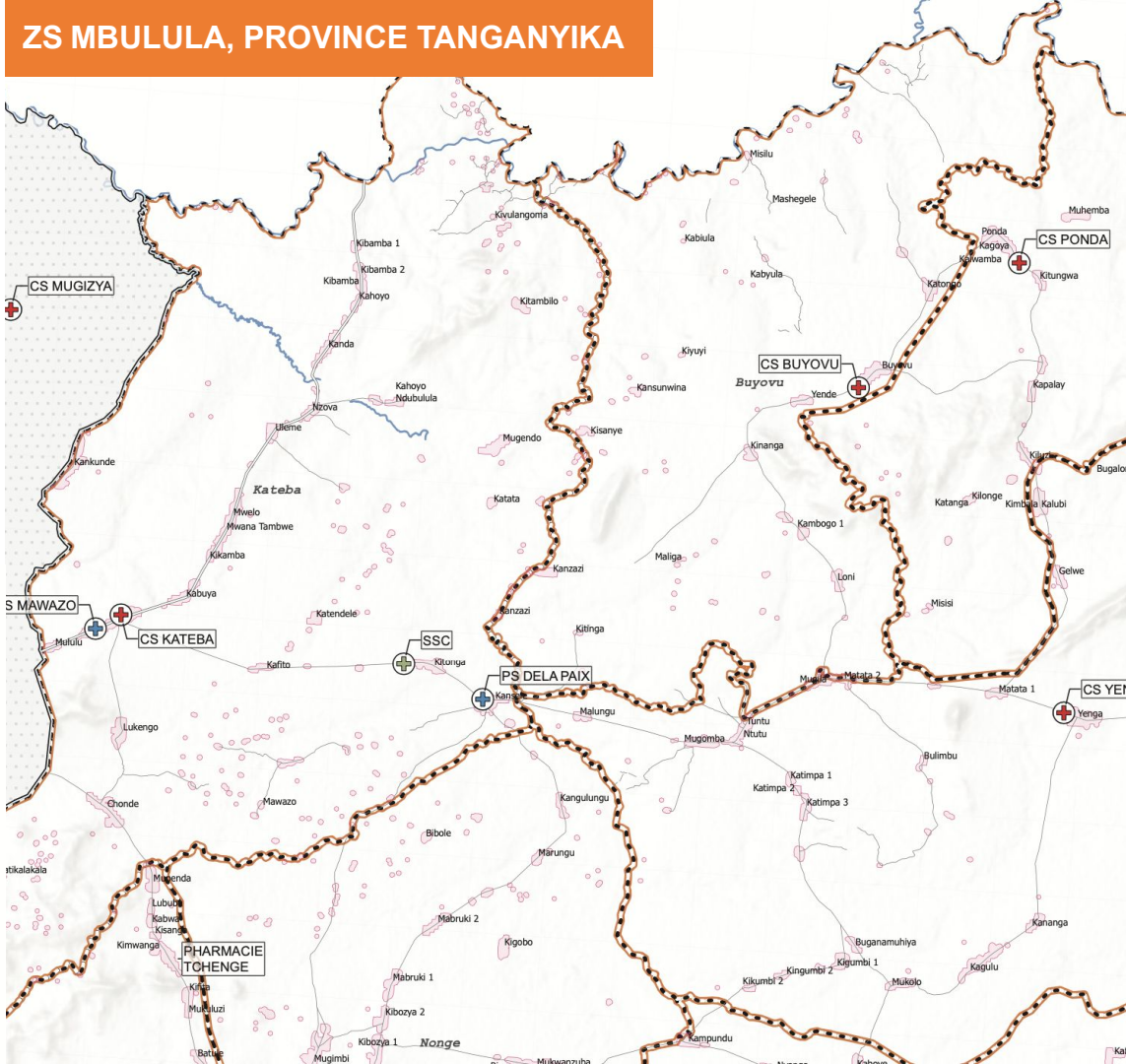
Axes de transport

Routes

- Primaire
- Secondaire
- Tertiaire / chemin
- Chemin de fer
- Aéroport
- Gare maritime
- Gare ferroviaire

