Cartography M.Sc.

Geovisualization and processing of mobility data to identify impact factors on mobility patterns

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Introduction and Motivation

Africa is an economically growing continent. But in rural areas its very difficult to achieve the growth.

First and last-mile problem is the transportation.

A lot of initiatives have been taken for the economic growth in rural areas of Africa to combat hunger and unemployment.

German Federal Ministry for Economic Cooperation and Development (BMZ) has developed green innovation centers in those regions for agricultural food production.

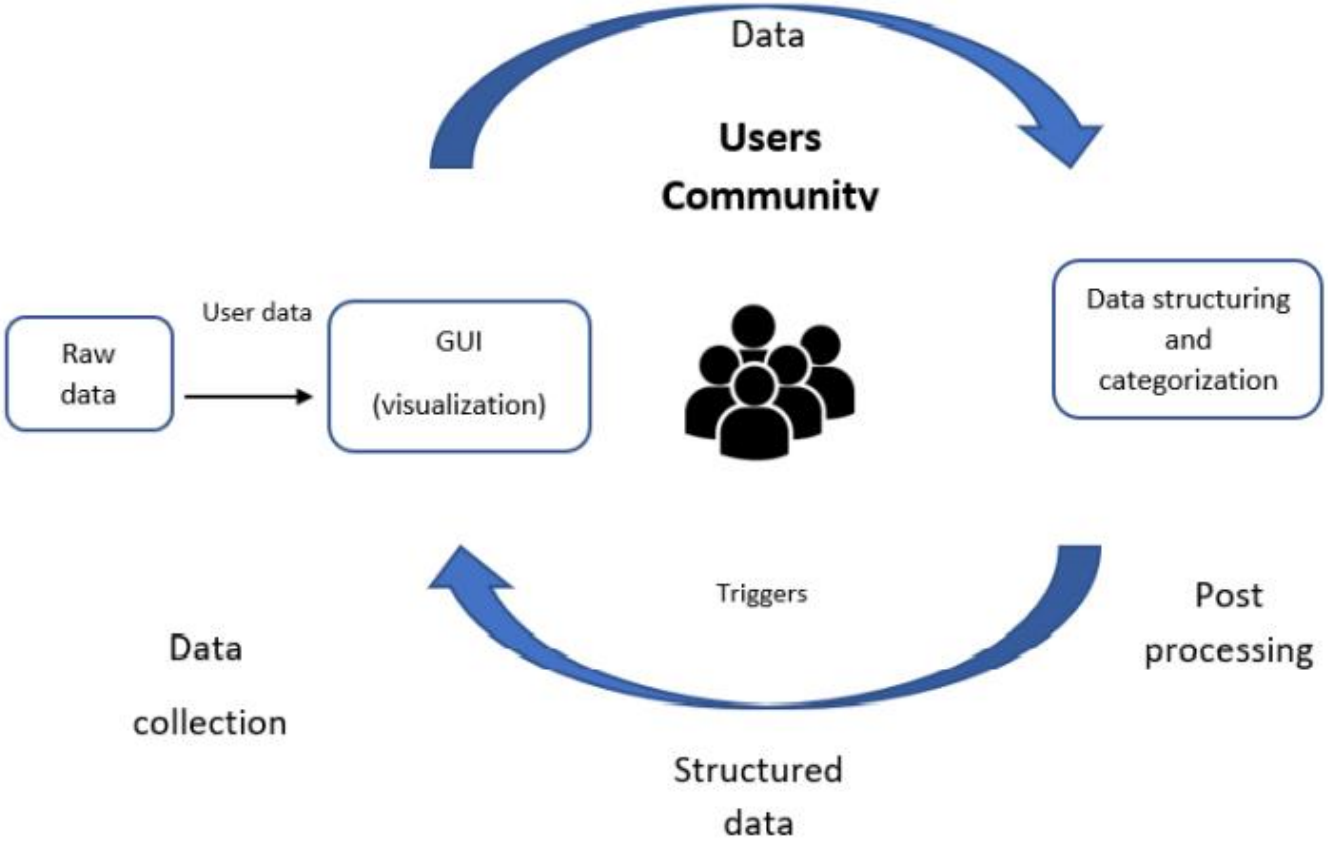
Introduction and Motivation

- The aCar Mobility project integrates into this initiative to significantly improve rural mobility by integrating new electric transport means.
- In this phase, which is related to mobility patterns and their different impact factors for electric mobility in the target regions Ethiopia and Côte d'Ivoire.
- The main motivation to work on this topic is that it combines the research & development and focuses on electric mobility specifically which is of my interest.

