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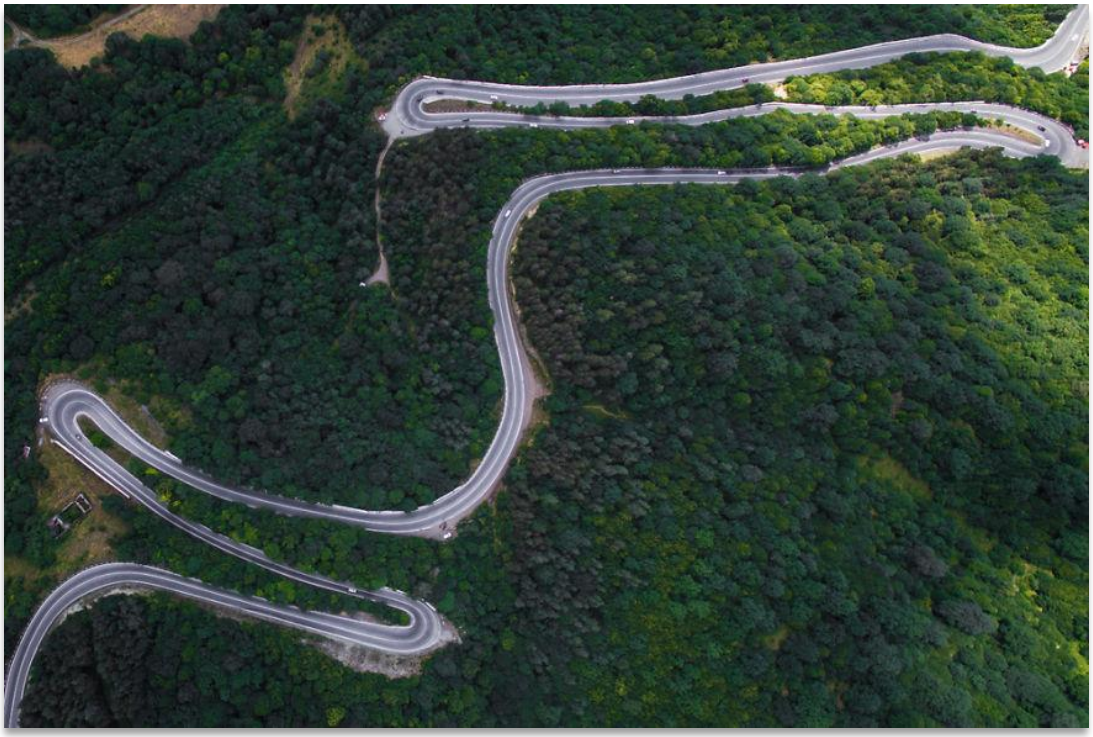

# Measuring Rural Accessibility in the GIS environment: Case Study of Armenia

Artak Piloyan, Ph.D.
Aram Gevorgyan, Ph.D.

30 November, 2018
Yerevan, Armenia

# Motivation behind the Study

The studies were conducted in the framework of the project

**“Impacts of Roads on Poverty and Access”**

carried out in cooperation with the **World Bank**

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# Motivation behind the Study

Study seeks to answer two questions:

- **how do we characterize physical accessibility in Armenia**

- **what are the main constraints for accessing markets and services?**

# Motivation behind the Study

## Armenia - Context

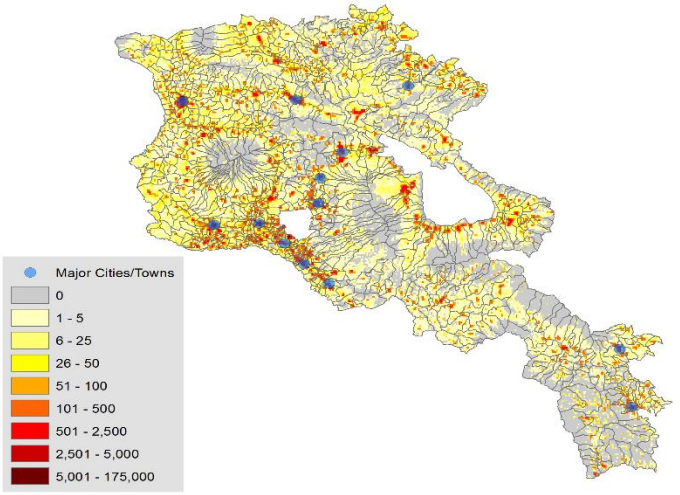
Compact size – Urban primacy but high share of rural population

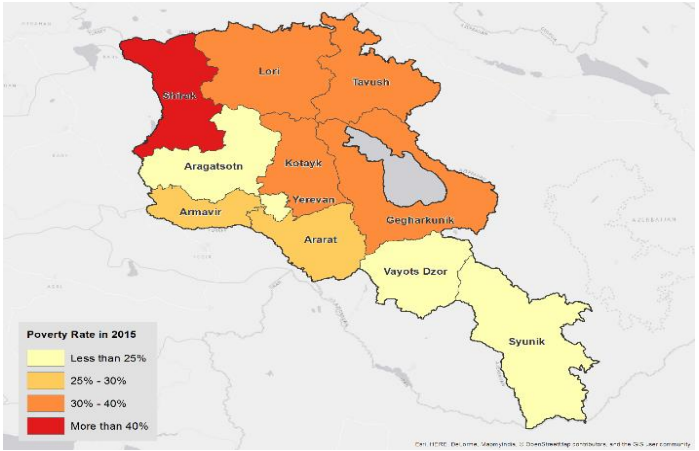
Significant cross-regional disparities – lagging areas

Large migration flows and seasonal employment

Dependence on remittances

Process of community consolidation

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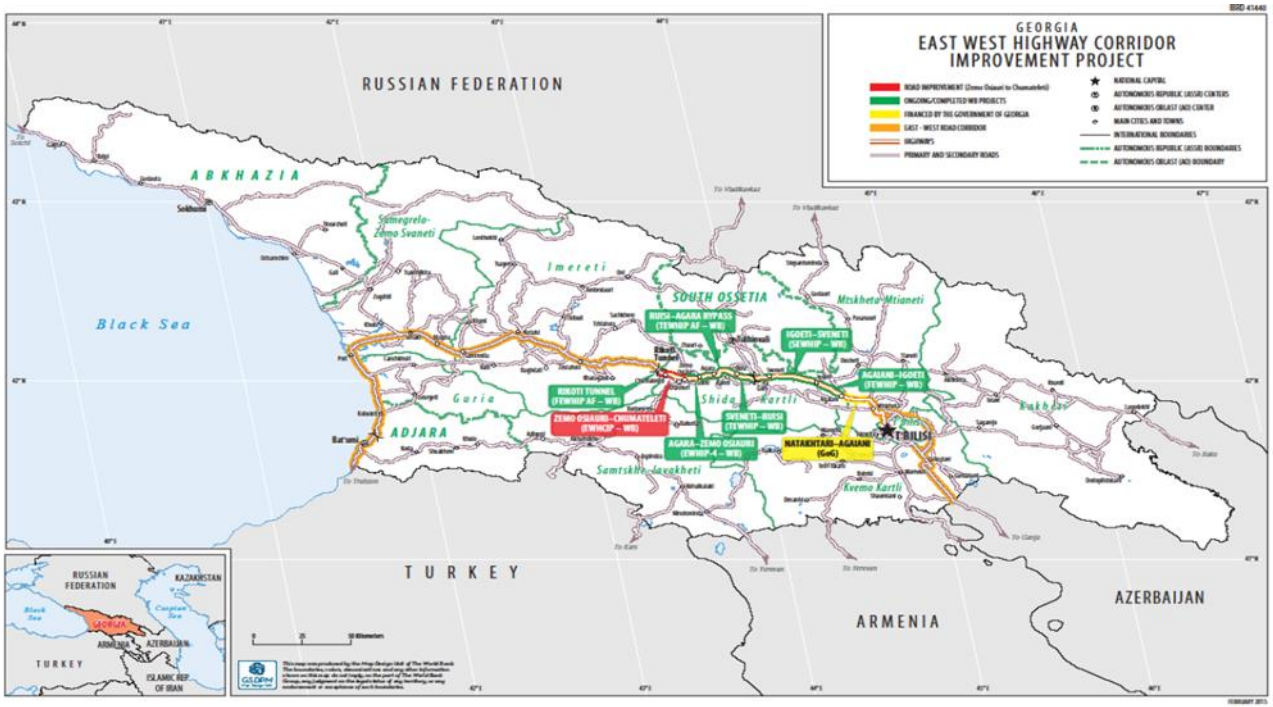
# Evidence from the Literature – Georgia

- Georgia is upgrading 350 kilometers of principal highway between the Black Sea and Azerbaijan
- World Bank financed $500 million of the total amount $2.3 billion (14% of Georgia' s 2014 GDP)
- Economy simulation - wide effects




## Estimated Long-term Impact

- Georgia's real GDP would be 4.2 percent higher
- household income gains ranging from 2.6 percent to 4.4 percent

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# Tools and Methodologies

Three indices are proposed:

(a) Rural Accessibility Index (RAI),

(b) Market Accessibility Index (MAI),

(c) Service Accessibility Index (SAI)

