Cartography M.Sc.

Faculty of Geo-Information Science and Earth Observation (ITC)

UNIVERSITY OF TWENTE.

# Design of a multiscale base map for a tiled web map service


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Enschede, Netherlands

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# Acknowledgement

First of all, I would like to express

- colossal and immense thanks to my supervisor, Richard Knippers

- profound gratitude to all members and staff of the Faculty of Geo-Information Science and Earth Observation (ITC) of the University of Twente, especially to Corné van Elzakker and Menno-Jan Kraak

- tremendous and boundless thanks to everyone who is involved in the International M.Sc. in Cartography program

Thank you all

# Agenda

1. Introduction
2. Research Identification
3. Theoretical Foundations
4. Methodology & Implementation
5. Results & Discussion
6. Conclusions
7. Future Work & Recommendations

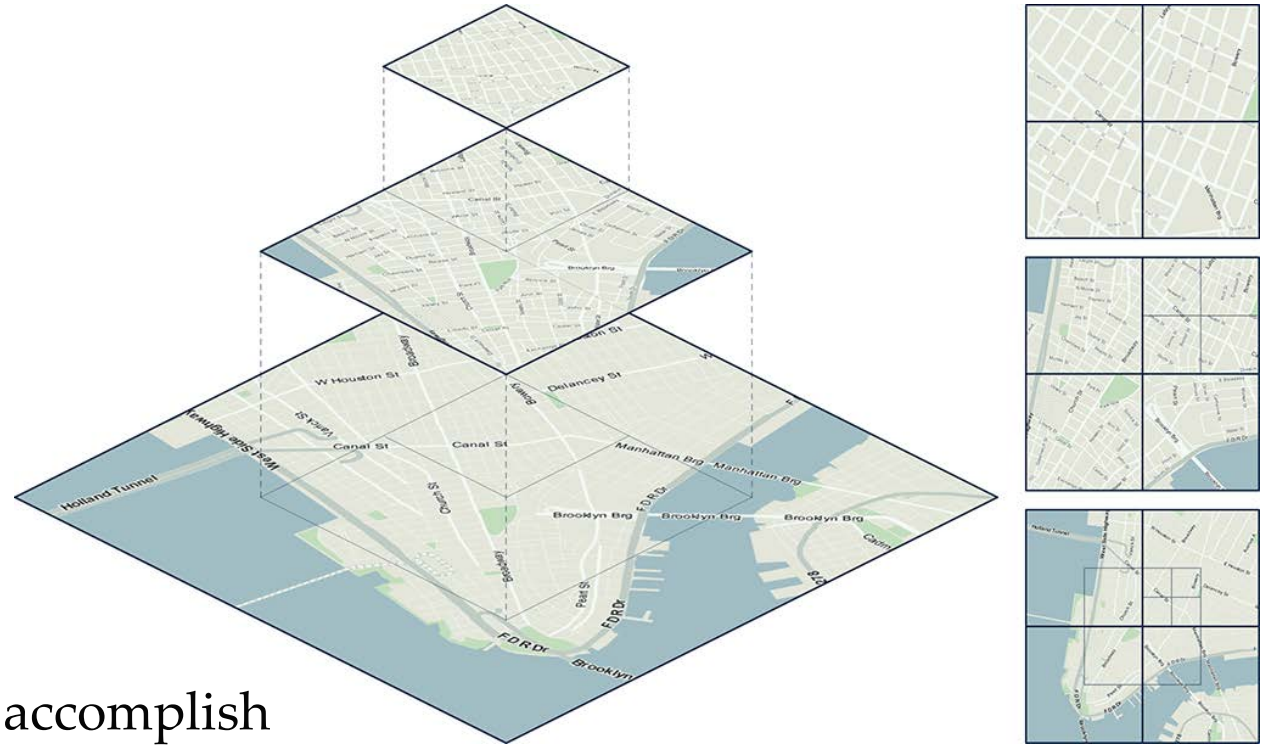
# 1. Introduction

Google Maps service was launched for public usage in 2005.

The core enabling approach is a tile-based mapping.

It leads to:

- quicker map representation over the Internet
- reduced data transmission capacities
- other benefits when overlaying with thematic foreground map




BUT, pre-rendered raster tiles not always accomplish user requirement and needs because of the chosen design, styles and content

# 1. Introduction

There are many possibilities to access tiled web maps and services with those maps.

Already known: Application Programming Interfaces (APIs), Web Map Service (WMS), and other web mapping frameworks.

There is a group of services exist, based on standards and applied tile-numbering schemes.

The best-known are:

- Tile Map Service (TMS) developed by the Open Source Geospatial Foundation (OSGeo),
- Web Map Tile Service (WMTS) by Open Geospatial Consortium (OGC).

# 1. Introduction

Currently, many software, especially in GIS domain, which handles geospatial and cartographic data, have nested packages that operate with existing web map services. One of such software is ILWIS.

ILWIS was using the TMS provided by MapQuest. Unfortunately, the MapQuest service stopped being free in August 2016 and then the ILWIS programmers changed the URL used for the background map to the next free available TMS server, which was the TMS provided by OpenStreetMap.

However, the ILWIS users do not find the new background map as nicely styled as the one that was provided by MapQuest.

Therefore, ILWIS would like to have their own tiled-web map service for their users.

# 2. Research Identification

The main goal of this M.Sc. research is to produce a functional multi-scale base map with a pre-defined design and set it with an access on the Internet as a tested prototype of a tile-based web map service.

There are several specific objectives in this M.Sc. research, namely:

- Provide a procedure for styling and rendering of the OpenStreetMap data into a tiled web map service;
- Produce a multi-scale base map for the application, that satisfies user requirements;
- Draw up specifications for scale levels, tiling scheme, content, styling, symbolization, layout, and other technical specifications;
- Build a prototype of a tile-based web map service.

# 2. Research Identification

Research questions:

1. How should the base map be designed to meet the requirements of users of GIS software?
   - How appropriate are the styling settings, that are used by some well-known tiled web map services?
   - How to involve users' wishes and desires into the design directives?

2. How appropriate are TileMill and Mapnik as a software and a tool to style and render OpenStreetMap data?
   - What is the basic architecture of the prototype tile-based web map service?
   - What is the workflow for tiles generating and rendering?
   - How does the styling work?
   - How does the tiling work?

# 3. Theoretical Foundations

Tile-based mapping systems have certain properties, that distinguish them from other types of mapping systems:

1. Map views are based on multiple discrete zoom levels, each corresponding to a fixed map scale.

2. Multiple image tiles are used to virtualize a single map view.

3. Image tiles are accessible using a discrete addressing scheme.

4. Tiled images stored on a server system, and are sent to the client with minimal processing time

# 3. Theoretical Foundations

Most tiled web map services follow Google Maps convention:

- Each tile is typically composed of 256x256 pixels, for a total 65.536 pixels. A tile is a raster image usually JPEG or PNG file.
- The entire world can be represented in a single map tile on the lowest-scale zoom level.
- Each zoom level doubles in both dimensions, so a single tile is replaced by 4 tiles when zooming in. Tiles form a tile pyramid, sometimes termed as “zoom pyramid”.
- Mercator projection on a spherical approximation of the Earth is used, with latitude limits of around 85 degrees.

# 3. Theoretical Foundations

A map which is created for multiple scales and broken into tiles is a more complex structure which requires certain technical considerations and rules.

One of the essential elements of tile-based mapping systems is a tile numbering scheme that outlines:

- the discrete addressing of map tiles
- the method for generating multiple zoom levels of tiles
- and the conversion method between tile addresses and an incessant geospatial coordinate system.


There are three main indexing schemes: Google Maps; Tile Map Service (TMS); and QuadTree (Bine).

