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# World

## Measuring Rural Access: Update 2017/18

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# Measuring Rural Access: Update

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2017/18



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## Acknowledgment

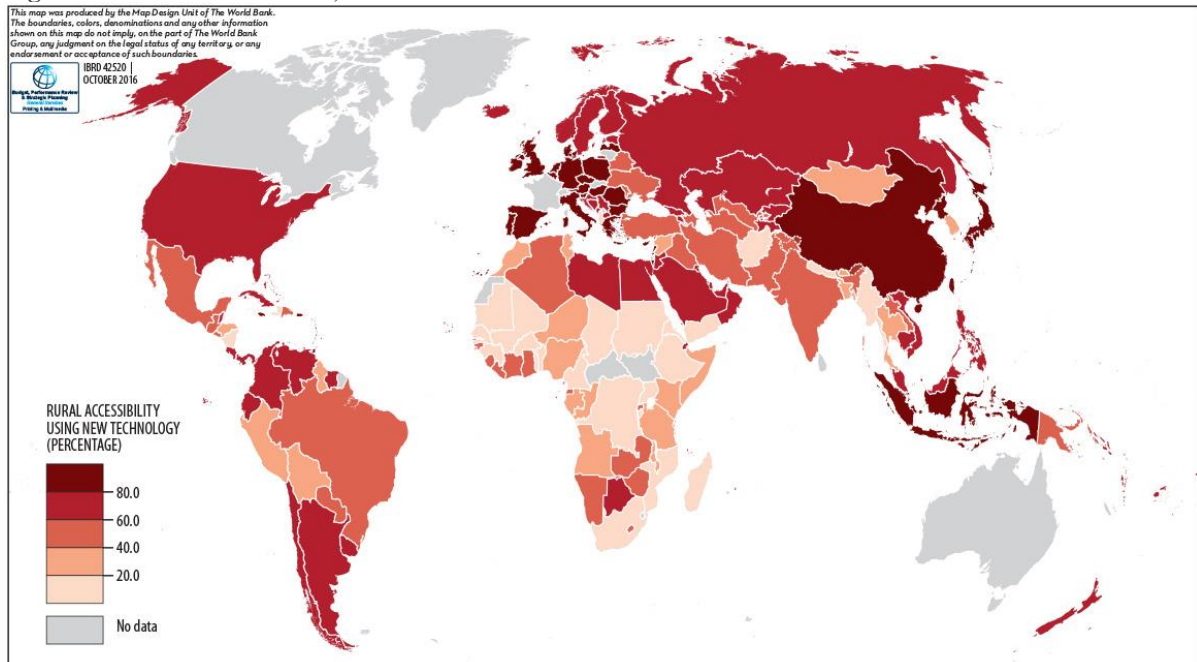
This update was prepared by Transport Global Practice under the supervision of Jose Luis Irigoyen, Senior Director, and Aurelio Menendez and Maria Marcela Silva, Practice Managers. The report was prepared by a World Bank team comprised of Atsushi Iimi (Task Team Leader), Adam Stone Diehl, Laban Maiyo, Muneeza Mehmood Alam, Fernanda Ruiz Nunez, Tatiana Peralta-Quirós and Farhad Ahmed, in collaboration with Steven Farji Weiss, Noroarisoa Rabefaniraka, Sevara Melibaeva, Rajesh Rohatgi, Kulwinder Singh Rao, Cheick Omar Tidiane Diallo, Aiga Stokenberga, Li Qu, Ben Gericke, Olatunji Ahmed, Ana Rodriguez Coteron, Stephen Muzira, Sofia Guerrero Gamez, Ana Silvia Aguilera, Muhammad Zulfiqar Ahmed, Emmanuel Taban, Heinrich Bofinger, James Markland, Haileyesus Mengesha, Mira Morad, Ibrahim Dajani and Ziad Nakat on country-specific issues. The work also benefited from support provided by Almud Weitz, Olivier Le Ber, Shomik Raj Mehndiratta, Benedictus Eijbergen, Nicolas Peltier-Thiberge, Marianne Fay, Neil James Fantom, Umar Serajuddin, Buyant Erdene Khaltarkhuu, Simon Ellis, Nancy Vandycke, Holly Krambeck and Wei Winnie Wang. The team would also like to acknowledge the generous cooperation of the Governments of Armenia, Burundi, Iraq, Jordan, Lebanon, Lesotho, Liberia, Madagascar, Malawi, Mali, Nigeria, Peru, Rwanda, Sierra Leone, and Somalia, as well as other organizations, such as the United Nations, which provided necessary data for the analysis.

## I. Introduction

1. Transport connectivity is an essential part of the enabling environment for inclusive and sustained growth. In many developing countries, particularly in Africa, the vast majority of people are still not connected to local, regional, or global markets. Such rural accessibility is crucial to reduce poverty and promote inclusive economic growth. The Sustainable Development Goals (SDGs) aim to build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation (Goal 9), for which Target 9.1 is to “develop quality, reliable, sustainable and resilient infrastructure...to support economic development and human well-being, with a focus on affordable and equitable access for all.” The Rural Access Index (RAI) was proposed and accepted as an indicator to measure this target.

2. The RAI is one of the most important global indicators in the transport sector. It measures the proportion of people who have access to an all-season road within an approximate walking distance of 2 kilometers (km). There is a common understanding that the 2 km threshold is a reasonable extent for people’s normal economic and social purposes. The definition is also simple enough to understand and use not only in the transport sector, but also in the broader development context, such as poverty alleviation. The initial RAI study in 2006 was based on household surveys and other simplified methods,<sup>1</sup> estimating the global index at 68.3 percent, leaving a rural population of about one billion disconnected around the world (Figure 1).

**Figure 1. Rural Access Index, 2006**



<sup>1</sup> Roberts, Peter, K. C. Shyam, and Cordula Rastogi. 2006. “Rural Access Index: A Key Development Indicator.” *Transport Papers* TP-10. The World Bank Group, Washington, DC.

## II. Methodology

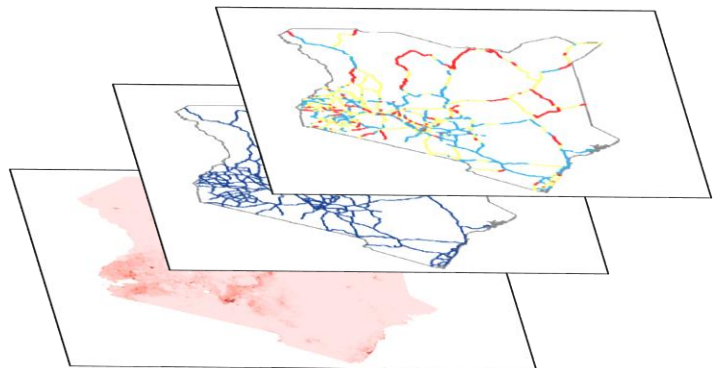
3. The World Bank partnered with the Department for International Development (DFID) of the United Kingdom and the Research for Community Access Partnership to develop a new methodology to measure rural access, one which is sustainable, consistent, simple, and operationally relevant. Conceptually, the methodology is still focused on access to an all-weather road, but uses technically more objective, common parameters, such as roughness of the road and visual assessment. It measures the share of the population that lives within 2 km of an all-season road or an equivalent road as a proxy, for instance, a road in good condition, in rural areas. For more technical details, see World Bank (2016).<sup>2</sup>

4. This new methodology takes advantage of spatial techniques and data collected using innovative technologies. In recent years, various new technologies and data sets have been developed. For instance, high-resolution population distribution data have been developed by the international research community. The WorldPop data have the highest resolution (100 meters). Therefore, it is more or less known where people live. Digitized road alignment data, including road conditions, are also available at road agencies or in the public domain (such as OpenStreetMap).

5. Additional data required for the RAI calculation are minimal. Road condition data are needed at each road segment level. Many road agencies often possess their own road asset management systems, which provide detailed road condition data. There are a variety of ways of collecting such data. In traditional road inventory surveys, vehicle road profilers are used. In recent years, smartphone applications have been developed to assess road roughness while driving. Some other technologies, such as high-resolution satellite imagery, also have the potential to evaluate road conditions in mass. Crowdsourced or open data may be particularly attractive from a data sustainability point of view.

6. All these potential data sources can be used to examine and monitor road conditions (also see World Bank (2016) for the discussion on alternative data sources). Available data may not always be perfect: some data may only be partial with unofficial roads and paths excluded.

Figure 2. Spatial Technique for the New Rural Access Index Method



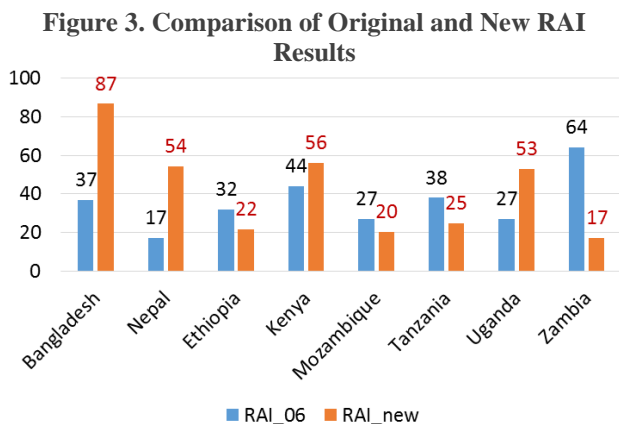
<sup>2</sup> World Bank. (2016). Measuring Rural Access: Using New Technologies.

Others may be more comprehensive but lack information on road condition. It is essential to agree on how to measure road conditions given available data and country-specific circumstances.

7. By spatially combining (i) global population distribution data, (ii) geo-referenced road alignment data, and (iii) road condition data, the RAI is virtually computed by spatial software (**Figure 2**). The methodology ensures accuracy, consistency and sustainability. The new method also allows the index to be computed at any subnational level (such as districts or villages). The index is no longer one national number but often highlights significant inequality in rural accessibility across areas. It is intended to be used in actual road sector operations, for example, in the rural road prioritization context.

### III. The Results: Update

8. In the first phase report prepared in 2016, the new method was applied to eight pilot counties: Ethiopia, Kenya, Mozambique, Tanzania, Uganda, and Zambia in Africa, and Bangladesh and Nepal in South Asia. Rural access was found to vary significantly across these countries, from 17 percent in Zambia to 87 percent in Bangladesh (**Figure 3**). In total, it is estimated that about 34 percent of the rural population is connected, with roughly seven million people left disconnected.<sup>3</sup>



9. The results turned out to be comparable to the 2006 initial estimates in some countries, and significantly different others. This is because the methodologies are different between the two studies, and particularly because the 2006 study did not use actual data on the ground but relied on a model approach comparing similar countries.

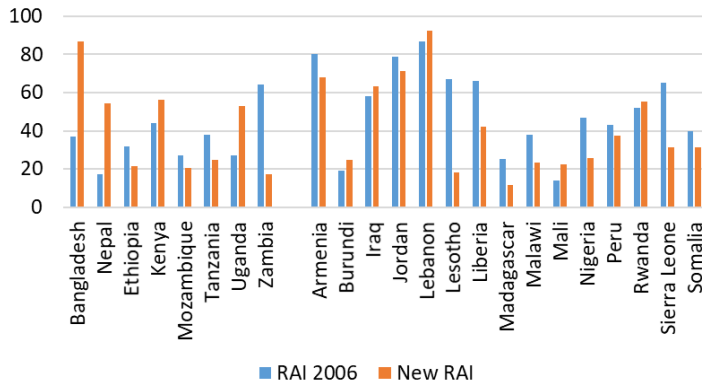
10. The same methodology has now been applied to 15 additional countries, in collaboration with the national road agencies. The estimated RAI varies from 11.4 percent in Madagascar to 68 percent in Armenia and 93 in Lebanon (**Figure 4**). The new RAI are broadly consistent with the original estimates from 2006, with the majority of countries finding a decrease in access. Again, it is noteworthy that it is difficult to compare them directly. In addition, the underlying data for the new estimates still may or may not be perfect. For Nigeria, for instance, the RAI is calculated based on about 107,000 km of roads of which road condition data are available. This represents only half of the total road network according to the

<sup>3</sup> See World Bank. (2016). Measuring Rural Access: Using New Technologies.



national statistics. Malawi and Somalia also have the same issue. See the attached country notes for country-specific technical issues.

**Figure 4. Original and New RAI Estimates for Additional 15 Countries**

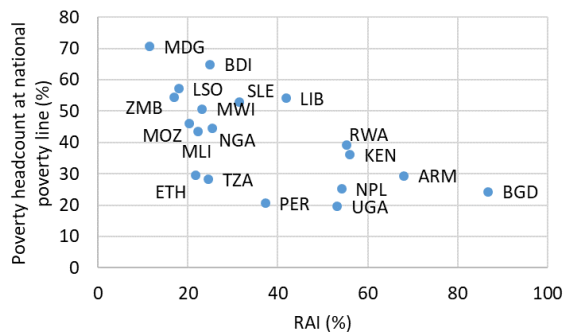


11. At the cross-country level, the new estimates seem to be consistent with available macroeconomic data. Not surprisingly, for instance, poverty is high where rural accessibility is limited (**Figure 5**). The correlation coefficient is about -0.627.

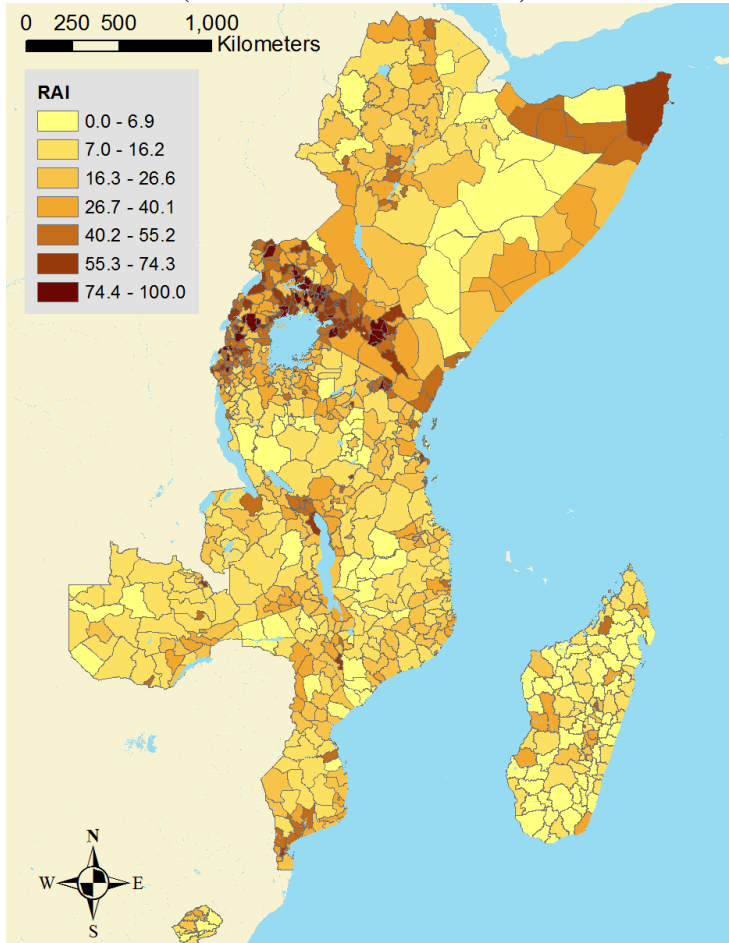
12. There is significant inequality within each country (**Figure 6**). One of the advantages of the new spatial method is that accessibility can be computed at the subnational level. In Kenya, Uganda and Rwanda, rural connectivity is systematically high along the Northern Corridor. Similarly, rural access is relatively high along the North-South Corridor, connecting Dar es Salaam to Mbeya, Malawi and Lusaka, Zambia. Apart from the areas along the regional corridors, rural accessibility tends to be limited in Africa.

