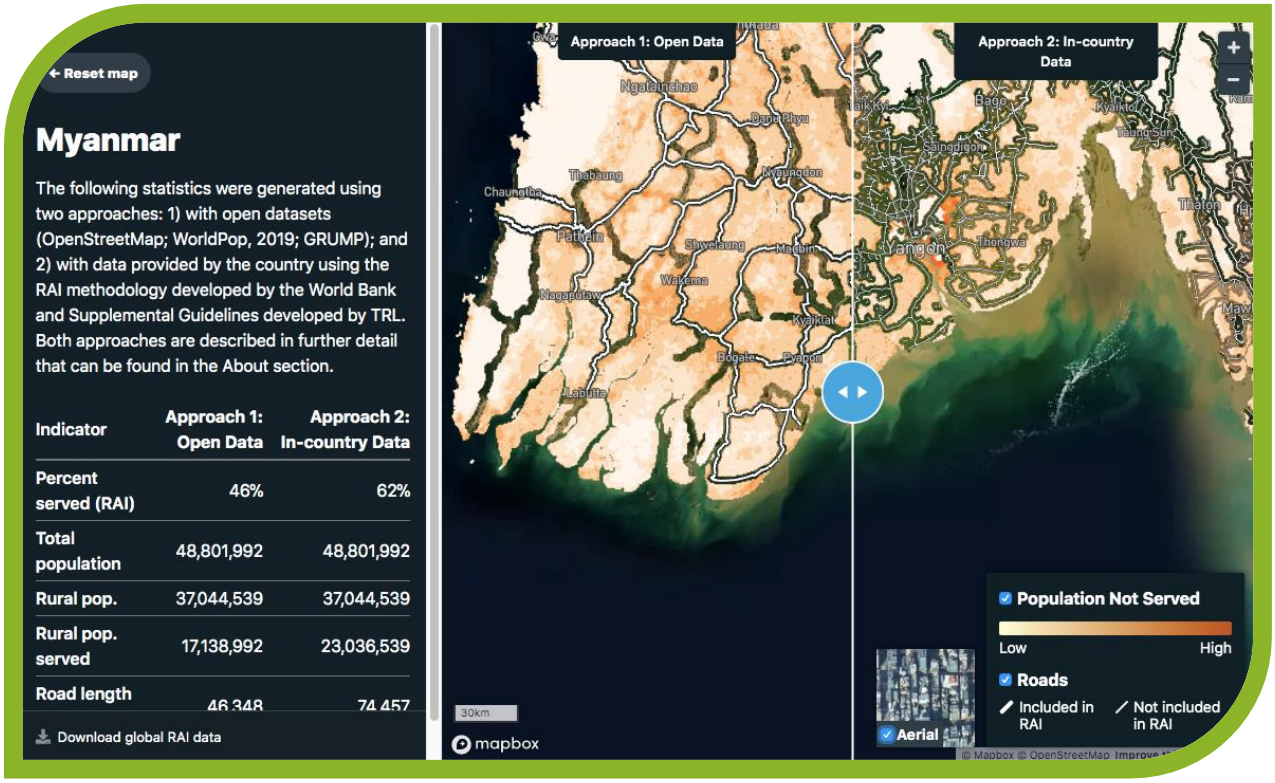
Rural Access Indicator (RAI) Measurement Tool: Proof of Concept

Final Report



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ReCAP Database Details: RAI Measurement Tool: Proof of Concept

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1 Executive Summary

Cardno contracted Azavea to develop a software framework for the Rural Access Index (RAI) Measurement Tool that enables the calculation of the proportion of the rural population who live within 2 km of an all-season road for every country globally. The proof of concept application is complete and the results are available at **rai.azavea.com**. The tool calculates the RAI value for all countries using open datasets (OpenStreetMap, WorldPop (2019), GRUMP) and the methodology for measuring SDG 9.1.1 developed by the World Bank in 2016, and Supplemental Guidelines developed by TRL. For three trial countries, the tool displays the results of the open data approach, in addition to the results of an approach using data provided by road agencies in each country.