# 3. Theoretical Foundations

Geographic information is an expensive resource and for this reason, standardization is needed to promote its availability and reuse.

The best-known standard specifications, also called protocols, are:

- Tile Map Service (TMS),
- Web Map Tile Service (WMTS),
- The de facto XYZ.

These protocols define a tiled web service interface that returns tiles in accordance with the request, means only a part of tiles will be delivered.

# 3. Theoretical Foundations

Raster images are insufficient and there are limitations of raster-only mapping application. Mapping companies applied vector tiles for web mapping purposes, e.g. Google Maps and MapBox.

*Vector tiles, tiled vectors* or *vectiles* are chunks of geographic features in vector form, that are transferred over the Web. Vector tiled map services can be defined as map applications built from vector tiles, that use geometric primitives and are precisely rendered in real-time.

Tiles may be rendered as they are requested. Generating tiles is done just-in-time, i.e. on-the-fly rendering procedure.

Unique things which distinguish tiling vector data from tiling imagery: storage space, processing time, and overview images.

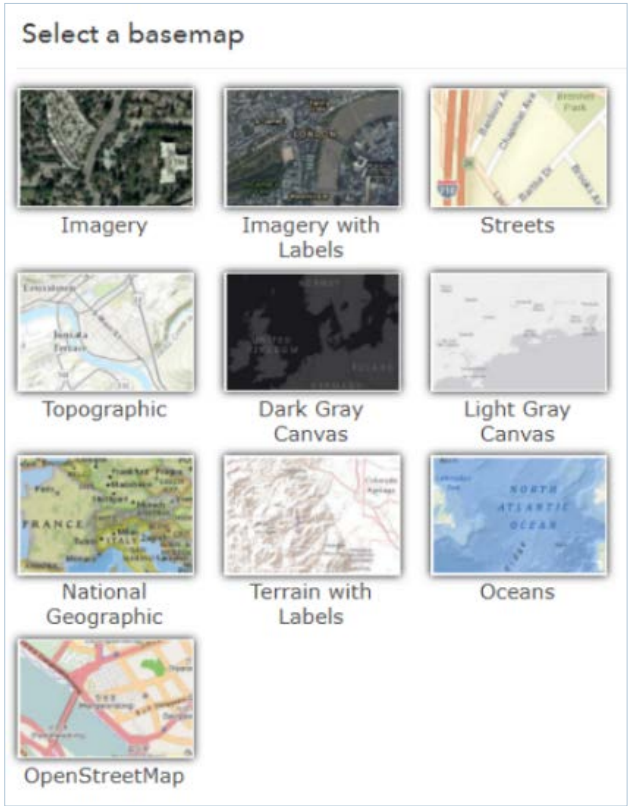
There is no dominant standard for vector tiles.

# 3. Theoretical Foundations

Base maps are aiming at the location reference to the thematic layer uploaded or created by a user and the improving the communication between custom and thematic contents.

Services afford location reference to the data placed upon them, however, styles and content of base maps are often not simplified or adjusted towards the project constraints, user wishes, and desires.

Some results on the way to reduced and simplified styles for use in thematic maps were implemented by GIS companies, which offered base maps for web mapping.



# 3. Theoretical Foundations

The intention of developers was to produce the variety of maps to meet the majority of user's needs defined by the application and the type of the working data they are using.

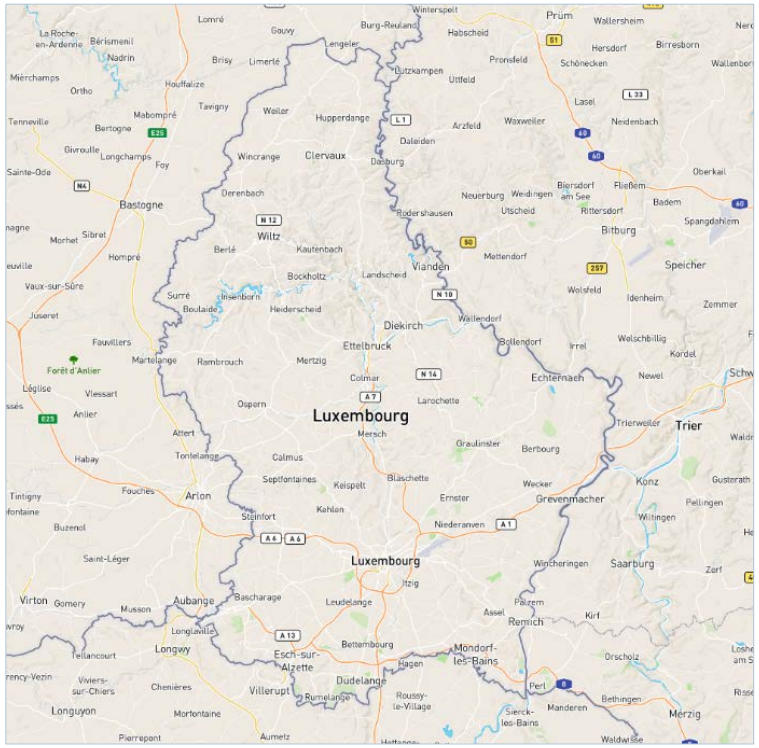
But on the other side, it is also not always possible to fulfil all of user's needs because of the large number of people that use maps.

User-centered design (UCD) is a part of user research studies. The purpose for UCD is driven by the need for on-demand maps, which might be exploited by the user, who can certainly have a need, a profile, some preferences about the map, and a context in which the map might be tested.

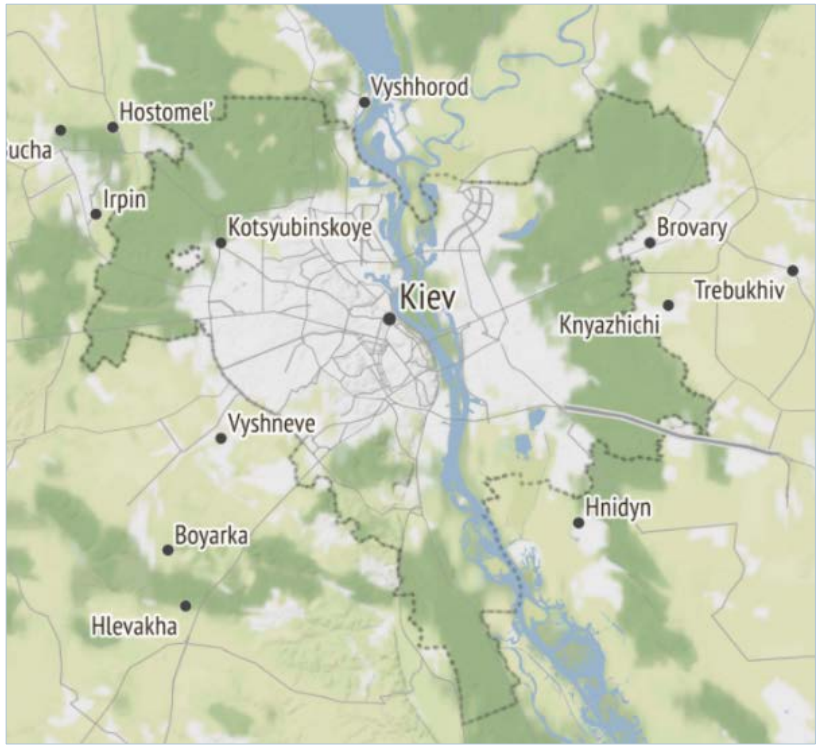
All these parameters are also known as *user requirements* and essentially the cartographer's role is to design a map which best suits those requirements.

# 3. Theoretical Foundations

Related work and examples in multi-scale base map design.




