Roads for Development Program (R4D)

Technical Paper

Rural Access Index (RAI)

The Case of Timor-Leste

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Introduction

This paper explains the applications of the Rural Access Index (RAI) as a tool for policy makers, government agencies and practitioners working in the roads sector, for formulating road policies and strategies, in guiding and managing investments in the roads sector, and in monitoring the effectiveness of investments in the sector.

The paper also compares different ways of calculating the RAI. Special attention is given to an innovative way in which the RAI was calculated in Timor-Leste. This was done within the framework of the Roads for Development Program (R4D) which is implemented since 2012. R4D is the Government of Timor-Leste's main program for the development of rural roads in the country. It is being implemented with financial support from the Australian Government and technical assistance from the International Labour Organization (ILO).

In the last section of this paper, conclusions are presented about the usefulness of the RAI and the methodology used to calculate the RAI. This section also includes recommendations on how the methodology for computing the RAI can be further improved – in a sustainable way – to assist governments in using it as a strategic and operational planning tool and for monitoring.

Evolution of methodology used to define the Rural Access Index (RAI)

When the World Bank introduced the RAI[1] as an indicator of the access of rural people to roads, the RAI was defined as:

The share of rural people who live within 2 kilometers (about 20 – 30 minutes walking time) of the nearest all-season road

An 'all-season road' is defined as a road that is motorable all year round by the prevailing means of rural transport. The 'all-season road' was included in the definition so that roads that were unusable for several months a year did not count[2].

It is important to realize that the **RAI relates to the percentage of rural people having access to any category of all-season roads and not only to all-season rural roads.** Illustrative for this is the case of Timor-Leste where 40% of the rural population lives along National and Municipal roads and 60% along rural roads[3].

The methodology used for calculating the RAI was found by the World Bank to have various shortcomings. The main point of criticism on the original RAI was that the methodology is primarily based on available data from household surveys and only provides one national RAI figure for each country. This results in the following shortcomings:

- Too costly to implement, thereby rendering it financially unsustainable;
- Only provides country-level RAI figures and does not provide adequate and equal spatial representativeness within the country[4]. This is a crucial defect for policy makers and other

[1] Rural Access Index, World Bank, (https://openknowledge.worldbank.org/handle/10986/17414).
[2] However, some predictable interruptions of short duration during inclement weather (e.g., heavy rainfall) are allowed.
[3] Government of Timor-Leste, Rural Roads Master Plan and Investment Strategy, 2015
[4] For instance, a Tanzanian household survey in 2010 covered 3,917 households nationwide, but the sample was only collected from 409 villages in the country's vast land area of 950,000 kilometer2

stakeholders who want to utilize the RAI for planning and monitoring on the ground. As a result, the take-up of the RAI as an indicator of access has been very low;
- Because of the differences in spatial representation and differences in survey methods used in different countries from which the data were gathered, the estimated RAIs for different countries are not comparable across countries;
- In many countries it is difficult to regularly update data using household surveys and data from household surveys are not available in all countries[5];
- Having consistent and extensive data on road conditions is required to provide accurate RAI figures but such data cannot be produced by household surveys.

Furthermore, setting the standard of road access as access to an all-season road was not very clear. The reference to an 'all-season' road in the definition of the RAI created confusion. Whereas this definition allows for predictable interruption of short duration, this was not clearly defined. It also caused confusion about what the difference is between an 'all-season' road and an 'all-weather' road[6].

As the measurement of rural access is one of the most important indicators for measuring and achieving several of the Sustainable Development Goals (SDGs), renewed interest in the RAI emerged and the World Bank[7] developed a more **sustainable**, **simple, consistent**, **accurate** and **operationally relevant** method for estimating the RAI, using newly available data and technologies. This revised method for calculating the RAI conceptually remained largely the same. The previous standard of having access to an all-season road was replaced with the standard of having access to an all-weather road. The new RAI is defined as follows:

The share of the rural population that lives within 2 kilometers (about 20 – 30 minutes walking time) of the nearest all-weather road in good condition.

The condition of the road is assessed in transport engineering terms. Roads considered in 'good' condition include paved roads in a good or fair condition, and unpaved roads in good condition

The new method of calculating the RAI uses emerging global spatial data and advanced techniques[8]. It uses high-resolution population distribution data such as WorldPop[9] and digitized road network data, including data on road conditions, which are often available at national road agencies. Road conditions are assessed in different ways, depending on the available data in the countries[10].

According to the World Bank, the new method has the following advantages over the originally used methodology:

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[5] E.g. when the RAI was introduced, for only 50 countries out of a total of 170 countries the RAI was calculated using data from household surveys. For all other countries, some existing national statistics were used, or a modelling approach was applied for a rough estimate of rural accessibility under simplistic assumptions

[6] An all-weather road is held to a higher standard than an all-season road, requiring a road to be motorable all year round and in normal weather conditions.

[7] In partnership with the Department for International Development (DFID) of the United Kingdom and the Research for Community Access Partnership

[8] Such as remote sensing and the use of high resolution satellite imagery, Global Positioning System (GPS) and Geographic Information System (GIS), crowdsourcing, open data. The new RAI measures the accessibility of every single local place (technically, every area of 100 x 100 meters).

[9] www.worldpop.org.uk/

[10] These could for example be the International Roughness Index (IRI), the Pavement Condition Index (PCI) or a visual assessment through traditional road inventory surveys using different condition categories (e.g. excellent, good, fair, poor, and very poor).

- The RAI is computed without counting households on the ground. This makes the RAI more sustainable as well as more consistent across countries. Consistency across countries is critical if the RAI is to serve as a global indicator and as a measure of achievement of the SDGs.
- It allows for estimation of rural accessibility at any disaggregated sub-national level. This facilitates the identification of sub-national rural access gaps and the prioritization of road investments at sub-national levels. Therefore, the new method of calculating the RAI is expected to be highly relevant for rural road prioritization and monitoring.
- The New RAI is designed to support the day-to-day operations of client countries which is expected to generate more interest of these client countries, thereby having a positive effect on the sustainability of the method.
- The spatial approach is more cost-effective and sustainable than the previous RAI method that was based on household survey data.
- Using spatial data and techniques makes it easy to overlay different themes in the same format. Whereas the RAI focusses on access to the road network, it can easily be expanded to other types of connectivity, such as access to markets or hospitals, by using thematic overlays.
- The new RAI relies primarily on government-owned data. This fosters client countries' ownership, which in turn motivates sustainability and regular updating

Key challenges that were identified by the World Bank in relation to the usefulness of the new method of calculating the RAI primarily **relate to the availability, quality, and level of detail of the data.**

Data sets that are often found to be missing or to be inaccurate are the following:

- The road network and the classification of the different roads in the network;
- Updated information on the condition of the roads;
- Data required at operational level to determine the passability of a road (like the condition of bridges or culverts);
- Information about typical original-destination routes of rural people;
- Urban-rural boundaries.

The new method for calculating the RAI depends largely on spatial data and the quality of available spatial data is therefore considered highly important.

A possible challenge with the new method of calculating the RAI, that has not been given much attention, is the question of the level of accuracy that can be achieved in geographically projecting data on population distribution, using modelling techniques (as applied by WorldPop; see also Footnote 8). Without reliable verification/calibration methods for the used modelling methods, the accuracy of the used modelling algorithms remains uncertain.

There is a potential concern with the use of modelling-based population distribution estimates, such as WorldPop, because populations are – by design of the model – distributed along the road network. In reality this may not always be the case and could possibly lead to an over-estimation of the RAI.

Such over-estimation of the RAI could e.g. occur in a situation where a country has a relatively large and well-maintained network of national and provincial/district roads, a comparatively small (mapped) network of rural roads that are generally not well-maintained, and a very scattered rural population of which the large majority lives more than 2 kilometers away from a road.

Under-estimating the RAI can also happen. This could for example result from a situation where not all the roads in the network have been mapped and/or where not accurate/complete information is available about the condition of all the individual road links in the network.

Other errors in spatial modelling may occur because geographic terrain features are not being considered. Imagine for example a situation where large segments of the rural population are living alongside a major river and that a well-maintained national road runs along this river, but at the other side from where the rural people are living but without access (bridges) to the road. If this factor is not taken into account, the RAI will be largely over-estimated.

Another example is the situation in a mountainous country. If horizontal "as the crow flies" distances are used to delineate 2 kilometers wide corridors along roads as a measure of a walking distance of not more than 20 – 30 minutes to the road for the people living within this corridor, this may lead to a gross under-estimation of the actually required walking distance. Available licensed mapping software like ArcGIS or free applications like Google Earth Pro can calculate the actual distances along the terrain and can provide a more accurate measure of the 2 kilometers's corridor.

