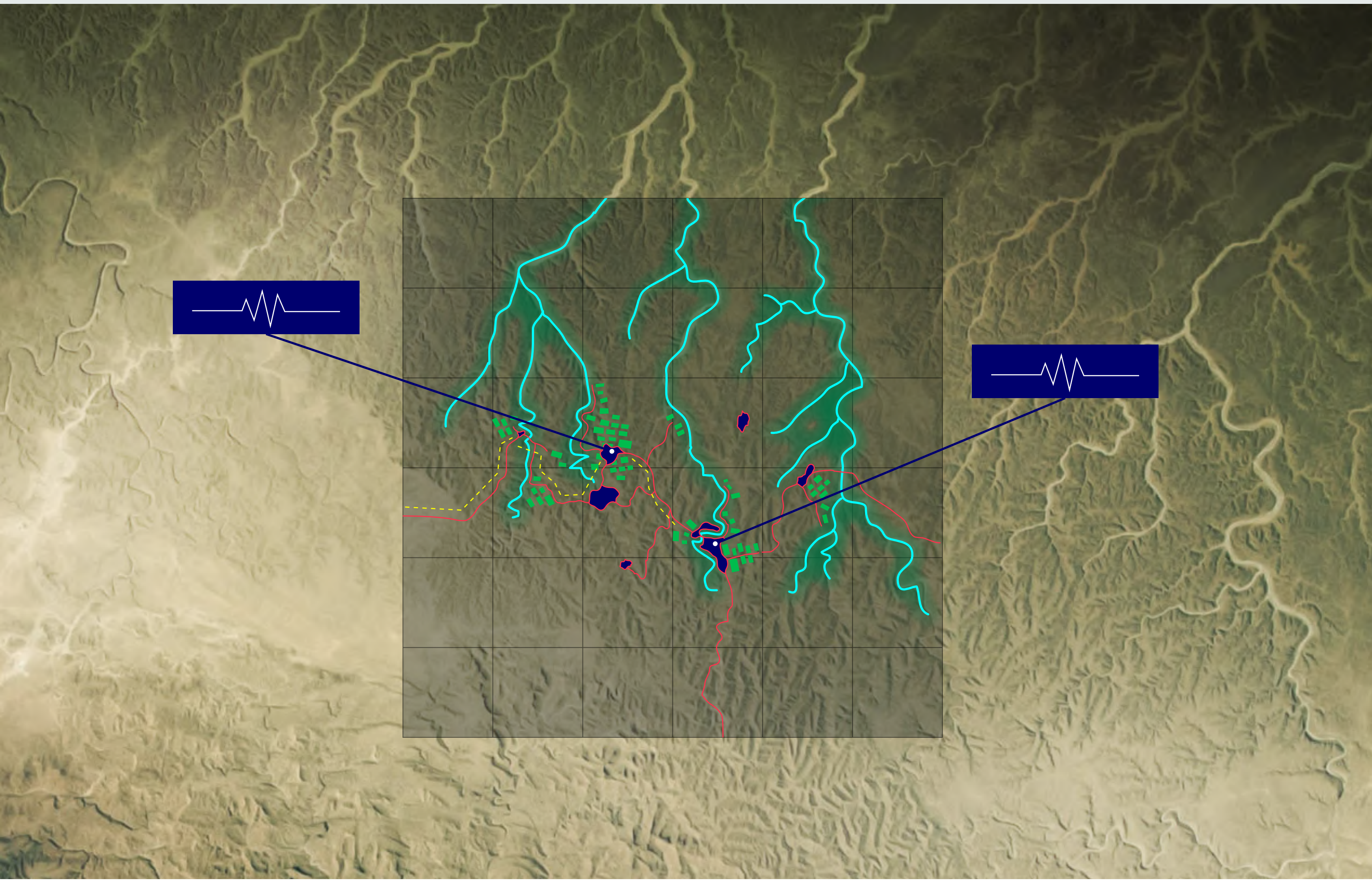
Planning for COVID-19 in developing countries using earth observation and data analytics



As the COVID-19 pandemic spreads across the globe and stretches the healthcare systems of cities like New York, London or Milan to breaking point, we are deeply concerned about how developing countries - our area of work - can deal with it.

