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**Master thesis**

# Visualization of Landscape Changes in a 3D Environment using the Storytelling Approach – the Example of the City of Pristina

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## Statement of Authorship

Herewith I declare that I am the sole author of the submitted Master's thesis entitled:

Visualization of Landscape Changes in a 3D Environment using the Storytelling Approach – the Example of the City of Pristina.

I have fully referenced the ideas and work of others, whether published or unpublished. Literal or analogous citations are clearly marked as such.

Munich, 10.10.2021 Festina Sadiku

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## Abstract

In recent years, new opportunities to visualize our environment in three or four dimensions have been created, including animations over time or moving through space. Advances are the increasing interest to the landscape and environmental professions. With the help of such visualizations, also landscape changes can be visualized with different techniques and in various forms. But are users able to extract relevant information about landscape changes from an animation that is projected on top of a 3D model?

In order to get insights into how landscape changes can be attractively visualized in such an environment, this thesis proposes a detailed concept of how landscape changes can be transferred and communicated in a 3D environment using the storytelling approach. Furthermore, this thesis presents a framework how the landscape change can be retrieved out of textual descriptions about landscape changes.

A prototype consisting of a 3D wooden model and 10 buildings with transparent PLA material has been developed. A projected lightshow overlaying the 3D model and the buildings for the City of Pristina was implemented. The key element of the integrated user interface is a timeline. The types of elements used within the projection are cadastral maps, orthophotos, text, graphics, and background sound.

Finally, a user test was conducted among users with different professional backgrounds and different prior knowledge. Users were asked for their experience regarding working with visualization methods to show the landscape changes and the first impression of the model itself and its features.

In general, users stated that the model looked accurate, informative, and attractive to them. Nearly all users really liked the preparation of the 3D wooden base model and the buildings, and how the landscape change was narrated. The tracking of the changes between the years, the combination of the orthophoto and the audio, the combination, and synchronization of the text part with the effects were considered excellent. Also, during the interviews, the users mentioned that the incorporation of the light source coming from the projector was exciting. However, users of the older age group had problems transmitting both elements: audio text and presentation changes.

The methodology and techniques applied in this thesis are developed to visualize urban changes as in the case of the City of Pristina and can be applied to cities with similar landscape changes. In general, every landscape change has to be narrated differently, but it is possible to visualize a landscape change in a 3D environment using the storytelling approach.

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# 1 Introduction

## 1.1 Motivation and Problem Statement

In 2011, Popelka and Brychtová stated that visualizations of landscapes and historical objects are used in many fields, especially in tourism. Visualizing landscape changes encourage users in understanding and comparison of the past with the present (Popelka & Brychtová, 2011).

Arroyo Ohori et al. (2017) clarify that objects with more than three dimensions can be used to model geographical phenomena. Geographical phenomena that occur in space, time and scale. Furthermore, they state that space can be modeled using solid primitive constructive geometry or different ways of representing boundaries among others. Time can be modeled on the basis of snapshots, space-time compositions, events, or a combination of all of these.

In 2018, Mocnik and Fairbairn argued that maps are good to represent a geographic space but text have a better benefit than maps for telling a story. The storytelling method uses geography as a tool for organizing and presenting information, combined with text, photos, illustrations, video, and audio and capture the attention of the map reader's where it includes the expression of emotions (Mocnik & Fairbairn, 2018).

In accordance with the three viewpoints above, this research will use cadastral plans with height attributes to create the 3D model. An animation composed of satellite images, texts, cadastral maps and other multimedia features will be projected on top of this 3D model to show historical landscape changes with the storytelling method.

The thesis idea is coming from the Stolen Heart Video animation[1] where the storytelling method is used to inform about the theft of the Jewish property in Berlin's Historic Center, between 1933 and 1945.

This story is inspiring and a similar story narrated for the City of Pristina could be a huge benefit for the city itself but also for the visitors and tourists to better understand the history. The case study will be based on the history of the Mother Teresa & Zahir Pajaziti Boulevard.

Until today, the landscape change of the Mother Teresa & Zahir Pajaziti Boulevard in Pristina is only told based on text. No map, interactive animation or visualization or 3D model is existing. The narration in textual format is neither attractive nor very informative.