MapBox Streets




Stamen Terrain map


OpenMapSurfer

# 3. Theoretical Foundations

To be able to achieve sufficient cartographic communication and fulfil intended users' requirements (preferences), there is a necessity for cartographers to take into consideration certain aspects in multi-scale base map creation and design.

In this Master Thesis, following aspects were considered:

- Content. map elements should be included or excluded driven by two principles: the purpose of the map and the probable map audience.
- Zoom levels. Each zoom level should be assured and approved by the information significance and usefulness which must be given to that particular LOD.
- Generalization is aiming at improving map display at small-scale zoom levels by virtue of simplification and clarification of map features, and stressing the crucial meaningful information based on specific purposes and users' needs.
- Symbolization plays an important role in web map communication.

# 4. Methodology & Implementation

The multi-scale base map creation was done via:

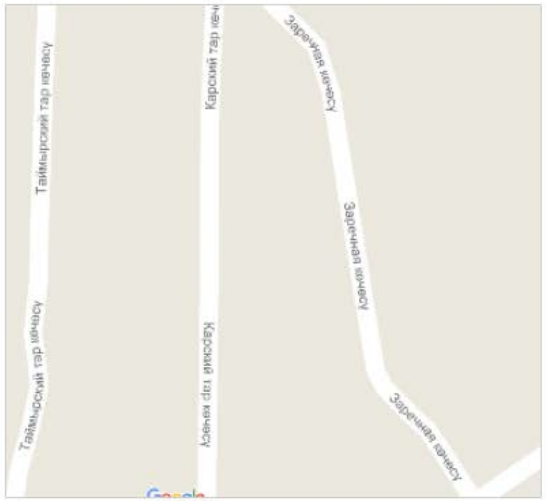
1. Review of best-known multi-scale maps
2. Consideration of guidelines for the multi-scale base map design
3. Analysis of user needs and requirements
4. Examination of related work and examples as inspiration sources
5. Research of aspects of the multi-scale base map design