Cours et plan d'eau

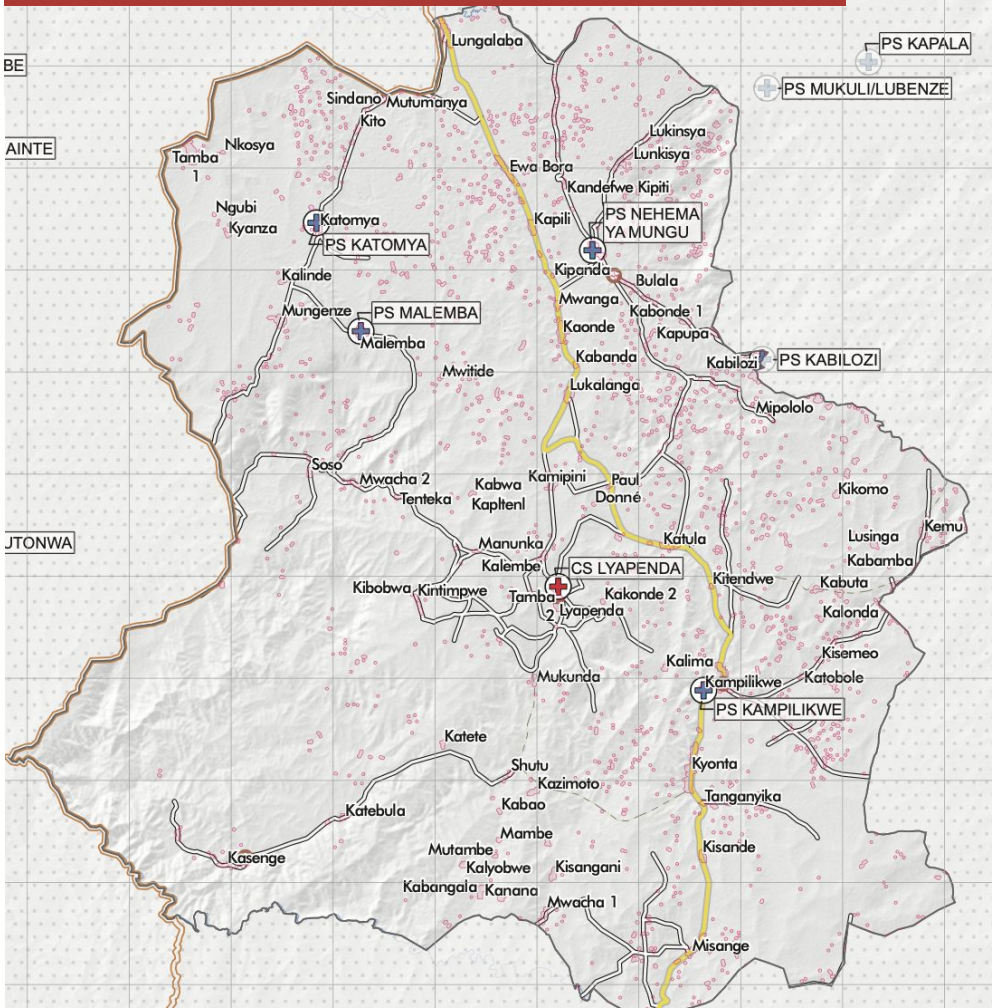
- Plan d'eau
- Marais
- Rivière



Map of health areas with a **matrix of distances between health facilities and villages** present in the microplans.

Village	Centre de Santé	Distance du CS (km)
Lungalaba	CS Lyapenda	22.8
Mwanga	CS Mulungwishi	13.1
Nkosya	CS Lyapenda	30
Tanganyika	CS Lyapenda	12.9
Kabao	CS Lyapenda	11.5
Mwacha 1	CS Lyapenda	25.4
Kabuta	CS Lyapenda	20.1
Ngubi	CS Lyapenda	26.6
Kitendwe	CS Lyapenda	8.9
Kalonda	CS Mambwe	7.1
Kisande	CS Lumono	9.5
Katebula	CS Lyapenda	15.7
Mwacha 2	CS Lyapenda	9.9
Katomya	CS Lyapenda	25
Kabamba	CS Lwala	49.2
Manunka	CS Lyapenda	4
Kalinde	CS Lyapenda	22.8
Kalyobwe	CS Lyapenda	14.1
Mipololo	CS Lyapenda	17.4
Kyonta	CS Lyapenda	11.5
Kaonde	CS Lyapenda	10.4
Kalima	CS Lyapenda	6.2
Tenteka	CS Lyapenda	7.9
Kito	CS Kabeya	3.3
Mungenze	CS Lyapenda	23.7
Paul	CS Kanteba	10.6

AS LYAPENDA, ZS MOBA, PROVINCE TANGANYIKA



3/ Improve mosquito net distribution coverage (during the campaign)

ISSUE

Villages and hamlets not visited. *"When validating each health zone, we would like to have a way to detect villages / hamlets / clusters of buildings from GRID3 data that have not been visited. We would need your expertise to help us find a reasonable way to list them, display them, and allow the HZ team to make a call to find out if this village/hamlet/cluster of buildings/ still exists, and if yes, why it was not visited."* ***PNLP - IMA World Health team***

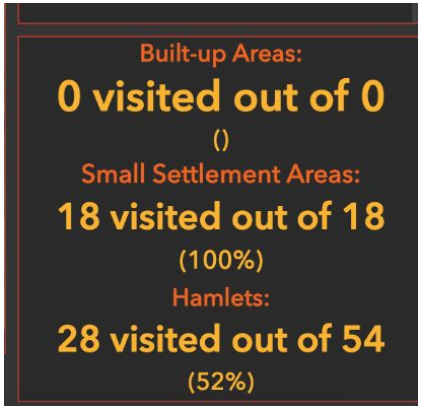
SOLUTION

Creation of a dashboard from high resolution geospatial data:

- Boundaries of health areas and zones
- Location of villages and hamlets (built-up areas) within each area
- Other points of interest (such as the location of health facilities) to add context
- Daily display of data collected from the ODK IMA / PNLP server in order to easily visualize progress in the field in terms of coverage of each zone or health area, or to check whether a village has been visited.

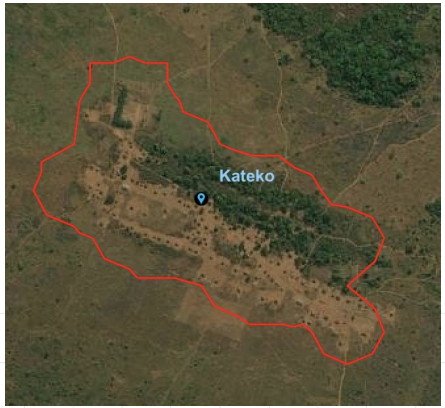
Daily dashboard for field distribution monitoring and coverage

The dashboard can serve as a data cleaning guide used by IMA to clean data during the live campaign (near real-time, and can continue until data validation)



(left) Key statistics for the selected health zone (right) Overview of the number of built-up areas visited within the health area

Village (small settlement area) visited during the campaign. Each dot represents a household



Village potentially problematic / to be revisited (omission of the collection of GPS points, etc.)

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Select a Health Zone: Kikongo | Select a Health Area: Kinkosi | Select a Village: Corbeau

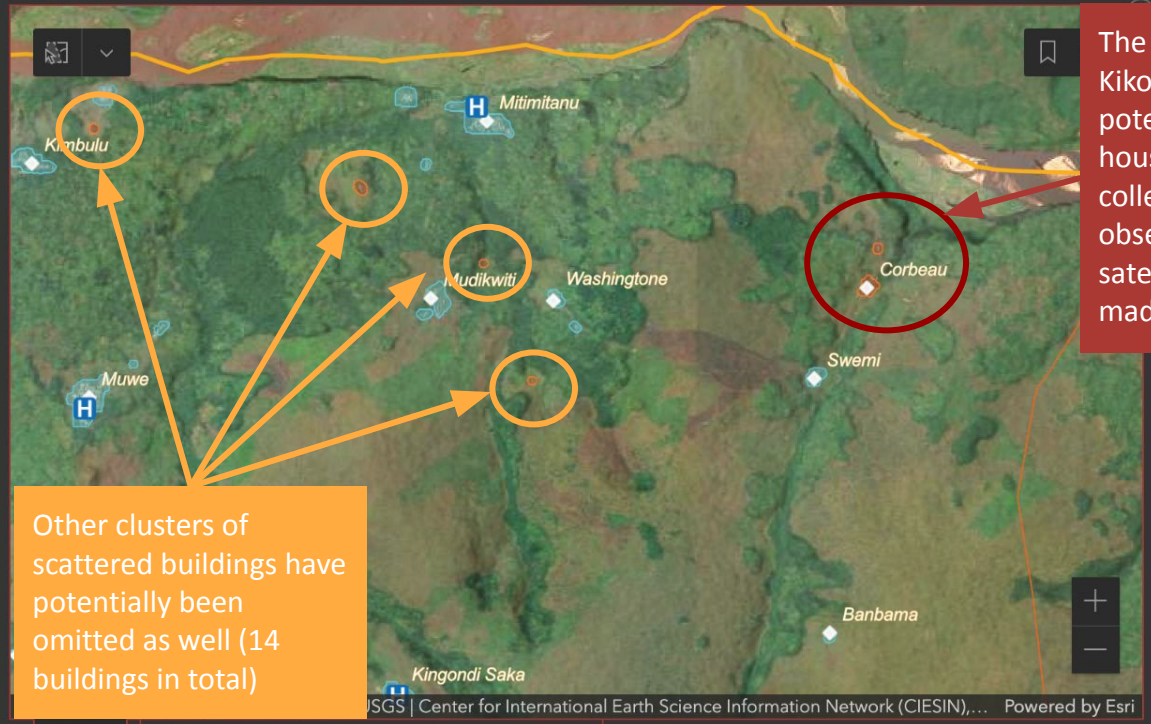
Door-to-door mass distribution of LLINs in Kwilu Province (PNLP/IMA World Health)