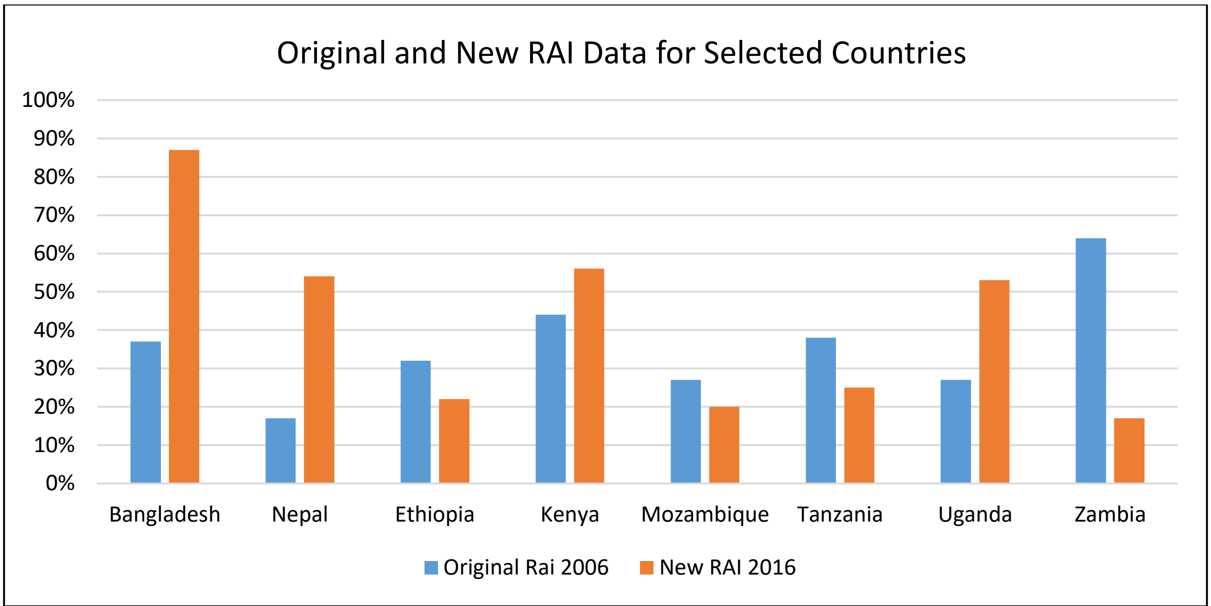
All above examples show that there actual situations on the ground can vary significantly from country to country, from province to province, from district to district, from village to village, and even from household to household.

Figure 1 shows a comparison of the RAI figures for 8 selected countries, comparing the figures calculated using the original method and those derived using the new method. Figure 1 shows that there are considerable differences between the RAI based on the original methodology and the RAI calculated using the new method.

In three cases (Bangladesh, Nepal, Uganda) the new method has resulted in significantly higher figures (compared to the RAI that was calculated using the original method). This may be related to possible flaws in modelling as explained in the previous paragraph. In the case of Nepal e.g. the new methodology may have overlooked the fact that actual walking distances and walking times for rural people to motorable roads are actually much more than have been projected in the model – which may not have considered the mountainous character of 67% of the country's land area. In the original method, when household surveys were used, more accurate information may have been obtained from the surveyed households about their actual travelling time to the nearest road.

In one case (Zambia) the new method resulted in a substantial decrease of the RAI (compared to the RAI as calculated using the original method). For the four other countries the differences in the RAI figures between the new method and the original method are smaller but still significant (between 7 and 13%).

Figure 1: comparing the RAI for selected countries using the original and new methodology



Data requirements

According to the World Bank, three sets of data are required for calculating the new RAI using the new method:

- **Road data/maps** showing all the roads in the road network (road agencies like ministries of public works are responsible for collecting this information on a regular basis, for example every 3-5 years).
- **Road condition data/maps** showing the condition of all the roads in the (classified road network (road agencies like ministries of public works are responsible for collecting this information on a regular basis, for example every 1-2 years).
- **Population data/maps** showing the geographical distribution of the rural population (usually collected through national census surveys, every 5-10 year).

Applications of the RAI

If accurate estimates of the RAI can be produced, the World Bank considers the RAI as a potentially very useful tool for different purposes:

1. **Indicating the extent of access of rural people**: The RAI indicates the extent to which transport and access services reach the entire rural population and the extent to which such services are not provided to the rural people.

2. **Defining road policy targets:** For national policy makers the RAI can be used to set a country's target for providing road access to its rural people. A policy target could for example be that a country wants to increase its RAI from the current 55% to 70% in five years' time. This translates to an annual increase of the RAI of 3% (assuming that the policy is to achieve a linear increase in the RAI).
3. **Formulating road asset development and management strategies**: Once a policy target for the RAI has been set and the current RAI is known, this information can be used to formulate a road asset development and management strategy. Additional information is however required about the percentage of rural people living within 2 kilometers (20 – 30 minutes walking distance) of the existing road network to enable the formulation of a road asset development and management strategy. To illustrate this, two different scenarios are shown in Table 1.

Table 1: Examples of Situation Analysis required to determine Road Management & Development Strategy

Scenario	Current RAI: 55%	Policy Target RAI: 70%
	Situation	**Road Management/Development Strategy**
1	All rural people live within 2 kilometer of a road - 55% of the road network is in a good or fair condition - 45% of the road network is in a poor condition	- Maintain all roads in good or fair condition (contributes 55% to RAI) - Reconstruct/rehabilitate 1/3rd of the road network that is in poor condition, i.e. 15% of total road network (contributes 15 percentage points to RAI)
2	61% of rural population lives within 2 kilometer of a road, equally distributed along road network - 90% of the road network is in a good or fair condition[11] - 10% of the road network is in a poor condition	- Maintain all roads in good or fair condition (contributes 55% to RAI, see footnote 2) - Reconstruct/rehabilitate all roads in poor condition (contributes 6.1% to RAI[12]) - Construct new roads that provide road access to an additional 8.9%[13] of the rural population.

4. **Estimating the required investments in the road sector**. Once the road asset management and development strategy has been formulated (see Point 2 above), the required level of investments can be estimated, using unit cost rates. These range from the typical routine maintenance costs per kilometer on a rural road to the typical reconstruction costs per kilometer for a national road. Such unit cost rates serve the purpose for overall budgeting purposes at national level and having approximate value is sufficient for this budgeting purpose.
5. **Monitoring the progress and effectiveness of road policies and road investment strategies**: Annually updated information on the RAI provides policy makers and responsible implementing agencies key information about the effectiveness and progress of investments in the roads sector. If for example the RAI decreases from one year to the next

[11] With 90% of the roads in good/fair condition and 61% of the rural people living within 2 kilometer of a road, the RAI can be calculated to be (0.90 * 0.61) * 100% = 55%
[12] (0.10 * 0.61) * 100% = 6.1%
[13] 70% (target) – 55% - 6.1% = 8.9%

despite significant investments in the road sector, this could indicate that there is something wrong, for example:

a. Too much emphasis on investments in the rehabilitation or (re-) construction of roads and insufficient attention to investments in maintenance. This could result in an overall deterioration of the road network.
b. The delivery of sub-standard work in the rehabilitation, (re-) construction or maintenance of the roads because of the use of inappropriate standards and specifications (that are not resilient and lead to a quick deterioration of the road) and/or the absence of effective systems for quality control, leading to a quick deterioration of the road assets.

Whatever the reasons may be, monitoring the progress in RAI will alert policy makers and responsible line agencies that targets are not achieved and that the cause(s) for the under-performance need to be identified and addressed.

6. **Providing an indirect indicator of the progress or feasibility towards achieving many of the Sustainable Development Goals (SDGs).** The correlation between improved road access for the rural population and poverty alleviation has already been documented many years ago[14]. Whereas improved rural road access alone is not sufficient to alleviate rural poverty, it is a key condition to rural economic and social development. As such the RAI is a very important indicator for countries to assess their progress, or likelihood of achieving progress, towards SDGs[15]. Apart from the RAI, there are very few – if any – global indicators that estimate rural transport connectivity systematically and as such the RAI is very important monitoring tool.

As mentioned under points 1, 2 and 3 above, once the actual and targeted **RAI** are known, the **situation analysis** has been completed, and the **unit cost rates** have been estimated, this information can be used to define investment strategies and to determine required investment levels in the roads sector.

Using the RAI a an instrument in formulating road investment and management strategies also eliminates the need for having very complicated, time-consuming, expensive and cumbersome criteria for the identification, prioritization and selection of roads to be included in road investment strategies, plans and budgets.

Another potential benefit of using the RAI as a key instrument to guide road investment strategies and investments is that it allows for rational and informed decision-making. Once a government has agreed to use the RAI as the key in formulating road policies, strategies and investment plans, this eliminates/reduces undue political influences in decision making and increases the levels of cost-effectiveness, transparency and accountability.