The resilience of their health care systems to the shock of a large-scale pandemic and that of their individual citizens to illness and economic isolation, is low. Already now, billions of people live in precarious conditions, including hundreds of millions in great poverty. Many, especially among the urban poor, have to earn everyday to be able to feed themselves and their families. For them, a lockdown might be just as life-threatening as the virus.

The need for planning

As it stands, developing countries have the benefit of a little bit of time: time to plan for the pandemic and time to learn from the positive and negative experiences of countries, where COVID-19 infection numbers are already much higher. This time must not be wasted.

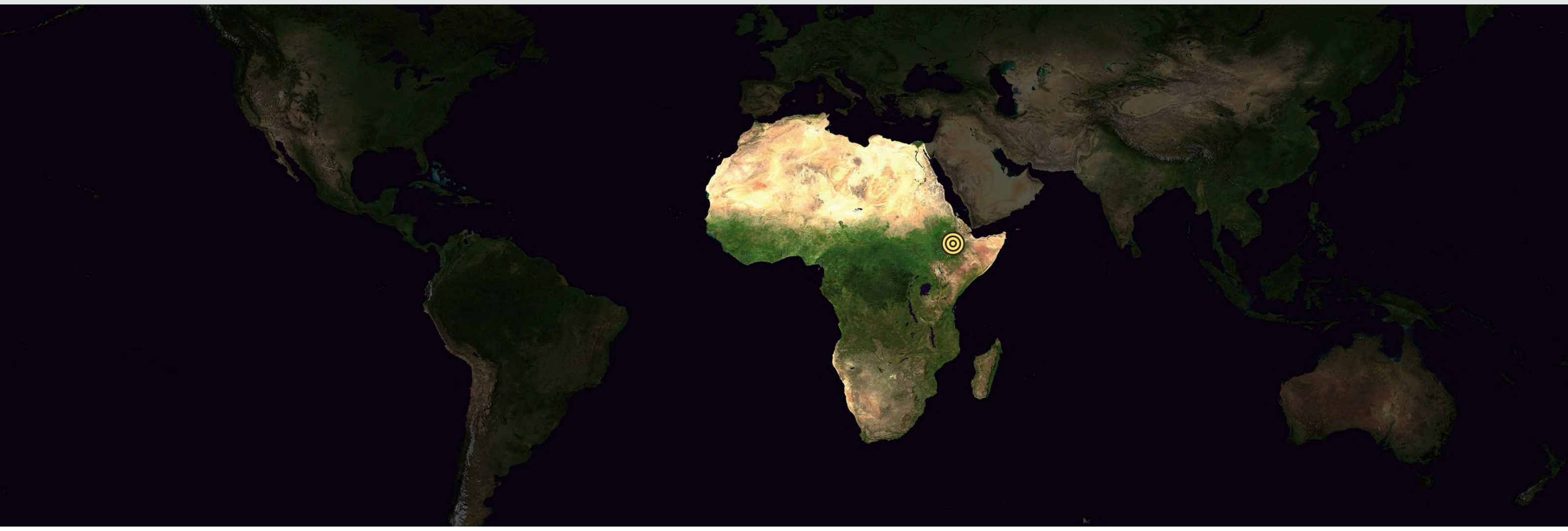
Planning requires lots of data and information - something often missing in "data lean" developing countries. We experience that in our everyday work on electrification in Africa and Asia. To address this challenge, we have, with support from the European Space Agency and appliedAI, built a data-based decision making tool that uses earth observation, on-ground data and artificial intelligence to improve how infrastructure, policy and investments can be planned (www.villagedata.io).

We recognise that the data-scarcity of developing countries is a particularly critical factor now as decision-makers are framing policies to combat the spread of COVID-19. They need reliable, real-time data. We want to contribute to this effort with the resources available to us. Together, we can get get started on questions such as:

- **Virus spread:** How could the virus spread, based on factors such as population clusters, transportation infrastructure, or certain public places such as markets or places of worship?
- **Locating testing facilities:** Where could testing facilities be strategically located? Is electricity and water available?
- **Predicting healthcare bottlenecks:** Where are health centers, hospitals, hospital beds and ICUs located? Which population groups are at particular risk of experiencing bottlenecks or unavailability of health services?
- **And much more:** And there are many other important questions. The situation is changing fast. We look forward to plugging into a much broader conversation and teaming up with like-minded partners.