Number of Households Visited:
2k

Number of Bednets Distributed:
6.2k

Settlement Extent Count:
106

Building Count:
2.4k



Other clusters of scattered buildings have potentially been omitted as well (14 buildings in total)

The hamlet of Corbeau, in ZS Kikongo, AS Kikosi, was potentially not visited (no household GPS points collected). According to observations derived from satellite images, this hamlet is made up of 26 buildings.

Built-up Areas:
0 visited out of 0
()
Small Settlement Areas:
16 visited out of 16
(100%)
Hamlets:
69 visited out of 90
(77%)

Map | Chart: Number of Household Visits per Day

Identification of areas potentially not visited door-to-door

- Sharing of building that might not have been visited door-to-door (in red): identification of locations of 25-50 buildings (56), 50-100 buildings (15), over 100 buildings (20) to potentially recover. 92 % are small hamlets.

Fig 1 ZS Kongila, AS kibeti

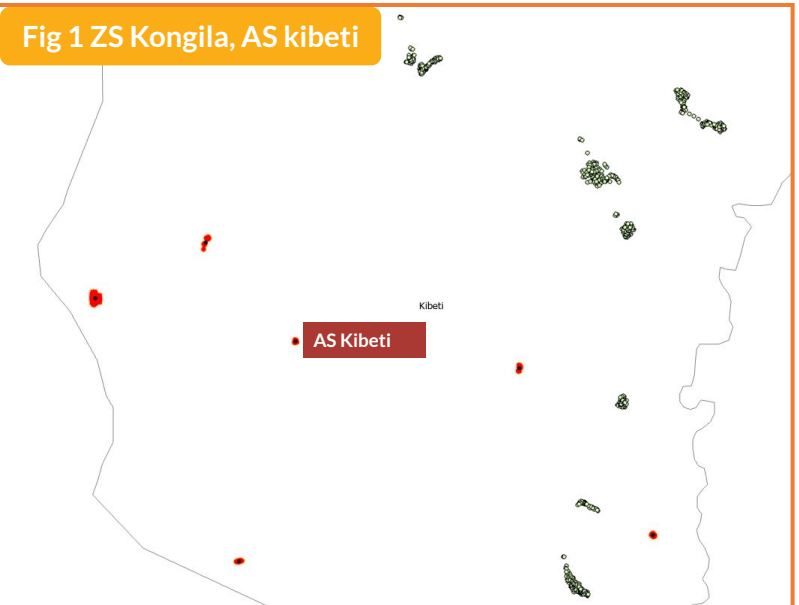
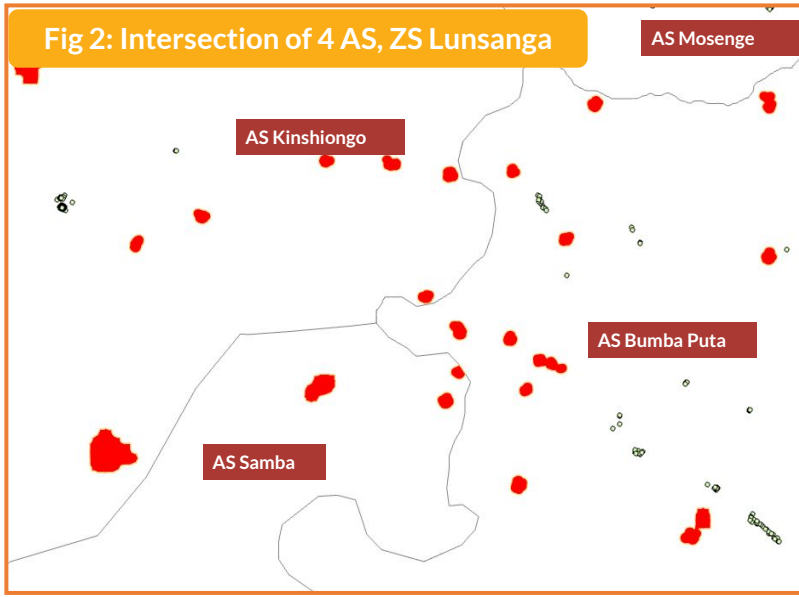


Fig 2: Intersection of 4 AS, ZS Lunsanga



- These locations are:
  (1) either difficult to access and far from the main transport routes (Fig 1)
  (2) either at the intersection of several health areas, whose boundaries are potentially blurred (Fig 2)

4/ Improving accountability (during the campaign)

PROBLEME

Too many GPS coordinates in one place. *"One source of fraud is users filling out forms without going door to door to deliver nets. They can then keep the nets and simulate a bunch of data. A similar fraud would be to inflate the number of households/persons in a village and keep the excess nets. We would like to be able to detect these cases automatically."* ***PNLP - IMA World Health team***

SOLUTION

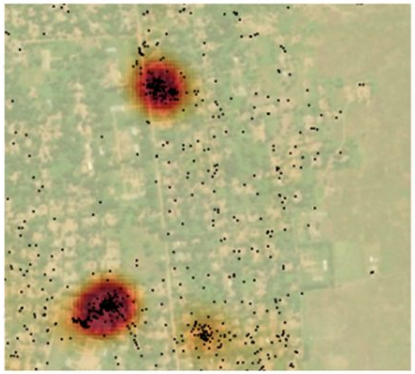
Created a distribution anomaly detection algorithm that compares:

- the spatial distribution of buildings observed by satellite image
- the spatial distribution of the GPS points collected by the interviewers during the distribution

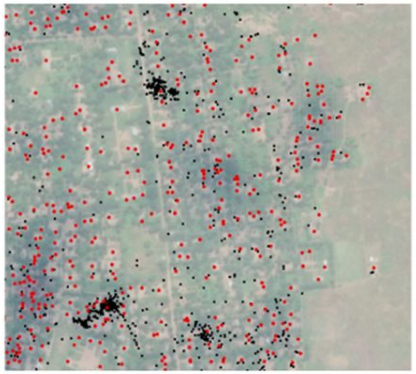
The aim is to detect unexpected clusters of household GPS coordinates where LLINs are not delivered door-to-door

These scripts are created in Jupiter notebook in order to be able to detect these anomalies and follow up with the terrain regularly. These activities were carried out by WorldPop from April 2022.