# Tools and Methodologies

## Accessibility Indicators – Rural Access Index

**Where do people live?**

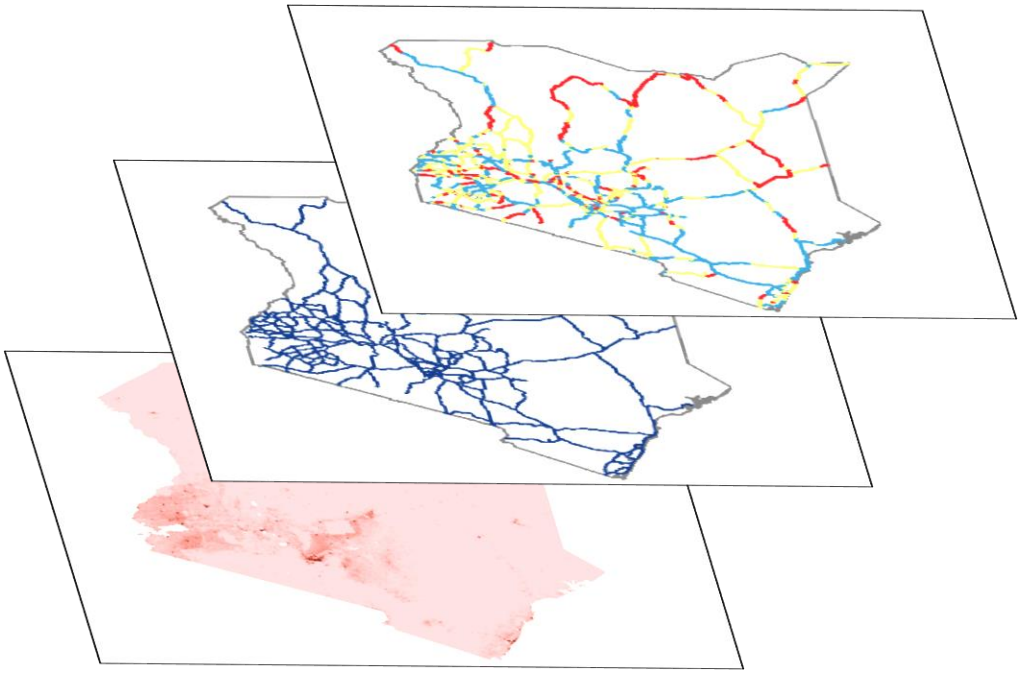
- Global Datasets of population are publicly available (ie. WorldPop)

**Where does the road network exist?**

- Georeferenced road network (government-owned, open source data)

**In what condition?**

- Data exist, though often fragmented



***Share of rural population living within 2 km of an all season road***

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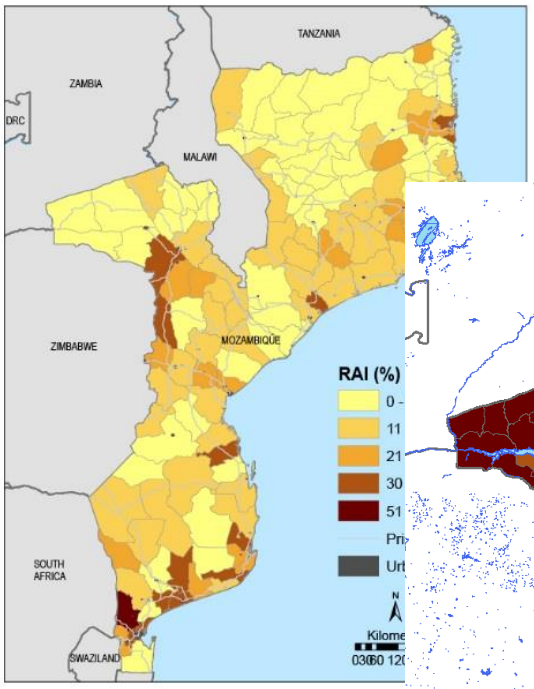
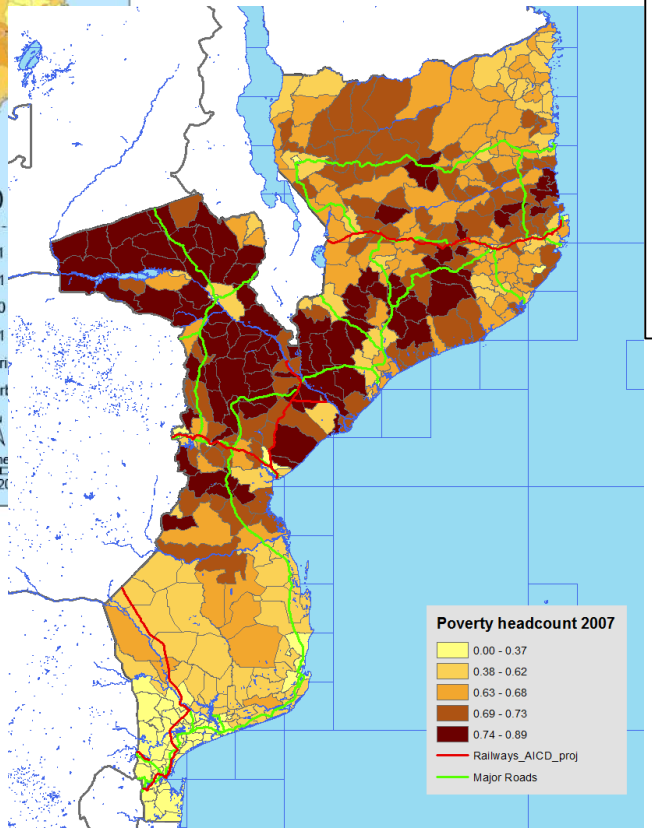
# Tools and Methodologies

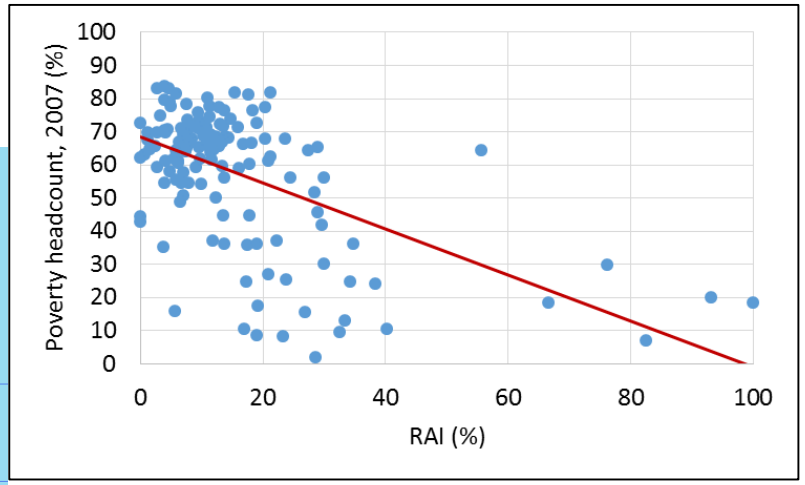
## RAI




## Poverty




## Poverty is high where RAI is low

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# Tools and Methodologies

## Accessibility Indicators – MAI and SAI

**MAI** is defined as the travel time required for the population in a given area to reach a town, city, or any other high-density population center

**SAI** is shows the average time it takes for the population to reach social services, e.g health facilities, schools, universities.

**(Yoshida and Deichmann 2009)**

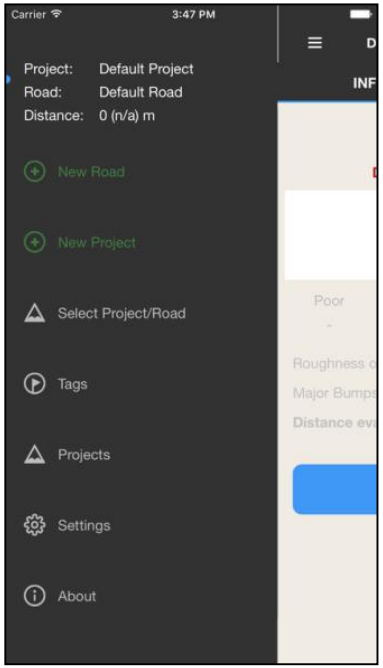
**The simplest formula for an accessibility index**

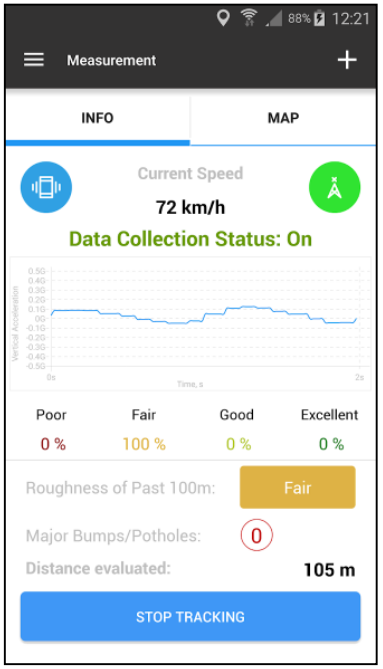
$$I_i = \sum_j \frac{S_j}{T_{ij}^{\alpha}}$$

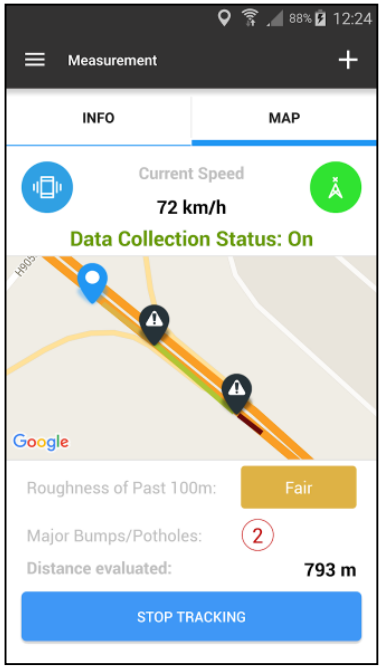
where, $S_j$ is a size indicator at target j (for example, population of large cities/towns), and $T_{ij}$ is the distance (or travel time) between origin i and target j.