[14] Some examples of literature on this subject are mentioned at the end of this paper under References

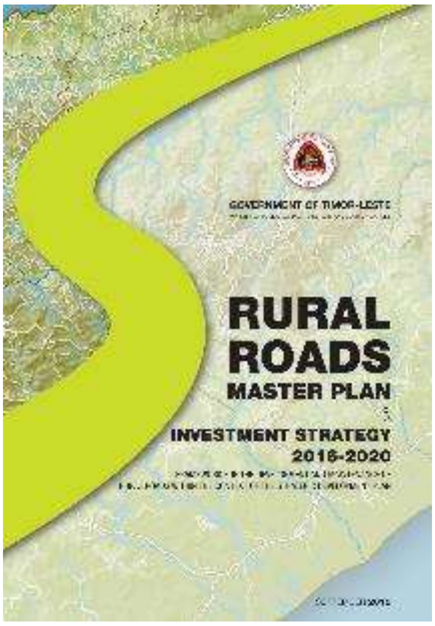
[15] In particular target 9.1 of the SDGs: develop quality, reliable, sustainable, and resilient infrastructure to support economic development and human wellbeing, with a focus on affordable and equitable access for all

Alongside information on current and targeted RAI numbers, additional information that is required to enable the **annual** planning, programming and budgeting of investments in roads relates to information about road connectivity and government priorities:

- **Information about road connectivity**: Investments in roads need to be limited to those roads that either directly connect to places that rural people need to have access to (e.g. places of social-economic importance) or roads that connect to all-weather roads. It does not make sense to invest in the rehabilitation of a rural road if that road is not connected to an all-weather road in the road network;
- **Government priorities**: Specific government priorities provide a very important layer of information that guide the strategy and investment plan. If a government wants to prioritize and phase investments in those (existing) roads that will provide all-weather access to the largest numbers of rural people first, this will guide the (annual) investments. At the same time a government may also want to distribute investments to particular provinces that are underserved. This provides a further guidance for the allocation of the investments. Specific economic development priorities of a government may also provide guidance in directing the investments;

The RAI can be a very useful instrument in helping decision-makers to make decisions about investments in the road network as whole – against specific rural access objectives and targets. Within the framework of such an overall road investment strategy, country-specific or area-specific information also needs to be known to decide on the specifics of the investments (and investment levels) in the different classes of roads (like national, district and rural roads).

Application of the RAI in the R4D Program in Timor-Leste



In 2014 the ILO technical assistance (TA) team to R4D started with its work in assisting the Government of Timor-Leste (GoTL) in the development of a Rural Roads Master Plan and Investment Strategy (RRMPIS) for Timor-Leste.

As major data gaps existed, much work needed to be done on the collection and analysis of data required for the formulation of the RRMPIS – which included the calculation of the actual RAI of Timor-Leste. As the RRMPIS was meant to provide strategic operational investment planning guidance, a large level of accuracy and detail of the different data sets was needed.

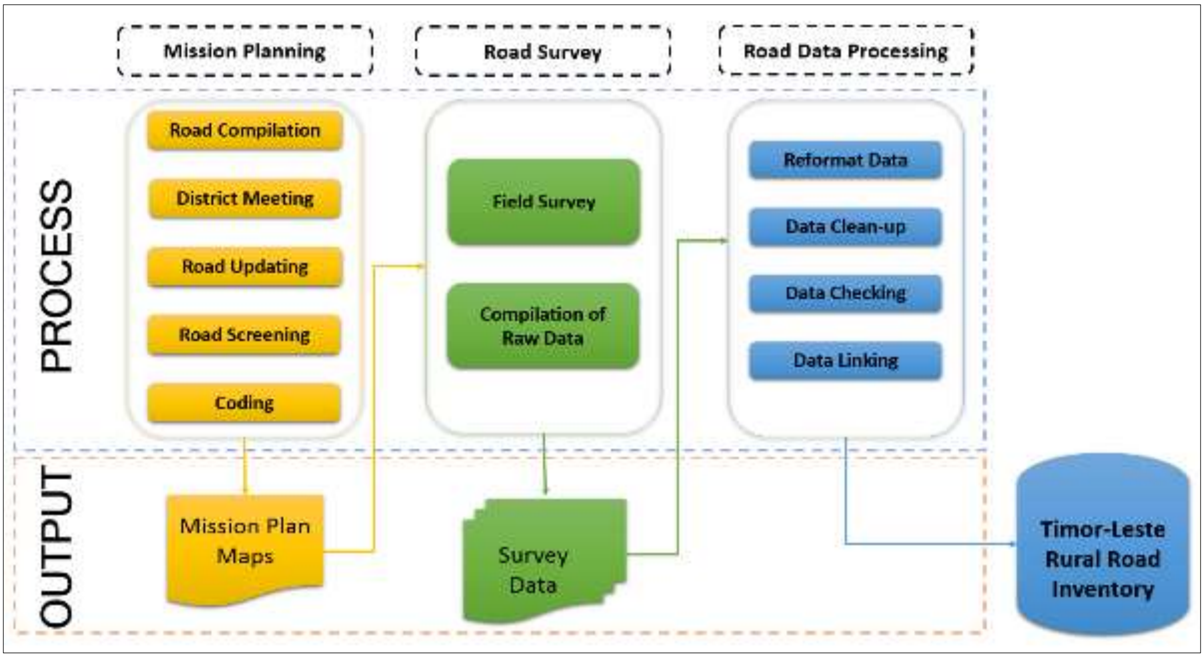
At the start of R4D's work, the situation regarding available data and capacities was as follows:

1. No properly digitized road data;

2. No comprehensive up-to-date tabular lists of all National and Municipal roads;
3. No up-to-date information about the condition of the National and Municipal roads;
4. Missing or inaccurate GPS coordinates on the location of National and Municipal roads;
5. Contradicting information on the classification of some National/Municipal roads;
6. No information about the rural road network;
7. No information about the condition of the rural road network;
8. Absence of a class of rural roads[16];
9. No design standards and no uniform technical specifications for rural roads;
10. No information about typical unit costs for maintenance, rehabilitation or (re-)construction costs of different classes of roads;
11. Unclear administrative boundaries between Sucos (i.e. villages);
12. Conflicting data about the population in individual Sucos
13. Absence of a platform for spatial data entry, processing and analysis;
14. No local GIS capacity and no mapping convention;
15. Absence of systems and funding for road condition inventory surveys;
16. No clear system/approach for the prioritization of investments in roads;

To address the data gaps on the road condition inventories – with a main focus on the rural roads – the process as shown in Figure 2 was used. During the process a working definition of a rural road was agreed upon with the key stakeholders.

Figure 2: Workflow Process for the Preparation of the Rural Road Inventory



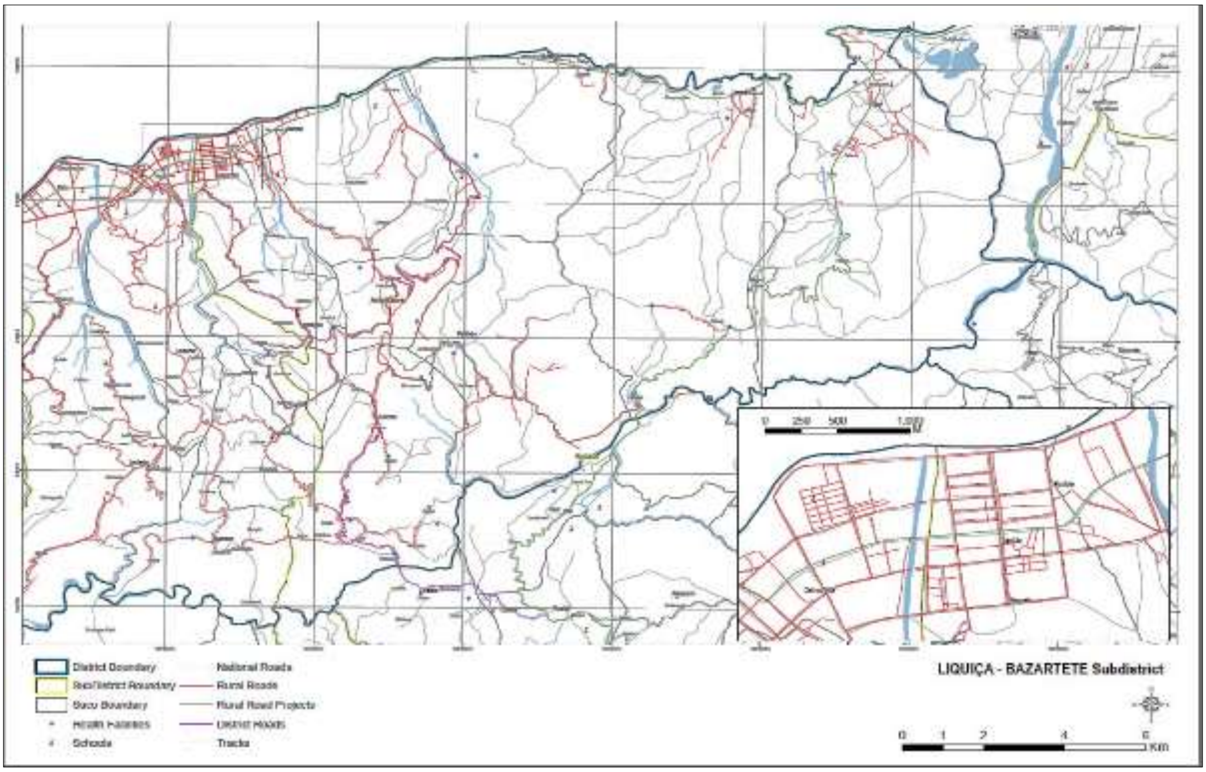
GIS capacities and systems that were developed with support from R4D since 2012 for the National Directorate of Roads, Bridges and Flood Control (DRBFC) of the Ministry of Public Works, Transport and Communications (MPWTC) were used to capture road inventory data.