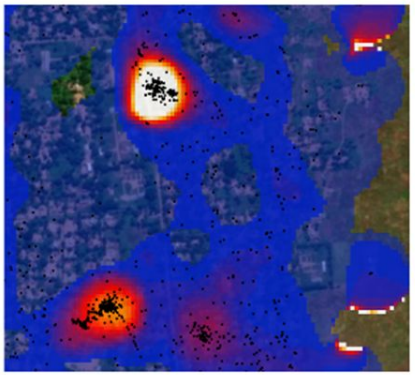
Spatial anomaly detection approach



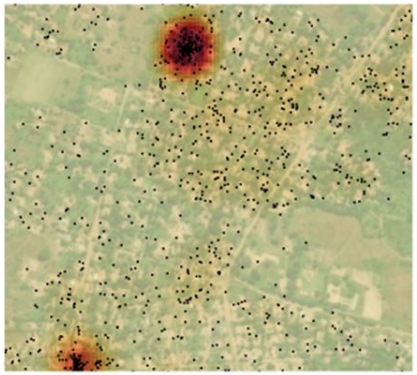
Density of GPS points with GPS points overlaid

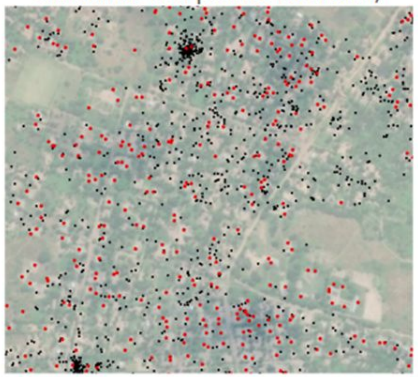


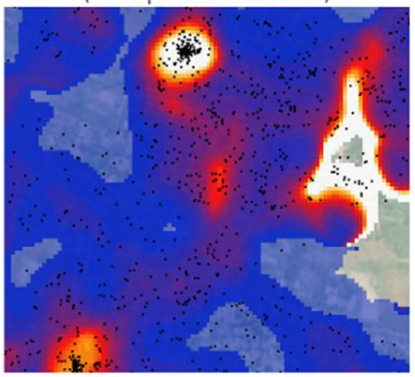
Density of building footprints (building footprint locations shown as red points overlaid)

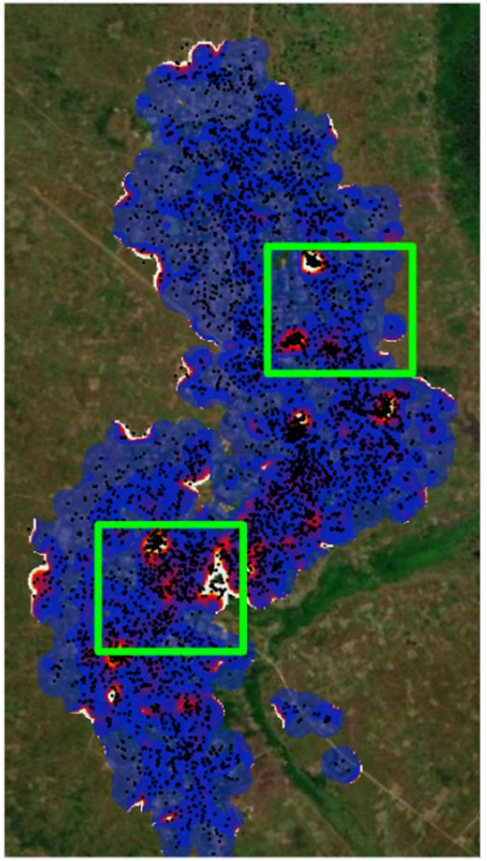


Ratio of density of GPS points to density of building footprints (GPS points overlaid)



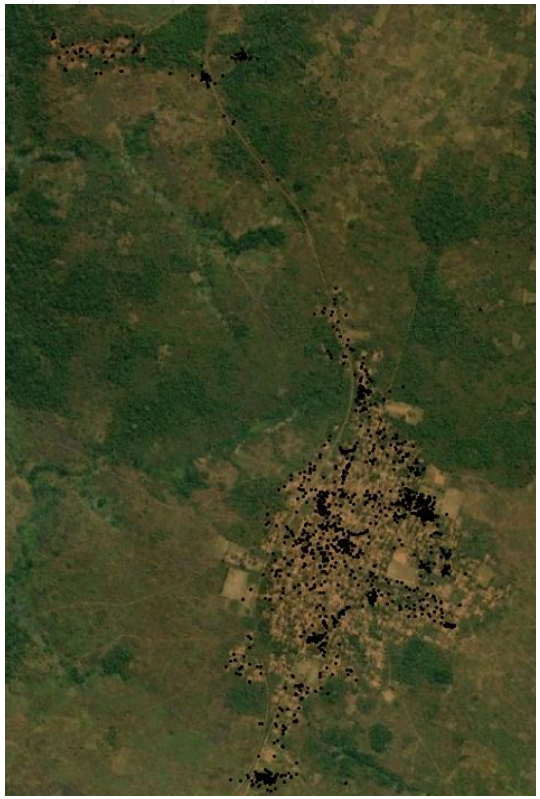






Example (26.0781312°E 6.7810864°S)

PNLP / IMA GPS points
(Households)



Density of GPS points
(darker colours = higher density)