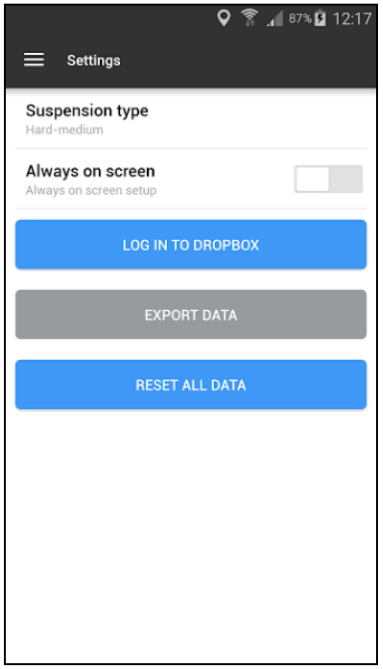
# Data Collection

**RoadLabPro -** An Android app for evaluating road pavement quality




RoadLabPro uses **accelerometers, gyroscopes and GPS** to autonomously measure and evaluate **road roughness on IRI scale (International Roughness Index)**

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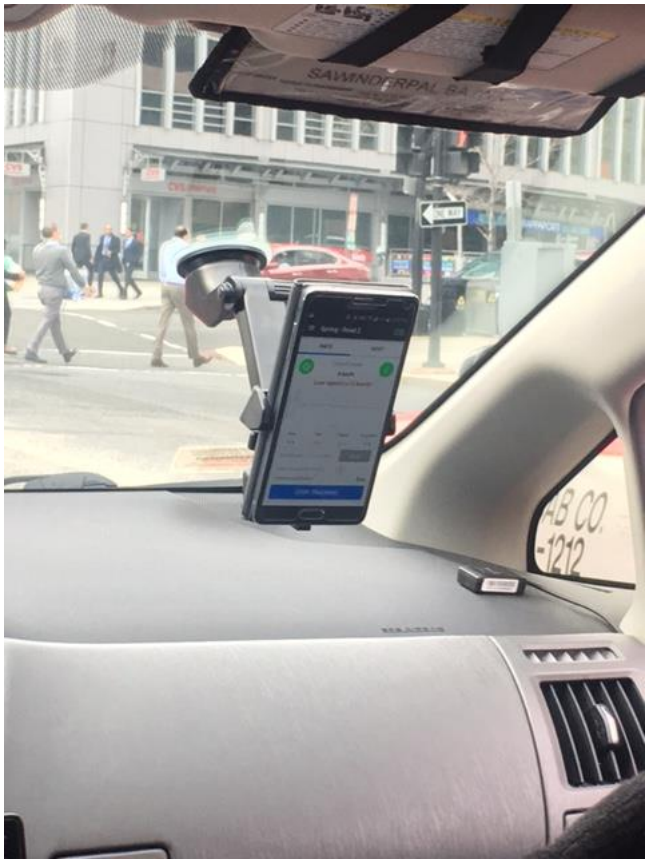
# RoadLabPro

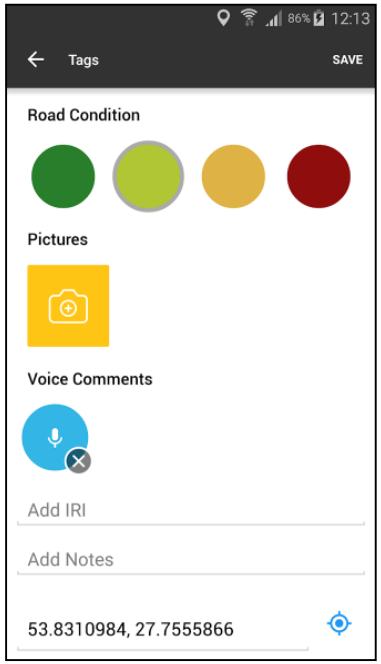
## Required conditions

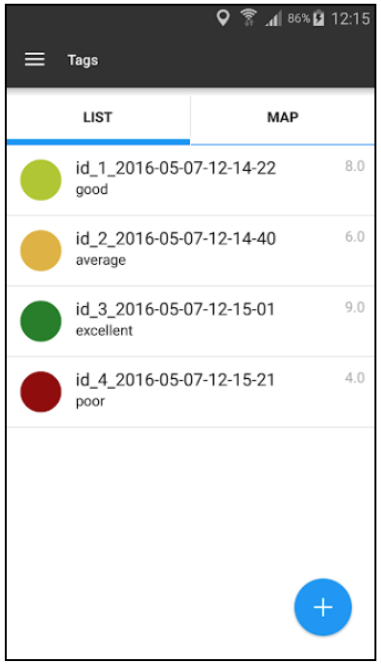
- Minimal speed of vehicle – 15 km/h
- Suspension type – Soft, medium, hard
- Phone position – Vertical, well fixed

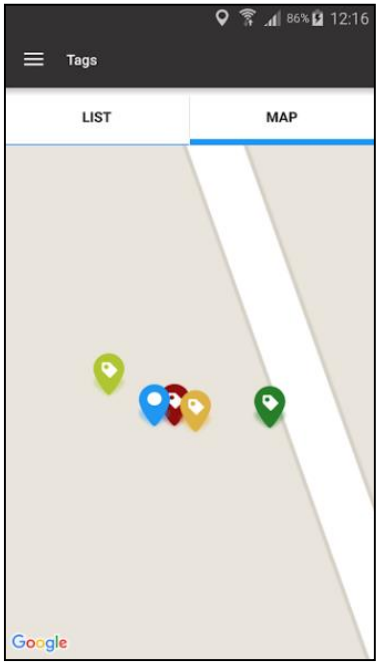


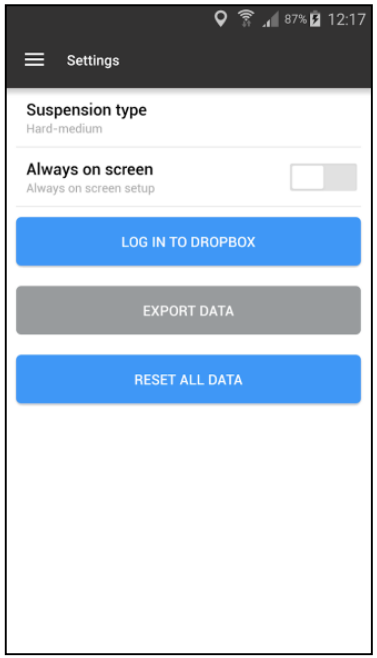
# RoadLabPro

## Other settings




- Possibility to upload a picture of potholes, black spots, or road accidents, etc with a simple tag.
- All data collected can be emailed to yourself or uploaded to your own Dropbox account when wifi is available.

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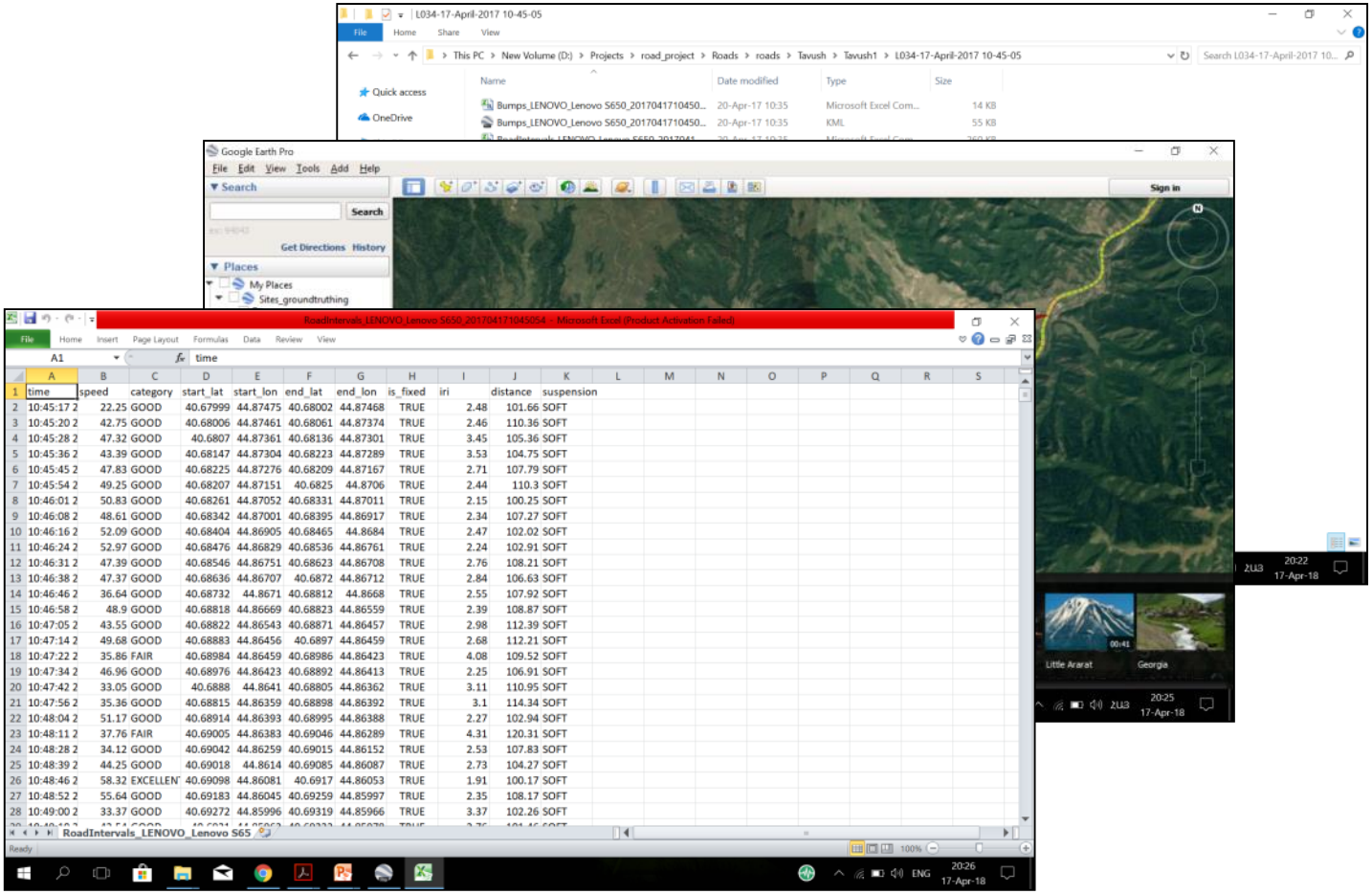
# RoadLabPro