With this paper, we seek to reach

- **Decision-makers:** National decision-makers preparing for, or managing an outbreak, the national and international organizations that support them, and local decision-makers (governors, mayors, hospital administrations, etc).
- **Collaborators:** Especially data-providers, planning experts, healthcare experts and other GIS and data analytics experts.



How we can support planning (example of Ethiopia)

We have started to answer some of the questions, taking the example of the healthcare system in Ethiopia. Our current analysis is based on earlier work from Bruno Sanchez under the World Bank's Data partnership.

Our code and sample data is available on Github, it can be found here. The interactive maps can be found online (for a link see the description for each figure). The basis for our analysis are open-source datasets from OSM (link), health facilities in Sub-Saharan Africa from the WHO (link) and on settlements from Facebook's HRSL (link).

In addition, we used the GridFinder dataset (link) for estimates of the electricity grid infrastructure in Ethiopia. Areas that are beyond 5 km of transmission and distribution lines in the GridFinder dataset are considered off-grid for the purpose of our analysis.

We looked at the distribution of hospitals and of smaller health centers (together "health facilities") across the country and with respect to the population distribution and access to grid power. We wanted to learn:

- How accessible are hospitals? We evaluate this by estimating how long people from different parts of the country have to travel to reach their nearest hospital (that could offer treatment and ICUs in severe cases of sickness).
- How would hospital accessibility change, if critical infrastructure is lacking? We took the example of electricity infrastructure and built a scenario where we excluded all hospitals that are not grid connected to see where that would put additional people at risk.
- How accessible are health centers? Health centers are small health facilities that could play a crucial role in testing and vaccination.
- How many of the test centers do not have access to grid power? Since power is required for cold chains for vaccines, they should be electrified as a priority.