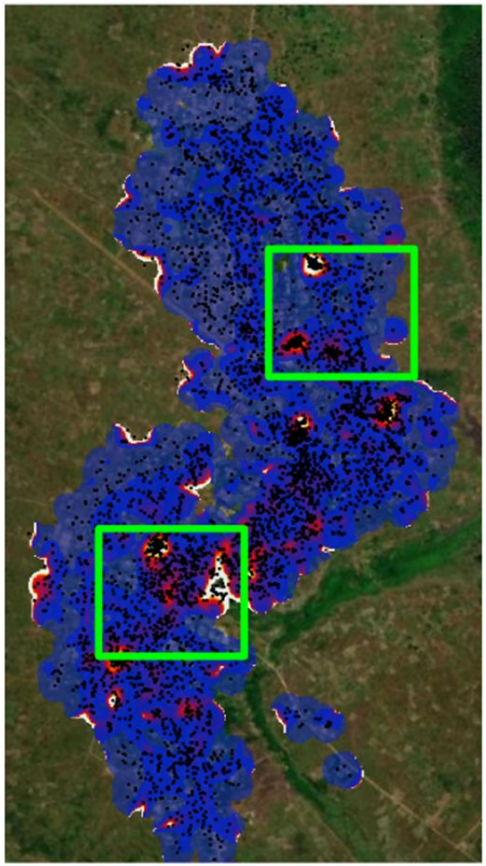
On its own, a high density of points can be a useful indicator of unusual clusters of GPS points, which could be associated with:

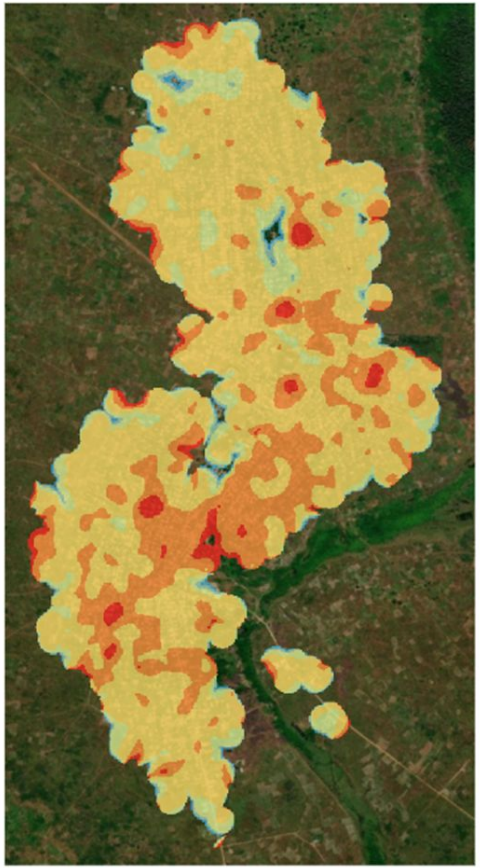
- A distribution that did not take place in every household (point distribution)
- A potential fraudulent addition of additional households

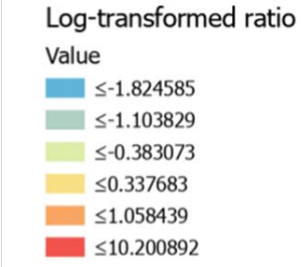
Approach

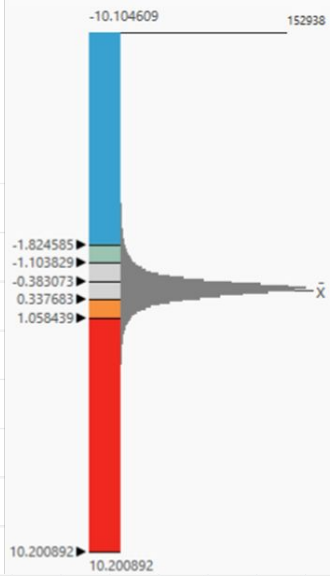
Apply a threshold to identify locations considered to be an anomaly:

- Much higher or lower density of GPS points than expected

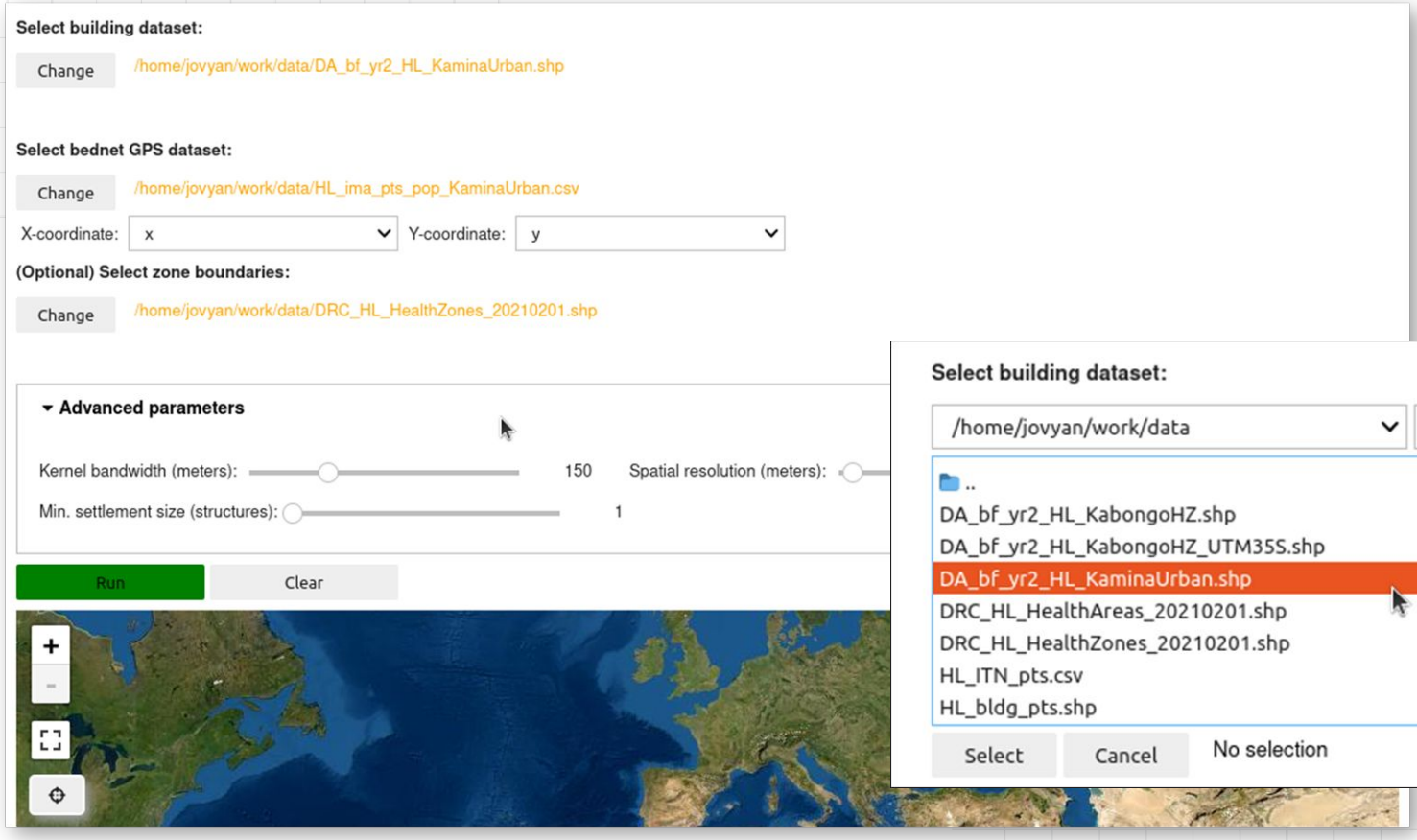








Interactive software tool



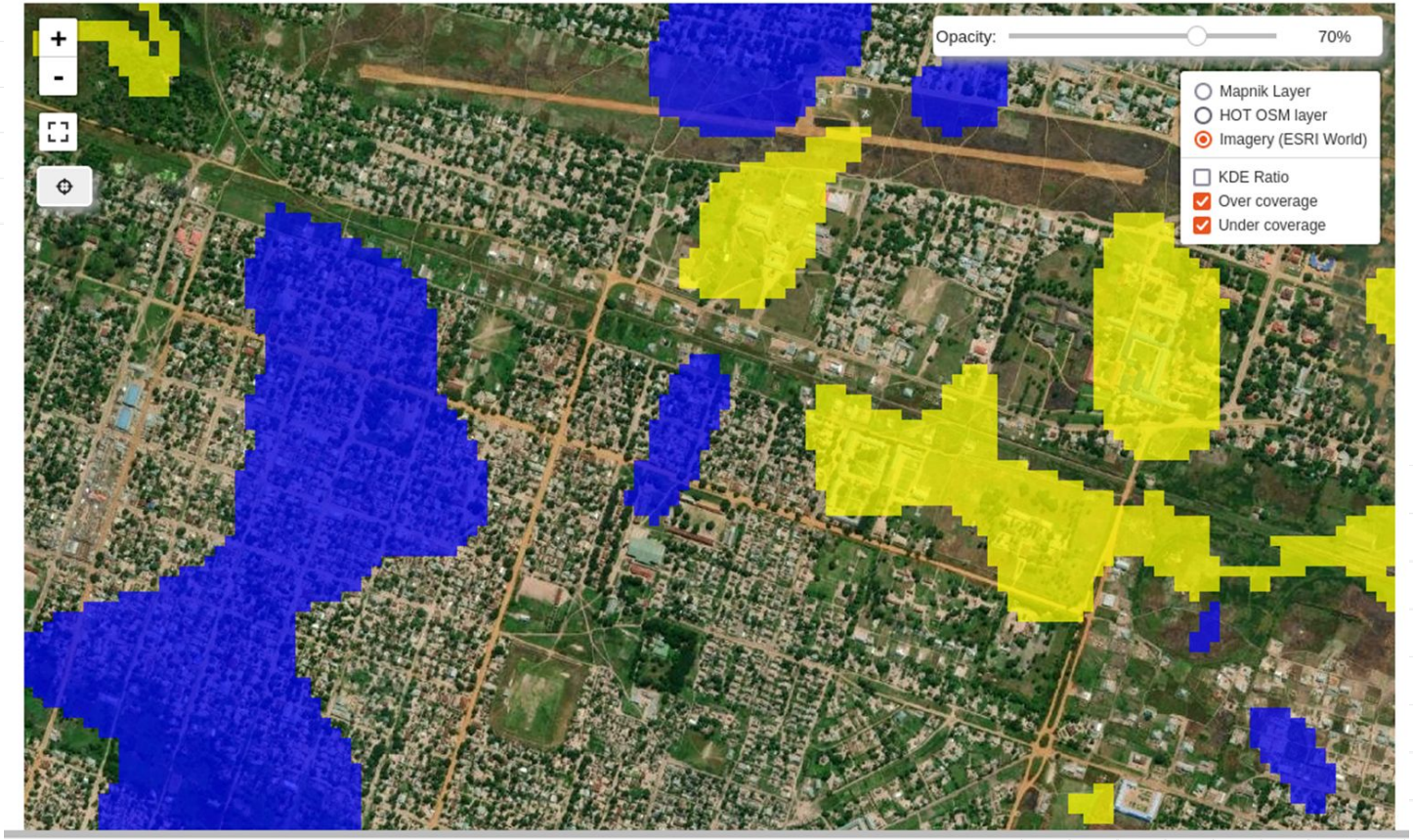
User specifies input data files from folder view:

-Building footprints

-Household locations (GPS)

-Health zone / areas boundaries (optional)