13. Strong correlation between poverty and rural accessibility can also be observed at the subnational level. When using data from Madagascar, Mozambique, Kenya, Rwanda, Uganda and Zambia where recent district-level poverty data are available, the correlation coefficient is -0.619 (**Figure 7**). The evidence supports proposed approaches by which the RAI can be used to plan and prioritize rural road investments at the subnational level.

**Figure 5. RAI and poverty headcount**



**Figure 6. Rural Access Index at the Subnational Level  
(Eastern and Southern Africa)**



**(Western Africa)**

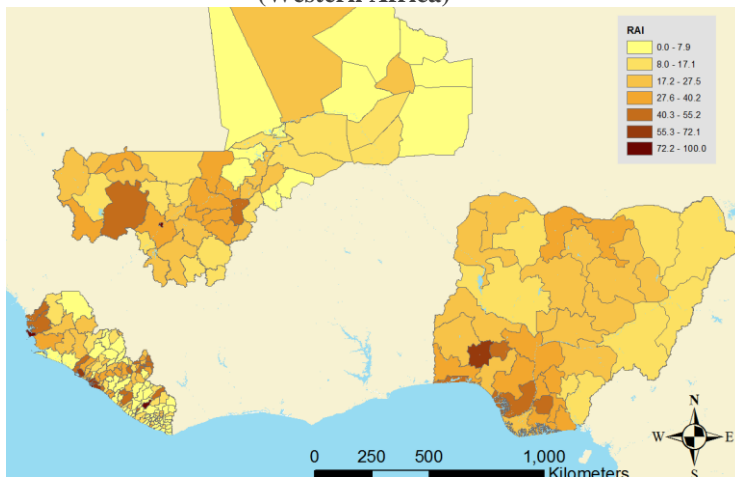
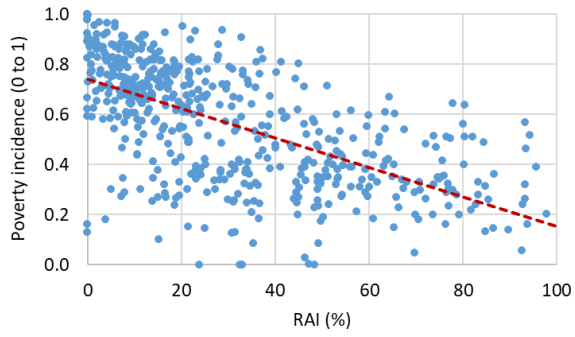


Figure 7. RAI and poverty headcount at subnational levels



## IV. Country Notes

### A. Armenia

#### Overview of road network

14. Armenia has a relatively well-developed road network, serving all areas of its economy. Most freight and passenger traffic is carried by road. The road network is 7,700 km long with 1,400 km of interstate roads, 2,520 km of regional roads and 3,780 km of local roads. The surface condition of these roads varies from good to fair. According to a recent road survey, close to 41 percent of roads are in good or very good condition, 19 percent are in fair condition, and 40 percent are in poor or very poor condition.

Basic Data		
Population <sup>1</sup>	2.90 million	(2015)
Land area <sup>1</sup>	29,740 km <sup>2</sup>	(2015)
Population density <sup>1</sup>	97 per km <sup>2</sup>	(2015)
Length of road <sup>2</sup>	7,700 km	(2015)
Paved road (%) <sup>2</sup>	84%	(2017)
Length of road (GIS) <sup>3</sup>	8,280 km	(2017)
Of which, "Good quality road"	3,390 km	(2017)
Of which, road quality data are missing	30 km	(2017)
RAI <sup>3</sup>	66 %	(2017)

<sup>1</sup> World Development Indicators

<sup>2</sup> UNOPS, EU & AfDB (2015)

<sup>3</sup> World Bank estimates based on a road inventory survey

15. Because of its difficult terrain, the road system of the country is of vital importance. Most of the road network was built in the 1960s and 1970s, and the majority of republican and local roads have deteriorated since independence. The roads linking villages to the main highways are often called "lifeline roads" in Armenia. They are vital for the communities, located dozens and hundreds of kilometers away from urban areas. With a significant part of them last rehabilitated in the Soviet era, the lifeline roads have deteriorated in the intervening years with many now in desperately poor condition, effectively cutting off rural communities from near-by towns and big cities.

16. To update the road network condition, a road inventory survey using a smartphone application was carried out in the entire country during May, 2016. In total, 8,280 km of roads were surveyed. While more than 90 percent of inter-state highways are in good or fair condition, nearly 60 percent of unpaved roads are in poor or very poor condition.

17. The road network density of Armenia is 279 km per 1,000 square km, which is low compared to other countries in the region, reflecting in part the difficulties to provide basic access to the rural population. Despite of the Government's recent efforts, e.g., the Lifeline Road Improvement Project in 2009 and the Lifeline Roads Network Improvement Project approved in 2012, road quality remains a matter of concern. The lack of maintenance during the long civil war has damaged the road network significantly. While the paved road network is relatively well maintained, the condition of unpaved roads is mostly poor.

#### Classification and standards

18. While 83 percent of interstate roads are in good or very good condition, evidence of the relative importance that the government places on the maintenance of the long-haul and inter-city networks, only 36 percent of secondary and tertiary roads are in such condition. This compares favorably with other countries in the region such as Albania or Georgia, where less than 20 percent of rural roads are in good condition, but still lags behind Macedonia and Serbia.

### Data issues and assumptions

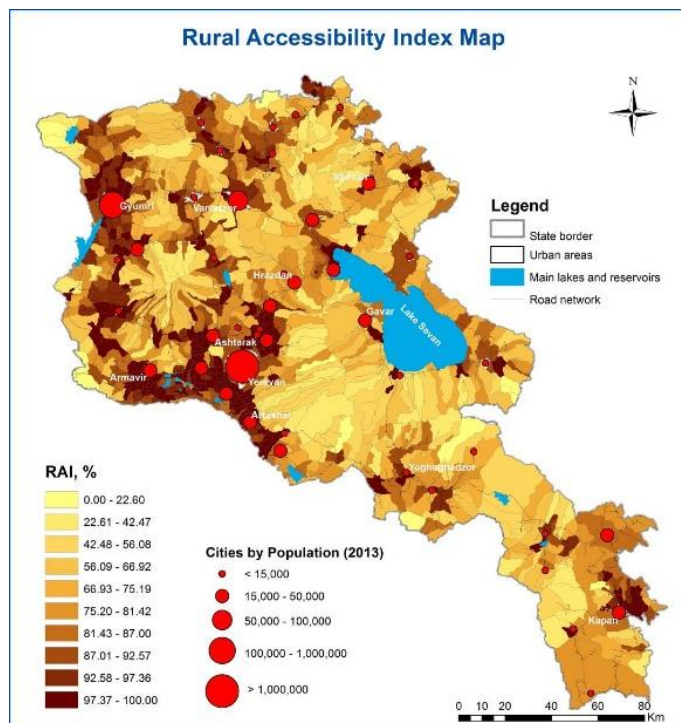
19. A country-wide road survey was carried out to obtain geo-referenced data of the entire road network of Armenia from March to May 2017. The survey used a smartphone application, RoadLabPro, collecting road surface type, category and road condition data, as well as geo-tagged information of service and market location. The survey result is assessed based on the observed IRI and type of pavement: For paved roads, a road is considered as very good when  $1 < \text{IRI} < 2$ , good when  $2 < \text{IRI} < 4$ , fair when  $4 < \text{IRI} < 6$ , poor when  $6 < \text{IRI} < 10$ , and very poor when  $10 < \text{IRI} < 16$ . For unpaved roads, a road is considered as very good when  $5 < \text{IRI} < 8$ , good when  $8 < \text{IRI} < 10$ , fair when  $10 < \text{IRI} < 15$ , poor when  $15 < \text{IRI} < 20$ , and very poor when  $20 < \text{IRI} < 25$ .

20. The Rural Accessibility Index (RAI) for Armenia was calculated based on the Road Condition data and WorldPop 2015 (UN adjusted) raster image. The communities of Armenia are used as an administrative unit for RAI calculations. Urban areas were excluded from the calculation.

### Estimated Rural Access Index

When cross-referencing the population data and the road condition data we obtain a RAI of 66 percent for Armenia, which is calculated for the “very good”, “good” and “fair” road condition categories. The analysis suggests that 1,190,000 persons live within 2 kilometers of a road in good condition, while 610,000 do not have access to an all-weather road.

21. The estimated RAI varies significantly across regions: While Armavir Marz has the highest RAI (92 percent), the Gegharkunik Marz has the lowest RAI (34.1 percent).



## B. Burundi

### Overview of the Road Network

22. Burundi has a total network of 4,456 km of national and provincial roads, which translate into 17.3 km per 100 km<sup>2</sup> of land area. This is slightly lower than but comparable to its neighboring countries (e.g., 27 km in Rwanda, 14 km in Malawi, 5.5 km per 100 km<sup>2</sup> in Tanzania). While the national road network, which is largely paved, is relatively well maintained, provincial roads are generally in poor condition. While about 38.3 percent of the National Roads are in excellent or good condition, only 14.9 percent of the Provincial Roads are in good condition.

Basic Data		
Population <sup>1</sup>	11.2 million	(2015)
Land area <sup>1</sup>	25,680 km <sup>2</sup>	(2015)
Population density <sup>1</sup>	435.3 per km <sup>2</sup>	(2015)
Length of road <sup>2</sup>	4,456 km	(2015)
Paved road (%) <sup>2</sup>	37.2 %	(2015)
Length of road (GIS) <sup>3</sup>	4,115 km	(2016)
Of which, "Good quality road"	1,437 km	(2016)
Of which, road quality data are missing	1,540	(2016)
RAI <sup>3</sup>	24.9 %	(2016)

<sup>1</sup> World Development Indicators

<sup>2</sup> L'Office des Routes, Projet de Developpement du Secteur Routier

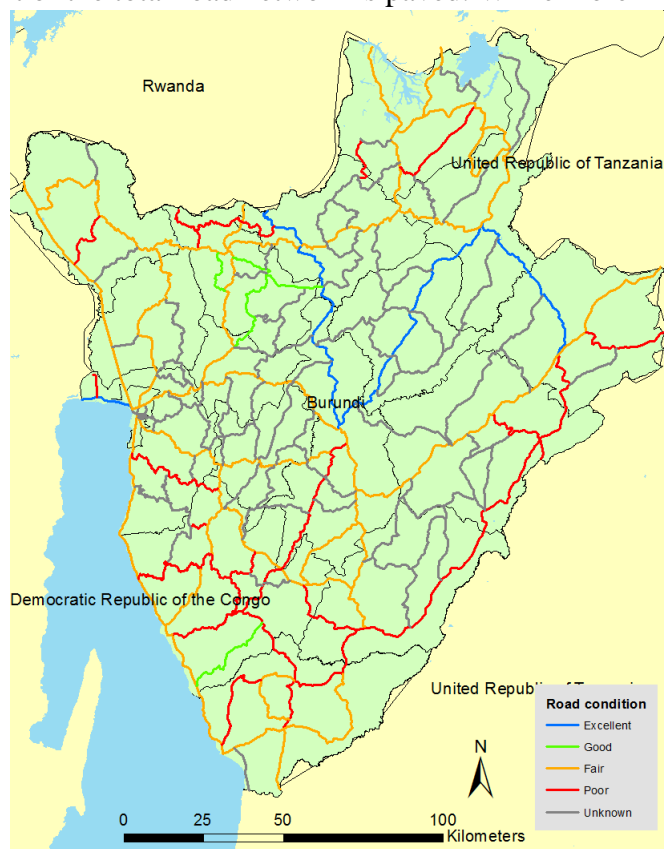
<sup>3</sup> World Bank estimates based on a road inventory survey

### Classification and Standards

23. The road network consists of 1,952 km of National Roads and 2,504 km of Provincial Roads. About 1,656 km or about 37 percent of the total road network is paved. While more than 80 percent of National Roads are paved, only less than 0.5 percent of Provincial Roads are paved.

### Data Issues and Assumptions

24. The latest road condition data available is from 2016, covering 4,456 km of national and provincial roads. It classifies each road into one of four categories: Excellent, Good, Fair and Poor, by length of each category. On the other hand, georeferenced road network data comprising about 4,100 km of roads, are available from the Africa Infrastructure Country Diagnostic (AICD) study. All National Roads are matched between the two datasets. However, the location of about 1,500 km of Provincial Roads is not identified because of inconsistency between the two datasets.



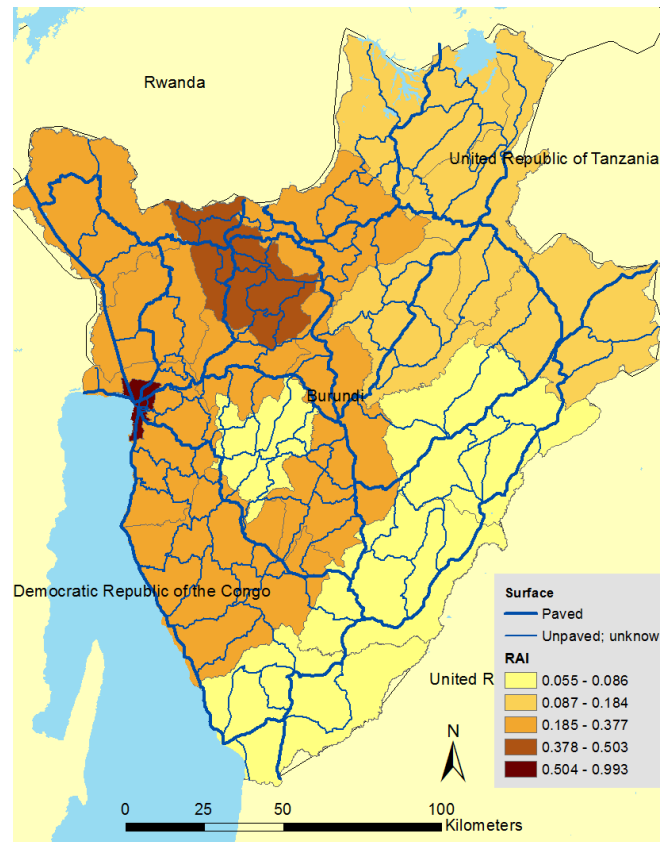
25. The rural accessibility calculation takes into account only paved roads in excellent, good or fair condition, and unpaved roads in excellent and good condition. Therefore, these unlocated provincial roads do not affect the result of the rural access index much, because more than 80 percent of these roads are unpaved and in poor or fair condition.

26. For population data, the WorldPop data (2010 edition) is used, and urban areas are defined based on the 1995 University of Columbia (CIESIN) urban area imagery. These datasets estimate Burundi's rural population at about 8.3 million in 2015.

### Estimated Rural Access Index

27. The Rural Access Index is estimated at 24.9 percent in Burundi. It is estimated that about 6.3 million rural people do not have good access to the road network in the country.

28. There is significant variation in rural accessibility across Provinces: Bujumbura Mairie Province around the national capital Bujumbura has the highest RAI of 99.3 percent, because rural areas are limited in the Province. Southeastern provinces have low accessibility, for instance, 8.6 percent in Makamba and Rutana, and 8.4 percent Ruyigi Province.



## C. Lesotho

### Overview of the Road Network

29. The current national road network of Lesotho is in excess of 7,500 km in length. The latest visual road survey in 2015 indicates that there are 4,625 km of roads in Lesotho, of which 1,527 km or about 33 percent are paved. About 3,014 km of roads are gravel, and the rest are earth roads or tracks.

30. According to the visual survey, the surveyed paved road network is in fair condition, with an average Visual Condition Index (VCI) of 58 percent. About 26 percent of Lesotho’s surveyed paved roads are in very good to good condition. About 42 percent and 32 percent are in fair and poor condition, respectively. Note that only 88.7 percent of the paved road network was surveyed. For unpaved roads, 92 percent of equipment-based gravel roads are in poor and very poor condition according to the Visual Gravel Index (VGI). The rest are in fair condition. There are no gravel roads of which the condition is considered good. For labor-based unsurfaced roads, the country’s road network mostly delivers a medium level of service, with 44 percent in high Level of Service (LOS) and 55 percent in medium LOS condition categories.