[16] As per the GoTL Basic Law of 2003 on the Road Transport System there were 3 road classes: National Roads (class A), Municipal Roads (Class C) and Local Roads (these included urban and rural roads).

As a first step available secondary data were compiled, reviewed, checked and converted to GIS to produce initial **working maps** for each Municipality and Administrative Post[17]. Figure 3 presents an example of such a map (for Bazarette Administrative Post, Liquica Municipality).

Data sources that were used included data available with DRBFC and with other line ministries, as well as satellite images. Apart from road-specific data, available data on administrative boundaries, geomorphologic terrain features, and the location of infrastructure like bridges, hospitals, clinics, schools, land-cover and land-use, were collected.

Figure 3: Example of Working Map before Field Verification



During **consultation workshops**, the information on the initial working maps was **verified** and, as required, the maps were updated, including the demarcation of the urban areas. As part of this exercise, a preliminary categorization of the rural roads was made – distinguishing four categories of rural roads[18].

The next step involved a desktop screening of the available data and follow-up consultations with DRBFC staff and Municipal Administrations as a final round of verifying and validating the information.

[17] Until 2015 these used to be named respectively Districts and Sub-Districts.

[18] 1) Suco to higher level roads or to Municipal/Administrative Post centers 2) Suco to Suco roads; 3) roads from Sucos to Aldeias (every Suco is composed of a number of Aldeias – i.e. Hamlets) or to agricultural areas; 4) roads from Aldeia to Aldeia or to agricultural land.

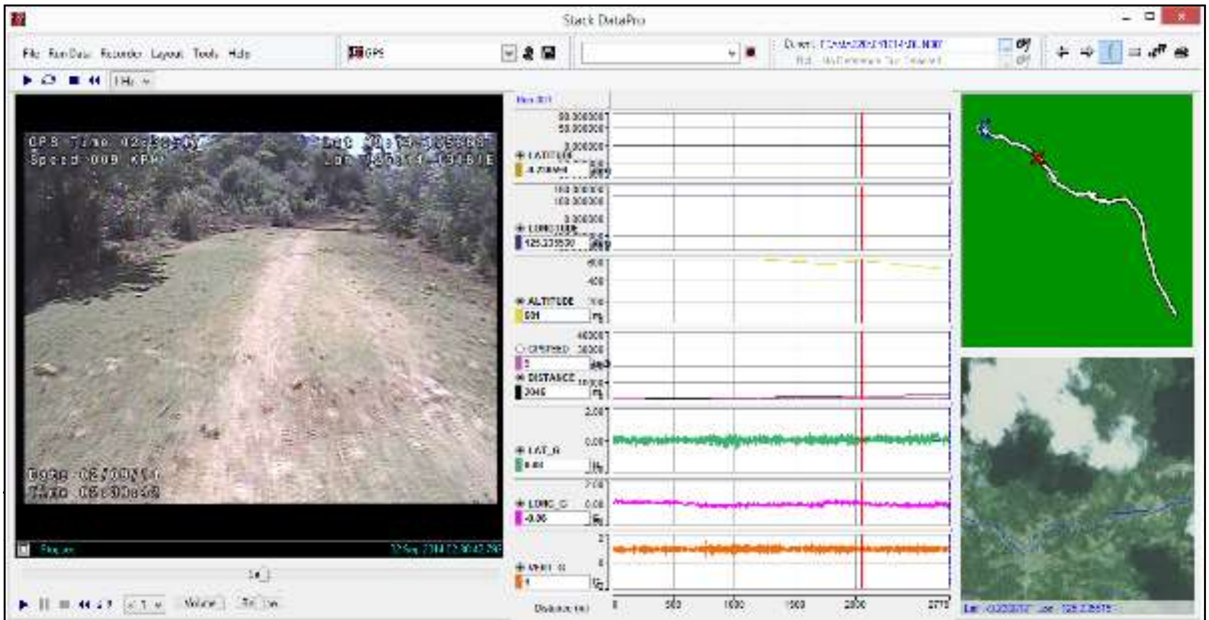
This resulted in an agreed list of existing rural roads (with a total length of 3,855 kilometers) that can provide access to the large majority of the rural people if in good or fair condition (these were the roads from the categories 1 and 2 mentioned in Footnote 18). These rural roads were considered as candidate core rural roads and they were subjected to a road condition survey.

The data collection methods that were used for the different road features that were surveyed, are summarized in Table 2. An example of a screenshot from the digital video recording equipment that was used, is shown in Figure 4.

Table 2: Overview of Data Collection Methods & Instruments used in Road Condition Inventory Survey

	Features / Attributes	Data Collection Methods and Instruments
1	Location of road and structure (incl. latitude and longitude), terrain type, maximum gradient of the sidelong slopes	• Continuous video recording and photos at spot locations • Inspections, using survey forms – every 200 meters for alignment and point locations for ancillary structures. Summarized average condition and typical features for every 1 kilometer section • GPS – every 200 meters for alignment, point locations for structures
2	Road condition[19] (pavement, drainage and other structures, incl. information on e.g. landslips, erosion, width flooding and gradient	• Continuous video recording and photos at spot locations • Inspections using survey forms – every 200 meters for alignment and point locations for every ancillary structure. Summarized average conditions and typical features for every 1 kilometer section • GPS –every 200 meters for alignment, point locations for structures • Travel speed
3	Landmarks and social facilities	• GPS point location, photos and spot inspections • Interviews with local residents every 5 kilometer
4	Details of gravel pits, quarries and relevant local industries	• GPS point location, photos and Spot inspections • Interviews with local residents every 5 kilometer • Survey forms
5	Traffic and priority interventions	• Moving observer counts during drive on (windscreen traffic counts) • Interviews with local residents every 5 kilometer • Engineering assessment every 5 kilometer of required priority interventions