Research Objective

- This thesis aims to make a user interactive and collaborative platform to upload, process the mobility data to identify and visualize impact factors on rural mobility patterns.
- **RO1: Data Collection & Processing**
- **RO2: Methods for Processing and Categorization of data**
- **RO3: Visualization of mobility data**

Research Objective



Concept of workflow

Research Questions

- RQ1: What will be the sources and contributors for mobility data?
- RQ2: What will be the methods for processing the data?
- RQ3: What are the best cartographic techniques for visualization and platforms for the development of GUI?

Previous research and related works

- Geisa Bugs et al. (2010) developed an application for public interaction by using an open source tool for web mapping service.
- Lwin, Koko et al. (2014) researched real-time geotagged data collection and visualization on mobile phones.
- Lwin et al. (2014) worked on public participation in the field of GIS using mobile applications. They described three processes with different scales and purposes. The context is urban monitoring & planning, and tourism optimization.

Previous research and related works

Lwin, Koko et al. (2014)

Mobility Studies

- Mobility is the possibility for movement and it is the ability to move from one place to another using different modes of transportation to meet their daily needs. (Etlis, 2021)
- During the movement of human beings, they move in an equal way which then can be unveiled by certain patterns that show the human travelling behaviour on the ground from origin to the target point. The mobility patterns are the outcomes of the human movement analysis. (Zhao, C. et al. (2021))
- The definition of sustainable mobility can be derived from sustainable development. The definition contains three aspects i.e. economic, environmental, and social.

Mobility Studies

- Tafidis et al. (2017) reviewed the huge number of sustainable mobility indicators from literature and examined the data availability. In the end, he summed up an efficient, realistic and comprehensive indicator system as an evaluation tool for checking mobility conditions in the Greek Urban areas.
- Dominique et al. (2016) have done intensive research and gave a systematic overview of mobility indicators that covers different aspects of sustainable mobility [20]. They have found 22 indicators during their research.

Mobility Studies

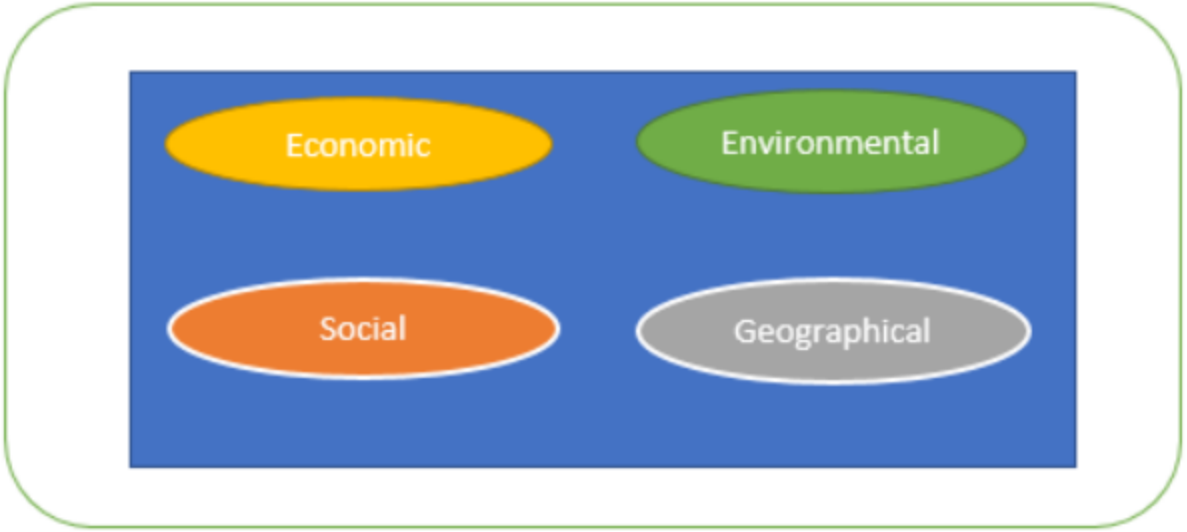
Indicators for the Sustainability of Urban Mobility	Short Name	Dimension
Emissions of greenhouse gases	GHG	Global environment
Energy efficiency	Energy efficiency	Global environment
Net public finance	Public finance	Economic success
Congestion and delays	Congestion	Economic success
Economic opportunity	Economic opportunity	Economic success
Commuting travel time	Travel time	Economic success
Mobility space usage	Space usage	Quality of life
Quality of public area	Public area	Quality of life
Access to mobility services	Access	Quality of life
Traffic safety	Safety	Quality of life
Noise hindrance	Noise hindrance	Quality of life
Air polluting emissions	Air pollution	Quality of life
Comfort and pleasure	Comfort and pleasure	Quality of life
Accessibility for mobility impaired groups	Accessibility for the impaired	Mobility system performance
Affordability of public transport for poorest group	Affordability	Mobility system performance
Security	Security	Mobility system performance
Functional diversity	Functional diversity	Mobility system performance
Intermodal connectivity	Intermodal connectivity	Mobility system performance
Intermodal integration	Intermodal integration	Mobility system performance
Resilience for disaster and ecologic/social disruptions	Resilience	Mobility system performance
Occupancy rate	Occupancy rate	Mobility system performance
Opportunity for active mobility	Active mobility	Mobility system performance