The authors Houtkamp et al. (2014) state that 3D digital models and virtual environments have been used in the fields of archeology and cultural heritage for several decades. The preferences of digital visualizations of landscapes over time have been broadly recognized and acknowledged. Much information is presently available about their usability and viability in meeting particular objectives, for example in education (Houtkamp et al., 2014). However, it

[1] https://segd.org/stolen-heart-video-map (last access: 24 July,2021).

is not well understood how entirely textual data without any geo-location can be transferred and communicated in a spatial 3D model. Therefore, this thesis main motivation is to demonstrate how the existing textual information can be transformed into an attractive narrated and animated story projected on top of a 3D model.

## 1.2 Research Objectives and Questions

### 1.2.1 Research Objectives

The main objective of this thesis is to investigate how textual descriptions about landscape changes can be transferred and attractively communicated in a 3D model using the storytelling method.

This overall objective can be divided into two sub-objectives:

I. Visualization of textual descriptions using storytelling method.

II. Evaluation of the effectiveness of the visualization (3D model and projection).

### 1.2.2 Research Questions

In order to reach the research objective, I, the following research questions need to answered:

I-a) How are the landscapes changes revealed in textual descriptions?

I-b) How can the textual descriptions transferred into a spatial model?

I-c) Which further datasets are needed for the creation of a 3D model and what further storytelling elements are beneficial for projection in order to visualize landscape?

In order to reach the research objective II, the following research questions need to answered:

II-a) Is a projection (lightshow) on top of a 3D model an attractive opportunity to visualize landscape changes?

II-b) Can the user see the changes through time in this visualization?

## 1.3 Innovations Intended

The innovative part of the research is twofold: First, a method will be developed how the available textual descriptions can be systematically analyzed. Second, it will be proposed how the textual information can be spatialized, means how they can be transferred to the projection on top of a 3D model using the storytelling method.

The hypothesis guiding this research is that it is possible to spatialize textual information in such a way that they can be visualized as projected layers (lightshow) on top of a 3D model. This is a useful and an attractive way to visualize landscape changes and should be preferred over entirely textual descriptions.

## 1.4 Thesis Structure

The summary of each chapter of this thesis is outlined here. The thesis is divided into six chapters.

Chapter 1: Motivation and problem statement are given, research objectives, and research questions are defined.

Chapter 2: Chapter two provides first an overview of state of art related to the visualization of landscape changes. It describes the needs, methods and examples of visualizing landscape changes in different environments. Furthermore, this chapter includes information on how landscape changes can be narrated, including storytelling and spatialization of textual descriptions.

Chapter 3: The third chapter describes the research methodology chosen to distinguish the thesis goals. The whole workflow from crafting the 3D model to building the animation and setting up the evaluation is explained.

Chapter 4: The fourth chapter will give a brief introduction to the location of the case study and data used. The applications for building the 3D model and implementing the animation narrating the landscape changes for the city of Pristina are explained in detail.

Chapter 5: In this chapter, the questionnaire and interview results and their discussion are presented.

Chapter 6: In the last chapter, the conclusion and outlook for future research, are outlined.

# 2 State of the Art

This chapter focuses on the state-of-the-art related to the visualization of landscape changes. Chapter 2.1 describes the need of visualizing landscape changes. In order to show the methods of visualization of landscape changes, several currently existing examples in different environments are described (chapter 2.1.1-2.1.4). In each of the four chapters, several visualization examples will be introduced and the methods applied to the visualizations will be described. Chapter 2.2 outlines information about storytelling and spatialization that can be used for the narration of landscape changes.

## 2.1 Visualization of Landscape Changes

Landscapes are constantly changing due to the human interaction with the natural environment. Historical maps, landscape paintings and drawings give humans a visual impression how a specific landscape looked in the past (Sheppard, 2005).

Humans are interested to detect the landscape changes and being informed about them (Sheppard, 2005). In landscape changes, the relationship between humans and the natural environment is addressed to understand the consequences of these interactions in ecological, economic, and socio-cultural contexts (Sheppard, 2005).

As Sheppard (2005) noted, the community has become increasingly concerned with the visible effects of environmental change, especially in landscapes. For many people, understanding the change is linked to seeing their effects, and visual simulation is playing an increasingly important role in communicating landscape changes. Unlike technical language and information, visual images are easily readable and understood by the public. Sheppard (2005) present a concise history of landscape change visualization techniques. Over the past 15 years, there has been an increment in investigation projects looking to create or apply technological tools for 3D landscape modeling.