Figure 4: Example of Screenshot from Digital Video Recording Equipment

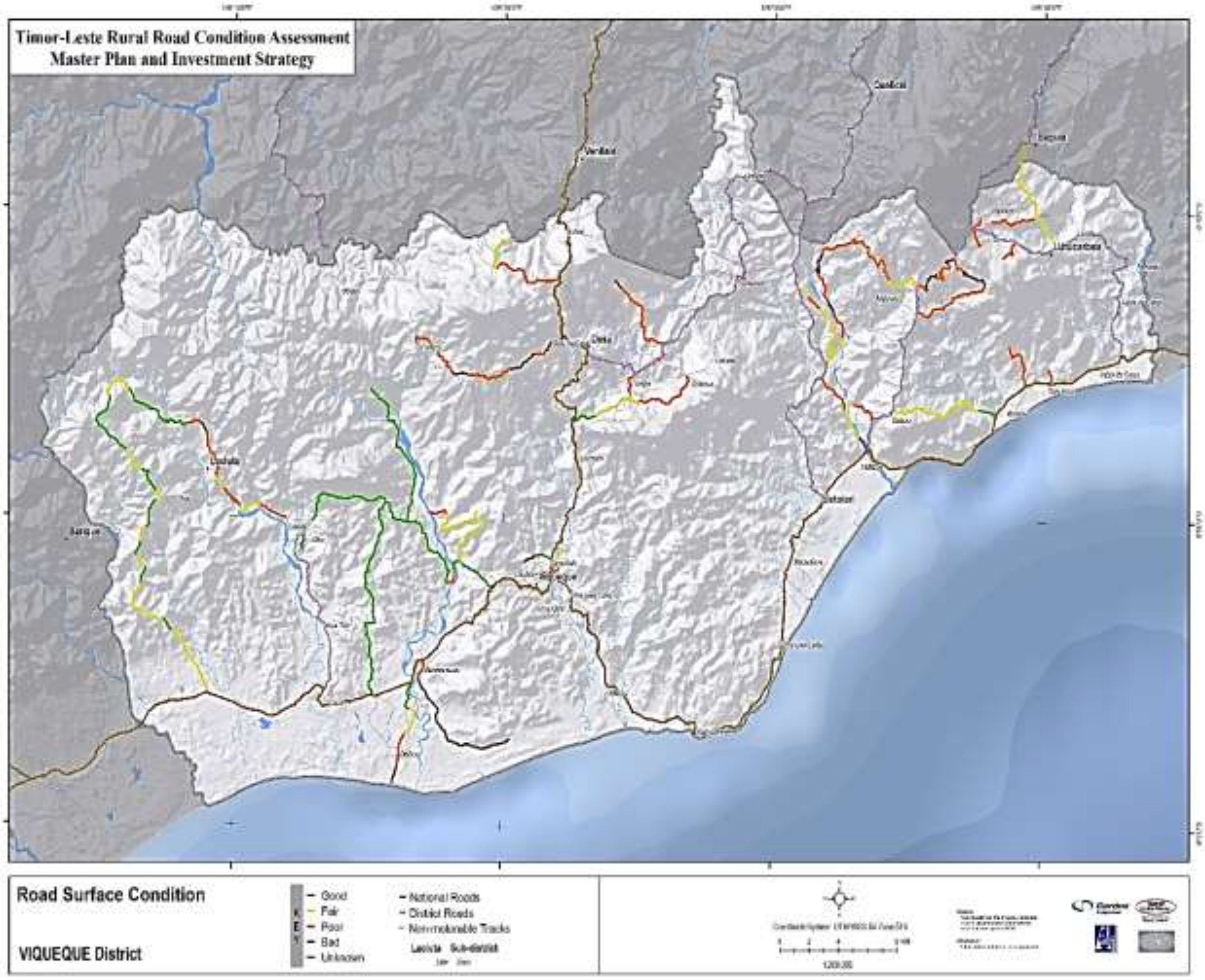


interrupted even for 4WD vehicles during dry season. Allowing driving speed of less than 10 kilometer/hour.

Video recordings of roads helped to verify and validate survey data to actual field reality. Aspects of a road such as road pavement, shoulder, side drain, and accessibility were assessed by an independent reviewer.

The corrected and processed data were presented in GIS and thematic maps were produced from attribute data. Figure 5 shows an example of a working map of the condition of the road surface.

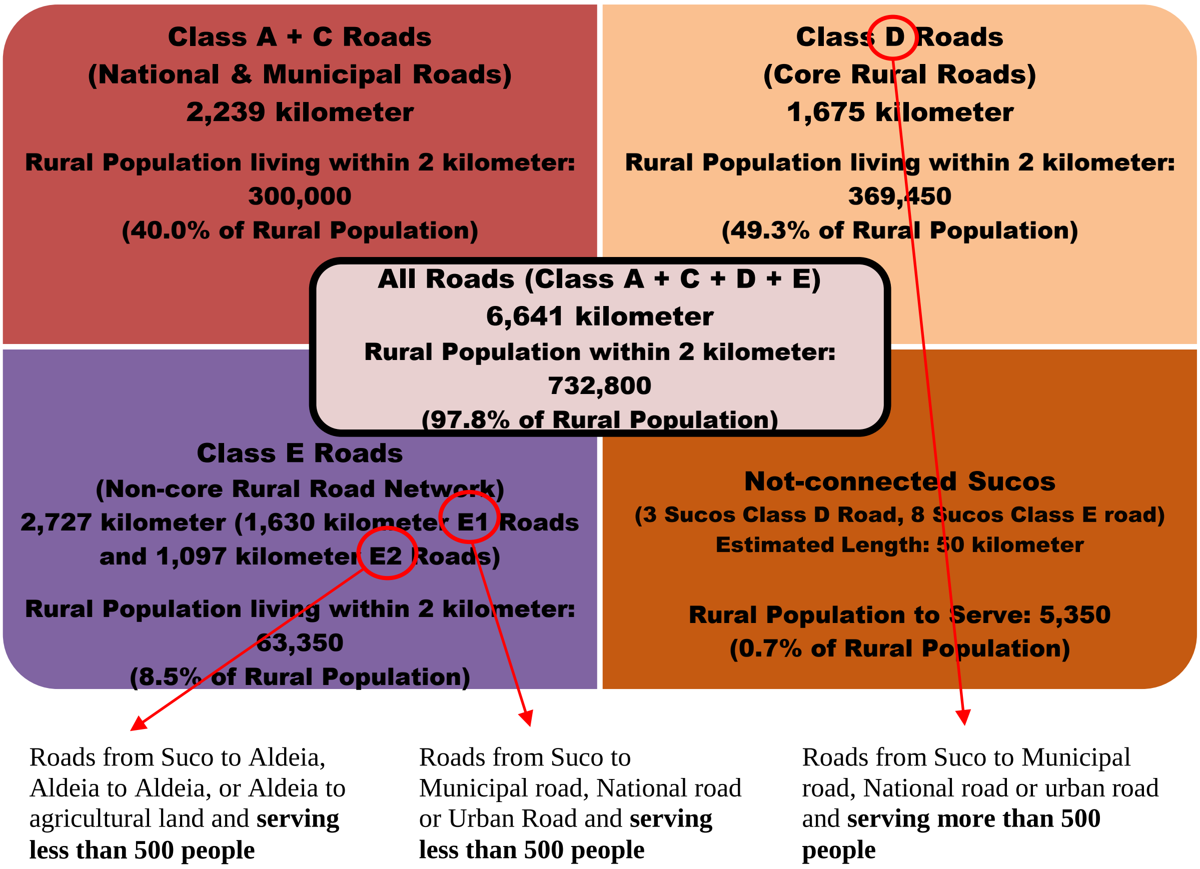
Figure 5: Example of Working Map of Condition of Road Surface (Viqueque Municipality)



Following the completion of the roads inventory, roads were classified. For National and Municipal roads such a classification already existed. For rural roads this this had to be done. Rural roads were divided in core rural roads – roads serving more than 500 people – and non-core rural roads – roads serving less than 500 people. For each of the classified road links in the road network the number of rural people served by that particular road was estimated.

Figure 6 presents an overview of the classified road network for Timor-Leste for the different classes of roads and the number of rural people served by these different classes or roads.

Figure 6: Classified Road Network of Timor-Leste for Different Road Classes and Number of People served



Setting the threshold of 500 rural people to distinguish between core and non-core rural roads was based on the most recent census data that showed that 94% of the Sucos have a population of more than 500. The distinction between the E1 and E2 road classes is related to the hierarchy of these roads in the network (E1 being of a higher class than E2).

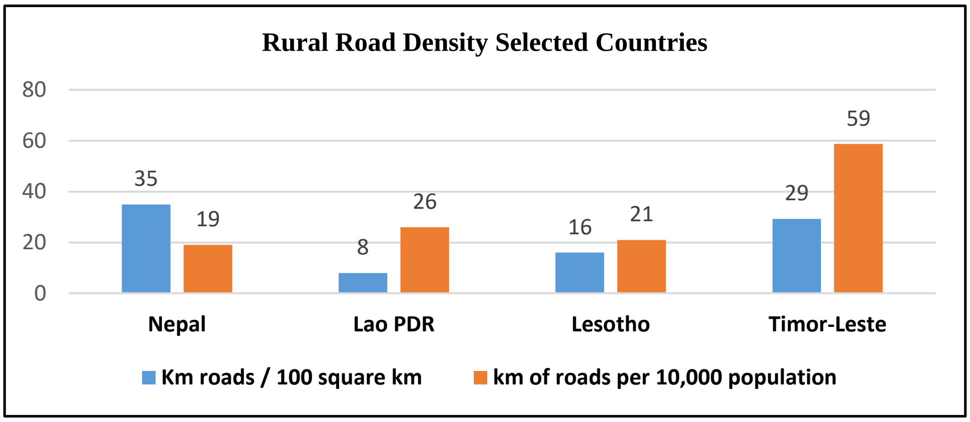
For the process of distinguishing whether a rural road class was a core or non-core rural road, the total rural population served by each particular road link was estimated, including the rural population accumulated from other road links that connect to that particular road.

During the census, the GPS coordinates of every household were collected and this information was mapped and overlaid with the road maps to provide the key information required to enable the analysis. Location specific information on typical origin-destination routes of the rural people was also used in the analysis. This information was collected during the road surveys.