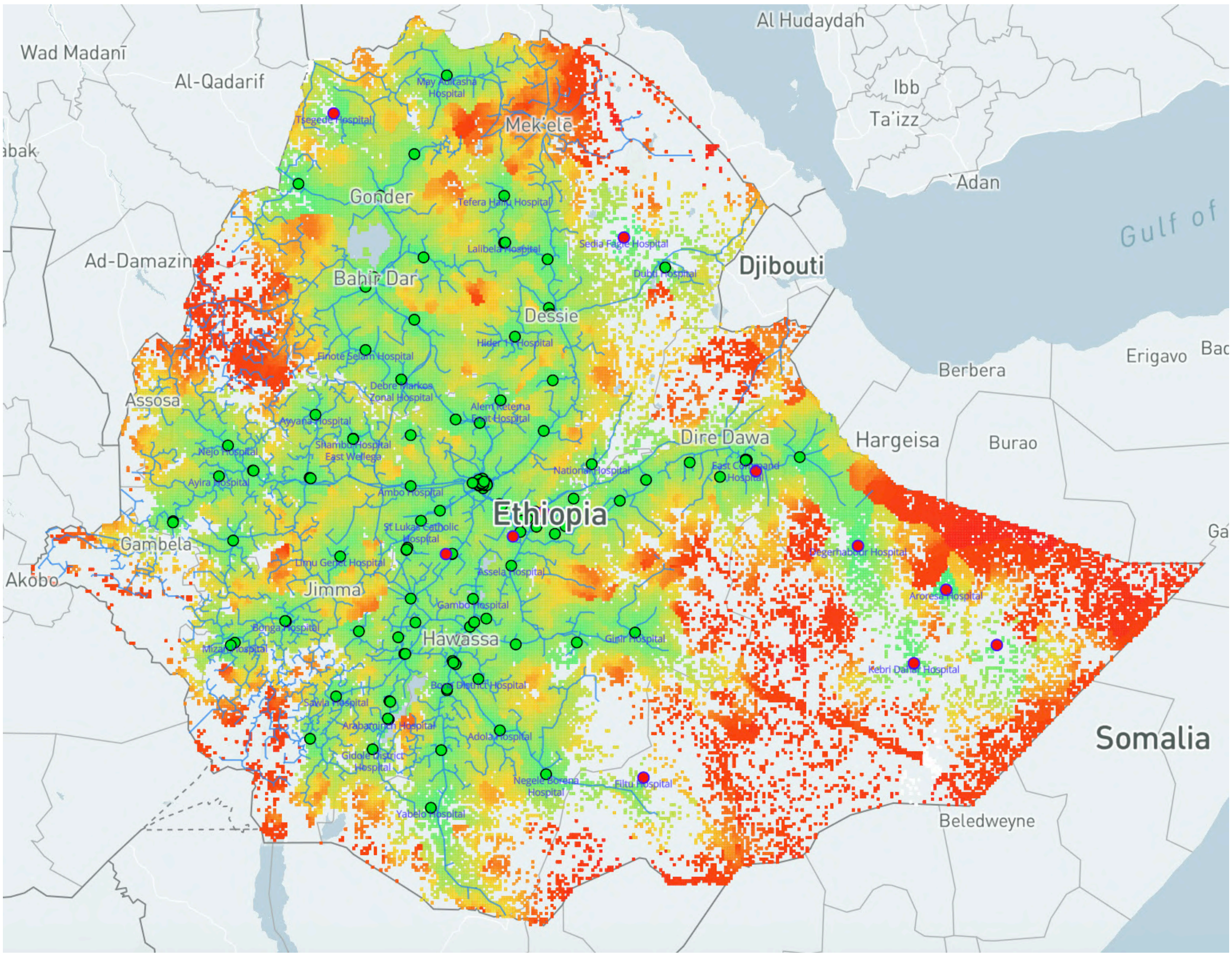


*Figure 1 shows the distribution of hospitals in Ethiopia and estimated travel times to the nearest hospital for different population groups. Hospitals that are further than 5km from the grid are marked in red. (*See Mapbox link*) Green represents the population that lives within 1 hour drive from a nearby hospital. Red represents the population that is more than 5 hours drive. That is the case for a substantial share especially in the peripheral regions of Ethiopia (Somali, Tigary and Benishagul Gumaz regions). Additionally, several hospitals in these regions do not have access to grid electricity. When these hospitals are not fully functional, the map turns more red, as shown in Figure 2*

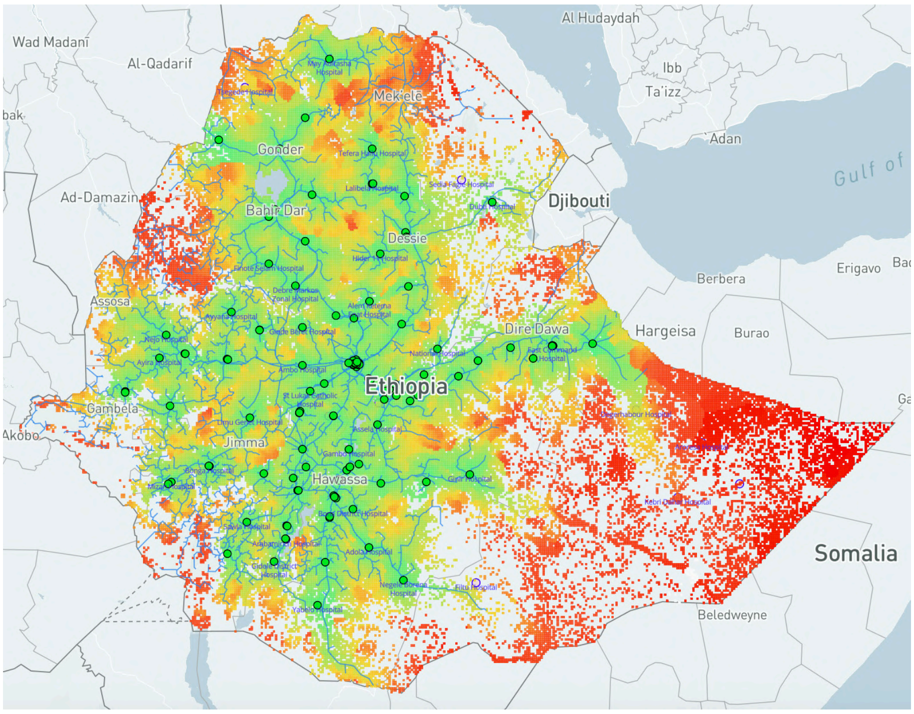


Figure 2 shows a scenario analysis of the population that is additionally at risk, if hospitals that are further than 5km from the grid are not fully functioning. (See Mapbox link)