A goal behind the development of this tool is to lower the barrier of entry to reporting on SDG indicator 9.1.1, which is synonymous with the RAI, and help to elevate it from a Tier II to a Tier I indicator. This tool is a proof of concept that will be used to move the conversation forward with stakeholders invested in the RAI and SDG 9.1.1., including the World Bank and the UN Global Platform. This report provides recommendations for next steps towards operationalising the tool through user interface functionality, automated analysis and administrative functionality.

The RAI Measurement Tool project is a collaborative effort with partner organisation TRL gathering a subset of country-level data (Project Ref: GEN2033D) and Azavea completing the following:

1. Calculating RAI data for every country globally using open source geospatial datasets;
2. Incorporating country-level data into the prototype RAI measurement tool for trial countries; and
3. Providing a proof of concept application for the RAI measurement tool that can be tested on the UN Global Platform.

2 Scope of Work and Project outputs

2.1 Generate RAI Using Open Data

Azavea leveraged the open source geospatial data analysis library, GeoTrellis, to provide the processing capacity to calculate the Rural Access Index (RAI) for every country globally. This includes the ability to filter data by road attributions on OpenStreetMap. Azavea followed the World Bank methodology as described in the report: Measuring Rural Access: Using New Technologies (World Bank, 2016)[1]. The generation of RAI data for every country globally using open data generates a benchmark based on a uniform methodology using the same input datasets. This enables the comparison of results for countries that have generated RAI values using country-specific datasets.

The following three datasets were used in the measurement:

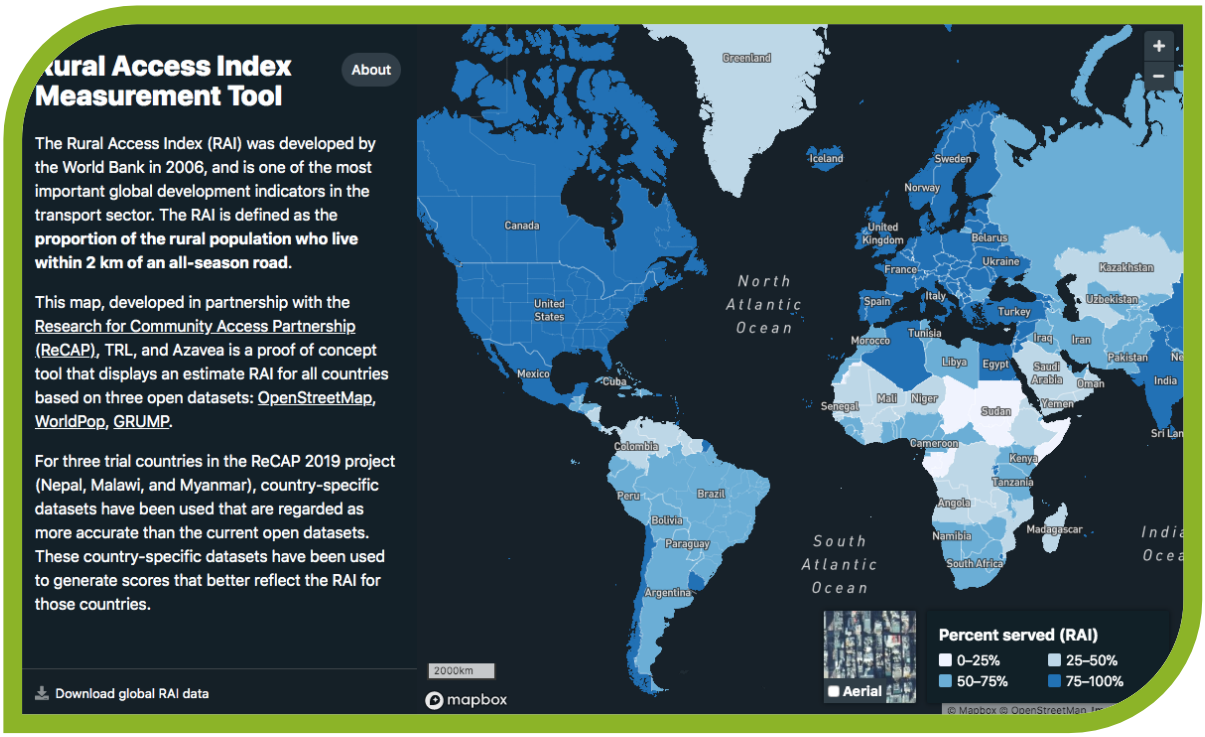
- OpenStreetMap (https://openstreetmap.org)
- GRUMP (https://sedac.ciesin.columbia.edu/data/set/grump-v1-urban-ext-polygons-rev01)
- WorldPop (https://www.worldpop.org)

The repository that contains the code and methodology used to complete the measurement is available at https://github.com/geotrellis/geotrellis-road-distance-sdg. Please refer to **Figure 1** for a choropleth map showing the RAI for each country globally.