# 4. Methodology & Implementation

**Multi-scale base map review**

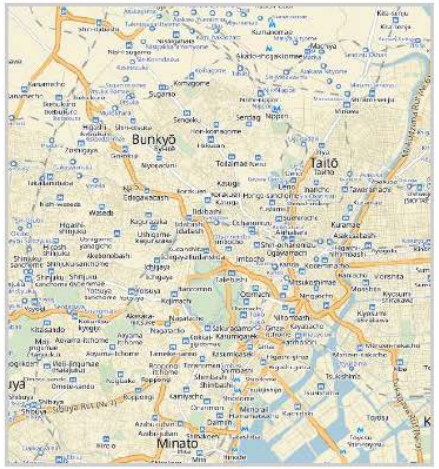
Google Maps



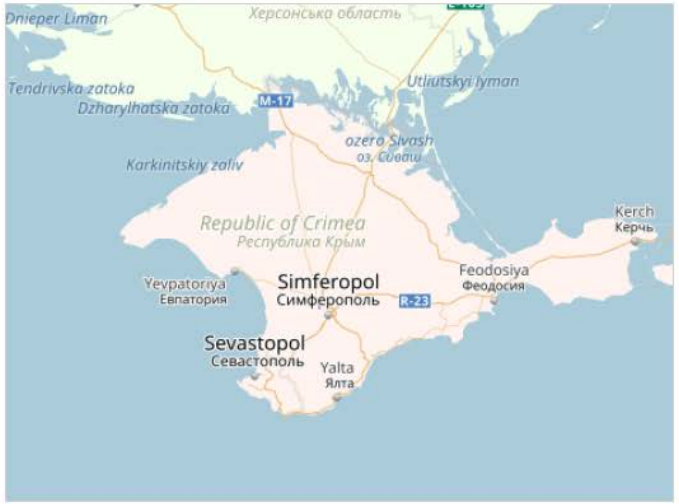



# 4. Methodology & Implementation

**Multi-scale base map review**



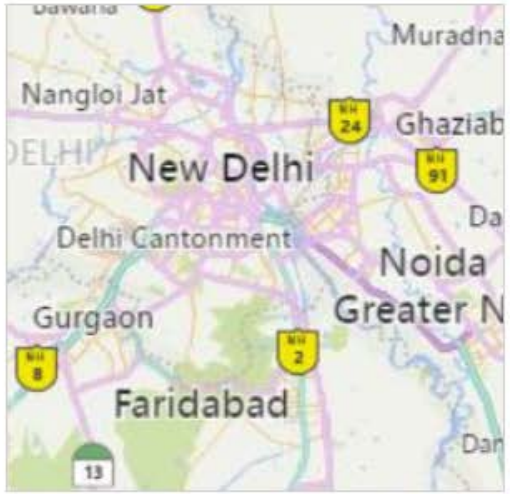

Yandex
maps



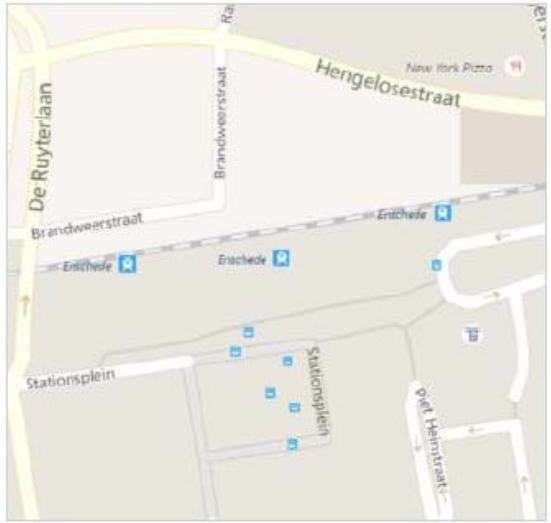



# 4. Methodology & Implementation

**Multi-scale base map review**







bing Maps

# 4. Methodology & Implementation

**Multi-scale base map review**





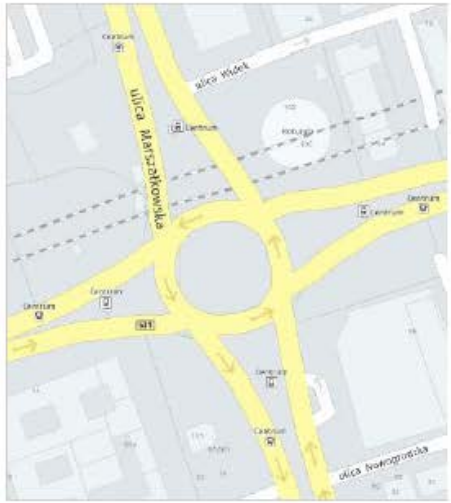
# 4. Methodology & Implementation

**Multi-scale base map review**

Maps for Life

HERE We Go