Mobilty Indicators Dominique et al. (2016)

Mobility Studies

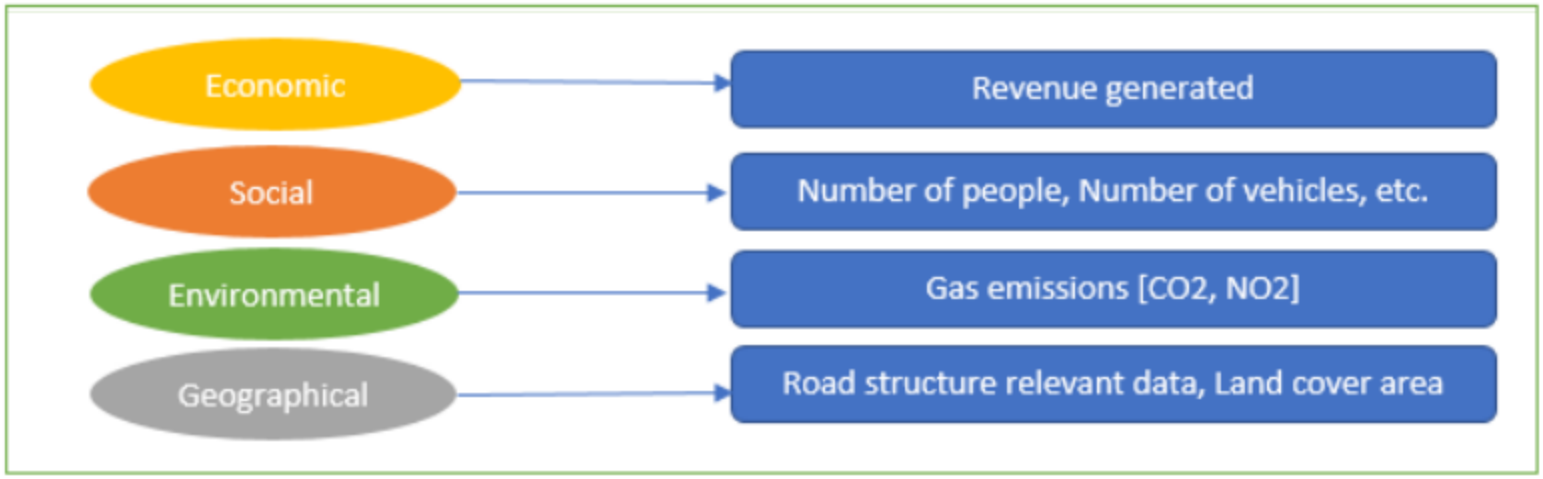
Mobility Data Derived Dimension

- Collected data are divided into four categories, economic, environmental, social and geographical.



Mobility Studies

- **Derived Mobility Indicators**
- There are major indicators selected are road condition, population, number of vehicles, gas emission values, land cover, number of deaths, number of men, number of women and number of accidents.