Basic Data		
Population <sup>1</sup>	2.2 million	(2016)
Land area <sup>1</sup>	30,360 km <sup>2</sup>	(2016)
Population density <sup>1</sup>	72.6 per km <sup>2</sup>	(2016)
Length of road <sup>2</sup>	7,500 km	(2015)
Paved road (%) <sup>2</sup>	33 %	(2015)
Length of road (GIS) <sup>3</sup>	5,882.9 km	(2013)
Of which, “Good quality road”	1,101.9 km	(2013)
Of which, road quality data are missing	2,997.6 km	(2013)
RAI <sup>3</sup>	18.0 %	(2016)

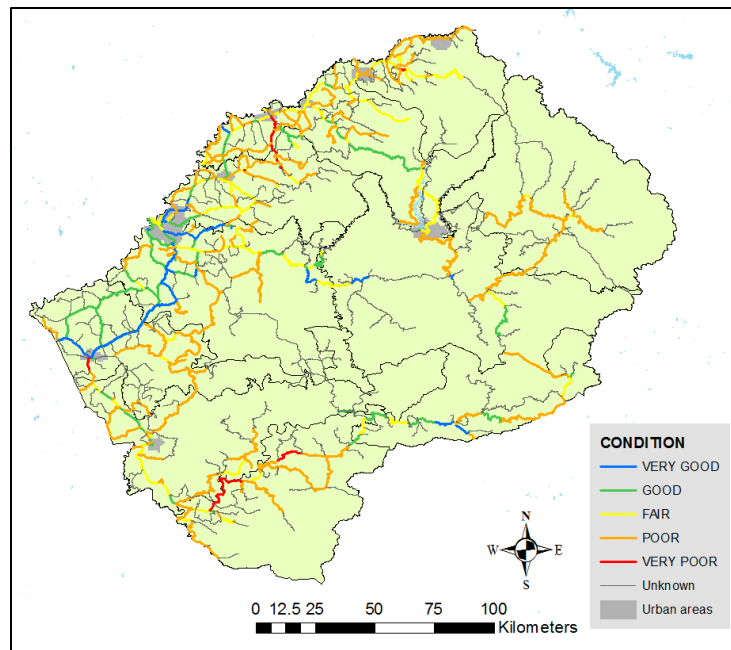
<sup>1</sup> World Development Indicators

<sup>2</sup> Roads Directorate

<sup>3</sup> World Bank estimates based on a road inventory survey

### Classification and Standards

31. Under the recent reform, the responsibilities for managing the national road network were shifted from the Ministry of Public Works and Transport to a semi-autonomous Roads Directorate set up in 2010 as an arm of the MoPWT, and management of the tertiary and feeder roads was decentralized to Local Authorities. The Roads Directorate (RD) manages 5,864 km of this network, of which only 1,526 km are paved and the rest are gravel (3,036 km), earth (1,170 km), and tracks (132 km).





32. The national road network is composed of surfaced roads (1,527 km), equipment-based unsurfaced roads (828 km of gravel roads), and labor-based unsurfaced roads (2,186 km of gravel roads, 76 km of earth roads, and 6 km of tracks). In the visual assessment, different measurements are used: The VCI, VGI and LOS are used to evaluate the condition of surfaced roads, equipment-based unsurfaced roads and labor-based unsurfaced roads, respectively.

### Data Issues and Assumptions

33. The geo-referenced road condition data in 2013 were used for the current RAI calculation. The data only cover 2,885 km of roads out of the total georeferenced network of 5,882 km. This is not likely to affect the RAI calculation because most of unpaved roads are estimated to be in poor condition, while most paved roads are covered by the data.

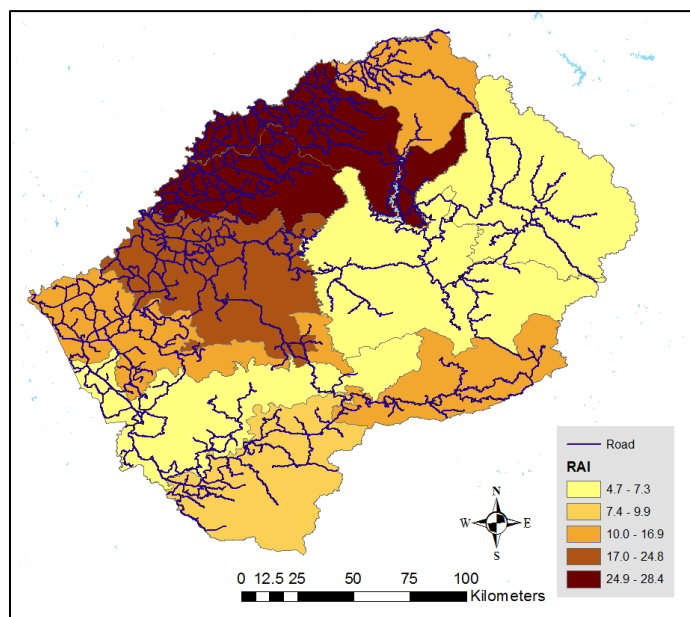
34. The VCI is calculated with various distress measurements, by summing each distress's degree and extent value, multiplied by its weight. A paved road is considered as very good, good, fair, poor and very poor, if the VCI is greater than 85, 70, 50, 30 and 0, respectively. The VGI is also a weighted score based on road distresses, such as gravel loss and corrugations. The thresholds are the same as VCI. In the similar way, the LOS is calculated for labor-based unsurfaced roads. A road is considered at a high, medium and low level of service if the LOS is greater than 70, 50 and 0, respectively.

35. For population data, the WorldPop data (2010 edition) is used, and urban areas are defined based on the 1995 University of Columbia (CIESIN) urban area imagery. These datasets estimate the Lesotho rural population at about 1.58 million in 2010.

### Estimated Rural Access Index

36. The Rural Access Index is estimated at 18.0 percent in Lesotho. It is estimated that about 1.29 million rural people do not have good access to the road network in the country.

37. There is some variation in rural accessibility across districts: Leribe District has the highest RAI of 28.4 percent, followed by 24.8 percent in Maseru District. Rural accessibility is low in Mokhotlong (4.7 percent), Thaba Tseka (6.9 percent), Mochale Hoek (7.3 percent) and Quthing District (9.9 percent).



## D. Liberia

### Overview of road network

38. According to the official statistics, Liberia possesses a total road length of 9,916 km, of which only 734 km are paved.<sup>4</sup> This translates into a road density of 10.3 km per 100 km<sup>2</sup> of land, which is not particularly high but reasonably comparable with other small countries in the region (e.g., 12.6 km in Ghana and 11.9 km in Sierra Leone). The network coverage is considered fairly sufficient to provide transport mobility all over the country. About 73 percent of the total population is estimated to live within 2 km distance from the current road network.<sup>5</sup>

#### Basic Data

Population <sup>1</sup>	4.5 million	(2015)
Land area <sup>1</sup>	96,320 km <sup>2</sup>	(2015)
Population density <sup>1</sup>	46.8 per km <sup>2</sup>	(2015)
Length of road <sup>2</sup>	9,916 km	(2015)
Paved road (%) <sup>2</sup>	7.4 %	(2015)
Length of road (GIS) <sup>3</sup>	11,423 km	(2016)
Of which, “Good quality road”	1,154.6 km	(2016)
Of which, road quality data are missing	0 km	(2016)
RAI <sup>3</sup>	41.9 %	(2016)

<sup>1</sup> World Development Indicators

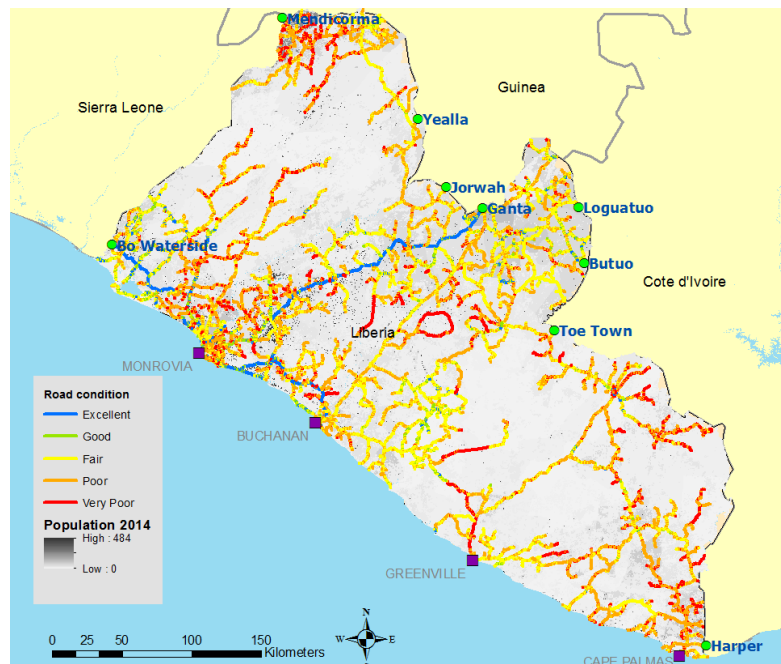
<sup>2</sup> Ministry of Public Works

<sup>3</sup> World Bank estimates based on a road inventory survey

39. However, road quality remains a matter of concern. The lack of maintenance during the long civil war has damaged the road network significantly. While the paved road network is relatively well maintained, the condition of unpaved roads is mostly poor. To update the road network condition, a road inventory survey using a smartphone application was carried out in the entire country in May 2016. In total, 11,423 km of roads were surveyed. While 90 percent of paved roads are in good or fair condition, nearly 60 percent of unpaved roads are in poor or very poor condition.

### Classification and standards

40. By road class, while the paved primary road network is maintained better, secondary and tertiary roads, including many rural roads, are largely in poor condition. Unpaved primary roads also need to be improved. About 40 percent of primary roads, 50 percent of secondary roads, and 60 percent of tertiary roads are in poor or very poor condition. These figures are less favorably compared with



<sup>4</sup> Ministry of Public Works (2012). “National Transport Masterplan.”

<sup>5</sup> Estimated using the WorldPop data and the georeferenced road network data.

Liberia’s neighboring countries. The shares of tertiary roads in poor condition are 48 percent in Sierra Leone 41 percent in Cote d’Ivoire, respectively. Africa’s average is 43 percent.

### Data issues and assumptions

41. To update the road network condition, a road inventory survey using a smartphone application was carried out covering the entire country in May 2016. In the survey, the road conditions are classified based on measured roughness, i.e., international roughness index (IRI). The Liberian national thresholds are adopted for condition classification.

	Excellent	Good	Fair	Poor	Very poor
Paved	< 2.5	2.5 - 4.0	4.0 - 5.5	5.5 - 7.0	> 7.0
Unpaved	< 4.0	4.0 - 5.0	5.0 - 9.0	9.0 - 16.0	> 16.0

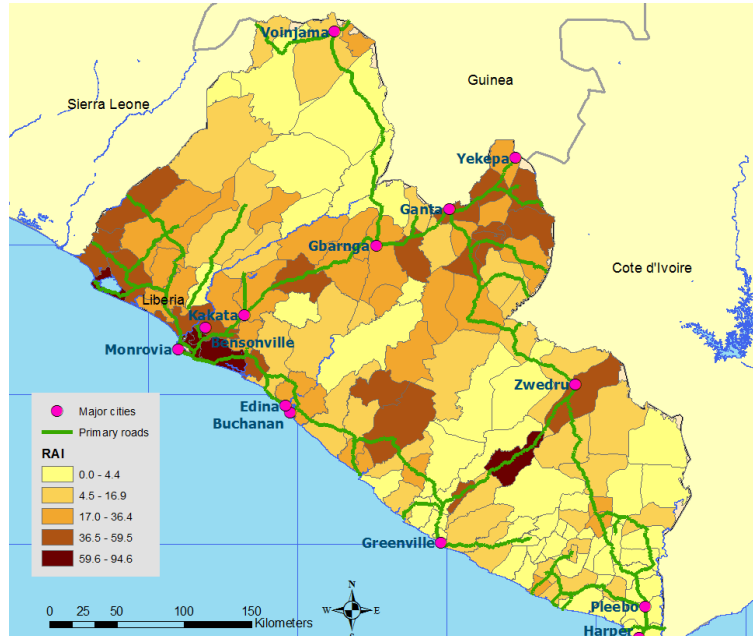
Source: Ministry of Public Works.

42. For population data, the WorldPop data (2010 edition) is used, and urban areas are defined based on the 1995 University of Columbia (CIESIN) urban area imagery. These data give a rural population estimate of about 3.9 million in Liberia.

### Estimated Rural Access Index

43. Given the current road condition, the RAI is estimated at 41.9 percent. While about 1.6 million rural people have access to the road network in good condition, about 2.3 million are left unconnected. The estimated RAI is lower than the previous estimate in 2006, which was 66 percent, although the two results cannot be compared directly due to methodological differences.

44. Rural accessibility differs among counties and districts. RAI is high around Monrovia and along the Monrovia-Ganta Corridor. Although urban areas are excluded from the RAI calculation, the district of Greater Monrovia has a RAI of 94.6 percent. For many districts in Montserrado, Bong and Nimba Counties, RAI is estimated at 30 percent or higher. In many other districts, accessibility is less than 10 percent. For some districts, the RAI is zero, meaning that there are no roads in good condition in the district.



## E. Madagascar

### Overview of road network

45. In Madagascar, limited transport connectivity is a common constraint across all sectors. The country possesses important transport infrastructure, including roads, railways and ports. However, their quality is generally poor due to past underinvestment and under-maintenance. In the road sector, official statistics account for about 32,000 km of classified roads, which translates into a road density of 5.4 km per 100 km<sup>2</sup>, low compared to other countries in the region.

46. The vast majority of non-primary roads (i.e., provincial and community roads) need to be repaired and rehabilitated. Paved national roads (about 5,600 km or 18 percent of the total network) are relatively well maintained. However, about two-thirds of secondary and tertiary roads are estimated to be in poor condition.

### Classification and standards

47. The classified roads comprise about 11,890 km of national roads, 12,250 km of provincial roads and 7,500 km of community roads. The Ministry of Public Works and the Madagascar Road Authority are jointly responsible for the national road network, which is composed of 2,563 km of primary national roads (RNP), 4,784 of secondary national roads (RNS), and 4,543 of temporary national roads (RNT).

48. While provincial governments manage the country's provincial roads (12,250 km), the communes are responsible for provisionally 7,500 km of communal roads. Most of the provincial and communal roads are in poor condition. In addition, there are presumably a number of unclassified feeder roads in rural areas, which are also in very poor condition.

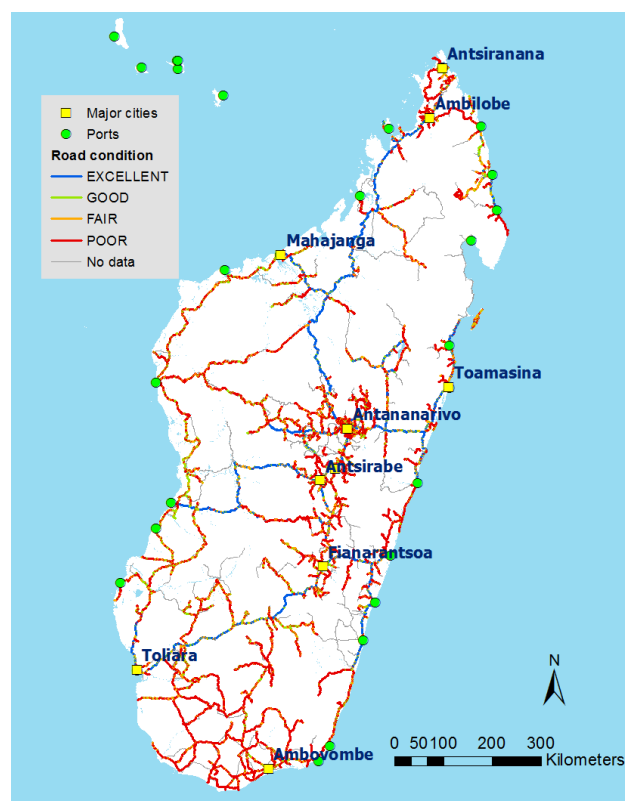
#### Basic Data

Population <sup>1</sup>	24.9 million	(2016)
Land area <sup>1</sup>	581,800 km <sup>2</sup>	(2016)
Population density <sup>1</sup>	42.8 per km <sup>2</sup>	(2016)
Length of road <sup>2</sup>	31,640 km	(2015)
Paved road (%) <sup>2</sup>	17.8 %	(2015)
Length of road (GIS) <sup>2</sup>	21,640 km	(2017)
Of which, "Good quality road"	7,042 km	(2017)
Of which, road quality data are missing	0 km	(2017)
RAI <sup>3</sup>	11.4 %	(2017)

<sup>1</sup> World Development Indicators

<sup>2</sup> Autorite de Routier Madagascar

<sup>3</sup> World Bank estimates based on a road inventory survey



### Data issues and assumptions

49. To update the road network condition, a road inventory survey using a smartphone application was carried out covering the entire country in May 2017. In the survey, the road conditions are classified based on measured roughness, i.e., international roughness index (IRI). The thresholds for condition classification were decided based on an actual field experiment in Madagascar.