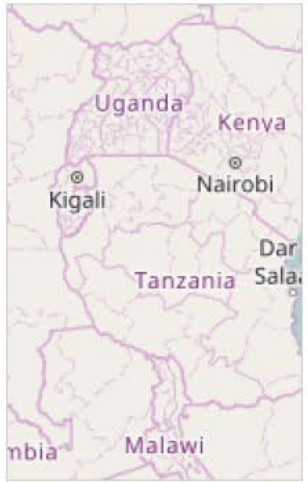


# 4. Methodology & Implementation

**Multi-scale base map review**



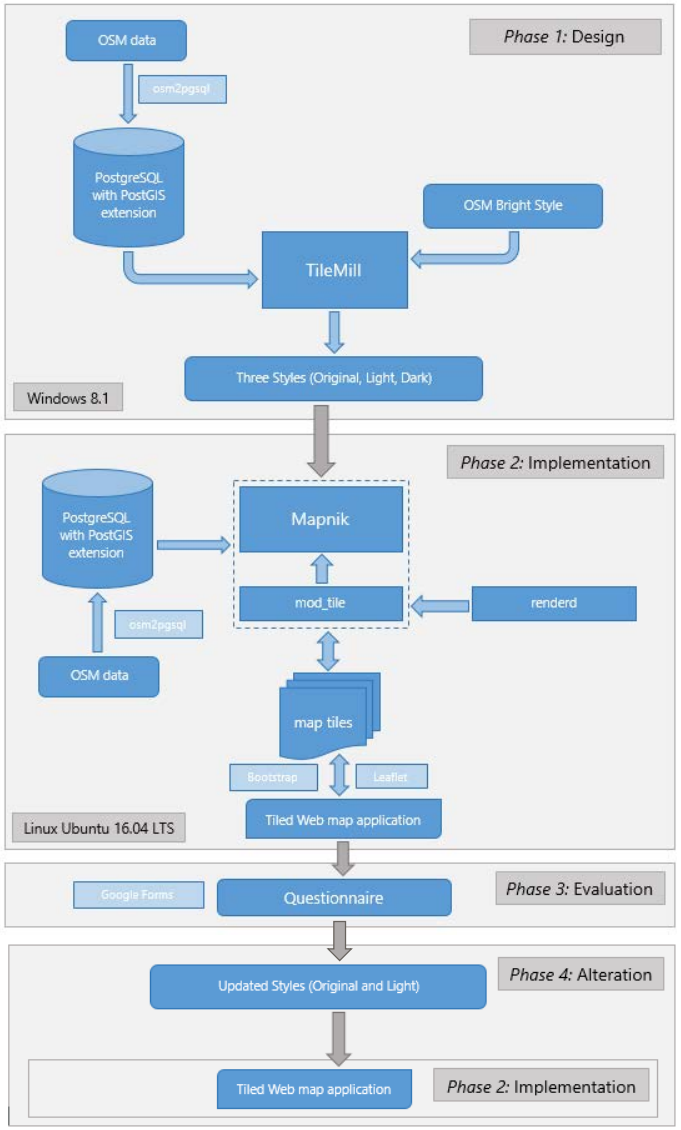





OpenStreetMap

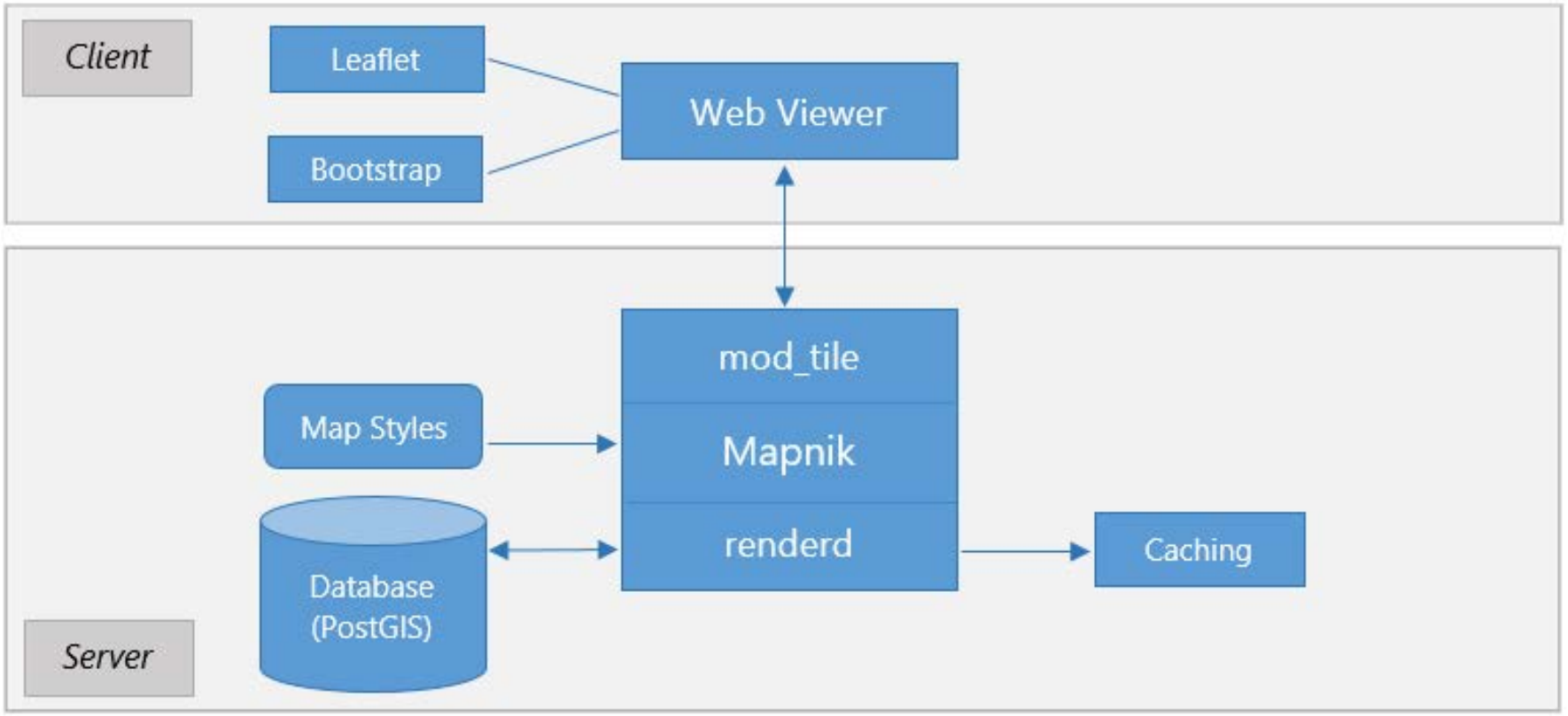
# 4. Methodology & Implementation

## Workflow



# 4. Methodology & Implementation

## Architecture



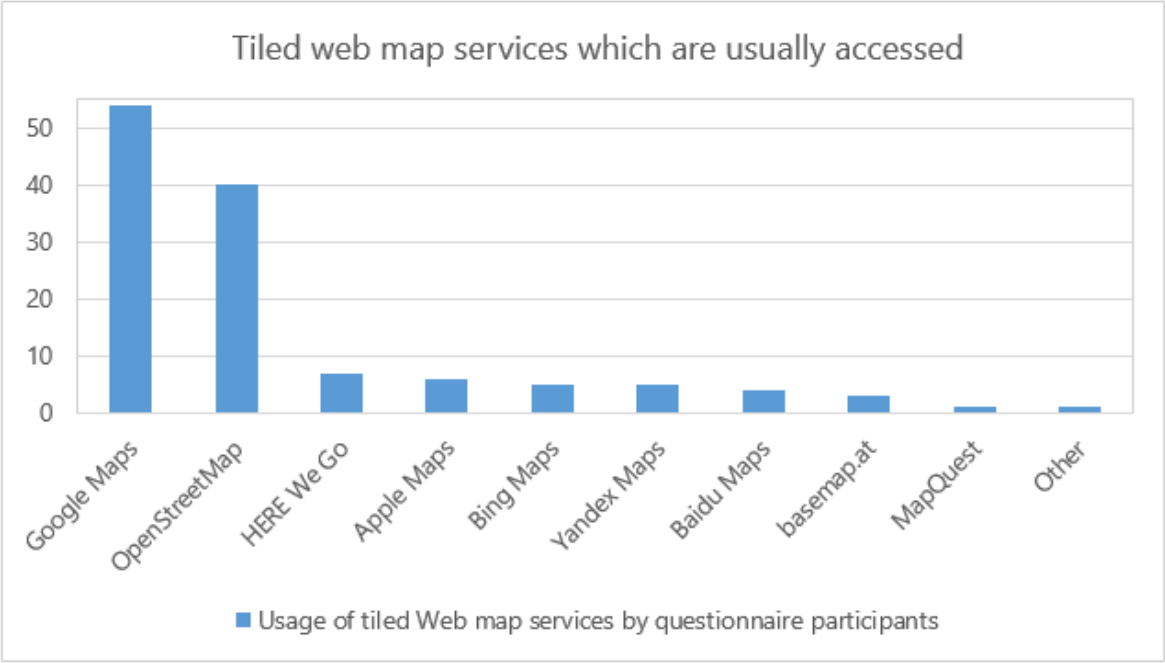
# 5. Results & Discussion

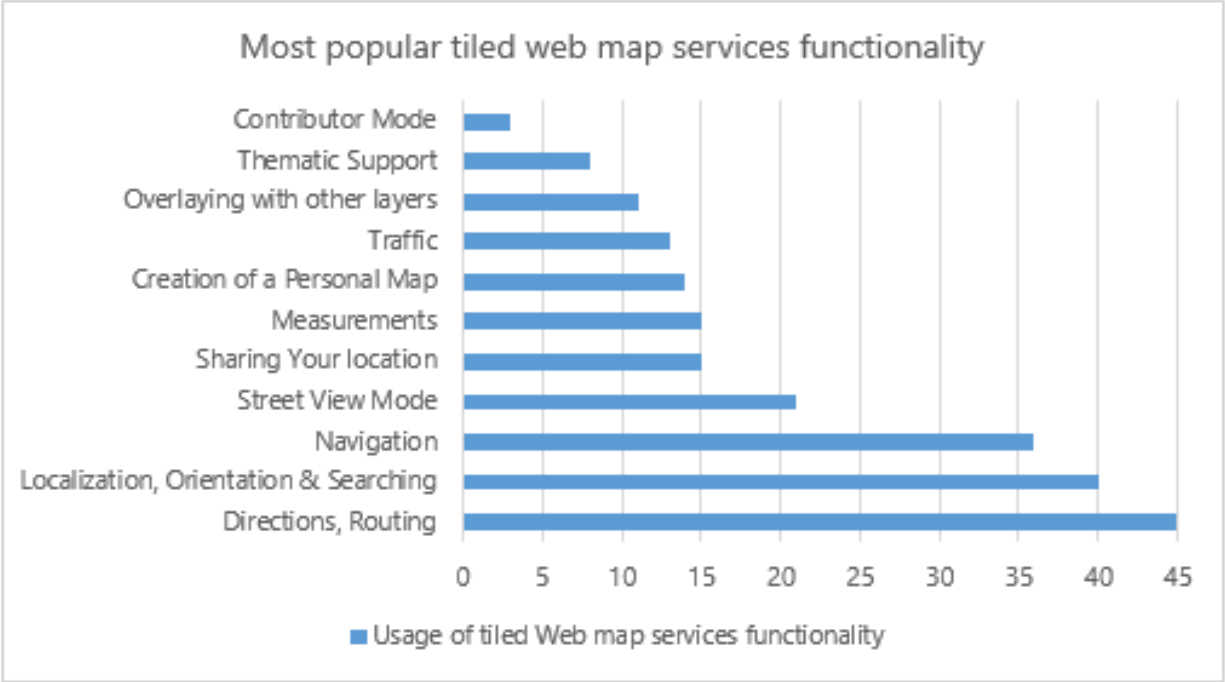
**Primary designed multi-scale base map application**

```
openwebsite = Try me!
if (openwebsite == false):
    open(http://188.226.166.167/)
else:
    print("Don't panic and keep smiling!")
```