Application Development Studies

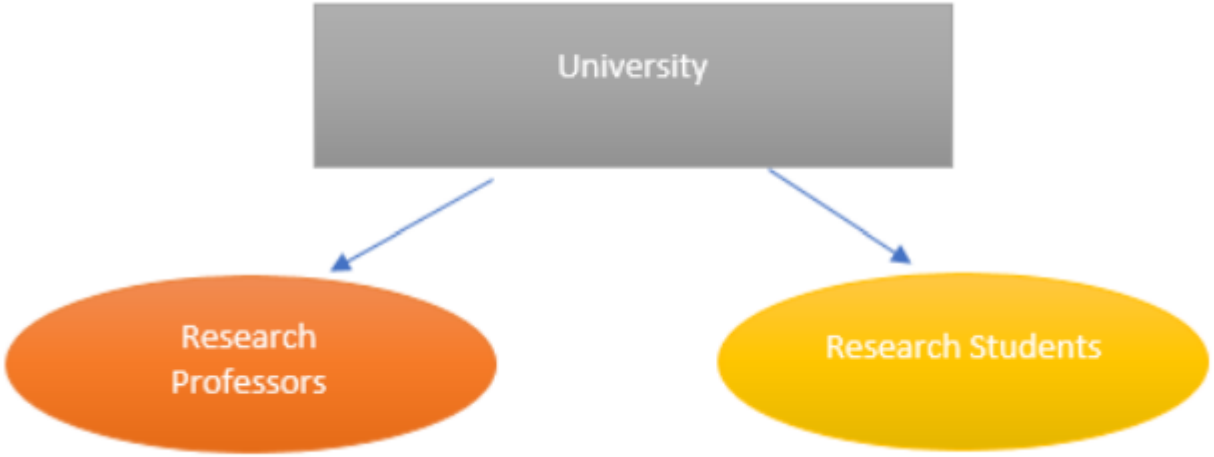
Data Collection

- In developed countries like Europe it is easy to collect data but in under-developing countries it is quite tough. Fragility and conflicts affect the data collection for researchers in various ways. There is a very limited capacity for doing surveys and analysis in these areas.
- Public involvement in those areas could not be possible but we can engage some of the research institutes together.

Application Development Studies

Participants

- aCar mobility project is collaborating with the ASTU (Adama Science and Technology University), INPHB and TUM (Technical University Munich). So they will be the part



Application Development Studies

User roles

- The user could perfrom any one of the specified roles.
- Either the user can Upload the data file or structure the data.

Role-1

Responsibility

Uploading and storing the raw data

Role-2

Responsibility

Do data processing on already available data

Application Development Studies

File formats

Document file types

- DOC and DOCX, XLS/XLSX, PDF, HTML, ODT, ODS, PPT and PPTX, TXT

Image file formats

- JPEG/JPG, PNG, GIF, TIFF, PSD, PDF, EPS, AI, INDD, and RAW

Audio file formats

- M4A , FLAC, MP3, MP4, WAV, WMA and AAC

Video file formats

- MP4, MOV, WMV, FLV, AVI, AVHD, WebM and MKV file

Application Development Studies

Selected File formats for website

Image file format

- . There are normally various types of image formats but when we talk about website we normally stick to JPEG/ PNG and GIFs.

Document file format

- There are two common files which are used. Which includes Word and PDF files.

JPEG and PNG are selected because of web browser good efficiency and light weight

But PDF is selected for my research work because its more protective and un-editable.

Application Development Studies

Available methods for data structure

- Data Structuring languages (XML, JSON and RDF)
- Machine learning based model (DSL System)
- Manual User Input (HTML forms)

Methodologies	Publication	Reason
Data Structured Languages	Serena Pastore (2013)	No user Participation
ML-Based Model	Ledure et al. (2015)	Totally Automated
Manual user input form	Aydin, Y.E. (2006), Tasoulas et al. (2013), Cooper et al. (2006)	User Participation

Application Development Studies

HTML form/ User input form

- After getting the data from the users, the next step is to structure the data. For that the HTML form will be used in the platform because it will give the user the ability to collaborate and flexibility in structuring the partial data as well.

The platform has to be user interactive and user participation is needed.

Application Development Studies

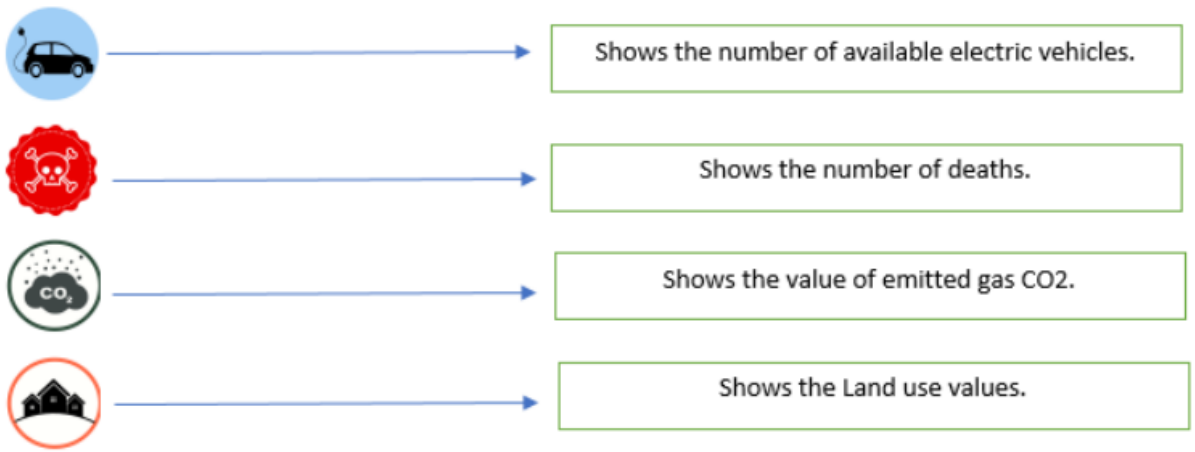
Types of geovisualization techniques

- Point based technique
- Line based technique
- Polygon based technique

Publication	Visualization technique	Reason
Chris Weaver (2006), J.Wood et al. (2007), Sobral, T et al. (2019)	Point-based visualization	Used for Numeric values and points
Krik Goldsberry	Line-based visualization	Used for roads, continuous values of lines
Yin et al. (2005)	Polygone-based visualization	Used for value spread on whole region