	Excellent	Good	Fair	Poor
Paved	< 1	1 - 2	2 - 4	> 4
Unpaved		< 3	3 - 5	> 5

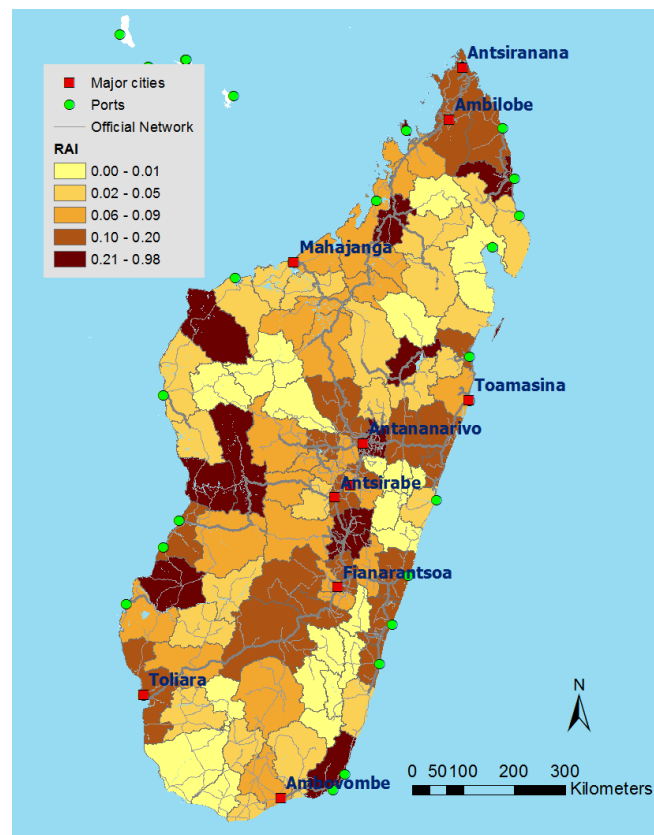
Source: Madagascar Road Authority.

50. For population data, the WorldPop data (2010 edition) is used, and urban areas are defined based on the 1995 University of Columbia (CIESIN) urban area imagery. These data give a rural population estimate of about 19.1 million in 2015.

### Estimated Rural Access Index

51. The RAI is estimated at 11.4 percent, leaving 16.9 million people unconnected in rural Madagascar. This is lower than the previous estimate in 2006, which was 25 percent. The current estimate is considered to be more accurate because it is based on actual road and population data. It seems to be consistent with the fact that road density is extremely low in Madagascar. Population density is also low, and the road condition is generally poor.

52. Rural accessibility differs significantly between semi-urban areas and the rest of the country. RAI is estimated at greater than 80 percent in Toamasina, Mahajanga and Antsiranana Districts. In most rural districts, rural accessibility is less than 5 percent.



## F. Malawi

### Overview of road network

53. According to the Government statistics, Malawi has a well-established road network comprising 15,451 km of classified roads (main, secondary, tertiary, district, and urban designated roads) and some 9,000 km of unclassified roads. This translates into a relatively high road density of 14 km per 100 km<sup>2</sup>, favorably compared with its neighboring countries (e.g., 5.5 km in Tanzania and 3.9 km in Mozambique). The current network is considered to be sufficient to serve the entire country, estimated to cover about 80 percent of the country’s total population. However, the quality of the road network, especially secondary and tertiary roads, remains largely poor. According to the latest official road survey conducted in 2011, paved roads were mostly in good or fair condition, but about 33 percent of unpaved roads were in poor condition. Based on a more recent condition survey in 2016, of which the results remain to be validated, the rural road condition seems to have been deteriorated: 64 percent of the unpaved road network surveyed is in poor condition.

### Classification and standards

54. In Malawi, about 4,000 km or 26 percent of the total road network is paved, and the rest remain unpaved and in largely poor condition. The Malawi Roads Authority (RA) is a quasi-government body, established in 2006, which is responsible for constructing, rehabilitating and maintaining public roads under the Ministry of Works and Public Infrastructure. While the RA’s primary responsibility is for Main (3,357 km), Secondary (3,125 km) and Tertiary Roads (4,121 km), the responsibility for other types of roads are delegated to local governments. In the country there are 3,500 km of District Roads and some 9,000 km of Community Roads, which are currently unclassified.

55. In the 2014/15 revised budget, the Roads Fund Administration (RFA) allocates MWK3.3 billion or 0.3 percent of GDP to road

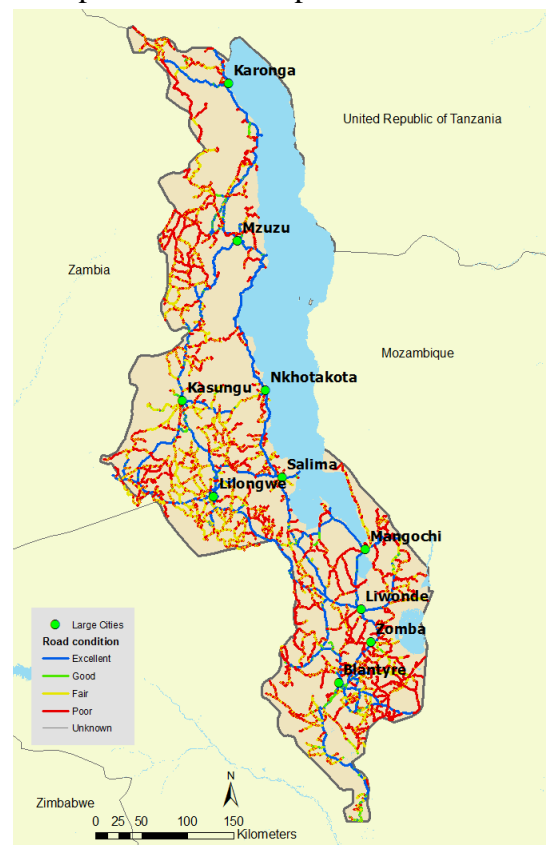
#### Basic Data

Population <sup>1</sup>	18.6 million	(2017)
Land area <sup>1</sup>	94,280 km <sup>2</sup>	(2017)
Population density <sup>1</sup>	197.6 per km <sup>2</sup>	(2014)
Length of road <sup>2</sup>	15,451 km	(2014)
Paved road (%) <sup>2</sup>	26.4 %	(2014)
Length of road (GIS) <sup>3</sup>	12,859 km	(2016)
Of which, “Good quality road”	3,441 km	(2016)
Of which, road quality data are missing	1,244 km	(2016)
RAI <sup>3</sup>	23.1 %	(2016)

<sup>1</sup> World Development Indicators

<sup>2</sup> Road Authority, Malawi.

<sup>3</sup> World Bank estimates based on a road inventory survey



maintenance by the RA and local governments. A fuel levy accounts for about 90 percent of the RFA's total revenue. While most of the Main Roads managed by the RA are paved and well maintained, other minor roads, such as District and Community Roads, tend to be underfunded. They are largely in poor condition and need to be rehabilitated.

### Data issues and assumptions

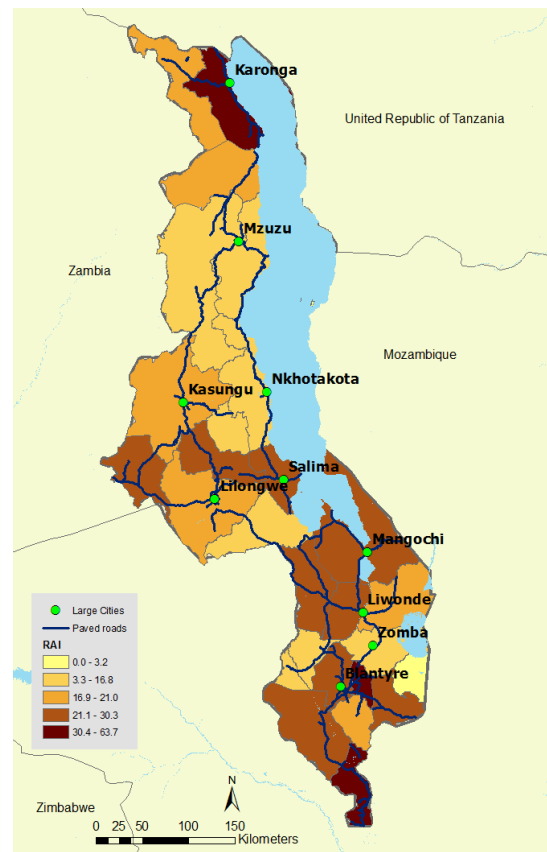
56. The road condition data in Malawi is fragmented. The latest comprehensive official road condition survey was carried out in 2011, though some assessments focused on primary roads are carried out every year. A quick road condition survey using a smartphone application, which measures road roughness while driving with it, was also carried out in 2016. The coverage is not complete but about 90 percent of the classified road network excluding urban roads. The survey was only focused on non-urban areas.

57. Paved roads are classified into 4 categories based on roughness measured: Excellent ( $IRI < 2$ ), Good ( $2 < IRI < 4$ ), Fair ( $4 < IRI < 6$ ), and Poor ( $IRI > 6$ ), out of which the first three are considered for the index calculation. For unpaved roads, average speed is used as a proxy: Excellent ( $speed > 80 \text{ km/h}$ ), Good ( $70 < speed < 80$ ), Fair ( $40 < speed < 70$ ), and Poor ( $speed < 40$ ).

58. Using WorldPop data (2010 edition), rural population in 2015 is estimated at 14.7 million with urban areas excluded.<sup>6</sup> Urban areas are defined based on the 1995 University of Columbia (CIESIN) urban area imagery.

### Estimated Rural Access Index

59. The national RAI is estimated at 23.1 percent, leaving about 11.3 million rural residents unconnected to roads in good or fair condition. While RAI is relatively high around large cities, such as Blantyre, Lilongwe and Karonga. The RAI tends to be low in some of the hilly or hinterland districts, such as Ntchisi (9.8 percent), Mwanza (16.7 percent) and Neno (14.5 percent).



<sup>6</sup> The figure may be different from the official statistics because a different definition of urban areas is used.

## G. Mali

### Overview of road network

60. Mali owns a total of about 140,000 km of roads, out of which the primary and secondary road networks amount to about 35,000 km. Of these, about 8,500 km of main national roads are paved. While the country's population density is low, road density is also low at 2.87 km per 100 km<sup>2</sup> of land when primary and secondary roads are considered.

61. While paved roads are relatively well maintained, unpaved roads and tertiary roads are generally in poor condition. About 5,000 km or 60 percent of paved roads are passable. For unpaved roads, on the other hand, 9,090 km or 35 percent of unpaved primary and secondary roads are passable.

### Classification and standards

62. In Mali, there are about 14,000 km of national roads and 7,000 km of regional roads. These are connecting main urban areas, border points and important economic activity zones. In addition, there are about 29,000 km of local roads and 89,000 km of communal roads, which are generally hardly maintained and in poor condition.

### Data issues and assumptions

63. Although the road network data in Mali is not comprehensive, lacking information on tertiary roads, the quality of such feeder roads is generally very poor and would not significantly impact the RAI calculation. Thus, the calculation only takes into account the primary and secondary road network for which the data on whether each road is passable or not are available.

64. Using WorldPop data (2010 edition), rural population in 2015

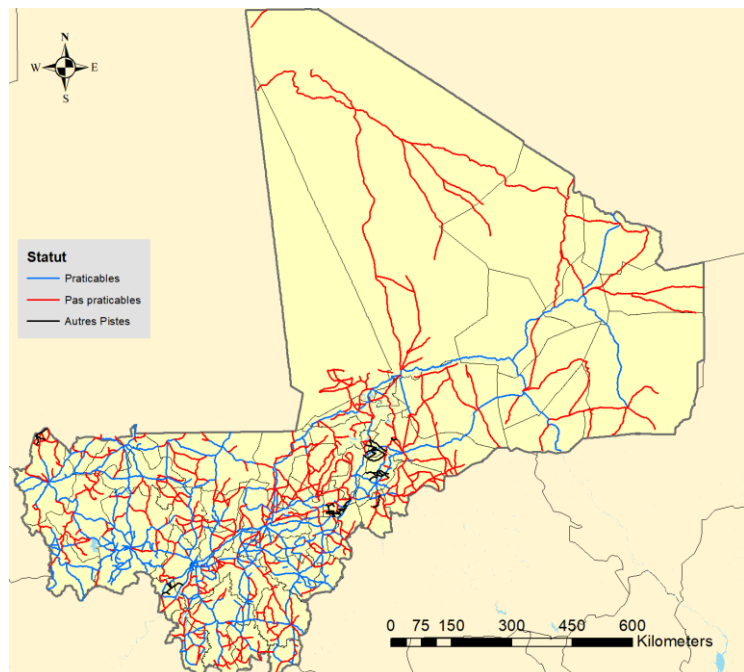
#### Basic Data

<b>Population</b> <sup>1</sup>	18.0 million	(2016)
<b>Land area</b> <sup>1</sup>	1,220,190 km <sup>2</sup>	(2016)
<b>Population density</b> <sup>1</sup>	14.7 per km <sup>2</sup>	(2016)
<b>Length of road</b> <sup>2</sup>	35,062 km	(2017)
<b>Paved road (%)</b> <sup>2</sup>	23.6 %	(2017)
<b>Length of road (GIS)</b> <sup>3</sup>	35,062 km	(2017)
<b>Of which, "Good quality road"</b>	14,094 km	(2017)
<b>Of which, road quality data are missing</b>	825 km	(2017)
<b>RAI</b> <sup>3</sup>	22.3 %	(2017)

<sup>1</sup> World Development Indicators

<sup>2</sup> Institut Géographique du Mali

<sup>3</sup> World Bank estimates based on a road inventory survey



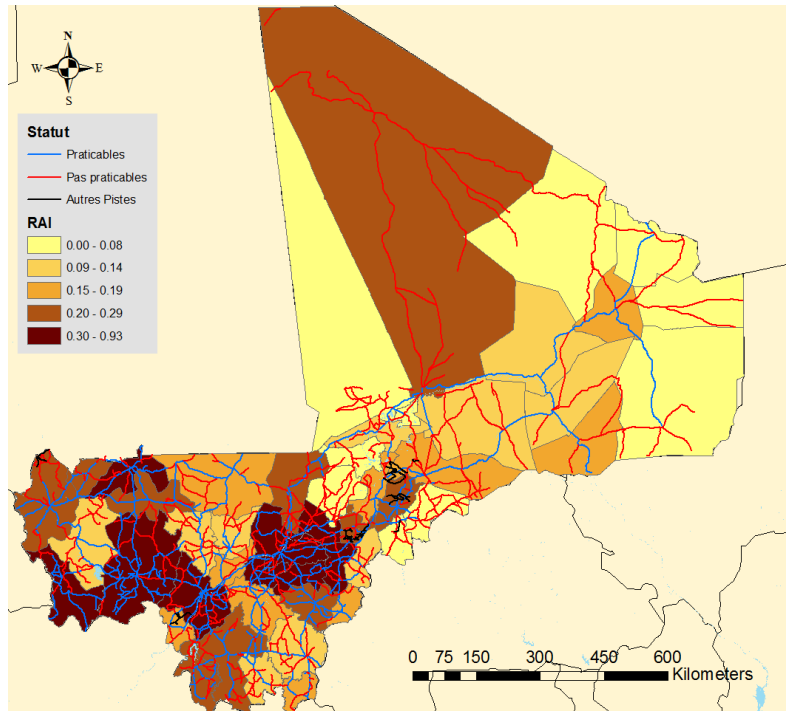


is estimated at 11.7 million with urban areas excluded. Urban areas are defined based on the 1995 University of Columbia (CIESIN) urban area imagery.