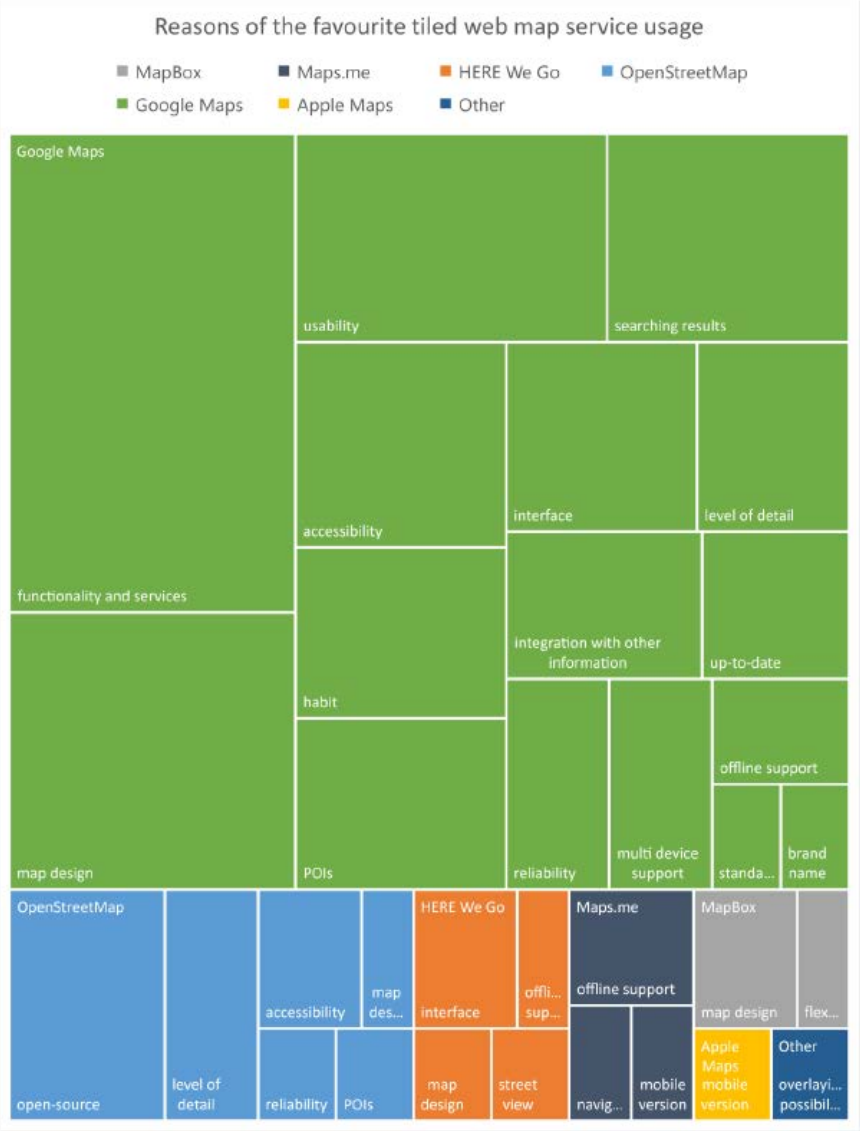
# 5. Results & Discussion

## Questionnaire results: General Information



# 5. Results & Discussion

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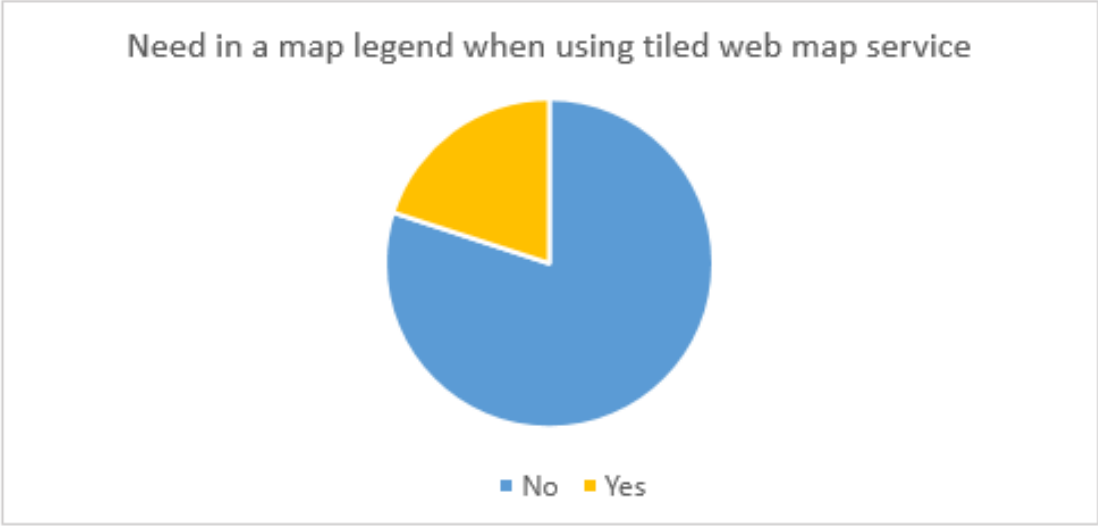
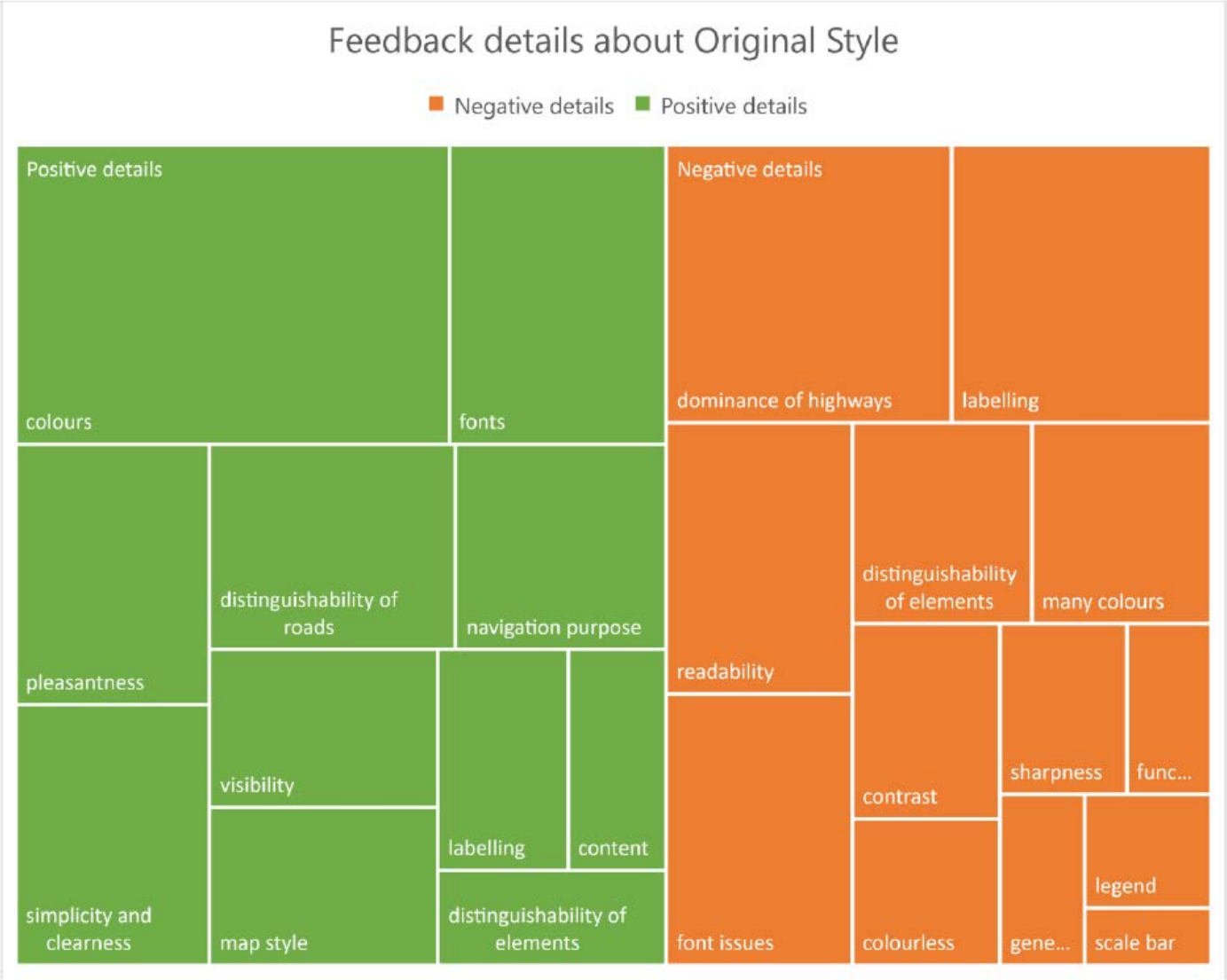
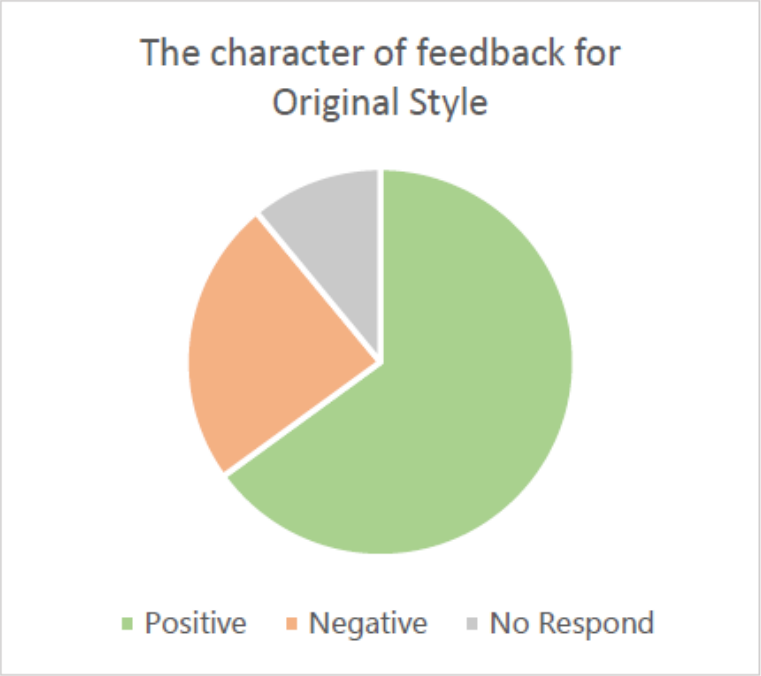