## Results




| time | speed | category | start_lat | start_lon | end_lat | end_lon | is_fixed | iri | distance | suspension |
|---|---|---|---|---|---|---|---|---|---|---|
| 10:45:17 2 | 22.25 | GOOD | 40.67999 | 44.87475 | 40.68002 | 44.87468 | TRUE | 2.48 | 101.66 | SOFT |
| 10:45:20 2 | 42.75 | GOOD | 40.68006 | 44.87461 | 40.68061 | 44.87374 | TRUE | 2.46 | 110.36 | SOFT |
| 10:45:28 2 | 47.32 | GOOD | 40.6807 | 44.87361 | 40.68136 | 44.87301 | TRUE | 3.45 | 105.36 | SOFT |
| 10:45:36 2 | 43.39 | GOOD | 40.68147 | 44.87304 | 40.68223 | 44.87289 | TRUE | 3.53 | 104.75 | SOFT |
| 10:45:45 2 | 47.83 | GOOD | 40.68225 | 44.87276 | 40.68209 | 44.87167 | TRUE | 2.71 | 107.79 | SOFT |
| 10:45:54 2 | 49.25 | GOOD | 40.68207 | 44.87151 | 40.6825 | 44.8706 | TRUE | 2.44 | 110.3 | SOFT |
| 10:46:01 2 | 50.83 | GOOD | 40.68261 | 44.87052 | 40.68331 | 44.87011 | TRUE | 2.15 | 100.25 | SOFT |
| 10:46:08 2 | 48.61 | GOOD | 40.68342 | 44.87001 | 40.68395 | 44.86917 | TRUE | 2.34 | 107.27 | SOFT |
| 10:46:16 2 | 52.09 | GOOD | 40.68404 | 44.86905 | 40.68465 | 44.8684 | TRUE | 2.47 | 102.02 | SOFT |
| 10:46:24 2 | 52.97 | GOOD | 40.68476 | 44.86829 | 40.68536 | 44.86761 | TRUE | 2.24 | 102.91 | SOFT |
| 10:46:31 2 | 47.39 | GOOD | 40.68546 | 44.86751 | 40.68623 | 44.86708 | TRUE | 2.76 | 108.21 | SOFT |
| 10:46:38 2 | 47.37 | GOOD | 40.68636 | 44.86707 | 40.6872 | 44.86712 | TRUE | 2.84 | 106.63 | SOFT |
| 10:46:46 2 | 36.64 | GOOD | 40.68732 | 44.8671 | 40.68812 | 44.8668 | TRUE | 2.55 | 107.92 | SOFT |
| 10:46:58 2 | 48.9 | GOOD | 40.68818 | 44.86669 | 40.68823 | 44.86559 | TRUE | 2.39 | 108.87 | SOFT |
| 10:47:05 2 | 43.55 | GOOD | 40.68822 | 44.86543 | 40.68871 | 44.86457 | TRUE | 2.98 | 112.39 | SOFT |
| 10:47:14 2 | 49.68 | GOOD | 40.68883 | 44.86456 | 40.6897 | 44.86459 | TRUE | 2.68 | 112.21 | SOFT |
| 10:47:22 2 | 35.86 | FAIR | 40.68984 | 44.86459 | 40.68986 | 44.86423 | TRUE | 4.08 | 109.52 | SOFT |
| 10:47:34 2 | 46.96 | GOOD | 40.68976 | 44.86423 | 40.68892 | 44.86413 | TRUE | 2.25 | 106.91 | SOFT |
| 10:47:42 2 | 33.05 | GOOD | 40.6888 | 44.8641 | 40.68805 | 44.86362 | TRUE | 3.11 | 110.95 | SOFT |
| 10:47:56 2 | 35.36 | GOOD | 40.68815 | 44.86359 | 40.68898 | 44.86392 | TRUE | 3.1 | 114.34 | SOFT |
| 10:48:04 2 | 51.17 | GOOD | 40.68914 | 44.86393 | 40.68995 | 44.86388 | TRUE | 2.27 | 102.94 | SOFT |
| 10:48:11 2 | 37.76 | FAIR | 40.69005 | 44.86383 | 40.69046 | 44.86289 | TRUE | 4.31 | 120.31 | SOFT |
| 10:48:28 2 | 34.12 | GOOD | 40.69042 | 44.86259 | 40.69015 | 44.86152 | TRUE | 2.53 | 107.83 | SOFT |
| 10:48:39 2 | 44.25 | GOOD | 40.69018 | 44.8614 | 40.69085 | 44.86087 | TRUE | 2.73 | 104.27 | SOFT |
| 10:48:46 2 | 58.32 | EXCELLENT | 40.69098 | 44.86081 | 40.6917 | 44.86053 | TRUE | 1.91 | 100.17 | SOFT |
| 10:48:52 2 | 55.64 | GOOD | 40.69183 | 44.86045 | 40.69259 | 44.85997 | TRUE | 2.35 | 108.17 | SOFT |
| 10:49:00 2 | 33.37 | GOOD | 40.69272 | 44.85996 | 40.69319 | 44.85966 | TRUE | 3.37 | 102.26 | SOFT |

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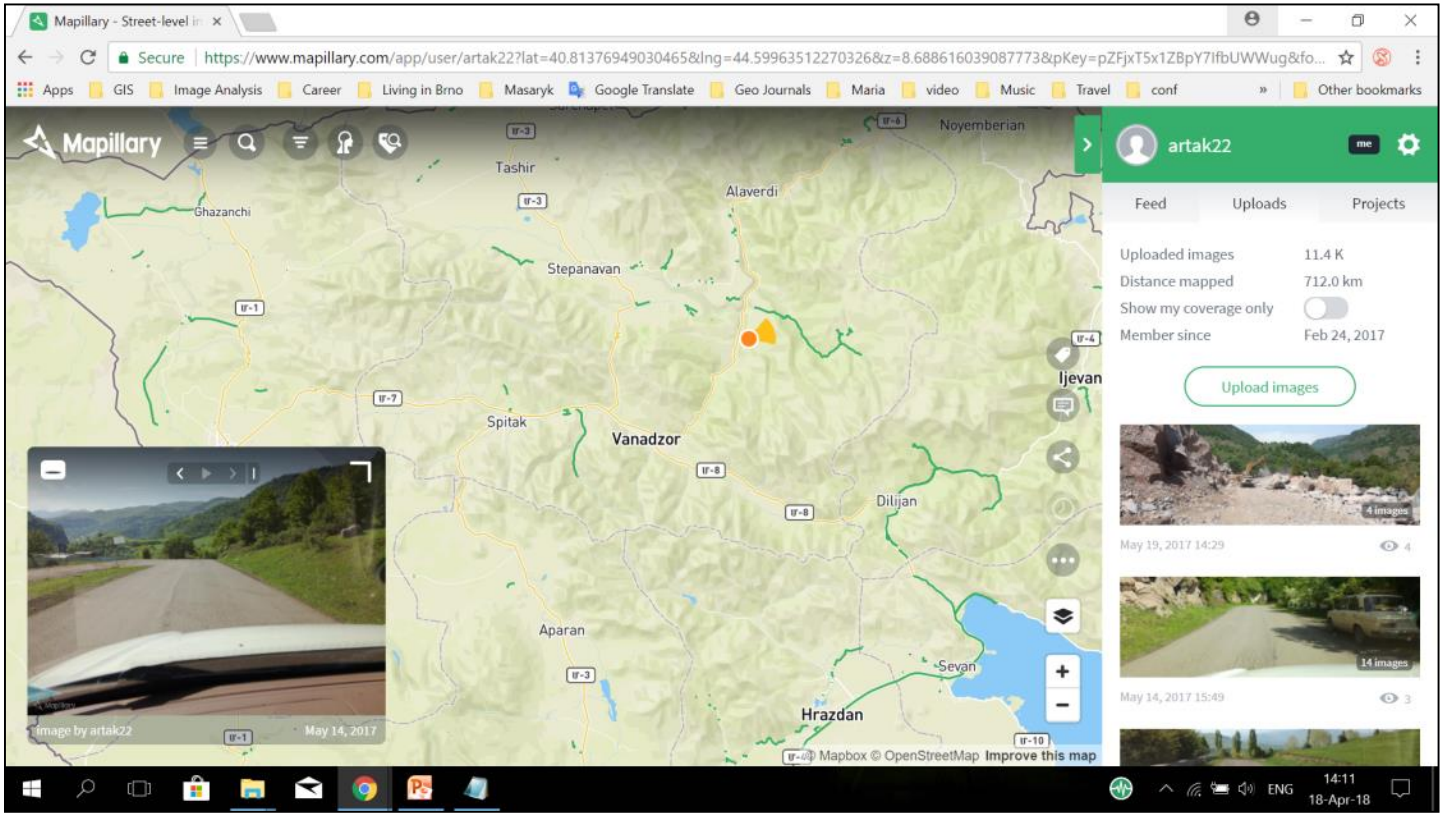
# Mapillary