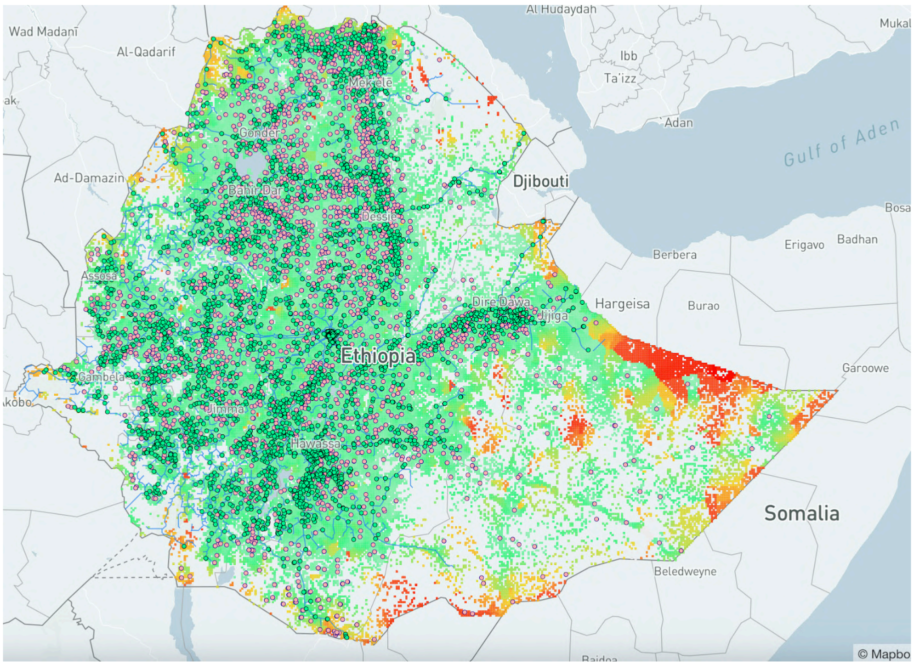


Figure 3 shows the distribution of local health centers in Ethiopia and estimated travel times to the nearest one for different population groups. Health centers that are further than 5 km from the grid are marked in red. (See Mapbox link)