To estimate the RAI, maps with combined information about the condition of the road network, the location of individual households, and terrain features, were used to estimate the RAI. On the maps, 2 kilometers corridors along the roads were marked to enable the estimation of the number of people living within these corridors. The 2 kilometers' corridors were drawn using as much as possible distances that followed terrain contours. Urban areas were excluded.

Based on an analysis of the available information, it was found that only 2.2% of the rural population live outside the 2 kilometers road corridor. **97.8% of the rural people live within 2 kilometers of a road of any condition.** This is a reflection of the high rural road density in Timor-Leste. Figure 7 presents a comparison of the rural road density between Timor-Leste and other countries with a similar topography.

Figure 7: Rural Road Density in Timor-Leste and Selected other Mountainous Countries



Available information about typical original-destination routes was used to further increase the accuracy of the calculations. Figure 9 on the next page shows an example of the type of maps that were used in calculating the RAI. The area colored in light-blue on the map demarcates the 2 kilometers corridors, the dark grey dots the location of the houses.

The data analysis resulted in a RAI of 49%. Figure 9 shows how this figure compares with the RAI that was calculated by the World Bank for 2001 and 2007.

Although caution should be used in comparing the figures – because of the different methods used by the World Bank and ILO-R4D – there appears to be a clear trend. In 2001 the RAI was high (89%), which is a reflection of the fact that during the Indonesian occupation of Timor-Leste from 1975 to 1999 Indonesia invested much in developing the road network, including its rural roads.

During the initial years after restoration of independence in 2002, relatively few investments were made in the country's road network. This explains the drastic drop in RAI between 2001 and 2007. Since 2007 the Government has substantially increased its investments in roads and this led to a significant increase in the RAI.

Figure 8: RAI for Timor-Leste in 2001, 2007 and 2015

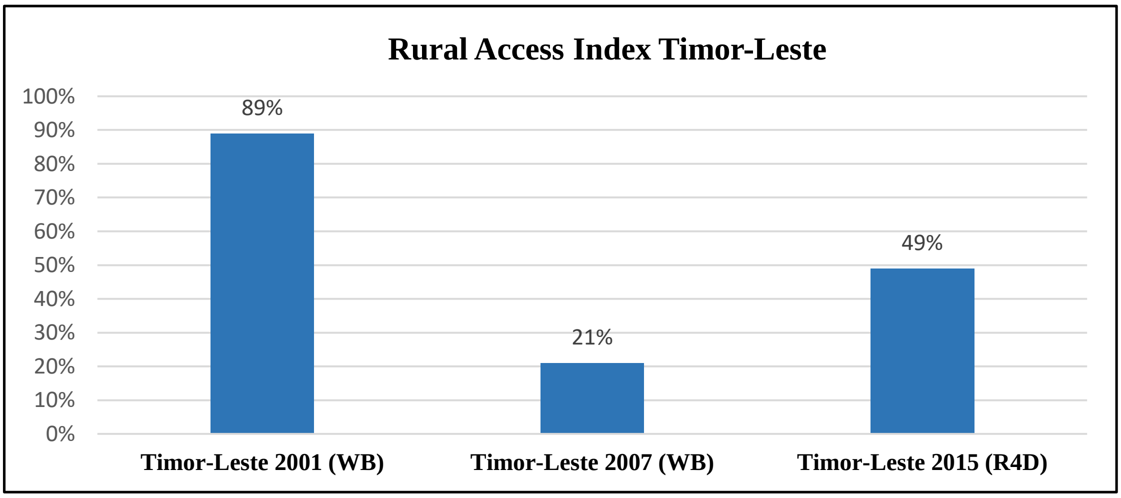
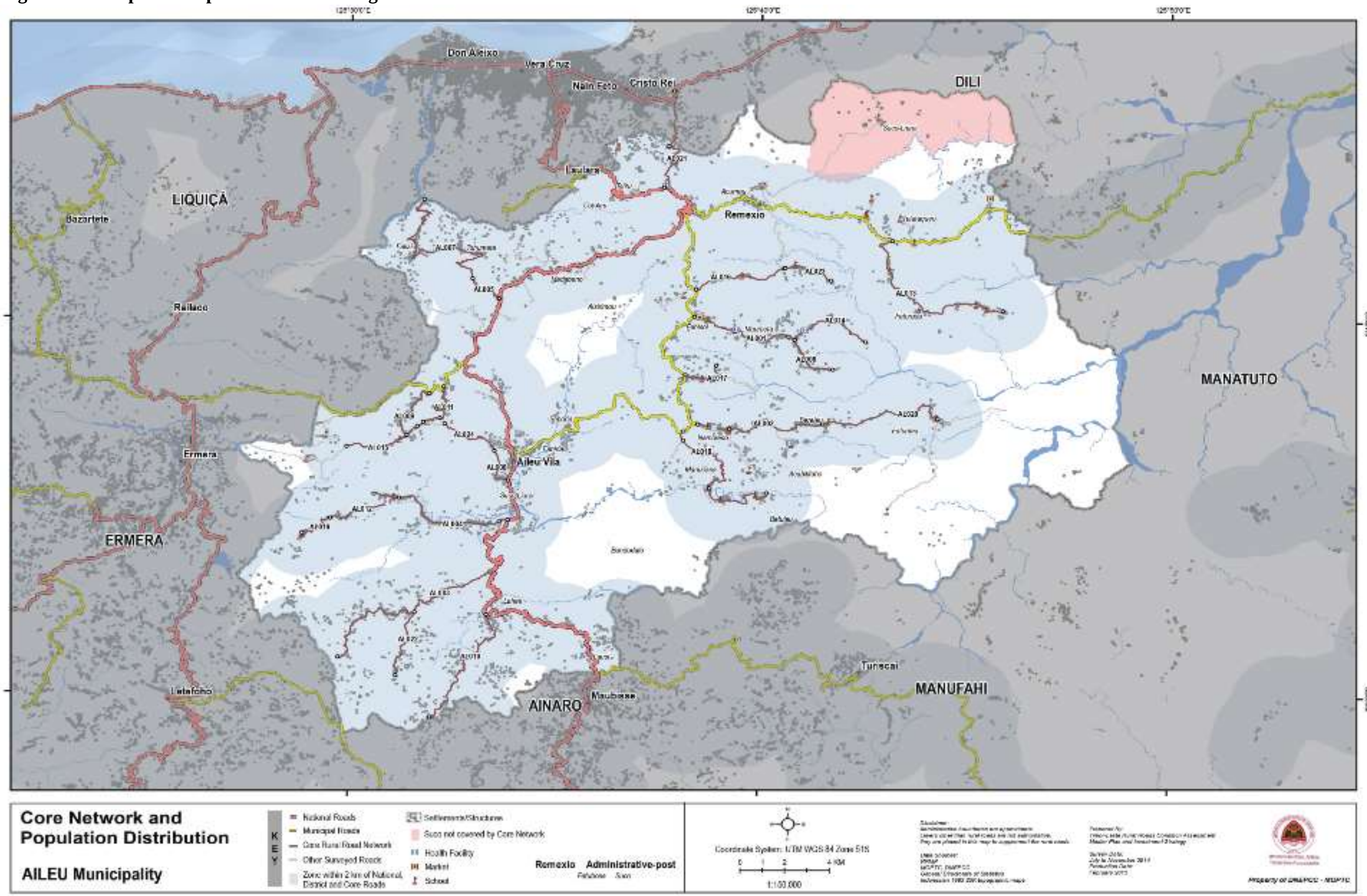


Figure 9: Example of Map used for estimating the RAI



As a target, a RAI of 90% in the year 2030 was set. This target reflects the priorities of the GoTL to develop rural access, as articulated in its Strategic Development Plan 2011-2030.

Based on the outcome of the analysis and with a policy target of a RAI of 90%, a rural roads investment strategy was formulated for Timor-Leste in accordance with the National Development Strategy (2011 – 2030), The strategy mainly focuses on maintaining the still maintainable core rural roads (class D) and rehabilitating/reconstructing all the other existing class D roads that have fallen below the threshold of being maintainable.

The overall plan is to achieve this over a 15-years period (from 2016 to 2030). Assuming that in this 15 years period all the National and Municipal roads will also be brought in a good condition (and be maintained), 89.3% of the rural population will have access to a road in good or fair condition (see figure 6).This translates to a required average annual increase of the RAI of 2.7%.,

As R4D is a rural roads program, its main focus is on developing an investment plan for the rural roads. The majority of the investments in the rural roads sector are proposed towards the core rural roads as maintaining and improving the core rural roads maximizes the return on investments in terms of increasing the RAI. Key principles and criteria in determining the investment strategy for the rural roads – within the context of the expected levels of annual funding for the rural roads sector – were:

- Prioritize the maintenance of maintainable core rural roads, i.e. protect what is still there;
- Allocate minimum funding to ensure continued basic access to the non-core rural roads;
- Gradually improve the condition of the core rural road network through the rehabilitation of roads that are not maintainable anymore;
- Take into account overall road connectivity considerations in directing investments in rural road rehabilitation works;
- In setting annual budget ceilings, take into account (evolving) capacities of local contractors and responsible government agencies for planning and implementing rural road works;
- Distribute the available annual budget between the Municipalities, proportionally to the rural population of the Municipalities;
- In prioritizing investments in rehabilitation works, start with those core rural roads that combine the condition of being in the worst condition and serving the largest numbers of rural people, against the lowest per capita rehabilitation costs per kilometer.