### Estimated Rural Access Index

65. The RAI is estimated at 22.3 percent, which is higher than the previous RAI estimated in 2006, i.e., 14 percent. It is estimated that 9.1 million people out of 11.7 million people are left unconnected to the road network in rural Mali. Regional inequality in rural access is substantial. The RAI in Bamako Circle is estimated at 92.8 percent, followed by San, Kita and Kati Circles with about 40 percent of accessibility.

66. Rural accessibility in Tombouctou Region is estimated at 21.2 percent, relatively high in the country. While population density in the region is extremely low, the areas where most people live are highly concentrated in the southern part, along Dire – Goundam and National Road RN33, which are passable. As a result, the region's RAI is relatively high.



## H. Nigeria

### Overview of the Road Network

67. Nigeria’s total road network consists of about 198,000 km of roads, including 34,1200 km of federal roads, 34,300 km of state roads and 129,580 km of registered rural roads. This translate into 21.7 km per 100 km<sup>2</sup> of land area, which is favorably comparable to other large countries in Africa (e.g., 10 km per 100 km<sup>2</sup> in Ethiopia and 9.8 in Tanzania). The vast majority of the road network is considered to be in poor condition. No updated road inventory data are available in Nigeria. It is only estimated that 10 to 15 percent of the total network is paved. Only about 15 percent of the federal network are estimated to be in good to fair condition. Out of the country’s 160,000 km of state and rural roads, less than 10-15 percent are likely to be in good to fair condition.

Basic Data		
Population <sup>1</sup>	182.2 million	(2015)
Land area <sup>1</sup>	910,770 km <sup>2</sup>	(2015)
Population density <sup>1</sup>	200.1 per km <sup>2</sup>	(2015)
Length of road <sup>2</sup>	198,000 km	(2015)
Paved road (%) <sup>3</sup>	20.3 %	(2014)
Length of road (GIS) <sup>3</sup>	107,794 km	(2014)
Of which, “Good quality road”	26,219 km	(2014)
Of which, road quality data are missing	0 km	(2014)
RAI <sup>3</sup>	25.5 %	(2014)

<sup>1</sup> World Development Indicators

<sup>2</sup> Nigeria Government

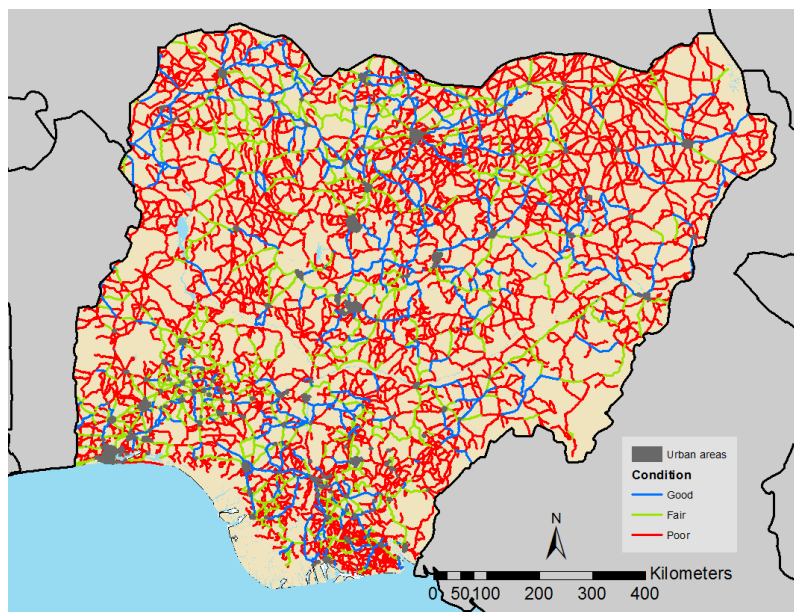
<sup>3</sup> World Bank estimates based on a road inventory survey

68. The available road network data that was collected in 2014 comprises only 107,794 km of roads, which account for about half of the total road network and lack many rural roads according to the national statistics. Based on the available data, about 40,200 km of roads are paved, out of which about 12,100 km were in good condition, 12,900 km in fair condition and the rest in poor condition. Only about 1,200 km or less than 2 percent of the unpaved road network is in good condition. Currently, several state governments are carrying out detailed road inventory surveys.

### Classification and Standards

69. The Federal Ministry of Power, Works and Housing (FMPWH) is responsible for the management of the federal roads. The State Ministry of Works are

responsible for State roads while in many states rural roads are under the jurisdiction of the State Ministry Agriculture and Rural Development and Local Government Authorities. The



Federal Roads Maintenance Agency under FMPWH is responsible for the maintenance of the Federal roads network. Yet, local governments have not been fully active in the development and maintenance of rural road network due to lack of capacity and inadequate funding. The state governments also mostly focus on the higher-level state roads.

### Data Issues and Assumptions

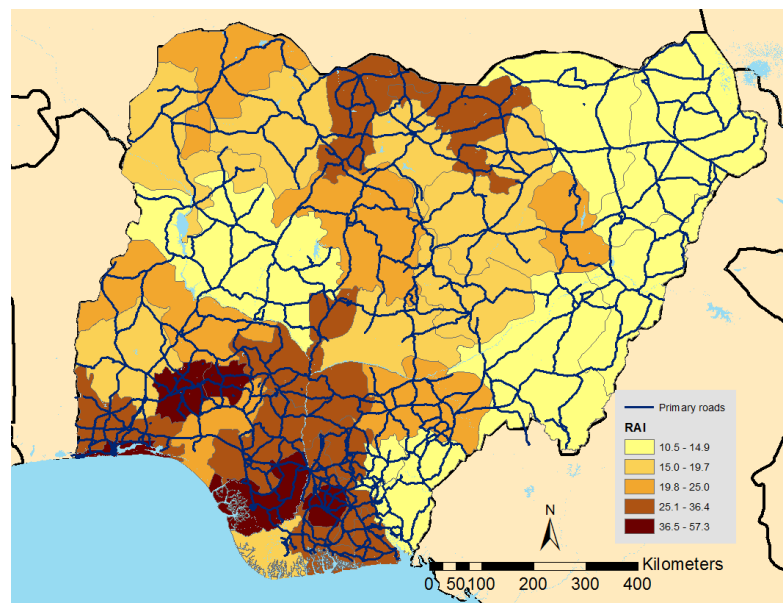
70. The latest georeferenced road network data were collected in 2014, which comprises only 107,794 km of roads. Many rural roads and some newly constructed major highways are not included. The road condition data is available for the year of 2014, which was collected through an interview survey with local government officials. All georeferenced were classified into three categories: good, fair or poor. The rural accessibility calculation takes into account only paved roads in good or fair condition, and unpaved roads in good condition. The current RAI calculation does not take into account the road links that are not covered by the available georeferenced network data. An underlying implicit assumption is that they are in poor condition, which is considered largely true in most cases.

71. For population data, the WorldPop data (2010 edition) is used, and urban areas are defined based on the 1995 University of Columbia (CIESIN) urban area imagery. These datasets estimate the Nigerian rural population at about 124 million in 2014.

### Estimated Rural Access Index

72. The Rural Access Index is estimated at 25.5 percent in Nigeria. It is estimated that about 92.5 million rural people do not have good access to the road network in the country.

73. There is significant variation in rural accessibility across states: Southern states tend to have relatively high accessibility, such as Lagos (49.7 percent), Imo (48.3 percent) and Delta State (41.0 percent). The northeastern region is lagging behind (e.g., 10.5 percent in Taraba, 12.8 percent Adamawa and 13.7 percent in Yobe State).



## I. Peru

### Overview of road network

74. Peru’s road network is 172,094 km long, with 27,362 km of national roads, 25,986 km of regional roads and 118,744 km of local or rural roads. This translates into a relatively long road network, and compares favorably with its neighboring countries. About 18,420 km or 70 percent of the National Road Network is paved. This percentage has increased by 20 percentage points since 2011, which shows a great improvement in the functional condition of this road network over the last few years.

Basic Data		
Population <sup>1</sup>	31.8 million	(2016)
Land area <sup>1</sup>	1,280,000 km <sup>2</sup>	(2016)
Population density <sup>1</sup>	24.8 per km <sup>2</sup>	(2016)
Length of road <sup>2</sup>	172,094 km	(2016)
Paved road (%) <sup>2</sup>	43.1 %	(2016)
Length of road (GIS) <sup>3</sup>	172,094 km	(2016)
Of which, “Good quality road”	72,094 km	(2016)
Of which, road quality data are missing	0 km	(2016)
RAI <sup>3</sup>	37.2 %	(2016)

<sup>1</sup> World Development Indicators

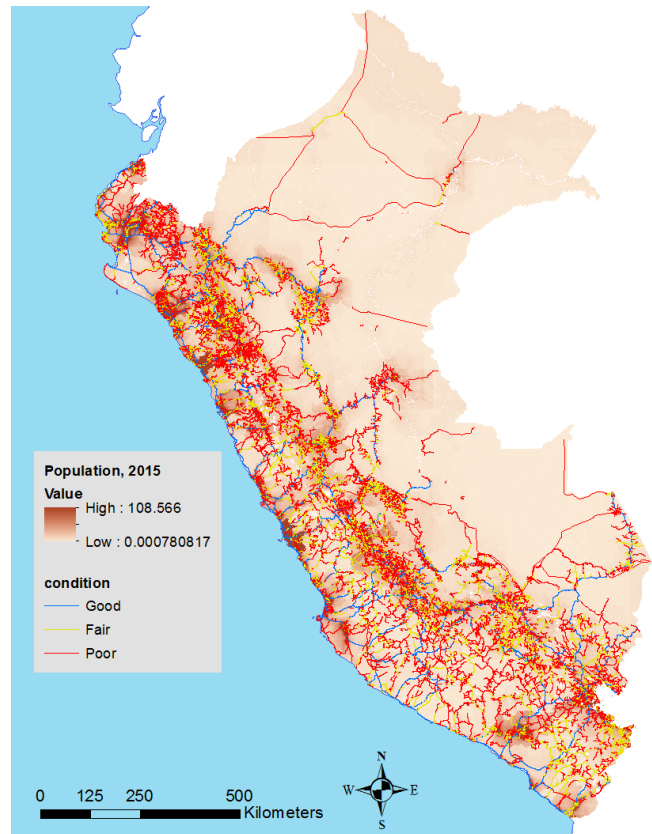
<sup>2</sup> Ministry of Public Works

<sup>3</sup> World Bank estimates based on a road inventory survey

75. The National Road Network is mostly paved; however, many regional and rural roads remain unpaved. According to government statistics, 2,430 km (9.7 percent) of regional roads and 1,925 km (1.7 percent) of rural roads have asphalted surfaces. The road network density is 13.4 km per 100 km<sup>2</sup> of land, and is even lower in the eastern part of the country as the network is concentrated in the coastal area and mainly connects urban centers, leaving the inland rural population with low accessibility to basic needs.

### Classification and standards

76. Provias Nacional and Provias Descentralizado are two entities under the Ministry of Transport and Communications, responsible for the construction, rehabilitation and improvement of the national, regional and rural road infrastructure, and adapting them to the demands of development and national and international integration. Furthermore, local governments also invest in road infrastructure with their own funds and funds from the Ministry of Economy and Finance. Regarding road condition, an inventory survey was carried out to analyze the National Road Network. This survey indicates that about 69 percent of national roads are in good



functional condition, 10,427 km more than in 2010. The remaining 30 percent are in fair or poor condition. The percentage of regional and rural roads which are paved is very low, at about 10 and 1 percent respectively. Furthermore, in some areas of Peru, roads need to be maintained on a constant basis due to heavy floods and other natural disasters.

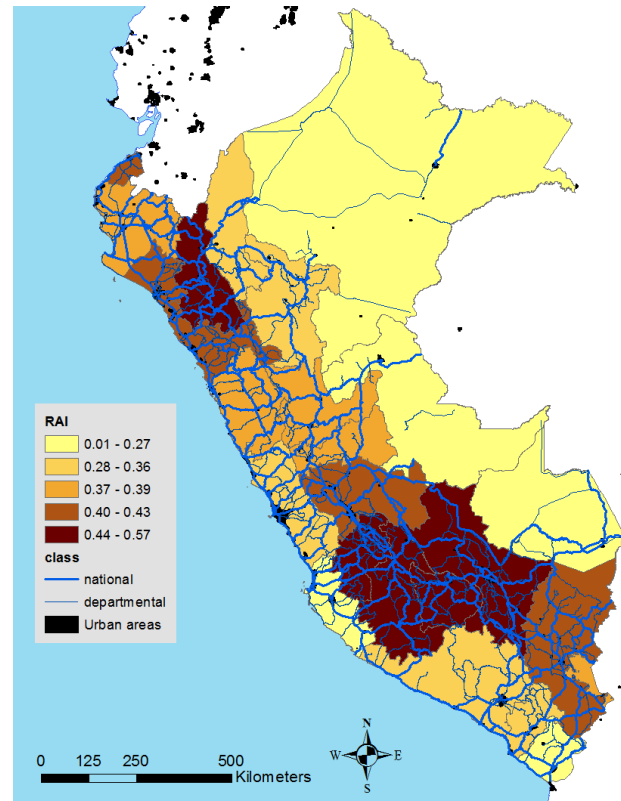
### Data issues and assumptions

77. The road condition data were collected in 2016 and categorized as good, fair or poor.

78. For population data, the WorldPop data (2010 edition) is used, and urban areas are defined based on the 1995 University of Columbia (CIESIN) urban area imagery. These datasets give a rural population estimate of about 19.5 million in Peru.<sup>7</sup> This data may overestimate the rural population due to rapid growth in urban areas during recent years.

### Estimated Rural Access Index

79. The Rural Access Index is estimated at 37.2 percent, which is lower than the previous estimate in 2006, i.e., 43 percent. About 12.3 million people are estimated to be left unconnected to the road network. While rural accessibility is relatively higher in coastal areas, estimates in inland regions, such as Loreto and Ucayali, tend to be low. RAI exceeds 50 percent in Ayacucho, Cajamarca and Huancavelica Departments. On the other hand, accessibility in Loreto and Ucayali is less than 5 percent.



<sup>7</sup> The figure may be different from the official statistics because a different definition of urban areas is used.

## J. Rwanda

### Overview of road network

80. Rwanda has a well-established road network comprising about 30,000 km of classified and unclassified roads. About 14,400 km is classified and consists of 2,749 km of National Roads, as well as 3,848 km and about 7,800 km of District Class 1 and 2 Roads, respectively. About half of the National Roads are paved. This translates into a relatively high classified road density of 27 km per 100 km<sup>2</sup> (or 58.4 km per 100 km<sup>2</sup> if District Class 2 Roads are included).