Application Development Studies

Point based Visualization

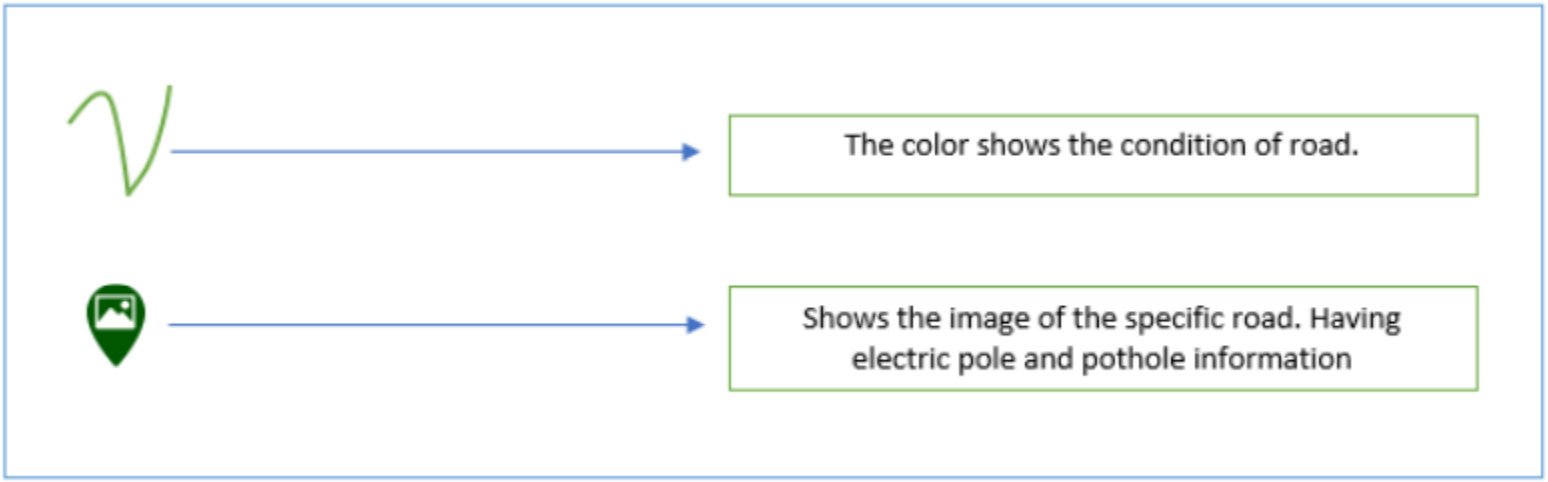


Line based Visualization

Platform is visualizing the discrete numeric values and the line-based information on the map that is why point-based and line-based visualization are used in my research work.