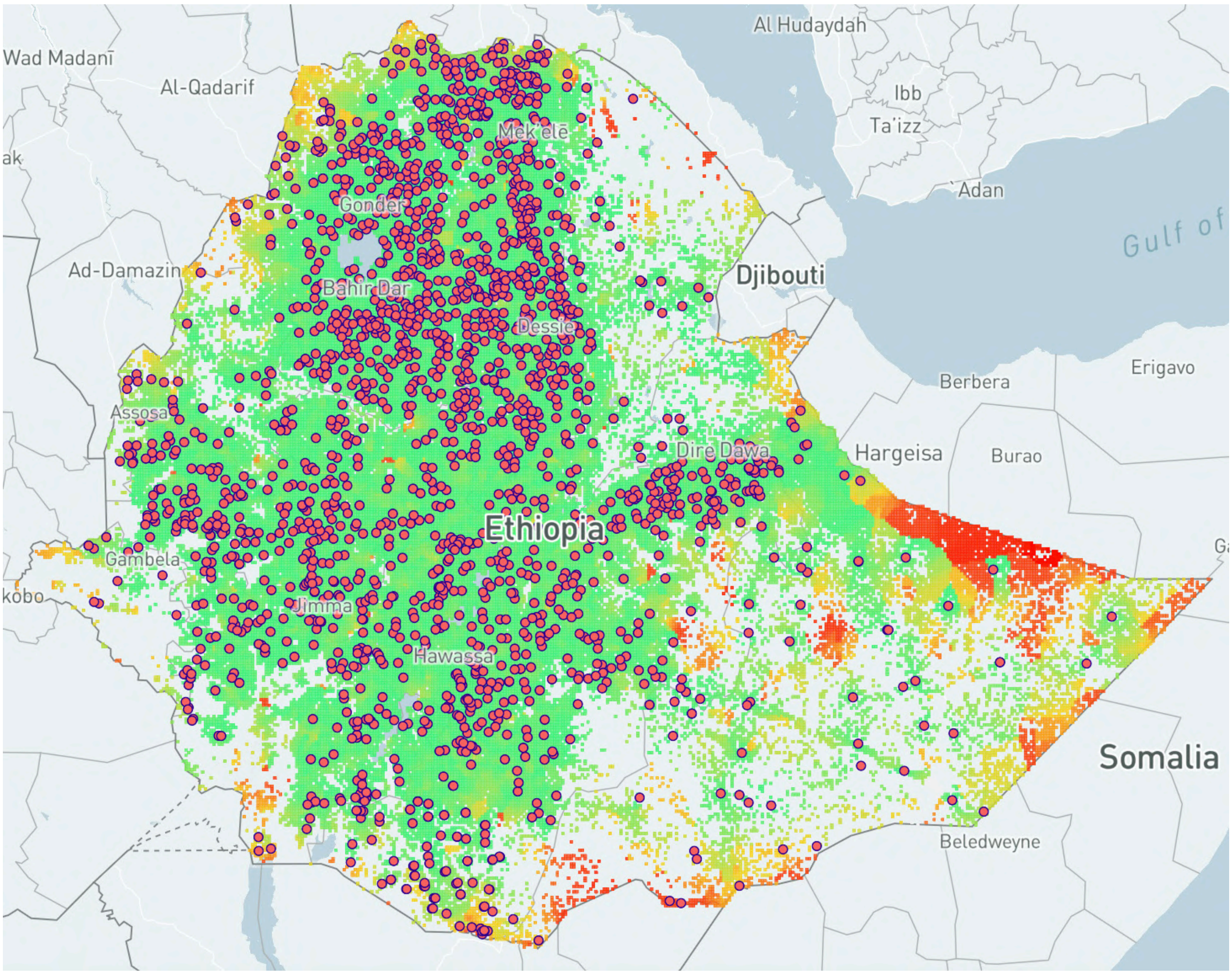


Figure 4 shows only those health centers that are more than 5km from the grid. These should be electrified on a priority. ([See Mapbox link](#)*).*

In total, we count 1,985 unelectrified health centers in Ethiopia. Just as a thought experiment: A 1kW system (including 4 250W solar panels, battery, inverter and controller) for a health center to power lights, a fridge, charging for electric diagnostic tools and a computer/ screen and internet access (e.g. for tele-health). Assuming that to deliver and install a system will cost $5,000, the total investment would be approximately $10 million.