#### Basic Data

Population <sup>1</sup>	10.8 million	(2015)
Land area <sup>1</sup>	627,340 km <sup>2</sup>	(2015)
Population density <sup>1</sup>	17.2 per km <sup>2</sup>	(2015)
Length of road <sup>2</sup>	21,830 km	(2015)
Paved road (%) <sup>2</sup>	12.6 %	(2015)
Length of road (GIS) <sup>3</sup>	104,074 km	(2016)
Of which, “Good quality road”	7,960 km	(2016)
Of which, road quality data are missing	...	(2016)
RAI <sup>3</sup>	55.3 %	(2016)

<sup>1</sup> World Development Indicators

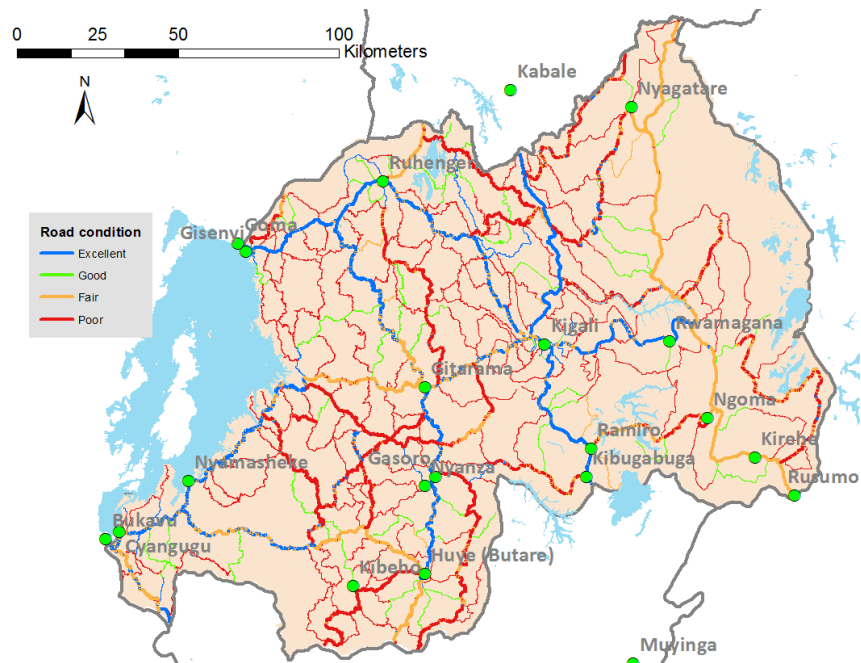
<sup>2</sup> RTDA

<sup>3</sup> World Bank estimates based on a road inventory survey

81. With intensive road rehabilitation works over the last decade, Rwanda has achieved notable success in maintaining the main paved road network in good condition. However, the quality of unpaved national and district roads as well as unclassified roads remains a matter of concern, with rural accessibility estimated at 55.3 percent in 2016. According to the Government statistics, in 2015/16, only about 45 percent of District Roads Class 1 are in good condition, and about 64 percent of District Class 2 Roads are in poor condition. In Kigali, about 85 percent of Roads remain unpaved. The unclassified roads network, which is estimated at about 15,000 km, are also predominantly low engineering standard earth roads and more than 70 percent are in dismal state.

### Classification and standards

82. Rwanda Transport Development Agency (RTDA), established in 2011, is responsible for improvement and maintenance management of the National Road network of Rwanda. The National Road network is comprised of about 1,200 km of paved roads and 1,500 km of unpaved roads. District Class 1 (about 3,800 km)



and Class 2 Roads (7,800 km) are managed by the Ministry of Local Government in collaboration with other ministries, such as Ministry of Infrastructure and Ministry of Agriculture. Unclassified roads include about 1,000 km of Kigali city roads as well as 15,000 km of feeder roads providing last-mile connectivity to local markets, farmers and mining sites.

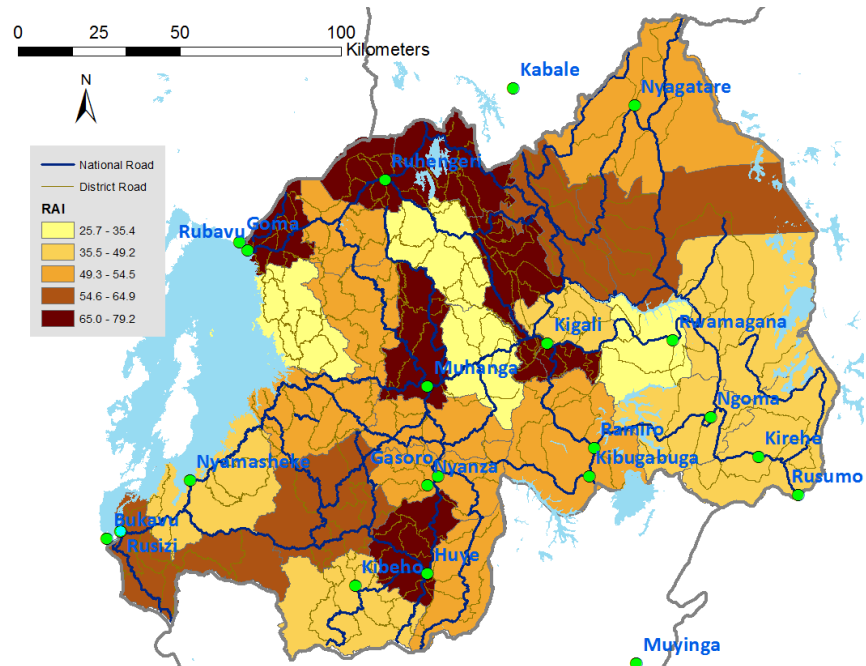
### Data issues and assumptions

83. For the National Roads, the road condition data for 2015/16, which are geo-referenced by every 100 meters, were used based on the Rwanda RTDA Road Condition Report 2015/16. For other District Roads, the 2015/16 data are not geo-referenced and provide only the total length of sections that are in good or poor condition for each road link. Therefore, the weighted average is taken under the assumption that roughness is 10 if a section is in good condition and 20 if it is in poor condition.

84. For population data, the WorldPop data (2010 edition) is used, and urban areas are defined based on the 1995 University of Columbia (CIESIN) urban area imagery. These datasets give a rural population estimate of about 8.75 million in Rwanda.

### Estimated Rural Access Index

85. The Rwanda's Rural Access Index is estimated at 55.3 percent with the 2015/16 data—a slight improvement from the original estimate in 2006, though the methodology is different. About 3.9 million out of 8.75 million are estimated to be still unconnected to the road network. By district, the measured RAI varies significantly from 25.7 percent in Rutsiro to 79.2 percent in Nyarugenge. Not surprisingly, it is generally high around the major cities, such as Kigali, Gisenyi and Butare.



## K. Sierra Leone

### Overview of the Road Network

86. According to the official road statistics, the country possesses a classified road network of 11,258 km, of which approximately 90 percent are unpaved. The primary and secondary roads amount to about 4,000 km, while the feeder road network comprises 4,152km, of which more than half were estimated to be in poor condition.

87. In May-June 2017, a detailed road inventory survey was carried out using a smartphone application, RoadLab Pro, to measure roughness. The survey, which covers about 8,640 km, shows that 55 percent of paved roads and 63 percent of unpaved roads are in poor condition.

88. Although the road inventory survey could not be completed in some areas where roads were impassable, there is a clear spatial trend: The main primary corridors, such as Freetown–Bo–Kenema and Freetown–Makeni–Yengema, are relatively well maintained. On the other hand, feeder roads in inland areas are generally in poor condition and need to be rehabilitated. The road condition is particularly poor in northern and southern regions.

### Classification and Standards

89. According to the Sierra Leone Road Authority (SLRA) Amendment Act 2010, the Authority is responsible for developing and maintaining the national road network including the core road network comprising primary and secondary roads, and all other roads. There are 2,241 km of primary roads (Class A) and 1,828 km of secondary roads (Class B).

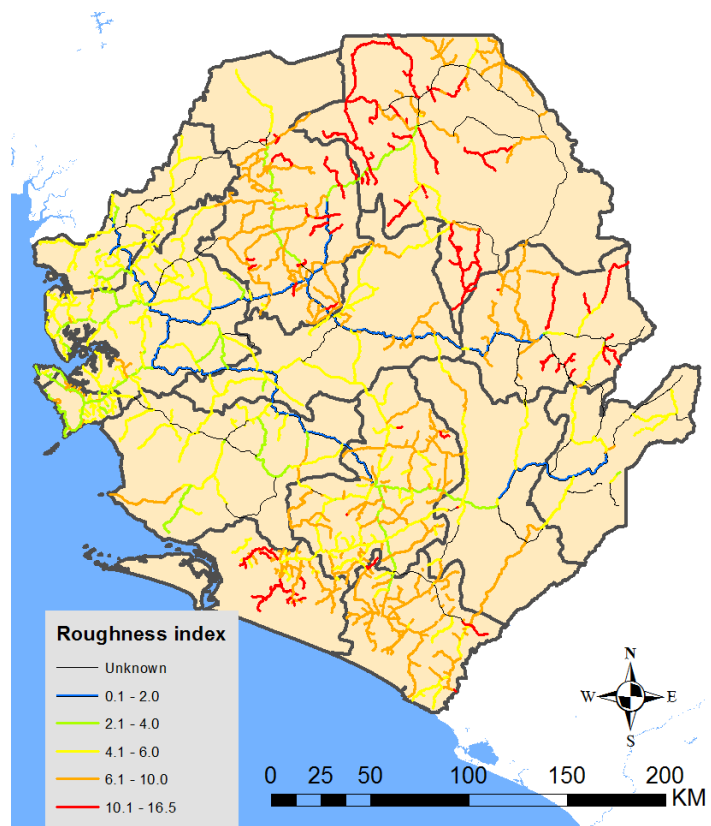
#### Basic Data

Population <sup>1</sup>	7.4 million	(2016)
Land area <sup>1</sup>	72,180 km <sup>2</sup>	(2016)
Population density <sup>1</sup>	102.5 per km <sup>2</sup>	(2016)
Length of road <sup>2</sup>	11,258 km	(2016)
Paved road (%) <sup>3</sup>	10 %	(2016)
Length of road (GIS) <sup>3</sup>	8,640 km	(2017)
Of which, “Good quality road”	2,845 km	(2017)
Of which, road quality data are missing	0 km	(2017)
RAI <sup>3</sup>	31.5 %	(2017)

<sup>1</sup> World Development Indicators

<sup>2</sup> Sierra Leone Government

<sup>3</sup> World Bank estimates based on a road inventory survey





## Data Issues and Assumptions

90. The 2017 road inventory survey was carried out using a smartphone application, RoadLab Pro, to measure roughness, which is converted based on the following categorization. The survey covered about 8,640 km with some impassable roads excluded, which are not taken into account in the current RAI calculation. The calculation relied on IRI thresholds of 4 for paved roads and 5 for unpaved roads.

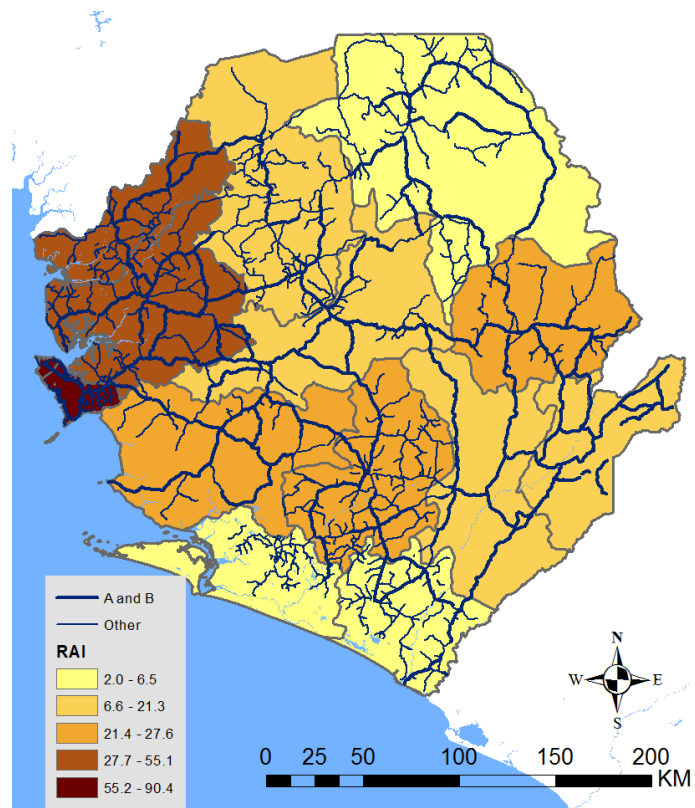
Surface type	Paved			Unpaved		
Condition	Good	Fair	Poor	Good	Fair	Poor
IRI range: Lower	0	2	4	0	3	5
Upper	2	4		3	5	
Length (km)	7.0	74.3	99.4	1,004.2	1,759.2	4,632.5
Share (%)	3.9	41.1	55.0	13.6	23.8	62.6

91. For population data, the WorldPop data (2010 edition) is used, and urban areas are defined based on the 1995 University of Columbia (CIESIN) urban area imagery. These datasets estimate the Sierra Leone rural population at about 4.9 million in 2014.

## Estimated Rural Access Index

92. Given the new road condition data, the Rural Access Index (RAI) is estimated to be 31.5 percent, meaning that in Sierra Leone, about 1.5 million or 68.5 percent of the total rural population do not have access to the road network in good condition.

93. While Western Region has higher rural accessibility primarily because of high urbanization, rural access is particularly low in the northern and southern districts, such as Koinadugu (2 percent), Pujehun (2.3 percent) and Bonthe (6.5 percent), where the feeder road conditions are generally poor.



## L. Somalia

### Overview of road network

94. In Somalia, many transport infrastructure assets have been damaged and under-maintained during the decades-long civil war. Few updated official data are available that reflect the latest actual conditions on the ground. According to a recent study by UNOPS, EU and AfDB (2015),<sup>8</sup> there are about 21,830 km of roads in Somalia, of which only about 2,750 km or 12 percent are paved. The network does look comprehensive over the country, but this translates into a very low road density of 3.5 km per 100 km<sup>2</sup> of land, unfavorably compared with neighboring countries (c.f., 10 km in Ethiopia and 28.4 km in Kenya).

Basic Data		
Population <sup>1</sup>	10.8 million	(2015)
Land area <sup>1</sup>	627,340 km <sup>2</sup>	(2015)
Population density <sup>1</sup>	17.2 per km <sup>2</sup>	(2015)
Length of road <sup>2</sup>	21,830 km	(2015)
Paved road (%) <sup>2</sup>	12.6 %	(2015)
Length of road (GIS) <sup>3</sup>	104,074 km	(2016)
Of which, "Good quality road"	7,960 km	(2016)
Of which, road quality data are missing	...	(2016)
RAI <sup>3</sup>	31.2 %	(2016)

<sup>1</sup> World Development Indicators

<sup>2</sup> UNOPS, EU & AfDB (2015)

<sup>3</sup> World Bank estimates based on a road inventory survey

95. While Somalia is a highly urbanized economy, there are presumably many other rural roads and paths that have not been mapped or classified. Using available satellite imagery, potential feeder roads can be mapped, which amount to about 104,000 km in total. Although no detailed data are available, most of them are presumably in poor condition.

### Classification and standards

96. The institutional arrangements in the road sector are complex and need to be clarified and strengthened. Various road agencies exist in the Federal Government of Somalia and other regional entities, such as the Puntland Highway Authority. With the assistance of the international donor community, the Somaliland Roads Authority has also recently been established to manage and construct roads. However, the road classification and functional assignments have not been completed yet, and the administrative responsibilities remain unclear.



<sup>8</sup> UNOPS, EU and AfDB. (2015). Somalia Transport Sector Needs Assessment Final Report.

## Data issues and assumptions

97. As discussed above, it is challenging to have an updated official road network map in Somalia. However, thanks to advanced technologies, such as satellite imagery, the currently existing road network can be estimated. For instance, Google Earth satellite imagery is available at ~0.5 m resolution for major towns in Somalia, which was updated in 2015. In total, 104,000 km of roads can be identified, including unclassified feeder roads.