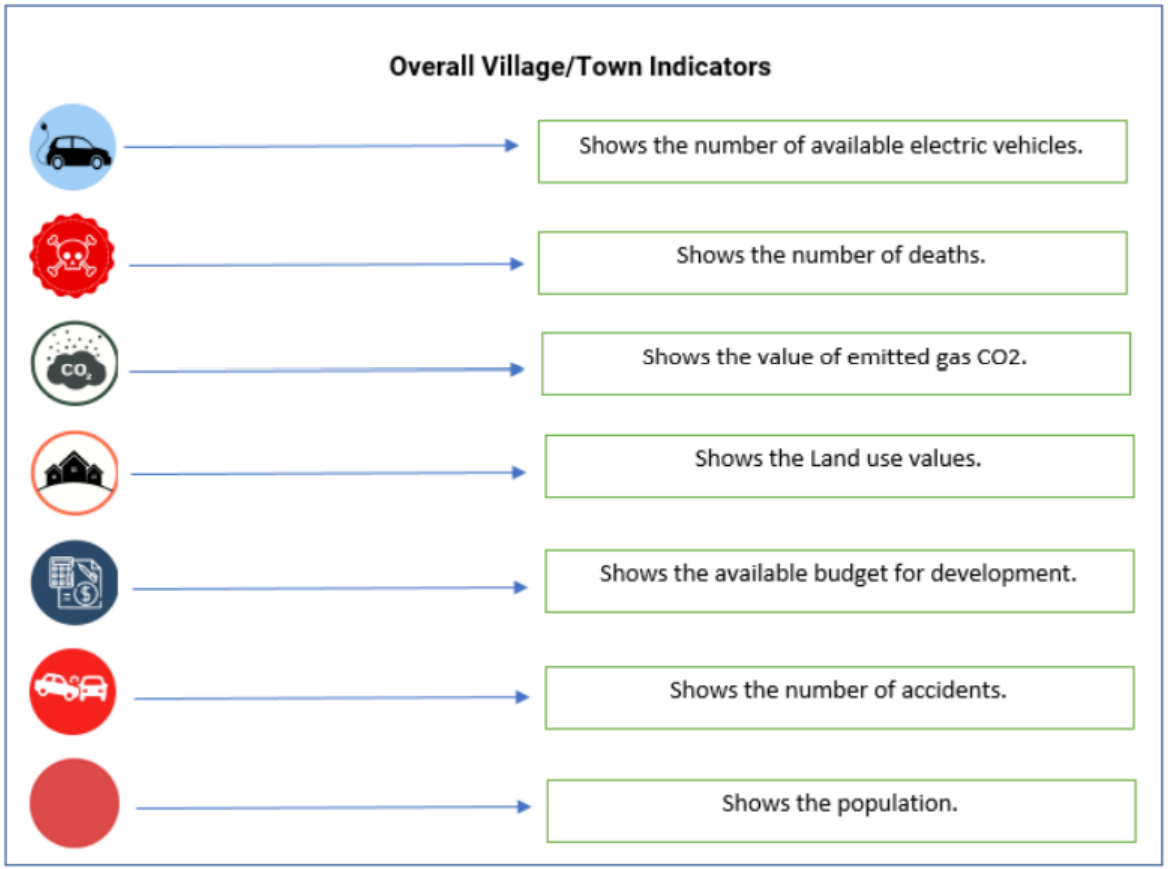
Application Development Studies

Road Level Indiactors Visualization



Application Development Studies

Town/Village Level Indicators Visualization



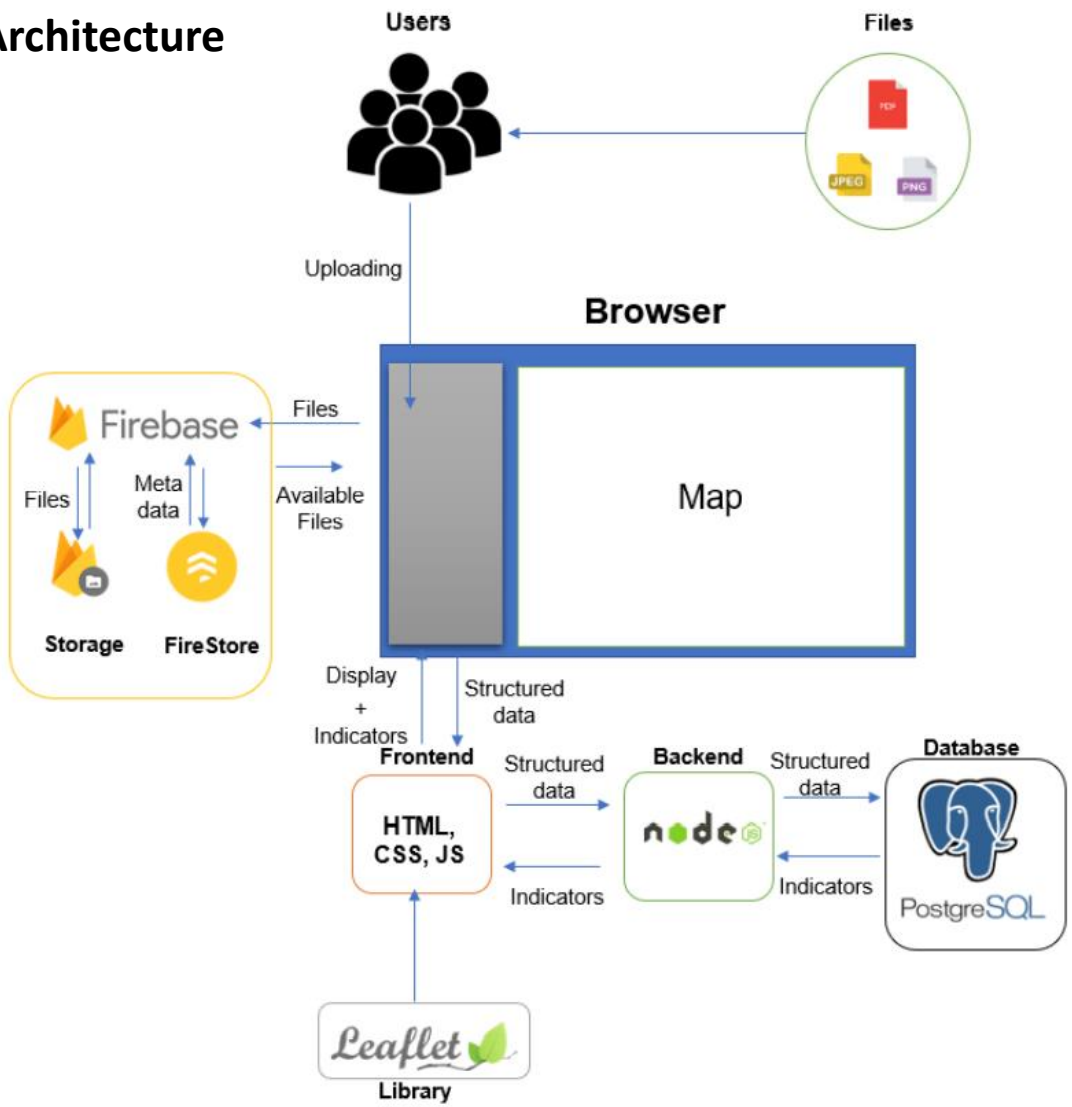
Prototype Development

Technologies Used

- Languages: HTML,CSS,JavaScript
- Platform: Node.js, Firebase, PostgreSQL
- Editing: Visual Studio
- Library: Leaflet.js

Prototype Development

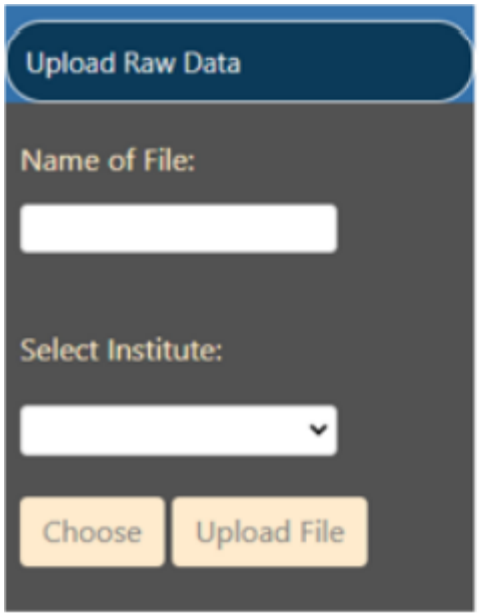
Prototype Architecture



Prototype Overview

Uploading Raw data

- There are two options for uploading the files one is for docuemnt and the second one is for images.



PDF files

Image files

Prototype Overview

Retrival of Available data

- The raw files are showing on side navigation bar and the map in the form of points.