**Online is a service for sharing geotagged photos**




https://www.mapillary.com/app/user/artak22

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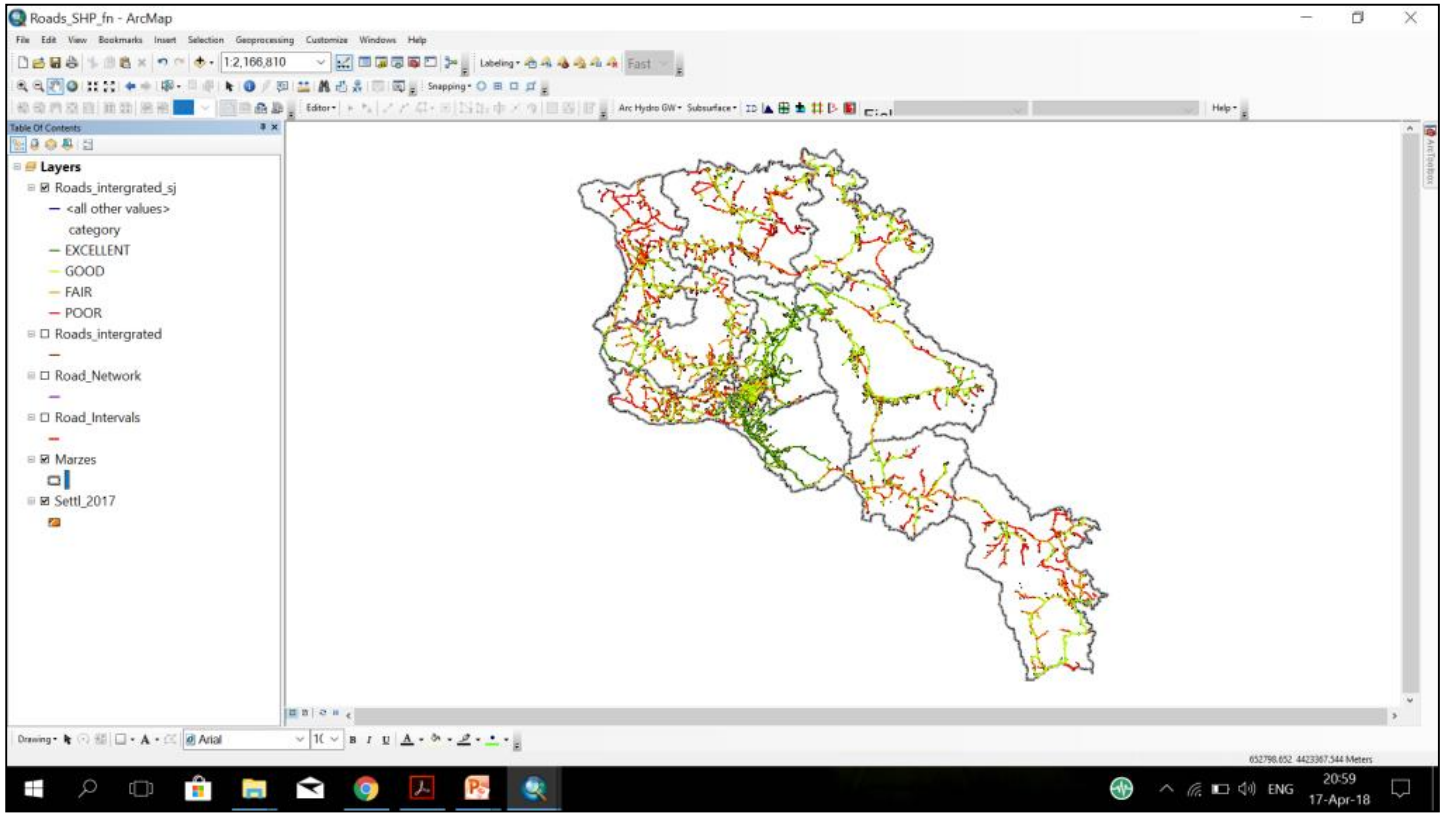
# Field work - Ground truthing

**Period : March-June, 2017**

**About 9200 km of roads passed**

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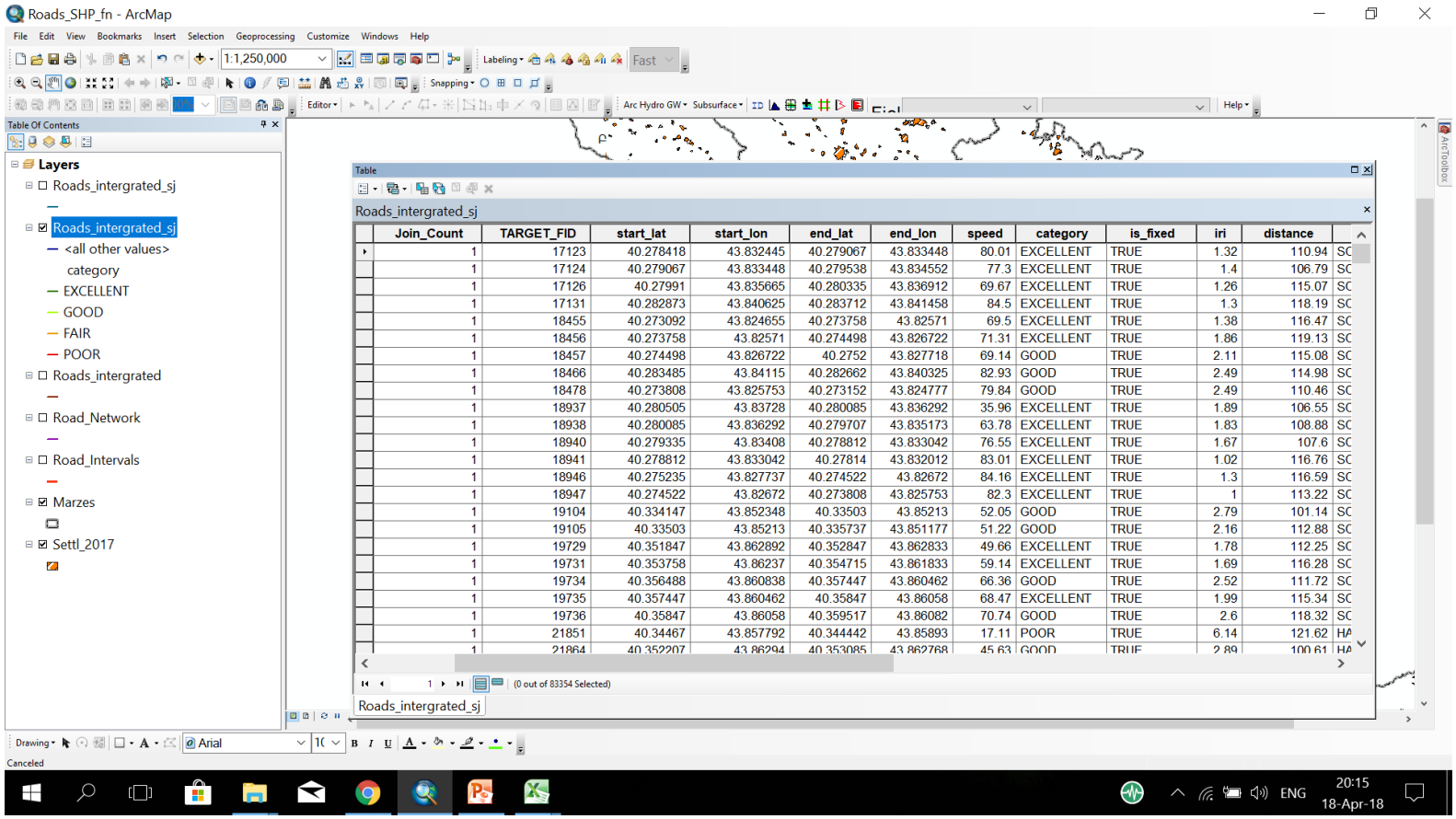
# Databases