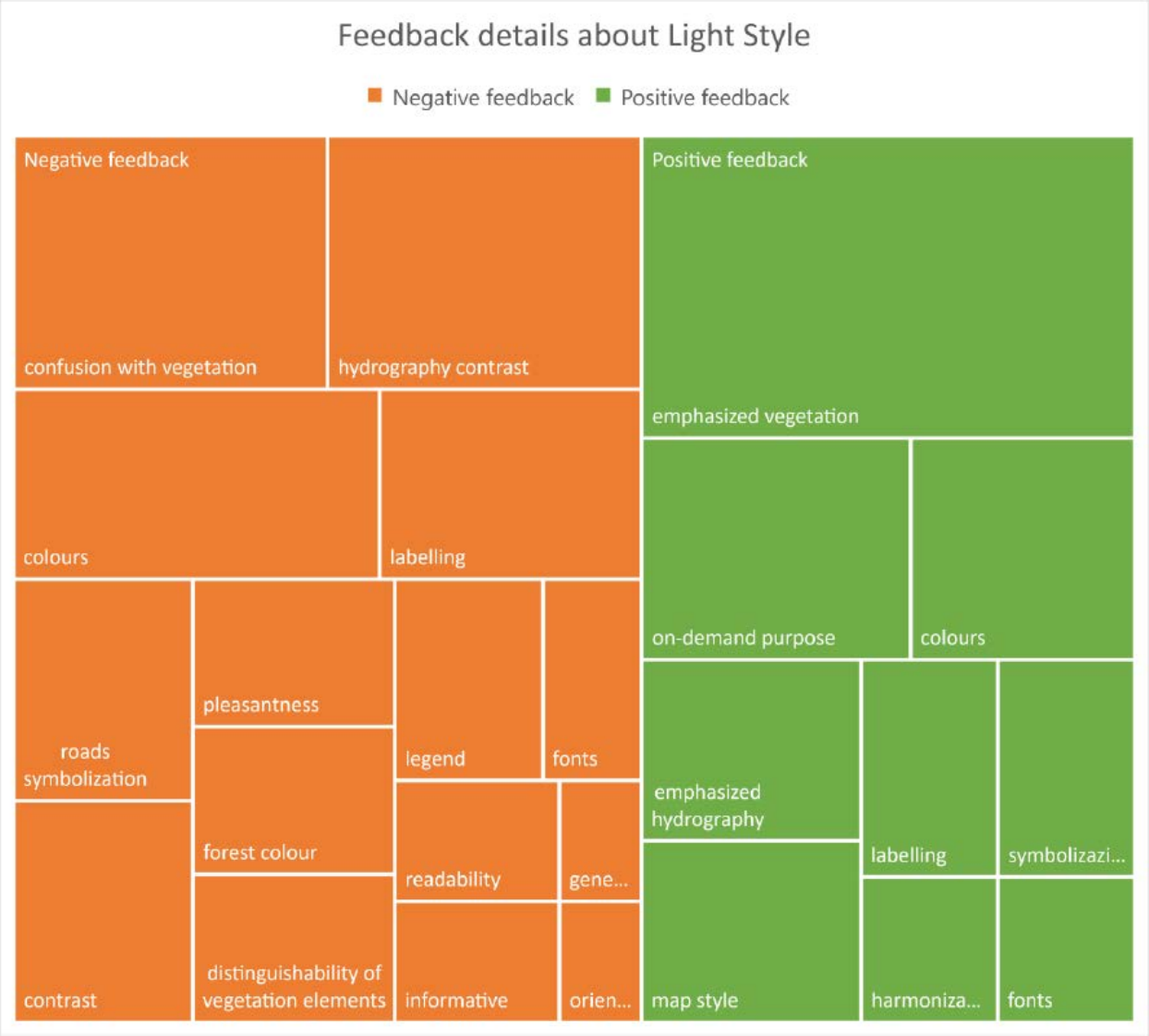
# 5. Results & Discussion



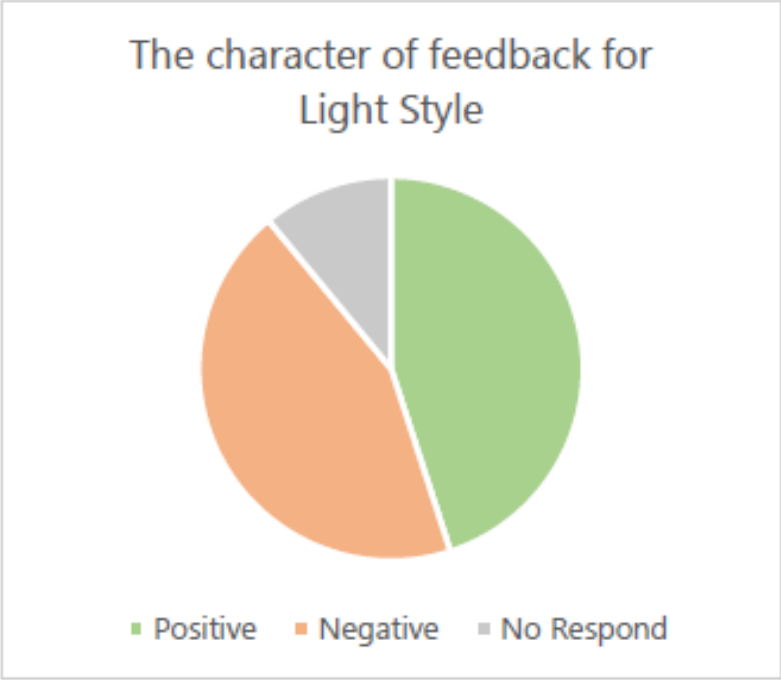

**Questionnaire results:**
**Feedback for the Original map style**



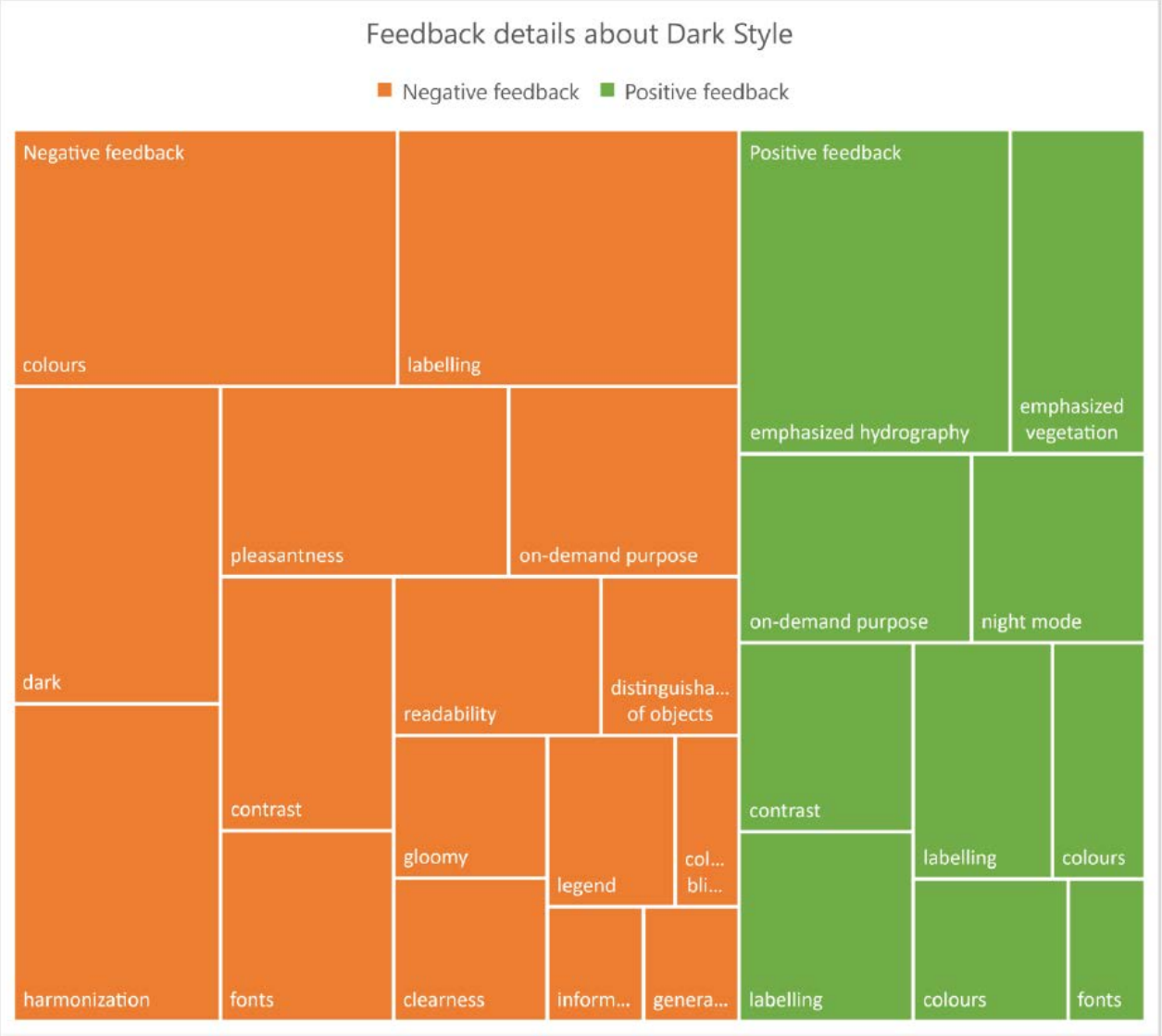
# 5. Results & Discussion



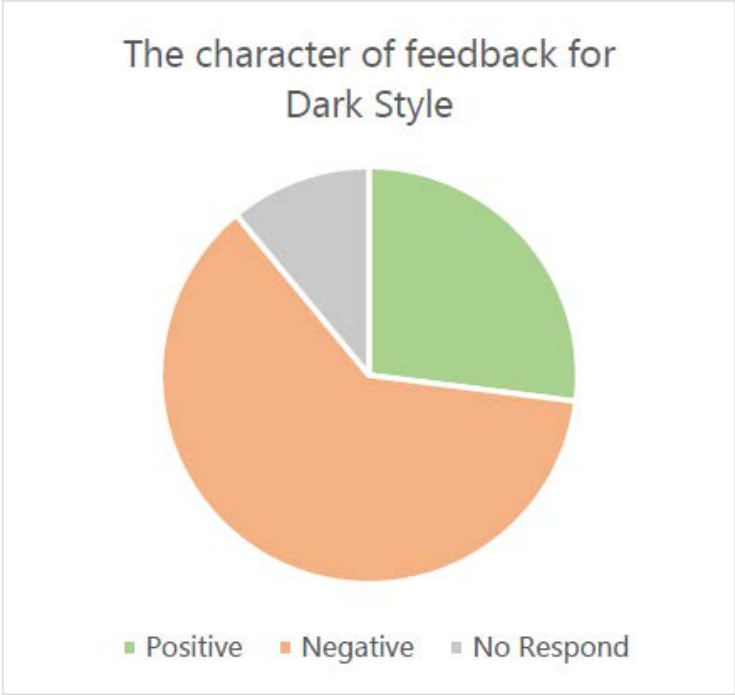

**Questionnaire results:**
**Feedback for the Light map style**



# 5. Results & Discussion




**Questionnaire results:**
**Feedback for the Dark map style**



# 5. Results & Discussion

**Updated multi-scale base map application**

Based on the conclusions of the questionnaire results, next changes were applied:

- Improve Original map style
- Improve Light map style
- Delete Dark map style

openwebsite = New try me! OR extralink = http://188.226.166.167/v2/

# 6. Conclusions

I. usage of raster tile-based map architecture remains the major approach in building web maps and tiled web map services

II. pre-rendered raster tiles have a lack in flexibility in the context of design, styles and content