Interactive software tool



Once the user clicks

Run

then mapped outputs are displayed in the interactive map window in the Notebook

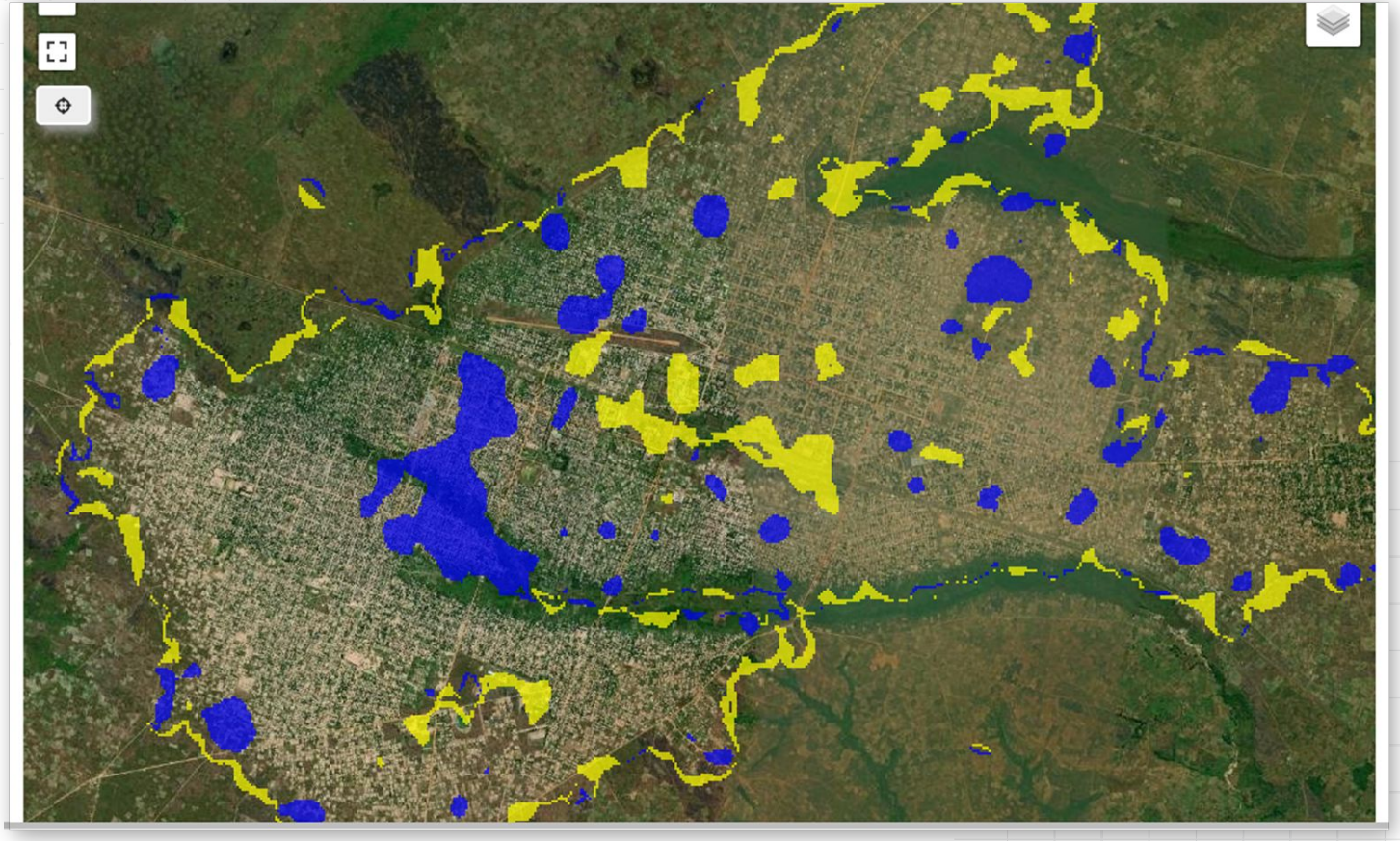
Options to display:

- KDE ratio raster
- Under coverage
- Over coverage

There are different basemap options, including satellite imagery and OpenStreetMap.

Users can also change the opacity of the displayed layers

Interactive software tool



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Geospatial data created from the collaboration with PNLP and implementation partners

Data integration of the PNLP into the national health system

Set up of an in-country Technical Committee, composed of GIS experts and led by the MoH (DSNIS and ANICNS)

- More than 50 participants from 26 organizations
- Active members of governmental organizations, United Nations agencies, NGOs, universities, civil society
- Monthly meetings monitored by the Cartography bureau of the DSNIS

Validation and integration of the PNLP data into the “carte sanitaire”

- Agreement of (over 10 million data points)
- Integration of the data into the NHS (DHIS2, official boundaries layers)
- Legitimate and sustainable platform to collaborate on geospatial data

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Agreement for the Use of Data

Whereas, the **Programme National de Lutte Contre le Paludisme** (“PNLP” – English translation National Malaria Control Programme) of the Ministère de la Santé Publique, Hygiène et Prévention of the République Démocratique du Congo (English translation - Ministry of Public Health, Hygiene and Prevention of the Democratic Republic of Congo) is the owner of certain Pre-Distribution Registration Survey (PDRS) data in République Démocratique du Congo (“DRC”- English translation Democratic Republic of Congo) as further described below (the “PDRS Dataset”) related to the distribution of anti-malaria bednets in the DRC;

Whereas the PDRS Dataset has and is being collected and held on behalf of the PNLP by IMA World Health, a US-based international church membership nonprofit organization organization that provides health services and works to build healthy communities around the world (“IMA World Health”) under a sub-contracting arrangement with Soins de Santé Primaires en Milieu Rural (“SANRU”), a non-governmental organization based in the DRC, pursuant to which IMA World Health (along with SANRU) works as a technical partner to the PNLP in order to collect and provide the PDRS Dataset to the Against Malaria Foundation, a charity registered in the UK, US, Canada and other countries (“AMF”), which has an agreement with the PNLP for the delivery of bed nets in the DRC;

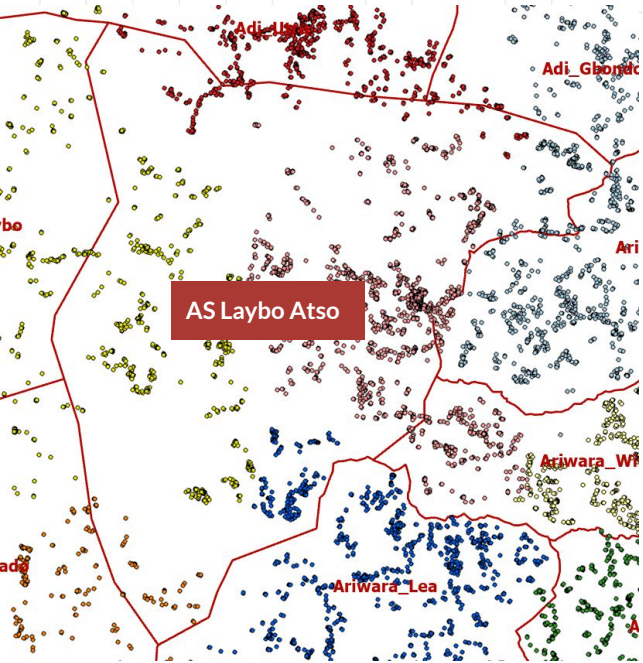
Organization serving as a focal point for settlement, health facilities, and health area/zone boundaries mapping