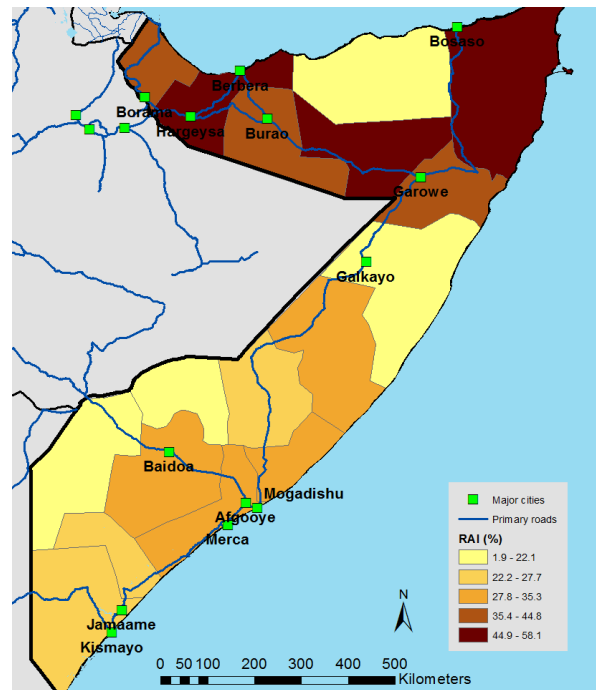
98. Out of 104,000 km of roads (including unclassified feeder roads), 614 km of roads or only about 6 percent of the total network are estimated to be in good or fair condition. The road conditions are more difficult to assess even if high-resolution satellite imagery is available. Based on visual assessment of satellite imagery, approximately 7,960 km of roads or 7.6 percent of the total network (including unclassified feeder roads) are considered to be in good or fair condition. Good roads are paved roads that look dark and are not eroded. Fair roads are either paved roads in fair condition or good gravel roads that are motorable. All other earth roads and paths, as well as potholed or worn out paved roads are considered as poor condition.

99. For population data, the WorldPop data (2010 edition) is used, and urban areas are defined based on the 1995 University of Columbia (CIESIN) urban area imagery. These data give a rural population estimate of about 8.9 million in Somalia.

## Estimated Rural Access Index

100. Given the above geo-spatial data, the RAI is estimated at 31.2 percent in 2016, meaning that about 6.1 million people still live far from a road in good or fair condition. The estimated RAI is particularly high in Puntland and Somaliland, but in certain areas, rural accessibility is minimal and can be less than 10 percent.

101. Compared with other countries in the region, Somalia's RAI is relatively high despite the fact that the vast majority of roads are in poor condition. This can be attributed to the country's high urbanization and the likely population distribution pattern that many people live along a few corridors that are in good condition.



## M. Iraq

### Overview of road network

102. Iraq owns a road network of 24,856 km, which is composed of 1,166 km of expressways, 8,653 km of primary roads, and 15,037 km of secondary roads. A significant share of the network has been damaged and deteriorated in recent years. About 84 percent of the roads are estimated to be in poor condition.

103. Extensive damage and the deterioration of Iraq’s road sector is an impediment for trade and economic growth. Iraq has three main transport corridors: North - South from Turkey; South - North through its port of Um Qasr; and East-West through the ports of neighboring countries in the Mediterranean and Gulf of Aqaba. Other corridors link Iraq with Iran in the East and Saudi Arabia in the South-West. Oil exports pass through oil-only ports such as Basra. Iraq’s transport corridors are inefficient because of institutional weaknesses and infrastructure deficiencies. The traffic along the South - Center Iraq and East - West Corridors is being served by Expressway 1 that used to carry between 15,000 and 30,000 Annual Average Daily Traffic, 40 percent of which is trade traffic, prior to ISIS taking over that region and the closure of the border with Jordan. The traffic along the North - South Corridor is being served by the road between Ibrahim El-Khalil and Duhok. Prior to 2014, about 3,000 heavy trucks used to enter Iraq daily from Turkey through Ibrahim El Khalil border crossing through Zakho to reach Duhok and the rest of Iraq.

### Classification and standards

104. Poor road infrastructure and limited transport services have adversely impacted the economic mobility and productivity of Iraqis, particularly for the poor and inhabitants of rural areas. Weak economic integration contributes to low economic productivity. Poor access to labor and markets hinders firms, reduces the employment and economic opportunities available to

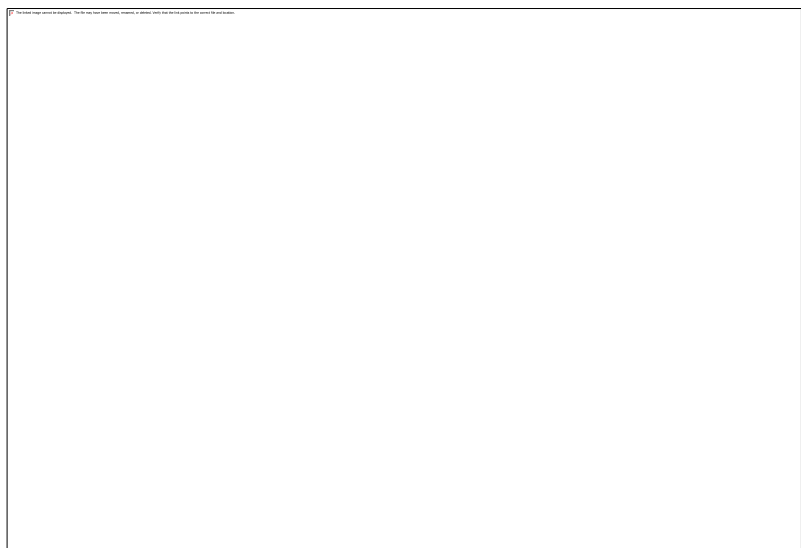
#### Basic Data

<b>Population</b> <sup>1</sup>	38.3 million	(2017)
<b>Land area</b> <sup>1</sup>	10,230 km <sup>2</sup>	(2017)
<b>Population density</b> <sup>1</sup>	88.1 per km <sup>2</sup>	(2017)
<b>Length of road</b> <sup>2</sup>	24,956 km	(2018)
<b>Paved road (%)</b>		
<b>Length of road (GIS)</b> <sup>3</sup>	96,381 km	(2018)
<b>Of which, assumed “good quality road”</b>	50,590 km	(2018)
<b>Of which, road quality data are missing</b>		
<b>RAI</b> <sup>3</sup>	63.4 %	(2018)

<sup>1</sup> World Development Indicators

<sup>2</sup> Ministry of Construction and Housing.

<sup>3</sup> World Bank estimates based on OSM data



households, and impedes access to health and education services. Furthermore, in a country divided by sectarian and other divisions, the ability to leverage a well-functioning road for political and social integration between various regions and communities is weakened. Most of the Iraqi population is inadequately served by unpaved roads, with the worst conditions experienced disproportionately by certain income groups. For example, poor workers in non-wage agriculture are more likely than others to live on unpaved roads and to live more than five kilometers from a market. Upgrading transport infrastructure has the potential to increase access to health services, education, and job opportunities.

### Data issues and assumptions

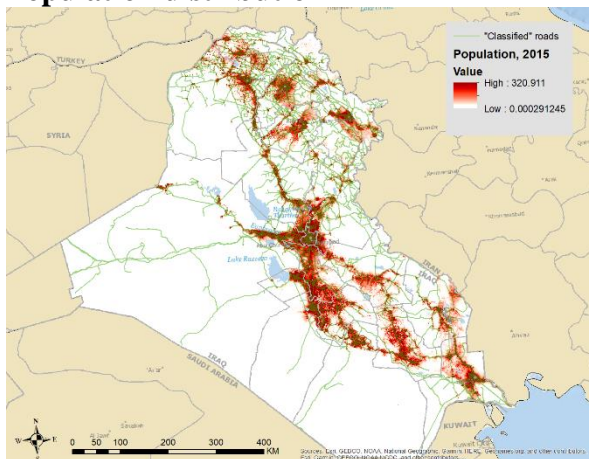
105. The RAI for Iraq is estimated using open source data, such as OpenStreetMap (OSM), which provide georeferenced road data and certain standardized classification. It can be a good source of data under certain circumstances where the coverage of OSM is good, roads are not highly susceptible to seasonality or weather conditions, and no other reliable data exist. It is assumed that all classified roads (i.e., primary, secondary and tertiary roads) in the OSM data are in good or fair condition and passable all around the seasons, which is a simplistic assumption but may not be unacceptable given the country's climatic condition.

106. For population data, the WorldPop data (2010 edition) is used. The estimation does not take into account the impact of a large number of refugees caused by the recent instability in the region. Urban areas are defined based on the 1995 University of Columbia (CIESIN) urban area imagery.

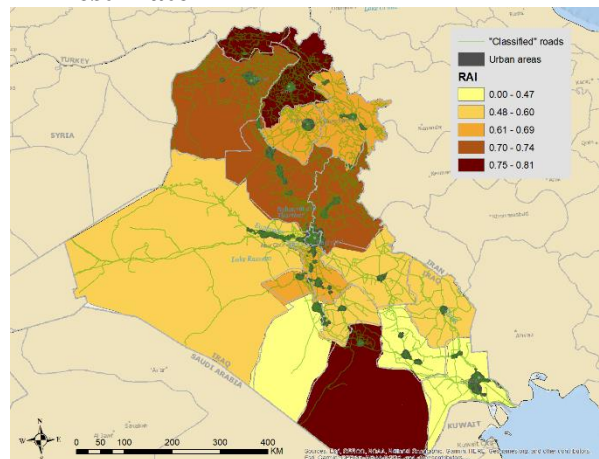
### Estimated Rural Access Index

107. The Rural Access Index is estimated at 63.4 percent. Note that the index is not calculated for Baghdad because the entire area is considered as urban and excluded from the calculation.

#### Population distribution



#### RAI estimate



## N. Jordan

### Overview of road network

108. The transport sector is a very important sector of the economy in Jordan. It serves the national economy essentially along the corridor Aqaba-Amman; it also plays an important role on a regional level to transport goods and passengers to and from the neighboring countries (Syria, Iraq, Saudi Arabia, Egypt, and potentially Israel and Palestine). The transport infrastructure in Jordan is composed of a road network of 7,200 km, 1 seaport, 2 railways and 3 international airports. About 40 percent of the country's roads are main roads, 28 percent are secondary roads, while the remaining 32 percent are rural roads.

#### Basic Data

<b>Population</b> <sup>1</sup>	9.7 million	(2017)
<b>Land area</b> <sup>1</sup>	88,780 km <sup>2</sup>	(2017)
<b>Population density</b> <sup>1</sup>	109.3 per km <sup>2</sup>	(2017)
<b>Length of road</b> <sup>2</sup>	7,201 km	(2018)
<b>Paved road (%)</b>		
<b>Length of road (GIS)</b> <sup>3</sup>	22,141 km	(2018)
<b>Of which, assumed "good quality road"</b>	10,366 km	(2018)
<b>Of which, road quality data are missing</b>		
<b>RAI</b> <sup>3</sup>	71.4 %	(2018)

<sup>1</sup> World Development Indicators

<sup>2</sup> WoPWH, Jordan

<sup>3</sup> World Bank estimates based on OSM data

### Classification and standards

109. The roadway/highway network in Jordan consists of nearly 7,200 km of roads with different classifications. All classified roads are generally under the umbrella of the MoPWH, with the exception of roads in the Greater Amman Area that are under the umbrella of the Greater Amman Municipality (GAM). The limited railway network and the limited number of ports have caused road transport to be the leading sector in the transport of freight and passengers in Jordan.

110. Generally, there are three main roadway classifications in Jordan: (i) Highways or main roads (2,718 km) that consist of two or more lanes that connect the capital with other governorate urban centers, connect governorate urban centers with each other, and connect Jordan with neighboring countries, (ii) Secondary roads or side roads (1,876 km) that are mainly two-lane (or more) roadways connecting main roads passing through urban areas other than governorates' centers, or serving village clusters, and (iii) Village roads or rural roads (2,607 km) that branch from main or secondary roads which usually serve villages or small communities.



© 1992 Magellan Geographix<sup>SM</sup> Santa Barbara, CA (800) 929-4627

### Data issues and assumptions

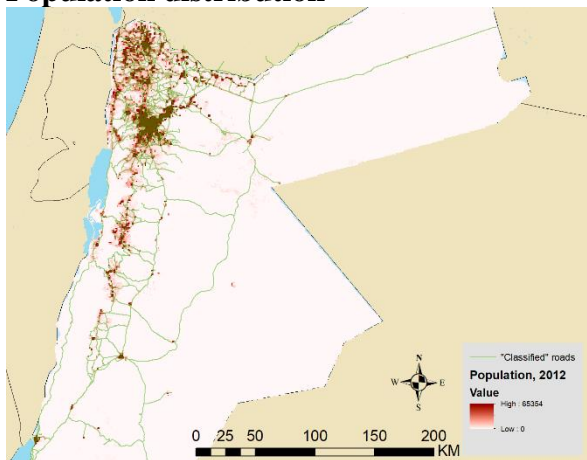
111. The RAI for Jordan is estimated using open source data, such as OpenStreetMap (OSM), which provide georeferenced road data and certain standardized classification. It can be a good source of data under certain circumstances where the coverage of OSM is good, roads are not highly susceptible to seasonality or weather conditions, and no other reliable data exist. It is assumed that all classified roads (i.e., primary, secondary and tertiary road) in the OSM data are in good or fair condition and passable during all seasons, which is a simplistic assumption but may not be unacceptable given the country's climatic condition.

112. For population data, the WorldPop data (2010 edition) is used. The estimation does not take into account the impact of a large number of refugees caused by the recent instability in the region. Urban areas are defined based on the 1995 University of Columbia (CIESIN) urban area imagery.

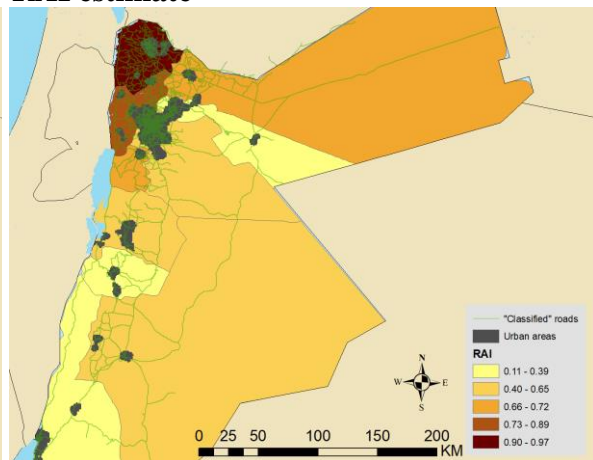
### Estimated Rural Access Index

113. The Rural Access Index is estimated at 71.4 percent. The highest rates are observed in the northwest region around Amman, the capital of Jordan. Amman itself has a relatively modest accessibility of 65 percent. This is because most of the urban areas are excluded from the calculation.

#### Population distribution



#### RAI estimate



## O. Lebanon

### Overview of road network

114. Road transport is by far the most dominant form of transport in Lebanon for passengers, freight, and commerce, with about 1.2 million vehicles in a country of only 4.5 million people.

115. The transport sector is one of the main employment generators in Lebanon. Currently, about 7 percent of Lebanon’s labor force is employed in transport services (truckers, taxis, ports, and airports). In addition, a significant part of workers in the construction sector are actually working in the construction of transport infrastructure.