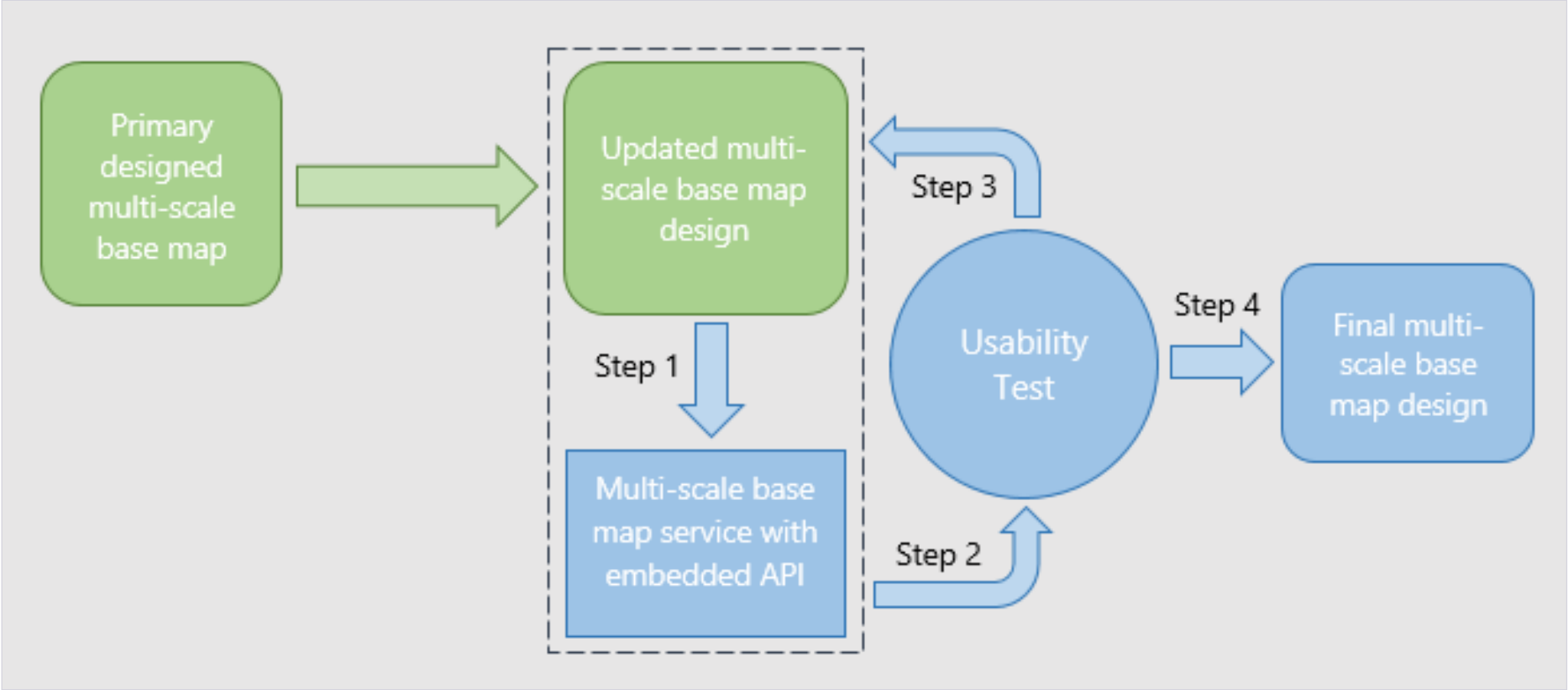
III. base map design must be conducted according to certain cartographic criteria, user requirements and map usage purposes

IV. created base map should be evaluated by experts and tested by users, and the feedback is essential

V. application of vector tiles adds some flexibility in the styling of tiles and it becomes more feasible

# 7. Future Work & Recommendations

Purposes of produced base maps are localization, orientation, and thematic support




Steps 1, 2 and 3 are continuing until the usability goals can be achieved

***Step 1.*** apply styles to the whole world and embed API (supported by ILWIS professional programmers)

***Step 2.*** conduct the usability test in ILWIS or any other GIS software

***Step 3.*** update the multi-scale base map with usability test outcomes

***Step 4.*** deploy and supply the multi-scale base map as a tiled web map service for GIS software

# Questions ?
# Comments !
# Suggestions ...

THANK YOU FOR YOUR ATTENTION

KIND REGARD, TARAS DUBRAVA