Additional technical information about the methods, inputs, and outputs of this tool are available here: https://github.com/geotrellis/geotrellis-road-distance-sdg/releases/tag/v3.0. A table containing the 2019 statistics for all countries is available directly through the application: **rai.azavea.com.**

[1] World Bank (2016). Measuring Rural Access Using New Technologies. Washington D.C.: World Bank

Figure 1 Global Choropleth Map of the RAI Value by Country



2.2 Incorporation of Country Data

A fundamental component of the RAI Measurement Tool is that it has the ability to override the default open source datasets with better data derived from individual countries. While a fully functional application that will support custom user uploads is beyond the scope of this proof of concept application, we manually uploaded data for three ReCAP trial countries that was obtained by TRL from the in-country road agencies. Following the methodology developed by TRL, Azavea calculated the RAI for these three countries, which can be compared with the measurements obtained using the open datasets.

Please refer to **Figure 2** for a population map showing the population for Malawi that lives beyond 2 km from a road displayed through the interactive web-based visualisation tool. Country-level data was delivered to Azavea from TRL with one modification: Ghana was removed from the trial country set because accurate country level data could not be obtained for Ghana[2]. The new set of trial countries includes Nepal, Myanmar, and Malawi.

The analysis for the three trial countries followed the RAI methodology developed by TRL and described in the Supplementary Guidelines. The results of the analysis were verified with TRL. Malawi and Nepal have results that are within ~1 and ~4 percentage point respectively compared to the open data approach. Myanmar varies from 62% to 46%. This is explained by the fact that the in-country road dataset for Myanmar represents a larger road network than presented in the OpenStreetMap road dataset used for the open data approach. Therefore, the resulting RAI is higher for the in-country data approach for Myanmar. One outcome of the verification was the discovery that the WorldPop values for Nepal were off by nearly 10 million people from the most recent estimates. After reaching out directly to the maintainers of WorldPop, TRL was able to obtain a more accurate dataset. This dataset has been incorporated into our calculation. This tool draws on WorldPop data directly. In the future when this tool is rerun, it will rely on the latest available WorldPop data. One benefit of this tool is increased exposure for WorldPop. In the future, if people notice an error in WorldPop data, similar to the experience of TRL in the course of this analysis, it can be reported to WorldPop, and this tool will then reflect the changes when it is rerun. See

[2] Please refer to TRL's TG2 Report for further detailed information on the data collection from the trial countries: http://www.research4cap.org/SitePages/RAI.aspx

Table 1 and Table 2 for the summary statistics for the three trial countries. **Table 3** contains the data sources for the in-country RAI measurement.

Figure 2 Visualisation of Population Raster for Malawi Comparing Two Approaches: (1) Open Data and (2) Country-Provided Data