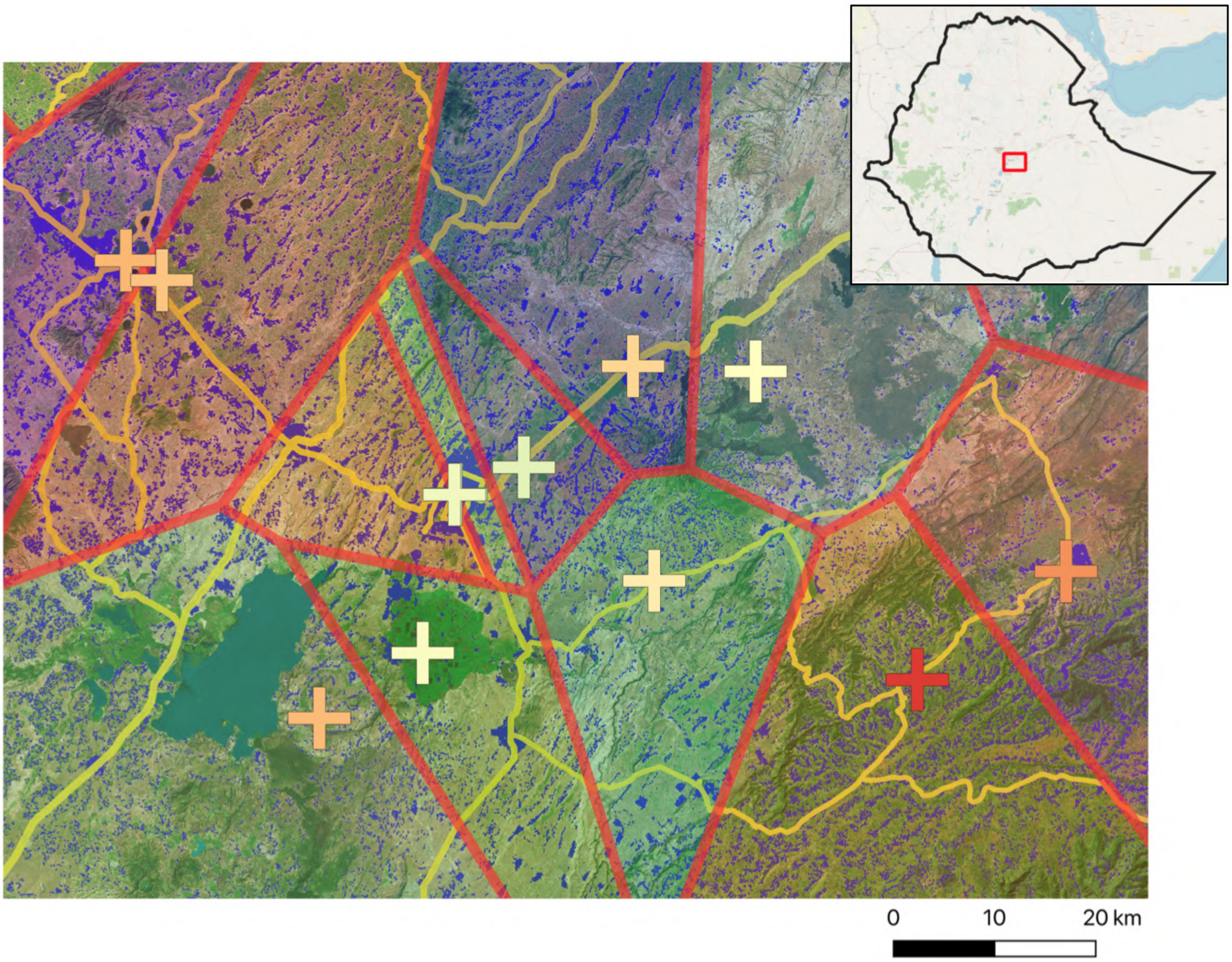


Figure 5: The analysis can also be localized - for example, focusing on the capital Addis Ababa or a district, where individual hospitals and health centers can be linked to population clusters (catchment areas). In this example, hospitals are represented as crosses and stipulated catchment areas are shown by the shaded red boundary lines. A green cross means a comparatively low number of people per hospital. Red means a comparatively large number of people per hospital. (We are here not taking into account the capacity of individual hospitals.) Settlements are indicated in blue and main roads in yellow. Such an analysis can help plan, which hospitals might be overwhelmed with patients and require support. In this first analysis, we simply used a straightforward distance measurement to the nearest hospital to identify the potential number of patients a hospital has to serve. This analysis can be improved by estimating travel time to hospitals, based on the length and type of access road. This can be achieved using open source datasets (e.g. OSM) and satellite imagery.

The analyses shown here are just a first step towards identifying areas where the health system is at risk of particular stress and where testing and vaccination facilities could be set up speedily.

There are many ways to expand and enrich the analysis. Much relevant work is already done across the world that developing countries can build on. These are examples:

- **Adding information layers:** Information on the number of actual beds and ICU resources available at each of the hospitals, on the availability of water and electricity, or on logistics and supply routes, could be particularly useful.
- **Granular analysis for urban centers:** In addition, a more granular analysis should be performed within the larger urban areas (Addis Ababa, Bahir Dar or Gondar). Here, the analysis could be conducted for areas within the city to assess the capacity of local health facilities and hospitals.
- **Adding the time dimension:** By estimating travel times and population movements based on road and other infrastructure, settlements, and important places of public interest (markets, schools, etc). Such an analysis could be enriched by using mobile phone data. This could help assess the possible spread of a disease and help in planning stationary or mobile testing units.
- **Making it real-time and highly usable:** The analysis should be converted into an online portal that provides real-time analysis to decision-makers and that is open to many more active participants, both on the level of data-supply (especially ongoing health data) and on analytics. Systematically building such a planning backbone will be critical to any effective national COVID-19 response strategy. With the right resources, this can be done in one month.
- **Supporting political decision-making:** By adding socio-economic and epidemiological aspects one can assess, for example, what the effects of political choices such as lockdowns are on critical systems such as food/agriculture/logistics, and how different lockdown restrictions or decisions on re-opening sectors or regions could impact the virus spread.

Going forward, we would be glad to work with partners across all of Africa. Our analyses range from the hyper-localized (e.g. at the level of households) to the national level, or larger.

For ideas and questions, feel free to reach out to our team: Tobias Engelmeier (tfe@tfe.energy), Philippe Raisin (philippe.raisin@tfe.energy), Nabin Raj Gaihre (nabin.gaihre@tfe.energy).

For more information, see website: www.villagedata.io