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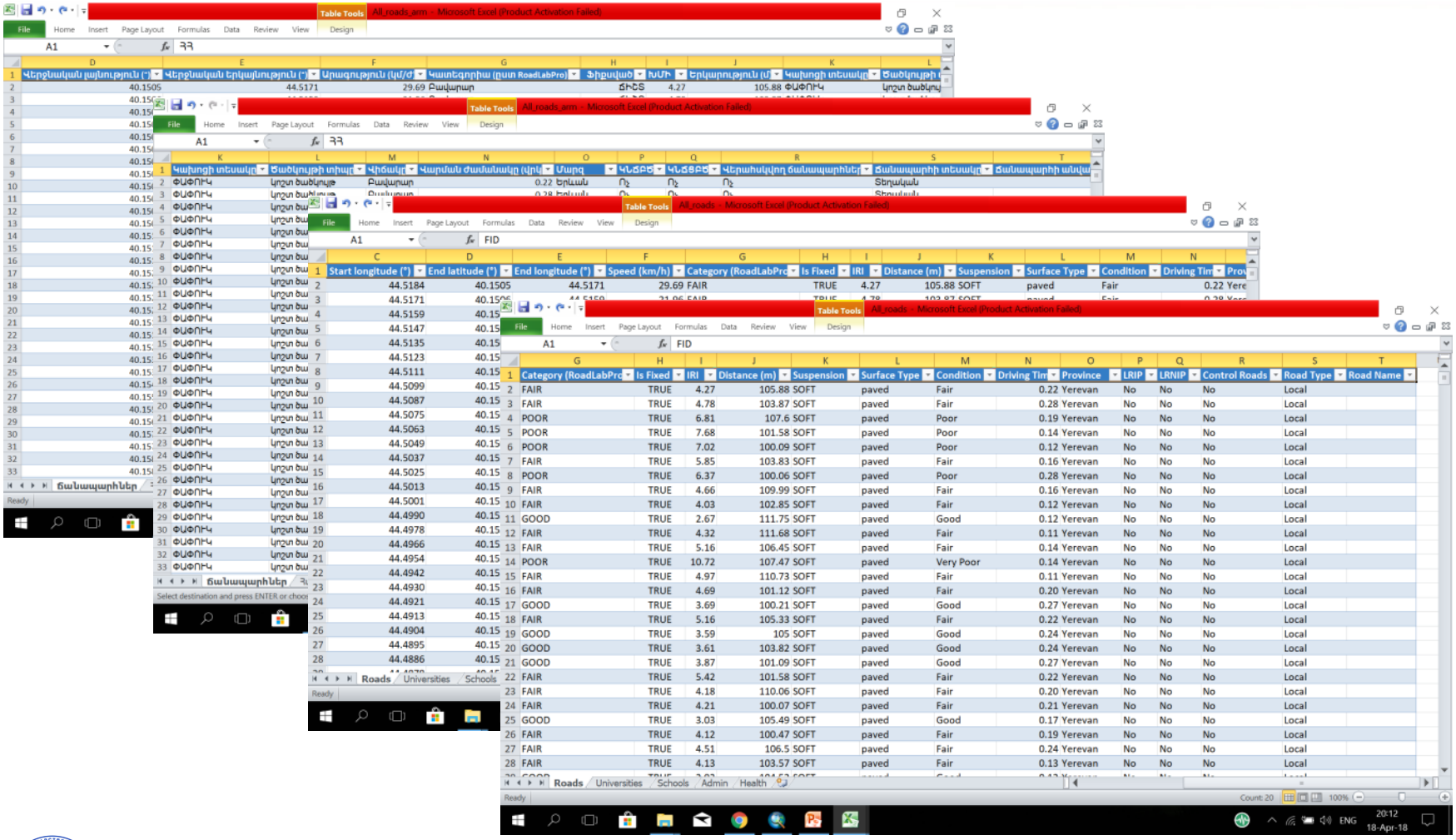
# Databases

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# Databases - Attributes

| | |
|---|---|
| ՀՀ | FID |
| Սկզբնական լայնություն (°) | Start latitude (°) |
| Սկզբնական երկայնություն (°) | Start longitude (°) |
| Վերջնական լայնություն (°) | End latitude (°) |
| Վերջնական երկայնություն (°) | End longitude (°) |
| Արագություն (կմ/ժ) | Speed (km/h) |
| Կատեգորիա (ըստ RoadLabPro) | Category (RoadLabPro) |
| Ֆիքսված է | Is Fixed |
| ԽՄԻ | IRI |
| Երկարություն (մ) | Distance (m) |
| Կախոցի տեսակը | Suspension |
| Ծածկույթի տիպը | Surface Type |
| Վիճակը | Condition |
| Վարման ժամանակը (վրկ.) | Driving Time (sec.) |
| Մարզ | Province |
| ԿՆՃԲԾ | LRIP |
| ԿՆՃՑԲԾ | LRNIP |
| Վերահսկվող ճանապարհներ | Control Roads |
| Ճանապարհի տեսակը | Road Type |
| Ճանապարհի անվանումը | Road Name |

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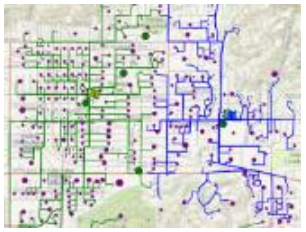
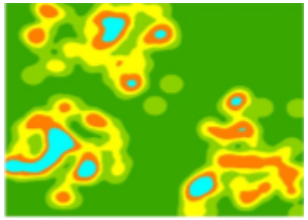
# Accessibility Analysis

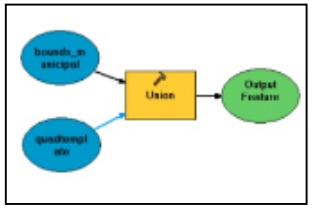
**The Geographic Information Systems playing a key role in performing Accessibility Analysis**



Network analysis



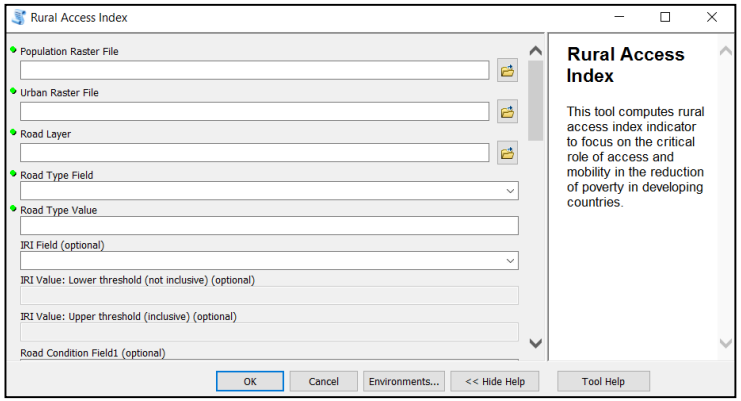
Spatial analysis

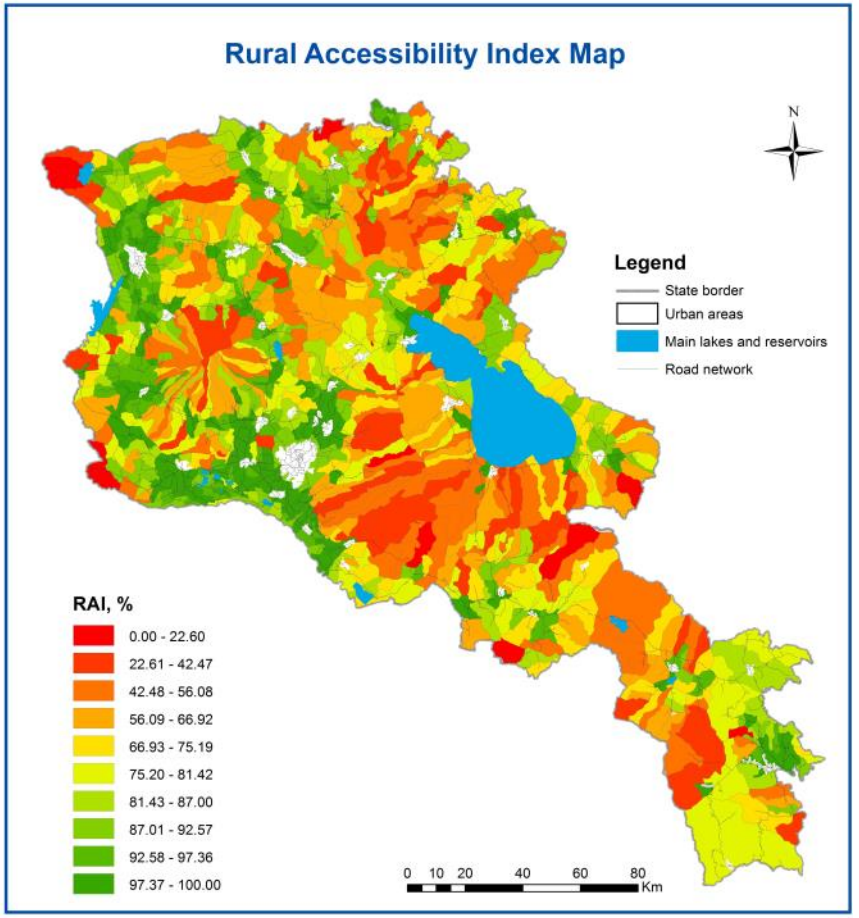



ModelBuilder

# Accessibility Analysis

## Rural access index tool




| Condition | Minimum Roughness | Maximum Roughness |
|---|---|---|
| Category | (IRI) | (IRI) |
| Very good | 1.0 | 2.0 |
| Good | 2.0 | 4.0 |
| Fair | 4.0 | 6.0 |
| Poor | 6.0 | 10.0 |
| Very poor | 10.0 | 16.0 |