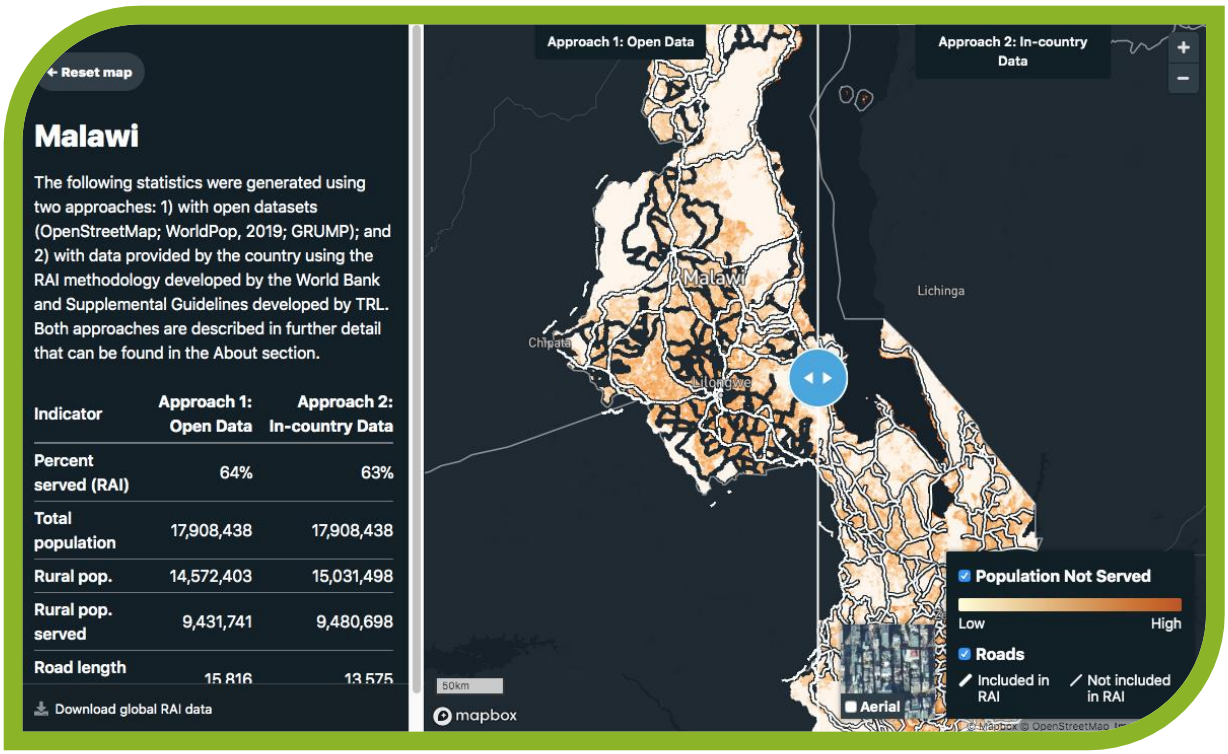


Table 1: Summary Statistics for In-Country Data for Trial Countries

Country	Year	Total Population	Rural Population	Rural not served (total)	Rural not served (%)	Rural Served (total)	Rural Served (%)
Malawi	2019	17,908,438	15,031,498	5,550,800	36.93	9,480,698	63.07
Nepal	2019	28,609,714	20,410,137	6,857,867	33.60	13,552,331	66.40
Myanmar	2019	48,801,992	37,044,539	14,008,000	37.81	23,036,539	62.19

Table 2: Summary Statistics for Open Data for Trial Countries

Country	Year	Total Population	Rural Population	Rural not served (total)	Rural not served (%)	Rural Served (total)	Rural Served (%)
Malawi	2019	17,908,438	14,572,403	5,140,661	35.28	9,431,741	64.72
Nepal	2019	28,609,714	20,410,137	6,127,646	30.03	14,282,491	69.97
Myanmar	2019	48,801,992	37,044,539	31,663,000	53.74	17,138,992	46.26

Table 3: Data Sources for In-Country RAI Measurement

Country	Road Dataset	Population Dataset	Rural Boundary Dataset
Malawi	Malawi Roads Authority provided road data	WorldPop	MASDAP: 4 largest cities and 26 town boundaries
Nepal	SRN, DRCN, LRN Roads	WorldPop	GRUMP
Myanmar	DOH, DRD_CBMG, MOBA_Roads	WorldPop	GRUMP

2.3 Proof of Concept Application

Azavea developed a user interface that enables the visualisation of the results of the RAI measurements tool. The Proof of Concept Application is complete and available at rai.azavea.com. For all countries globally, the RAI score is available that was generated using the three available open datasets (OpenStreetMap, WorldPop, and GRUMP). This data is visualised in a global choropleth map (**Figure 1**). The data is also available for download through the application. For the subset of three trial countries (Malawi, Myanmar, Nepal) where country-sourced data has been used, the application includes the option to toggle between the results of the two different approaches (open data and in-country data).

When this project began, the intention was to incorporate four trial countries: Nepal, Malawi, Myanmar, and Ghana. After many months of discussion between TRL and government representatives from Ghana, it became clear that the entirety of the necessary data would not be available for this country before the project deadline. Cardno, TRL, and Azavea agreed that if the Ghana data becomes available during follow-up Phase 2 work, the data will be included in the application at no additional expense (pending ReCAP funding of Phase 2).