To be able to estimate investments costs, road standards for the different classes of rural roads for different terrain and climatological conditions were established and typical unit costs for routine maintenance, periodic maintenance and rehabilitation of each of the rural road classes were developed for the distinguished terrain and climatologic conditions.

Table 3 provides a summary of the initial 5-years rural roads investment plan that was developed by R4D.

Table 3: Summary of the 5-Years Investment Plan for the Rural Roads Sector in Timor-Leste

Investments, length of roads in good and fair condition and incremental increase in RAI	Year 0 2015	Year 1 2016	Year 2 2017	Year 3 2018	Year 4 2019	Year 5 2020
Class D – required investments in million USD		20	24	24	25	25
Class D – kilometers of roads in good/fair condition	484	555	572	657	741	865
Class E1 – required investments in million USD		5	5	5	5	5
Class E2 – required investments in million USD		1	1	1	1	
Class A and C – kilometers of roads in good/fair condition[20]	957	1,010	1,063	1,116	1,169	1,222
Class A, C and D – kilometers of roads in good/fair condition	1,441	1,565	1,635	1,773	1,910	2,087
Estimated annual development of the RAI[21]	49%	52%	55%	58%	61%	64%

Lessons Learned

The RAI is **potentially a very useful instrument** for setting national or sub-national rural access **policy targets** and for **monitoring** progress in rural access, either in relation to Government targets or towards achieving a number of SDGs.

To be useful as a policy or monitoring tool, sufficiently accurate and representative data are required. The earlier method used by the World Bank relies to a large extent on data from household surveys that are available in countries to estimate the RAI. These data sets differ from country to country and do not provide adequate and equal spatial representativeness – within and between countries.

Furthermore, the method uses available data at country level about the road network and its condition – and these data are very often incomplete. This, in combination with the high costs of conducting household surveys, **significantly reduces the usefulness and sustainable of the RAI, calculated on the basis of household data.**

In 2016 the World Bank introduced a new method of calculating the RAI. The method relies on the use of emerging global spatial data and advanced IT techniques and is said to make the method therefore more consistent across countries, more cost-effective, that it allows for different levels of sub-national disaggregation, and that it makes it possible to overlay different (access) themes – over the core theme of access of rural people to the road network.

The method uses available government data on the road network and on the condition of the roads. Because these government data are often not complete, this can adversely affect the accuracy of the calculated RAI.

Another limitation of this method is that modelling-based population distribution estimates are used – using global country population data from sources such as WorldPop. By nature, such modelling techniques make use of certain assumptions and these may or may not be correct in the specific national or sub-

[20] Based on the assumption of a linear increase of the roads in good/fair condition, with the entire network of class A and class C roads in a good/fair condition in a period of 15 years.
[21] As the improvement of roads that serve the largest numbers of people is prioritized, this will result in a relatively higher annual increase of the RAI during the initial 5 years, compared to the increase in the RAI during the subsequent 10 years.

national contexts to which they are applied. This may lead to significant under- or over-estimation of the RAI.

Without having undertaken national or sub-national validation/calibration of the used model, **the accuracy of the modelling method that relies on emerging global population data and government road inventory data (which are often incomplete) remains unknown.**

- **The accuracy of the current methods that are used in calculating the RAI have not been sufficiently verified/calibrated and could result in significant under- or over-estimation of the RAI, reducing its usefulness as policy instrument or monitoring tool.**

The method of calculating the RAI that uses emerging global spatial data and advance techniques is also said to be useful in formulating operational road asset management strategies and estimating required investments in the roads sector. Considering the above mentioned limitations of the methods used for calculating the RAI, its operational usefulness of providing a sufficiently accurate benchmark for informing operational investment strategies and investment levels is limited.

As shown in the example of R4D, more detailed, accurate and comprehensive information at national and sub-national level is required to enable the formulation of a specific road asset management/development strategy and to provide sufficiently accurate estimates of required investments. This should not only include accurate and specific information about the condition of the road links in the road network and the actual geographic distribution of the rural population, but also:

- Provide realistic unit cost rates;
- Analyze the specific national and sub-national context in terms of road connectivity;
- Take into account specific terrain conditions;
- Consider people's typical origin-destination routes;
- Align with broad government priorities to guide annual programming of investments[22];
- Take into account 'absorption' capacities of the public and private sector to deliver investments in the roads sector.

- **Even when accurate estimates of RAI are available and target RAI figures have been set, this information alone is not sufficient to inform annual national or sub-national road management/development strategies and investment plans.**

A key question is **whether the current definition of the RAI is clearly defined and whether it provides for a realistic target benchmark for rural people's access to roads**. At the moment the RAI uses a benchmark of 2 kilometer, considered the equivalent of 20-30 minutes walking time – to a motorable road that is in good condition, as this benchmark. **There are a number of issues with the currently used definition**:

[22] e.g. starting with those roads in the network that maximize the return in investments in terms of rural people benefiting from these investments

- **Calculation of the distance to the road**: It is not defined whether the distance of 2 kilometers is the horizontal distance "as the crow flies" or whether it is the actual distance along existing path-ways (which normally includes bends and – in mountainous terrain – will require substantial up-hill and down-hill movement. This can make the actual distance significantly longer.
- **The used conversion from distance to walking time**: The definition translates the 2 kilometers distance into a walking time of 20-30 minutes. As explained under the above bullet point, this may not be the case, depending on how the 2 kilometers of walking time is defined. Furthermore it does not specify whether the walking time relates to people's outbound or inbound travel time to the motorable road – this may vary a lot[23].
- **The used means of transport to travel to the nearest motorable road**: The definition assumes that rural people always walk to the nearest road. Whereas this may be the case in many situations, there are also cases where people use other transport means or a mix of transport means. This could e.g. include traveling by horse or donkey, or traveling by canoe/small boat.
- **The access benchmark that relates to the nearest motorable road**: The geographically nearest motorable road may not be the road that rural people need to access, i.e. may not be part of their typical origin-destination route. This could e.g. be the case where more than one road is located within 2 kilometers of a village or when a village is separated from the nearest road by a large river that cannot be crossed.
- **The definition of the condition of the road:** The definition refers to all-weather roads in good condition. It would appear more logical to include roads in a fair condition as well as all-weather roads in a fair condition should – by definition – also be all-year round passable for motorized 4 wheel vehicles. The condition of the road is to be measured in transport engineering terms and instruments proposed to measure the road condition include the International Roughness Index (IRI), the Pavement Condition Index (PCI) or visual assessments through traditional road inventory surveys. The IRI and PCI have been mainly designed for checking the quality of pavement work on major roads. For the purpose of assessing the condition of roads in terms of providing good or fair road access, the method of visual inspections (using simple forms) is more than adequate and also easier and more cost-effective to implement. Using 5 different road conditions to assess the road condition (excellent, good, fair, poor, very poor) seems excessive. A differentiation between good (routine maintenance required), fair (periodic maintenance required) and poor (rehabilitation or reconstruction required) is sufficient.

- ➢ **The current definition of the RAI will require some re-thinking to make the definition more clear, to minimize the risk of different interpretations by different users, and to remove some internal inconsistencies in the definition.**

Whereas the RAI as an indicator of access of rural people to roads is conceptually very useful, the question is whether it is sufficient and/or desirable to have only one global benchmark (i.e.

[23] If e.g. in mountainous terrain a village is situated on the ridge of a mountain and the road is situated down in the valley, it may take the villagers maybe 30 minutes in walking downhill to reach the road. The uphill travel time however, back to the village, could easily take 2 hours.

the 2 kilometers distance to the nearest road in good condition) to set road access policy targets or to monitor progress.

There may be instances whether a country initially wants to achieve other benchmark road access targets. This could e.g. be 90% of the rural people living within 5 kilometers distance of a motorable road in good or fair condition after 10 years. Such interim targets may be more realistic to achieve in certain situations, e.g. in mountainous countries with a very low road density, with very high road construction costs, with limited government budgets, with a very low rural population density, and with very scattered household locations. If a country would set its benchmark at 5 kilometers, as in the above example, this may not (sufficiently) reflect the actual progress that a country achieved in increasing the RAI if only the currently used universal benchmark of 2 kilometers is applied to monitor the progress in improving road access to rural people.