Prototype Overview

Retrival of Available data

Prototype Overview

- **Structuring of Raw data**
- Two HTML forms are available one is for the streets level data and second one is for the village/ town level data.
- In both forms user is required to fill the required fields.

Prototype Overview

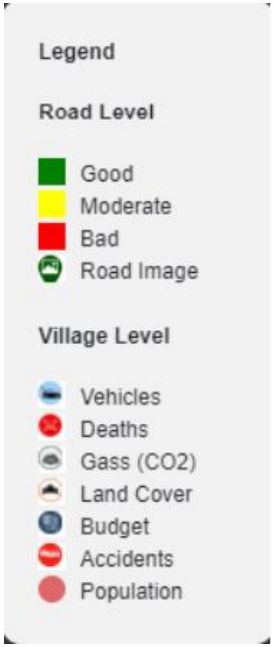
Base Maps

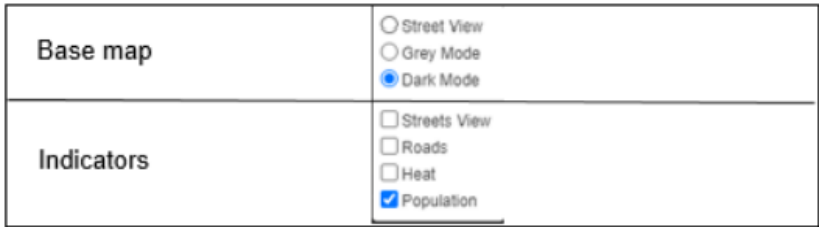
- There are options of switching the base map which suits according to the contrast

Prototype Overview

Interactive Element Box

- There is legend box which guides the users to see the signs of indicators.
- The base map and indictaors could be select by users to have the visualization of the selected indicator.