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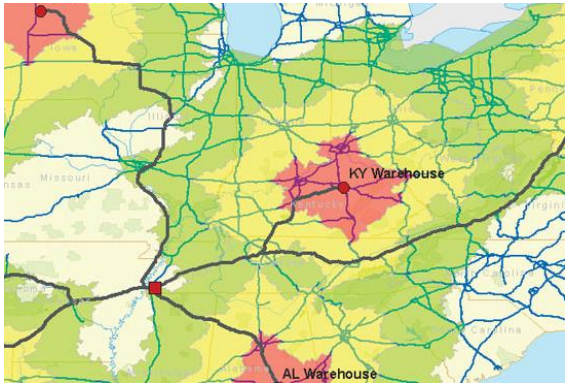
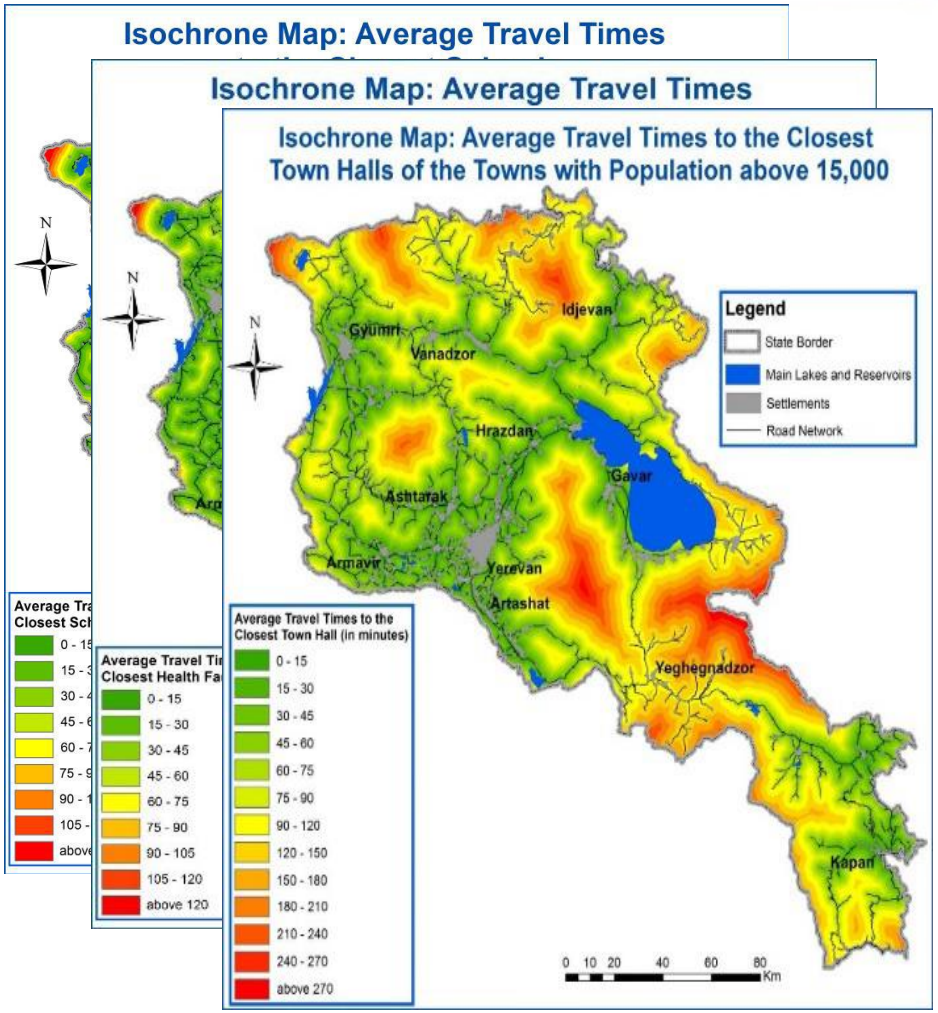
# Accessibility Analysis

**Network Analysis was used to create MAI and SAI maps**

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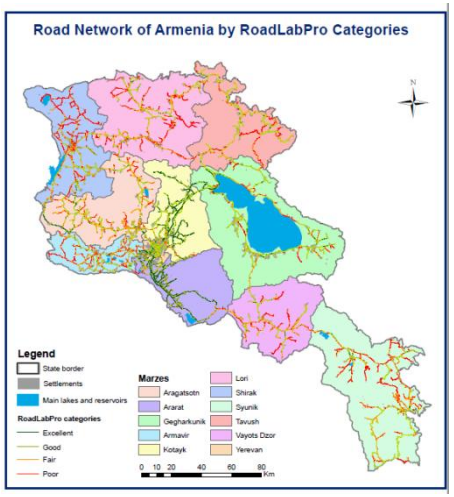
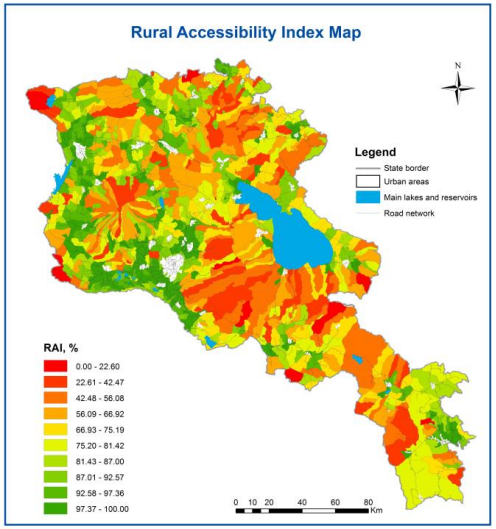
# Accessibility Analysis – Conclusions

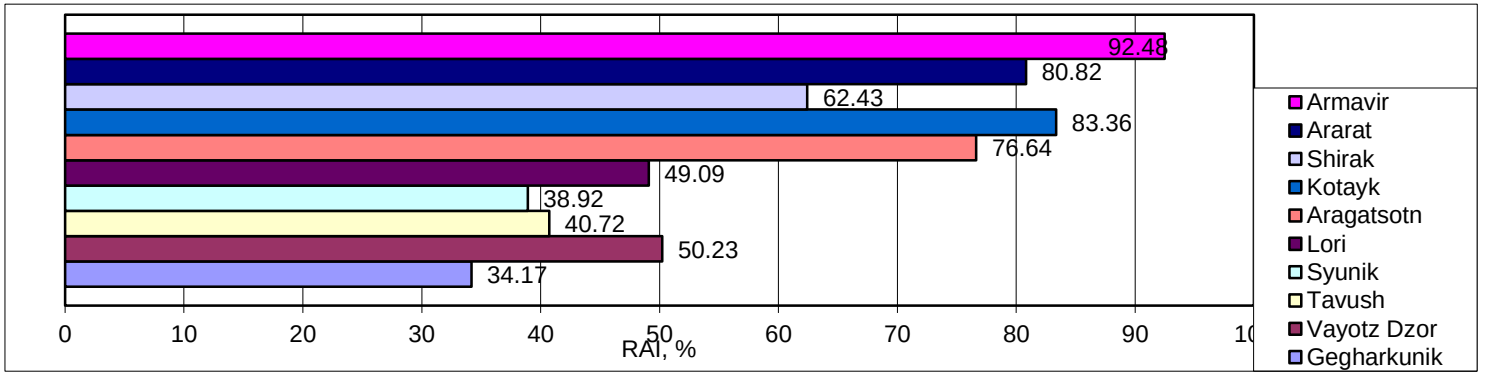
## Road quality is a matter of concern…




## At 66 percent, RAI is low compared to EU




## Low rural access in least populated regions

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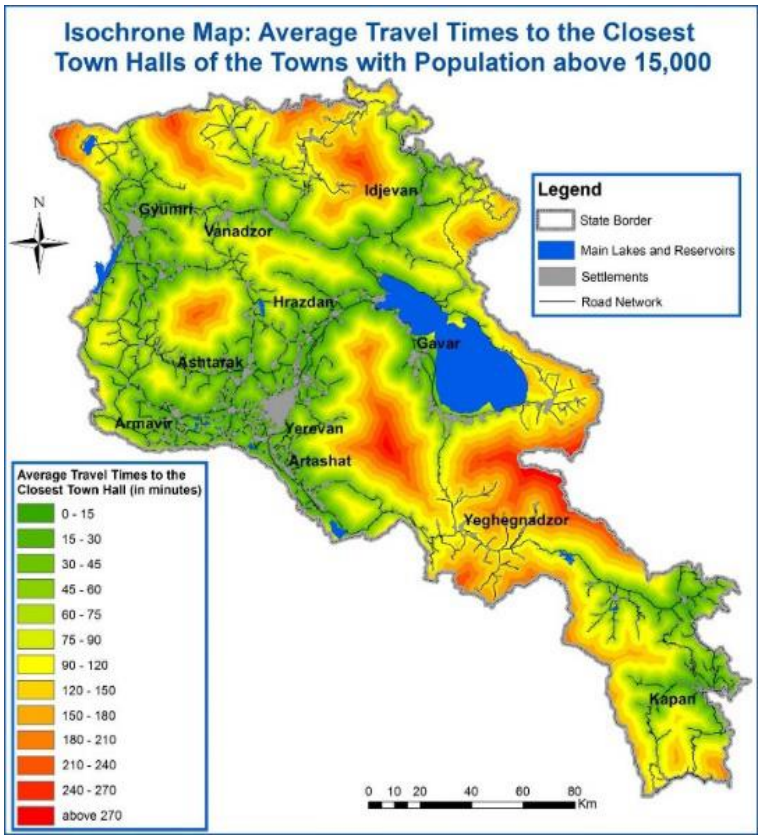
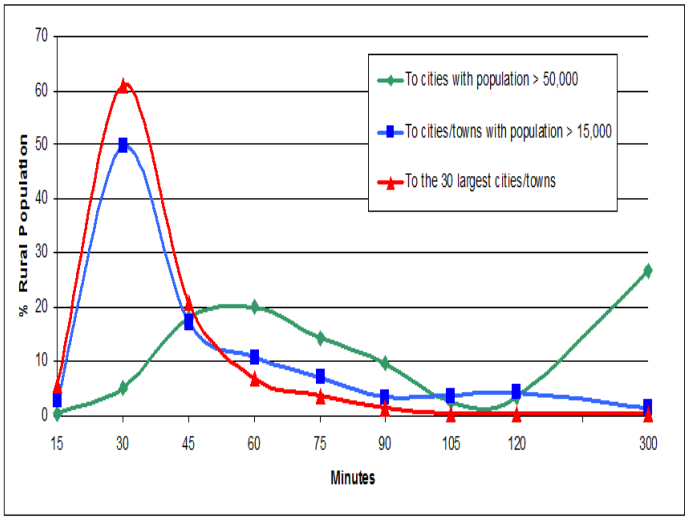
# Accessibility Analysis – Conclusions