- **It may be worthwhile to consider different (interim) standards for access of rural populations to good/fair roads in different countries, depending on the specific local context in those countries.**

To enable the formulation of a well-informed road asset management/development strategy and investment plan, the example of R4D shows the need for having detailed and complete information on the condition of the entire classified road network, on the distribution of the population, on unit cost rates, on typical original-destination routes, on broad government annual planning and programming priorities, and on capacities of the public and private sector, to deliver investments.

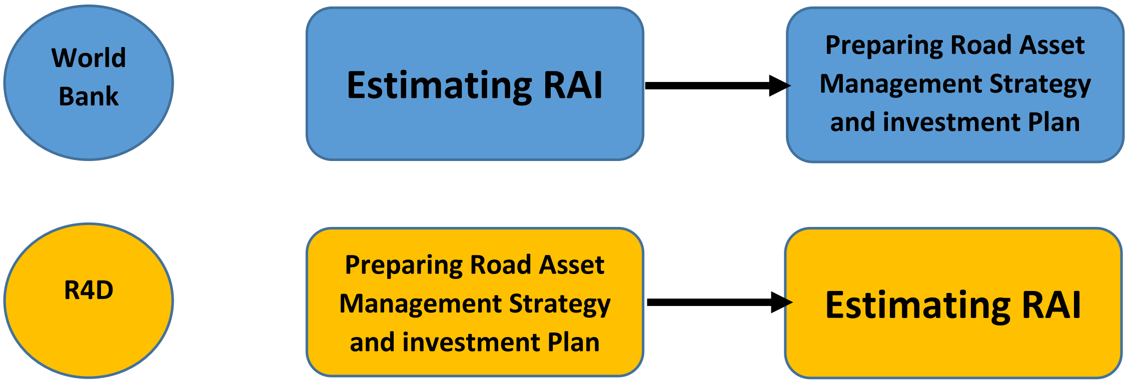
The R4D approach combines the use of primary data (like road condition data, data on typical origin-destination routes, unit cost rates), with the use of existing (secondary) data (like census data with GPS coordinates of each household, other relevant geo-referenced information).

It combines using modern IT technologies and applications, with traditional survey methods (like road condition surveys using simple visual inspection methods to assess the condition of the roads). GIS mapping features were used to present the data and to facilitate the in-depth analysis that was required to allocate rural populations to individual road links, demarcate the 2 kilometers zones around the roads, calculate the RAI, and prepare detailed annual investment plans and budgets.

The R4D approach is a modified one, compared to the World Bank's approach. It provides the level of detail and accuracy that is required to formulate a road asset management/development strategy, and program and budget investments. The information obtained can also be used to make accurate estimates of the RAI.

The difference in approach is visualized in Figure 10. As explained in these conclusions, **the R4D method is considered the preferred one as it provides the data that are required to formulate operational road asset management & investments strategies/plans, thereby also providing the data that enable making realistic estimates of the RAI**.

Figure 10: Different Approaches in Calculating the RAI



Furthermore, the majority of the work of data collection relates to undertaking road condition surveys. This work should anyhow be done regularly by agencies responsible for the road network. Road condition surveys can be done very quickly and in a very cost-effective way, using simple visual inspection methods. Such surveys can be conducted anytime when staff of Road Agencies visit a road.

What is very important – as observed by R4D – is to establish and institutionalize technical and managerial capacities within the Road Agency for collecting, storing, processing, analyzing and presenting data (including the presentation of data on maps).

Another lesson learned from the R4D experience is that it would have been more effective if the Rural Roads Master Plan and Investment Strategy (RRMPIS) was developed as part of an overall Roads Master Plan for all classes of roads. This would have further increased its quality as it would have looked at the overall road network in the country – including road connectivity considerations.

In terms of the prioritization of investments in rehabilitation/reconstruction works for the different road links, the RRMPIS could have omitted the use of complicated prioritization criteria like rankings based on formulas that included information on population, road roughness and costs/kilometer. A simple ranking system based on the number of people served by a road link – supplemented with information on road connectivity and other broad government priorities – would in principle have been sufficient.

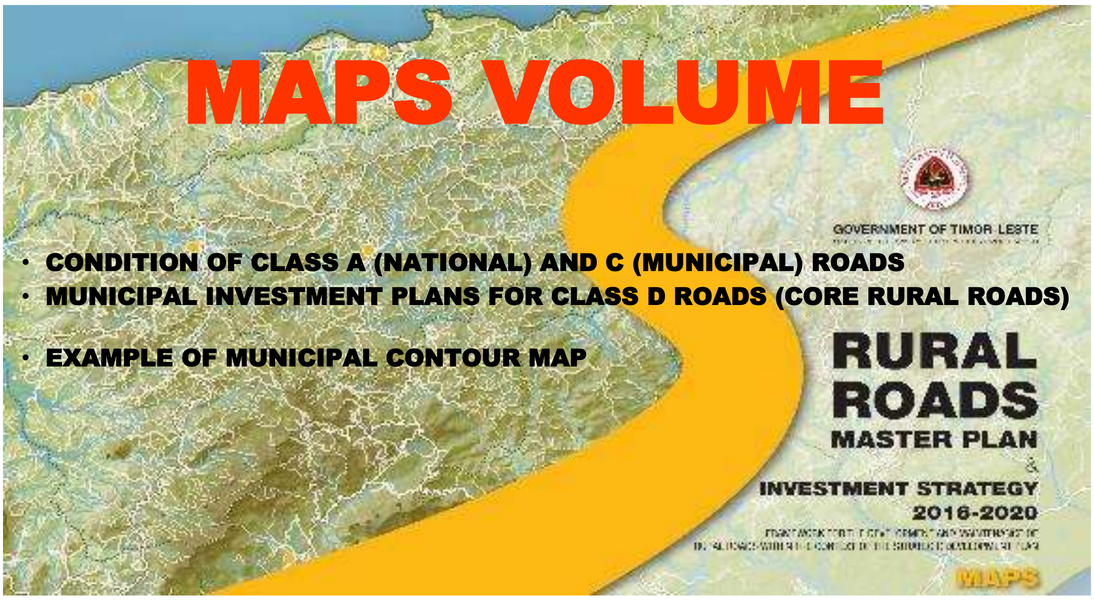
Conclusions and Recommendations

From this technical paper, the following key conclusions and recommendations are made:

1. As the RAI is a potentially very useful instrument to set policy targets and monitor the progress in improving access of rural people to roads in a good condition, it is worthwhile to promote its use to national Governments and Development Partners (including UN agencies).
2. To improve its usefulness, it is proposed to re-think the formulation of the RAI and also to consider different (interim) access benchmarks to better reflect differences in local contexts. A proposed working definition could be:

The share of the rural people for whom the travel time between their place of residence and the nearest road in good or fair condition that provides 4-wheel motorable access to their most required social-economic services/facilities, is less than xxx minutes (in either direction), using the locally most common means of transport.

3. Using a combination of primary data (like road condition inventories) and secondary data (like census data), supplemented with a well-informed analysis of the specific conditions on the ground (like road connectivity, terrain-related access conditions, typical origin-destination routes) will greatly improve the accuracy of the RAI and it is recommended that this approach is promoted.
4. As road agencies are already responsible for keeping complete and regularly updated information about the road network and the condition of the individual road links, it is proposed to give more attention to this aspect in rural road projects. This information can be generated relatively simply using visual inspections and is not very expensive.
5. Having geo-referenced coordinates of individual households, together with information of about typical origin-destination routes and actual travel times to the nearest motorable roads, can greatly improves the accuracy of the RAI. Such information can be collected in a relatively easy and cost-effective way through census surveys and it is recommended to promote the inclusion of such data in census surveys.
6. With the opportunities provided by IT technologies, it is very important to establish adequate capacities at national and sub-national level for storing, processing, analyzing and presenting data through computerized information systems and GIS mapping tools. Sufficient attention needs to be given in roads projects to these aspects.
7. The information that is required for developing an operational national or sub-national roads management strategy and budget will also allow for the estimation of realistic RAI figures. This approach is believed to provide much more accurate RAI figures compared to an approach where the RAI is estimated on the basis of spatial modelling techniques and more general information about the rural population and the condition of the road network.
8. To check the validity of the modelling techniques and approaches used by the World Bank, it may be useful to take the case of Timor-Leste to compare the RAI figures derived from R4D's work and the outcome of the modelling method applied by the World Bank.
9. When developing a Rural Road Strategy and Investment Plan, it is preferred to do so in the context of an overall road strategy and investment plan as it will enable a better informed and more cost-effective decision making about specific annual investments (in particular in relation to road connectivity issues).



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