#### Basic Data

<b>Population</b> <sup>1</sup>	6.1 million	(2017)
<b>Land area</b> <sup>1</sup>	10,230 km <sup>2</sup>	(2017)
<b>Population density</b> <sup>1</sup>	594.5 per km <sup>2</sup>	(2017)
<b>Length of road</b> <sup>2</sup>	21,705 km	(2018)
<b>Paved road (%)</b>		
<b>Length of road (GIS)</b> <sup>3</sup>	15,013 km	(2018)
<b>Of which, assumed “good quality road”</b>	8,177 km	(2018)
<b>Of which, road quality data are missing</b>		
<b>RAI</b> <sup>3</sup>	92.6 %	(2018)

<sup>1</sup> World Development Indicators

<sup>2</sup> Council for Development and Reconstruction, Lebanon

<sup>3</sup> World Bank estimates based on OSM data

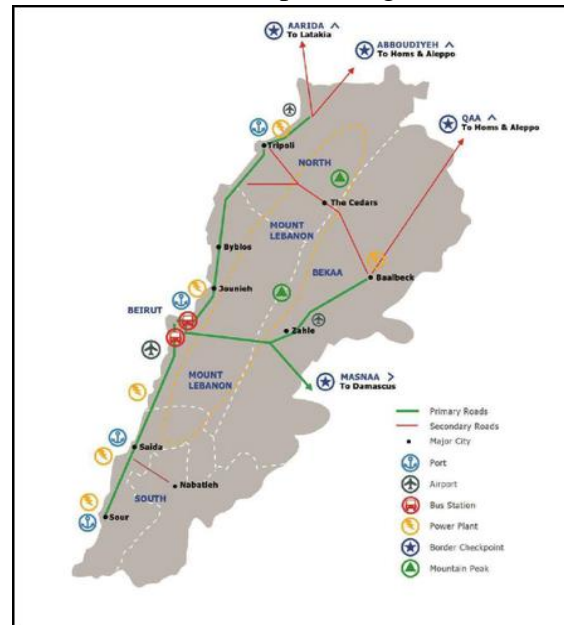
### Classification and standards

116. According to the Council for Development and Reconstruction (CDR), Lebanon has an extensive network of roads (around 22,000 km), 6,380 km under the responsibility of the Ministry of Public Works and Transportation (MoPWT) and around 15,325 km under the jurisdiction of municipalities. The network comprises 529 km of roads classified as international, 1,673 km as primary, 1,367 as secondary, and 2,811 km as local.

117. The condition of the classified road network is estimated to be 17 percent good, 70 percent fair, and 13 percent poor to critical. Figure 1.1 shows the major modes of transportation in the country. In fact, Lebanon ranks 121 out of 137 countries on road quality, with rural roads in lagging regions in particularly bad condition.

### Data issues and assumptions

118. The RAI for Lebanon is estimated using open source data, such as OpenStreetMap (OSM), which provide georeferenced road data and certain standardized classification. It can be a good source of data under certain circumstances where the coverage of OSM is good, roads are not highly susceptible to seasonality or weather conditions, and no other reliable data exist. It is assumed that all



Source: IDAL



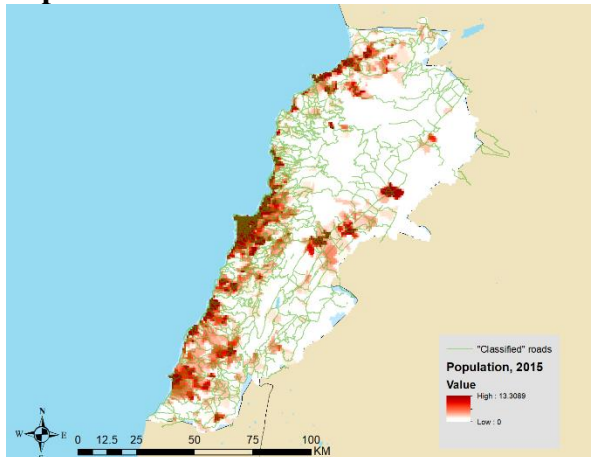
classified roads (i.e., primary, secondary and tertiary road) in the OSM data are in good or fair condition and passable all around the seasons, which is a simplistic assumption but may not be unacceptable given the country's climatic condition.

119. For population data, the WorldPop data (2010 edition) is used. The estimation does not take into account the impact of a large number of refugees caused by the recent instability in the region. Urban areas are defined based on the 1995 University of Columbia (CIESIN) urban area imagery.

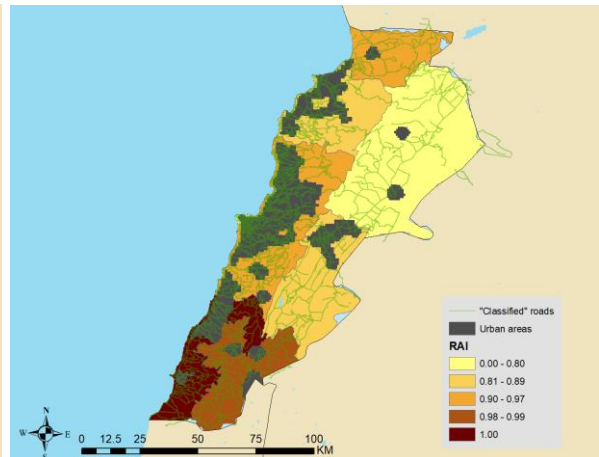
### Estimated Rural Access Index

120. The Rural Access Index is estimated at 92.6 percent. The estimate is extremely high. This is because of the country's high population density and high road density. Lebanon is a highly urbanized country. Note that a large part of the country, including Beirut, is excluded from the calculation because many areas are considered as urban. Relatively speaking, the southern areas where more population is concentrated tend to have higher accessibility.

**Population distribution**



**RAI estimate**



## References

- Roberts, Peter, K. C. Shyam, and Cordula Rastogi. 2006. "Rural Access Index: A Key Development Indicator." *Transport Papers* TP-10. The World Bank Group, Washington, DC.
- World Bank. (2016). "Measuring Rural Access: Using New Technologies." The World Bank Group, Washington, DC.

## Appendix. RAI estimated at sub-national level

### Burundi

Province	RAI (%)
Bubanza	27.5
Bujumbura Mairie	99.3
Bujumbura Rural	35.1
Bururi	29.6
Cankuzo	16.9
Cibitoke	33.8
Gitega	25.6
Karuzi	17.5
Kayanza	50.3
Kirundo	14.8
Makamba	8.6
Muramvya	37.7
Muyinga	18.4
Mwaro	5.5
Ngozi	28.4
Rutana	8.6
Ruyigi	8.4

### Lesotho

District	RAI (%)
Berea	26.7
Butha_Buthe	13.2
Leribe	28.4
Mafeteng	16.9
Maseru	24.8
Mohales_Hoek	7.3
Mokhotlong	4.7
Qachas_Nek	13.3
Quthing	9.9
Thaba_Tseka	6.9

### Liberia

DISTRICT	RAI
B'hai	6.4
Barclayville	5.9
Beawor	12.7
Belleh	4.3
Bleebo	0.0

Bodaé	0.0	Gbeapo	18.6
Boe & Quilla	6.3	Gbehlay-Geh	47.8
Boinsen	0.0	Gbi & Doru	7.8
Bokomu	26.1	Gboe-Ploe	4.2
Bockon	0.0	Gbor	47.6
Bolloh	0.0	Gee	6.2
Bopolu	13.5	Gibi	2.5
Buah	0.0	Glaro	0.0
Butaw	0.0	Glio-Twarbo	1.0
Buu-Yao	27.8	Golakonneh	36.1
Careysburg	56.6	Gounwolaila	0.0
Cavala	16.9	Grand Cess Wedabo	0.0
Central Rivercess	47.3	Greater Monrovia	94.6
Chedepo	5.4	Greenville	0.1
Commonwealth	69.4	Gwelekpoken	0.0
Commonwealth-B	46.6	Harper	0.0
Commonwealth-C	75.9	Jaedae	4.4
District # 1	12.2	Jeadepo	0.0
District # 2	5.4	Jo River	46.5
District # 3	2.6	Jorquelleh	31.4
District # 4	7.7	Juarzon	42.1
Doe	20.2	Kakata	36.4
Doedain	21.5	Karforh	0.0
Dorbor	0.0	Karluway#1	0.0
Dowein	26.5	Karluway#2	0.0
Dugbe River	10.6	Klay	35.1
Dweh	0.0	Kokoya	8.9
Felo-Jekwi	31.8	Kolahun	0.3
Fen River	25.5	Konobo	10.6
Fenetoe	0.0	Kpaai	43.8
Firestone	20.6	Kparblee	10.9
Forpoh	0.0	Kpayan	14.7
Foya	5.2	Kpi	9.1
Sanoyeah	9.4	Kulu Shaw Boe	0.6
Garr-Bain	50.0	Leewehpea	29.8
Garraway	0.1	Lower Jloh	0.0
Garwula	58.2	Mambah Kaba	70.1
Gbao	3.8	Meinpea-Mahn	16.2
Gbarma	24.4	Nanee	10.8

Neekreen	30.1	Wlogba	0.0	Ikongo	0.0
Norwein	7.3	Yarmein	22.1	Vohipeno	13.6
Nrokwia-Wesidow	9.3	Yarpea Mahn	21.4	Farafangana	11.8
Nyenawliken	23.3	Yarwein		Vangaindrano	2.5
Nyenebo	0.0	Mehnsosnoh	21.7	Midongy-Atsimo	0.0
Nyorken	0.0	Yeallequelles	32.8	Ihosal	11.7
Owensgrove	45.5	Zarflahn	32.6	Vondrozo	0.0
Panta	12.0	Zorzor	4.0	Ivohibe	0.4
Plahn Nyarn	0.0	Zota	1.0	Ikalamavony	16.6
Pleebo/Sodoken	0.0	Kongba	5.3	Lalangina	20.2
Porkpa	48.0	Zoe Gbao	48.6	Iakora	1.5
Potupo	3.0			Befotaka	0.0
Putu	11.2			Manandriana	22.9
Pynes Town	91.7			Vohibato	6.9
Quardu Bondi	24.5			Isandra	8.5
Salala	39.1			Toamasina I	97.8
Salayea	0.8			Sainte Marie	69.9
Sam Gbalor	0.0			Maroantsetra	0.0
Sanniquellie Mahn	37.5			Mananara-Avaratra	0.0
Sanoyeah	20.9			Fenerive Est	12.3
Sanquin Dist# 1	20.2			Brickaville	9.4
Sanquin Dist# 3	7.6			Vatomandry	13.0
Sanquin Dist# 2	0.0			Mahanoro	2.2
Sarbo	8.7			Marolambo	0.0
Seekon	0.2			Toamasina II	7.8
Senjeh	23.8			Antanambao	
St. John River City	28.9			Manampontsy	0.0
St. Paul River	59.5			Amparafaravola	37.4
Suakoko	36.0			Ambatondrazaka	5.4
Suehn Mecca	3.1			Moramanga	9.6
Tchien	42.8			Vavatenina	5.2
Tewor	53.3			Andilamena	0.0
Todea	33.1			Anosibe-An'ala	0.1
Trenbo	9.3			Soanierana Ivongo	1.6
Tukpahblee	24.5			Mahajanga I	84.7
Tuobo	3.5			Besalampy	25.5
Twa River	41.5			Soalala	3.3
Upper Jloh	2.6			Maevatanana	7.6
Vahun	0.0			Ambato Boeni	5.7
Voinjama	8.6			Marovoay	4.9
Wedjah	6.0			Mitsinjo	4.1
Wee-Gbehyi-Mahn	48.5			Tsaratanana	1.7
Whojah	0.0			Port-Berge (Boriziny-Vaovao)	5.8
				Mandritsara	1.9
				Analalava	7.6
				Befandriana Nord	4.0

### Madagascar

DISTRICT	RAI
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Antananarivo Renivohitra	
Antananarivo Avaradrano	45.0
Ambohidratrimo	10.6
Ankazobe	9.3
Arivonimamo	6.5
Manjakandriana	25.2
Anjozorobe	5.2
Antsirabe I	48.2
Betafo	4.8
Ambatolampy	17.3
Tsiroanomandidy	7.1
Miarinarivo	15.9
Soavinandriana	7.3
Antanifotsy	6.7
Andramasina	0.6
Faratsiho	6.9
Antananarivo	
Atsimondrano	37.4
Antsirabe II	14.5
Fenoarivobe	0.7
Mandoto	7.3
Fianarantsoa I	53.5
Ambatofinandrahana	5.7
Ambositra	33.2
Fandriana	28.7
Ambalavao	9.2
Ifanadiana	5.9
Nosy-Varika	0.4
Ambohimahasoa	16.9
Mananjary	11.7
Manakara Atsimo	10.3



Delta	41.0
Ebonyi	11.3
Edo	33.9
Ekiti	45.5
Enugu	36.4
Federal Capital Territory	27.3
Gombe	20.5
Imo	48.3
Jigawa	33.2
Kaduna	25.0
Kano	19.7
Katsina	32.0
Kebbi	17.7
Kogi	28.6
Kwara	21.7
Lagos	49.7
Nassarawa	19.6
Niger	13.8
Ogun	30.5
Ondo	22.2
Osun	57.3
Oyo	19.6
Plateau	17.1
Rivers	31.1
Sokoto	22.2
Taraba	10.5
Yobe	13.7
Zamfara	16.7

### Peru

Department	RAI
Amazonas	35.6
Huancavelica	50.7
Ica	23.5
Junín	43.4
La Libertad	39.8
Lambayeque	42.7
Lima	34.4
Loreto	1.3
Madre de Dios	14.6
Moquegua	32.7
Pasco	38.2
Ancash	37.6
Piura	37.2
Puno	40.3

San Martin	33.0
Tacna	27.4
Tumbes	40.2
Ucayali	3.4
Apurimac	47.9
Arequipa	31.0
Ayacucho	52.2
Cajamarca	56.9
Callao	36.6
Cusco	49.0
Huanuco	39.0

### Rwanda

District	RAI
Burera	77.4
Musanze	74.6
Kicukiro	76.3
Karongi	53.2
Nyamagabe	63.5
Rusizi	64.9
Nyagatare	54.0
Gatsibo	60.9
Nyabihu	54.5
Rubavu	76.0
Gakenke	32.2
Ngororero	52.8
Rutsiro	25.7
Nyarugenge	79.2
Kirehe	47.0
Bugesera	53.3
Ngoma	49.2
Nyamasheke	44.9
Huye	76.9
Gisagara	53.8
Rwamagana	35.4
Kayonza	43.9
NyanzaA	53.3
Ruhango	50.8
Muhanga	77.0
Kamonyi	29.9
Gicumbi	59.6
Gasabo	49.2
Rulindo	72.1
Nyaruguru	43.3

### Sierra Leone

District	RAI
Kailahun	15.6
Kenema	19.1
Kono	24.5
Bombali	16.3
Kambia	54.7
Koinadugu	2.0
Port Loko	55.1
Tonkolili	21.3
Bo	26.8
Bonthe	6.5
Moyamba	27.6
Pujehun	2.3
Western Rural	90.4
Western Urban	83.5

### Somalia

Region	RAI
Awdal	38.6
Bakool	3.2
Banaadir	27.7
Bari	58.1
Bay	35.3
Galguduud	35.3
Gedo	13.1
Hiiraan	23.0
Jubbada Dhexe	26.9
Jubbada Hoose	23.6
Mudug	22.1
Nugaal	41.0
Sanaag	1.9
Shabeellaha Dhexe	28.5
Shabeellaha Hoose	30.6
Sool	45.4
Togdheer	44.8
Woqooyi Galbeed	47.0

### Iraq

Province	RAI
Al-Anbar	57.0
Al-Basrah	45.5
Al-Muthannia	75.5

Al-Qadisiyah	59.9
An-Najaf	23.4
Arbil	80.6
As-Sulaymaniyah	68.8
At-Ta'mim	67.6
Babil	66.3
Baghdad	0.0
Dhi-Qar	46.8
Dihok	76.8
Diyala	69.4
Karbala'	60.9
Maysan	48.4
Ninawa	74.3
Sala ad-Din	71.0
Wasit	52.4

### **Lebanon**

Governorate	RAI
Akkar	92.8
Baalbak - Hermel	80.4
Beirut	n.a.
Bekaa	89.4
Mount Lebanon	97.0
Nabatiyeh	99.2
North	88.6
South	99.8

### **Jordan**

Province	RAI
Ajlun	97.3
Amman	65.1
Aqaba	10.8
Balqa	73.5
Irbid	94.6
Jarash	88.7
Karak	49.1
Ma`an	41.2
Madaba	68.0
Mafraq	71.5
Tafilah	38.7
Zarqa	32.5