The following features are available in the RAI Proof of Concept Measurement Tool and enable data exploration:

1. Basemap toggle between Satellite view and Mapbox dark view (see **Figure 3**)
2. Layer selection and on/off toggle for: (1) RAI raster view that visualises the populations beyond two kilometres from an all-season road and (2) roads that were included and not included in the RAI measurement
3. A slider view for three trial countries that enable a user to compare the results from the two approaches
4. Summary statistic preview: When a country is selected, the following statistics are made visible in the sidebar of the application: Percent of the Population served (RAI), Country's total population, Country's rural population, Country's rural population served, kilometres of road included in the RAI measurement.
5. Statistics data export: All the data can be exported as an excel table that provides additional statistics beyond those provided in the tool. Aggregated statistics show regional and global data summaries.
6. An about section that provides greater detail about the methodology and background context for the project history.

The following features were not included in the application in order to keep the tool intuitive for users, and to avoid confusion through use of historical geospatial data when no historical in-country data is available:

1. The ability to toggle between different years.
2. The ability to toggle between different open datasets through the user interface.

Figure 3 Visualisation Demonstrating the Satellite Basemap View
This is a small island off the coast of Madagascar that highlights the 2 km buffer around major roads

3 Results, Benefits, and Potential Impacts

Azavea is not aware of another tool that calculates and visualises the RAI for all countries globally. This project produced an intuitive user interface that displays the results for the measurement of a large amount of data. It is our hope that by using a standardised methodology, we can provide a benchmark for RAI research going forward. The methodology and code are available in the open source GitHub repository (https://github.com/geotrellis/geotrellis-road-distance-sdg/releases). This means that the outputs are replicable, and the data sources, methodology, and outputs are all freely available.

Azavea is optimistic that this proof of concept application can be used to start conversations with groups interested in SDG 9.1.1 and the RAI, including but not limited to National Statistics Offices, International Development Organisations, the UN Global Platform, and the World Bank.

Azavea intends to expand its current support for the UN Global Platform's (UNGP) geospatial data processing technology. We intend to build upon this relationship and incorporate additional custom processing tools into the UNGP. We are currently in discussion with representatives from the UNGP about using the RAI Measurement Tool as the first such example of incorporating a tool into the Platform. There are two avenues under discussion: (1) Link to the existing application through the UNGP Marketplace, and (2) generate a new UNGP URL that aligns with the current UNGP tools. There may be additional avenues for incorporation that have not been discussed yet.

This project is a proof of concept. It will be a significant effort, technically and operationally, to provide the application with the functionality required to be adopted broadly. A goal for an extension of this project would be to get official adoption by the UN Custodian Agency responsible for the RAI/SDG 9.1.1 (World Bank). The following list represents tasks that would expand the functionality and support the operationalisation of the tool in an official context:

- **User data upload:** In the proof of concept, Azavea manually uploaded the country-specific data for three countries. By enabling a user to upload custom datasets through the User Interface, we could reduce the barrier of entry for additional countries to calculate the RAI using a standardised methodology.

- **Ability to run the measurement on user-uploaded data:** Once the country-specific data is uploaded, the application will need to run the measurement on the data and update the application user interface with the new statistics.
- **Authentication:** Authenticated user login will be a necessary step to support the generation of official statistics. In addition to the technical authenticated user login, the tool will require an operational verification process of country datasets. Azavea would work with the RAI working group, or other decision makers to inform the technical implementation that will facilitate this verification step.
- **Ability to calculate the RAI at subnational administrative levels:** Azavea believes that this tool can be useful for planning purposes for road and other government agencies. The tool can provide more granular data, i.e. the ability to generate an RAI value at a provincial or district level to help prioritise investment in infrastructure as well as health, education, and other social services, in order to meet the needs of remote communities that are poorly connected.

Azavea will continue to promote this RAI Proof of Concept Measurement Tool. We believe this can be used to expand interest and adoption of the RAI and enable routine collection of data for SDG 9.1.1 in a greater number of UN countries going forward. Furthermore, we are optimistic that this technical approach, which combines open data and country-provided data, can be applied to additional development indicators and SDGs at a global scale.