## Overall, high market and service accessibility

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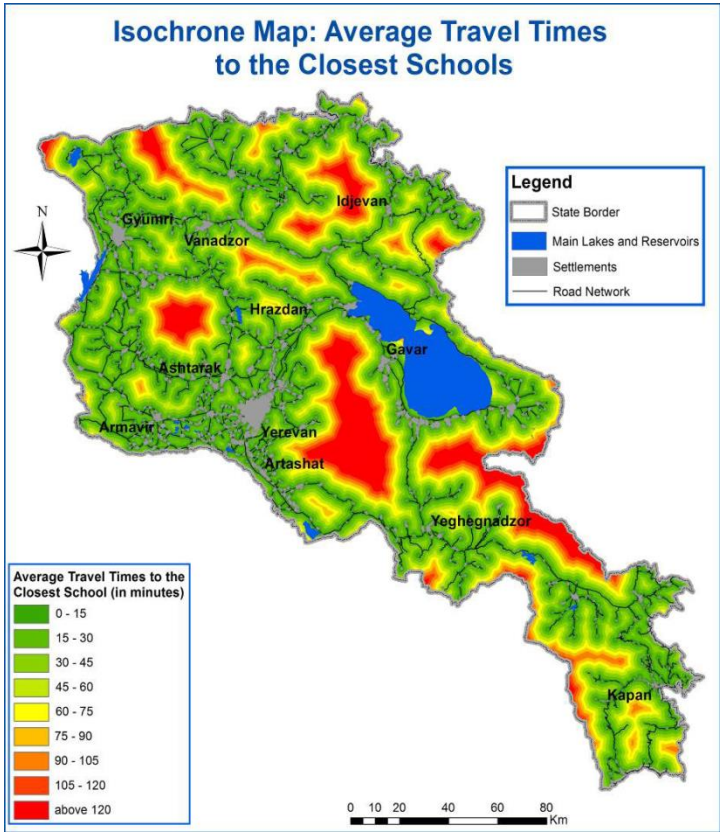
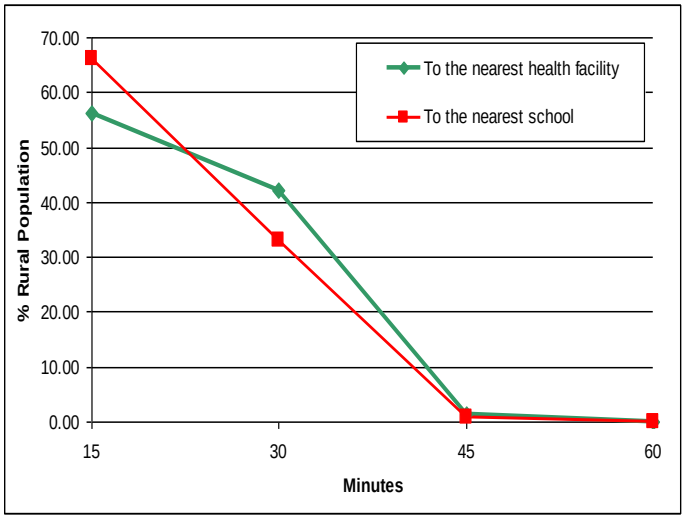
# Accessibility Analysis – Conclusions

## Overall, high market and service accessibility

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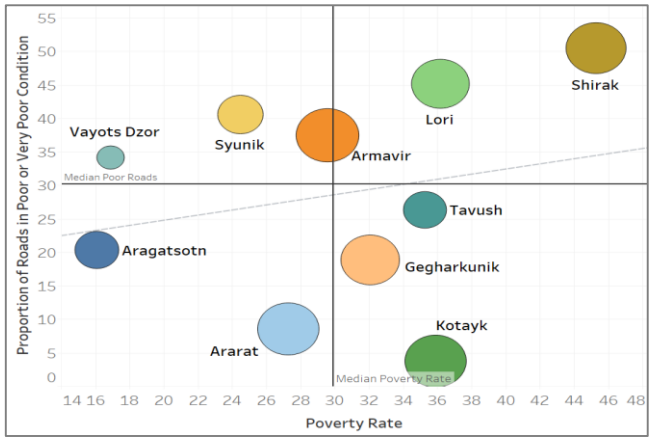
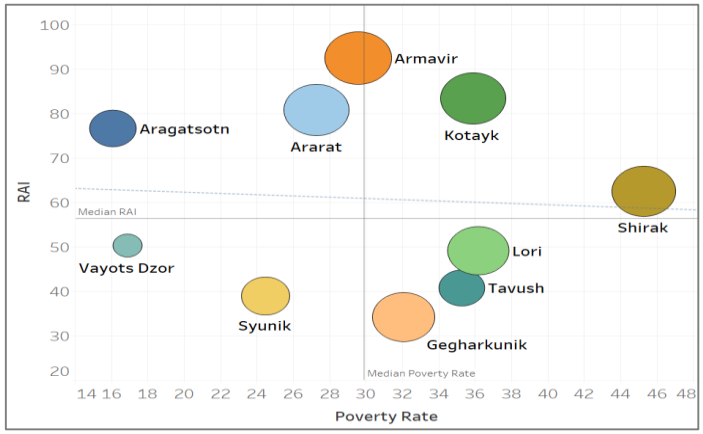
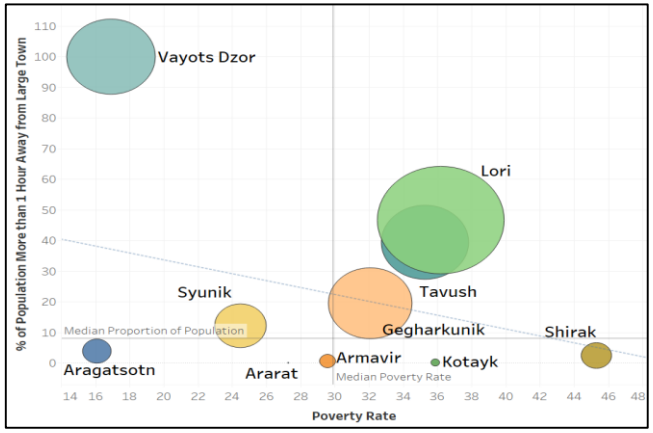
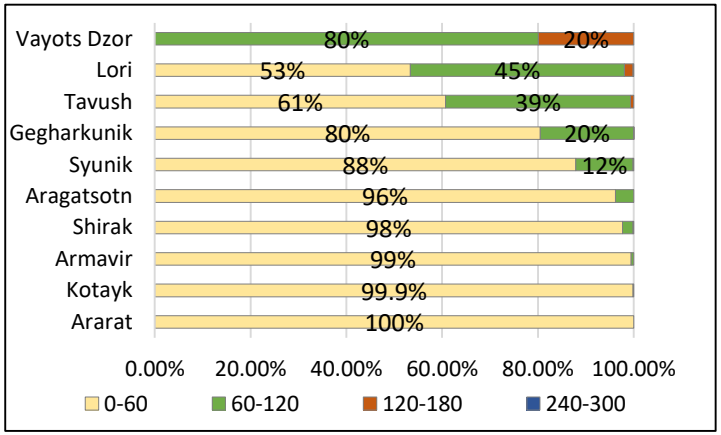
# Accessibility Analysis – Conclusions

## Poorest regions generally rank low in road quality and in market access

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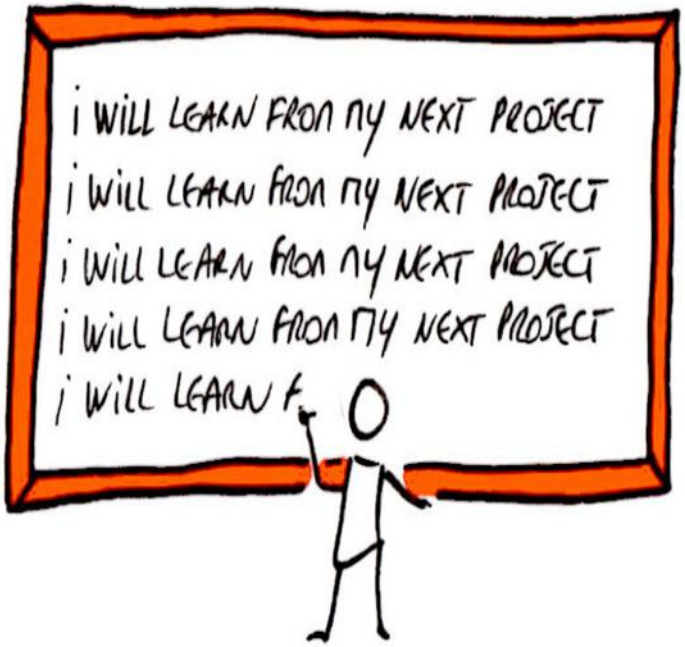
# Lessons and Directions for Future Research

**Choice of rigorous impact evaluation over other approaches to assess project outcomes**

**Understanding of the theory of change linking transport interventions and other high level outcomes**

**Timing for data collection and evaluation window**

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# Further reading


1. **Artak Piloyan, Aram Gevorgyan**. Measuring Rural Accessibility in the GIS environment: Case study of Armenia. Proceedings, 7th International Conference on Cartography and GIS, 18-23 June 2018, Sozopol, Bulgaria ISSN: 1314-0604, Eds: Bandrova T., Konečný M. 417-425 pp.

2. Connecting the Dots: Transport, Poverty, and Social Inclusion - Evidence from Armenia. December 2017. Transport and ICT Global Practice, The World Bank

**Thank you !!!**

**Շնորհակալություն !!!**

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