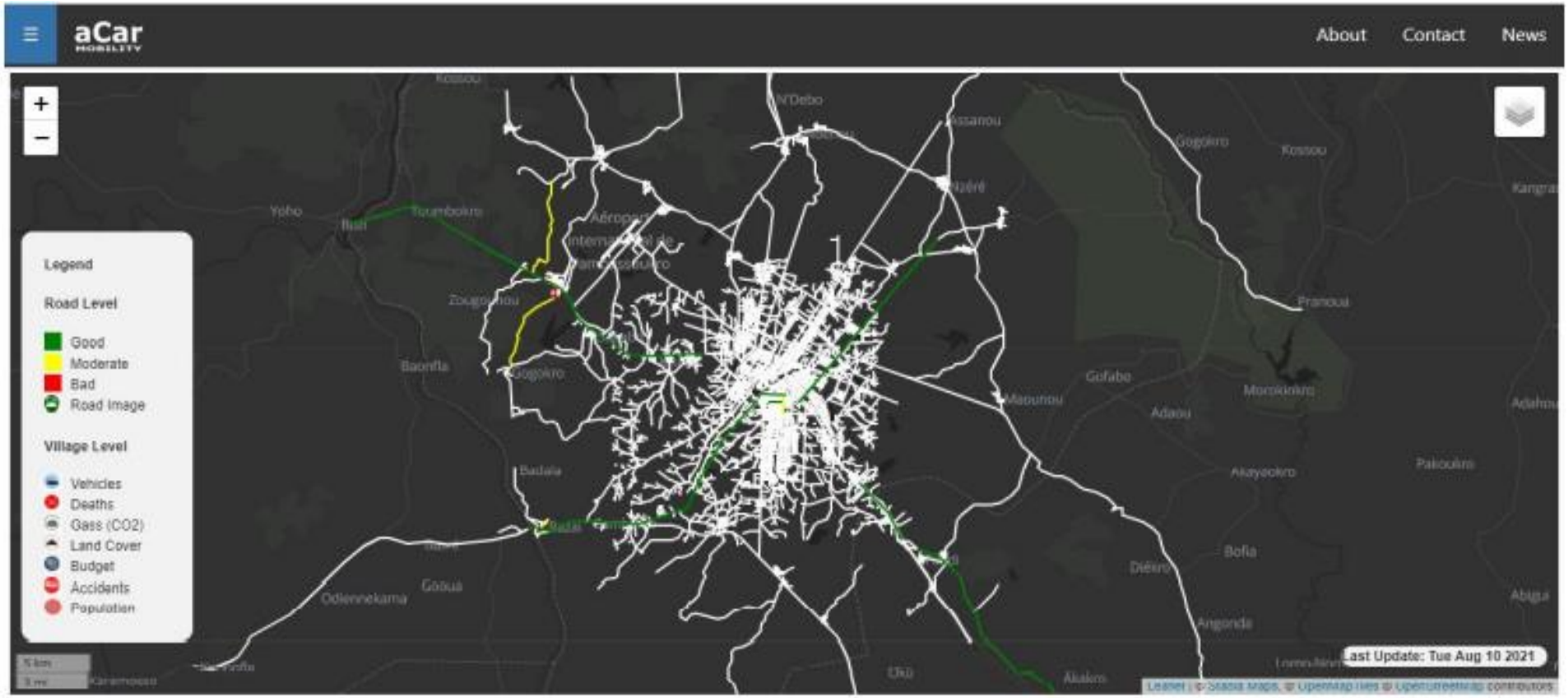


Results

- **Data files used: Image files (Côte d'Ivoire)**

Results

Roads Condition



Results

Street View

Results

- **Data files used: Documents files**

Indicators

Survey

Lat = 9.312594, Long= 42.119865

Village Name= Harar

Overall indicators for whole Town/City:

1. Total Vehicles = 8000
2. No. of cars = Not available
3. No. of bus = Not available
4. No. of motorbikes = Not available
5. No. of electric cars = Not available
6. No. of rickshaw = Not available
7. Population = 98829
8. No. of men = 49448
9. No. of women = 49380
10. No. of deaths = 42 per 1000 live births
11. CO2 gas emission value = 0.02
12. Percentage of fields/ pastures covered = 25.08
13. Percentage of built-up covered = 60.68
14. Budget = Not available
15. Accidents = 382

Results

Population viusalization

Conclusions

- The functionality of the application depends on the data provided.
- The more accurate data, the more precisely the information can be displayed as mobility indicators on the platform.
- The GUI can handle the large amount of data and can be used by multiple users at a same time. This GUI is tested on different devices such as laptops, mobile phones & tablets and compatible with these devices.

Improvements

- More data should be collected via surveys.
- A query tool can be embedded to help the new user to get the relevant information.
- The HTML form to organize and structure the data can be filled automatically upon uploading the raw data in a pdf file.
- More features can be added such as the automatic report generation in the end of geovisualization.
- Machine learning techniques can be used to calculate some of the indicators by browser itself.

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Thank you for your attention

Questions?