Humanitarian OpenStreetMap Team

Bluesquare

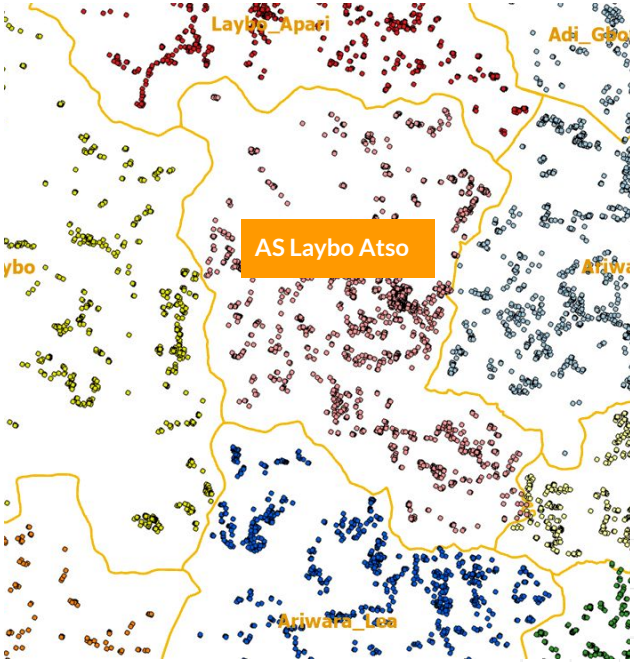
FÉDÉRATION INTERNATIONALE

Initial limits of the health area



Current boundaries

New, adjusted limits of the health area



Adjusted limits (GRID3)

Comparison

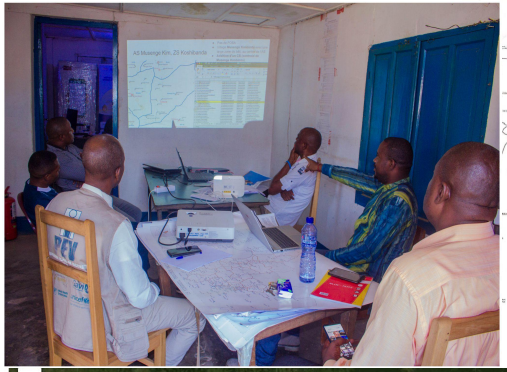
Current boundaries

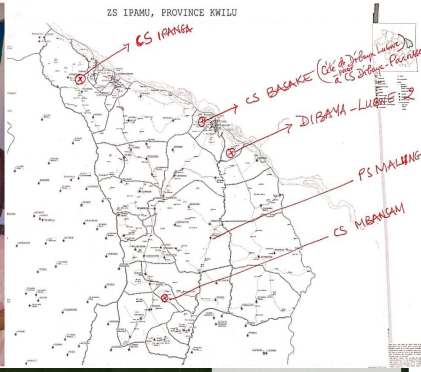
Adjusted limits (GRID3)

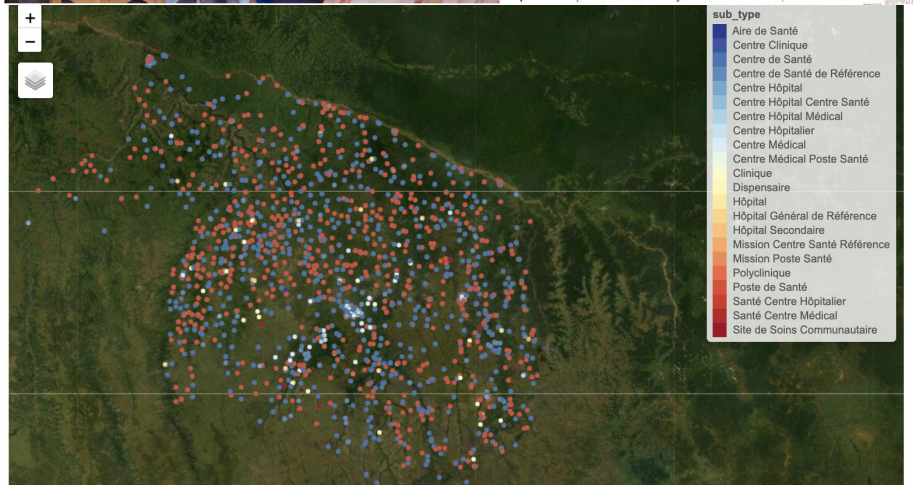
Using PNLP data to improve health boundaries

Validation of data with relevant provincial and authorities

- **Validation of the data from the bottom up:** once the data has been updated, meetings are organized to validate the data and make sure they are endorsed and integrated
- In Ituri for instance, **two 10 days workshops were organized in each antenna** - with 2 representatives of each health zone (Médecin Chef de Zone, Infirmier Superviseur) worked with a small GRID3 GIS team to make the sure the data was accurate and comprehensive
- The final data was then presented to the **Chef de Division and the data team** for validation at the **provincial level**, and then to the **Technical Committee** (led by the Cartography Bureau from the SNIS) at the **national level.**







Outcomes: high resolution geospatial data getting integrated into the health system

The use of data collected by the PNLP / IMA World Health in the Kwilu province (1,198,204 observations) allowed the creation of a complete and precise geodatabase with the following files :

- 24 health zones
- 655 health areas (including more than **70 new non-existing health areas, previously non-mapped**)
- 1,916 health establishments (**98% of FOSAs on the DHIS2 list of the SNIS have been georeferenced**)
- 8,186 villages / hamlets / camps / farms (**new villages localized for integration in the microplans)**

Extensive work on **data accuracy, validity, reliability** and **completeness** to ensure data is ready for use.

Important work done to ensure the **interoperability** of the data and to ensure that it is easily integrated with other information systems, such as **DHIS2**.

Benefit of an improved cartography

Adjustment of the health areas boundaries to accurately reflect areas of responsibility

Kwilu Province, ZS Lusanga & ZS Kikwit Sud

"It was this part [AS Bomoka] that gave us a lot of problems during the LLIN campaign. It was forgotten, we had not thought of assigning a quantity of LLINs for that area. During the campaign, the population of this area came ; even at the mayor of the city asked the Medecin Chef of Kikwit Sud health zone to find a solution so that this population could get access to the LLINs. We used to think this area was a part ZS of Lusanga."

Mr. Chrispin Batafwadi, Nurse Supervisor (IS) in charge of reproductive health for the Kikwit Sud health zone.

Inclusion of new settlements, not originally in the EPI microplans

Maniema Province, ZS Kibombo

AS Lweki : existence of temporary fishing camps that have become permanent (accessible in canoe only for some parts)

AS Likeri Reference : change in status from seasonal agricultural camps to permanent settlements

GRID3

GEO-REFERENCED INFRASTRUCTURE AND DEMOGRAPHIC DATA FOR DEVELOPMENT

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