According to Svatonova & Rybansky (2014), with the help of visualization, a realistic idea of the presented spatial relationships, landscape changes, and environmental processes can be created. Sheppard (1989) argues that mapping landscape changes is a fundamental mission of cartography. Bogucka & Jahnke (2017) agree and state that mapping landscape is the basic mission of cartography.

Landscape changes can be visualized with different techniques and in various forms. Traditionally, the changes have been visualized using topographic maps, photographs, drawings, and paintings.

Since the 1960s photographs and photomontages have been widely used and from the 1990s the improved capabilities to link CAD, GIS, and landscape visualization software have substantially enhanced the possibilities for digital representation also in a 3D environment (Sheppard, 2005). Static geographical phenomena need to be described by size, location, shape, and meaning while location together with time describes dynamic phenomena (Lewis & Sheppard, 2006).

In recent years, important advances in computer graphics have created exciting new opportunities to visualize our environment in three or four dimensions (where it can be animated over time or moving through space). Presentation of landscape visualizations can be static or dynamic, with different levels of interaction, and in immersive or non-immersive displays (Sheppard et al., n.d.). This results in a major interest to the landscape and environmental professions. Recent important developments include a highly realistic representation of vegetation, an efficient display of the terrain, and the automatic generation of landscape models and images from GIS-based data (Young, 2007).

Appleton et al. (2002) found, that nowadays a common approach is to compile data for a study area in a CAD or GIS database and create three fundamental sorts of 3D yields out of it. According to Appleton et al. (2002), there exist three fundamental sorts of 3D yields, which are:

1. Rendered images (or scrolling panoramas) from defined viewpoints,
2. Animated sequences (showing fly- through along specified paths or changes over time),
3. Real-time models (or virtual worlds) where the user can freely navigate a landscape.

In his research from 2005, Nicholson-Cole found that landscape visualizations include facilitating engagement (raising interest in an issue), developing shared understandings (social learning), collaboration (reaching agreement on a course of action), and education (Nicholson-Cole, 2005). Nicholson-Cole (2005) classified landscape visualizations as follows:

- Engagement (level of interest, and attention),
- Cognition (related to knowledge, awareness and understanding),
- Affect (related to feelings, perceptions, and emotions),
- Behavior (related to changes in the behavior of the viewer).

Consequently, several visualizations of landscape changes exist. Several examples have been collected and analyzed for this thesis. For a better overview, the visualizations have been categorized in four different groups: (1) 2D visualizations, (2) 3D visualizations, (3) 4D visualizations, and (4) visualizations in virtual, mixed, and augmented reality. The four categories will be explained in the following subchapters.

### 2.1.1 Visualization of Landscape Changes in 2D

In landscape visualization, visualization objects are the equivalents to mapping objects in two-dimensional maps (Egberts & Bosma, 2014). Most visualizations of landscape changes simply using one, two or more maps in a 2D environment. These maps are placed next to each other in order to allow the map reader to easily compare two or more different stages and to communicate the landscape change. Cajthaml & Pacina (n.d.) argue that old maps provide a large amount of information about the historical landscape. In addition, georeferencing, vectorization, and change analysis can lead to impressive results. Changes can be displayed as area change values, classic printed maps, or online mapping applications. 3D landscape printing is a bold new method for user-oriented visualization.

An example: Below in figure 2.1, the difference of "Mount St. Helens"[2] before and after the eruption is shown by a photograph taken from the same viewing location. Figure (a) shows the situation of Mount St. Helens before 1980, before the collapse of the dome complex. While it can be seen very clearly in figure (b) the change after 1980 where the eruption occurred.


Figure 2.1 A picture taken from the same viewing location, showing Mount St. Helens before (a) and after (b) the eruption [2].

The map on the figure 2.2 (a) shows that the volcano was a cone with a height of 9677-feet and the landscape before the eruption. The map on the (b) shows the topography of the mountain as it is today with the 8363-foot height of the peak. The event dramatically changed the volcano and surrounding land in southwestern Washington.

The "Swiss World Atlas" [3] used the same map extract and a shaded relief to make the landscape visible in a map. The same colors are used for forests, except that in the figure after

[2] https://www.reddit.com/r/pics/comments/86ub1c/Mount_st_helens_before_and_after_the_eruption_of/ (last access: 24 July,2021).
[3] Swiss World Atlas, 2010 (last access: 24 July, 2021).

(b) the eruption you can see the difference in the color of the forest and this is due to the eruption. The appearance of isohypse can also be clearly seen where the quota is 2550.

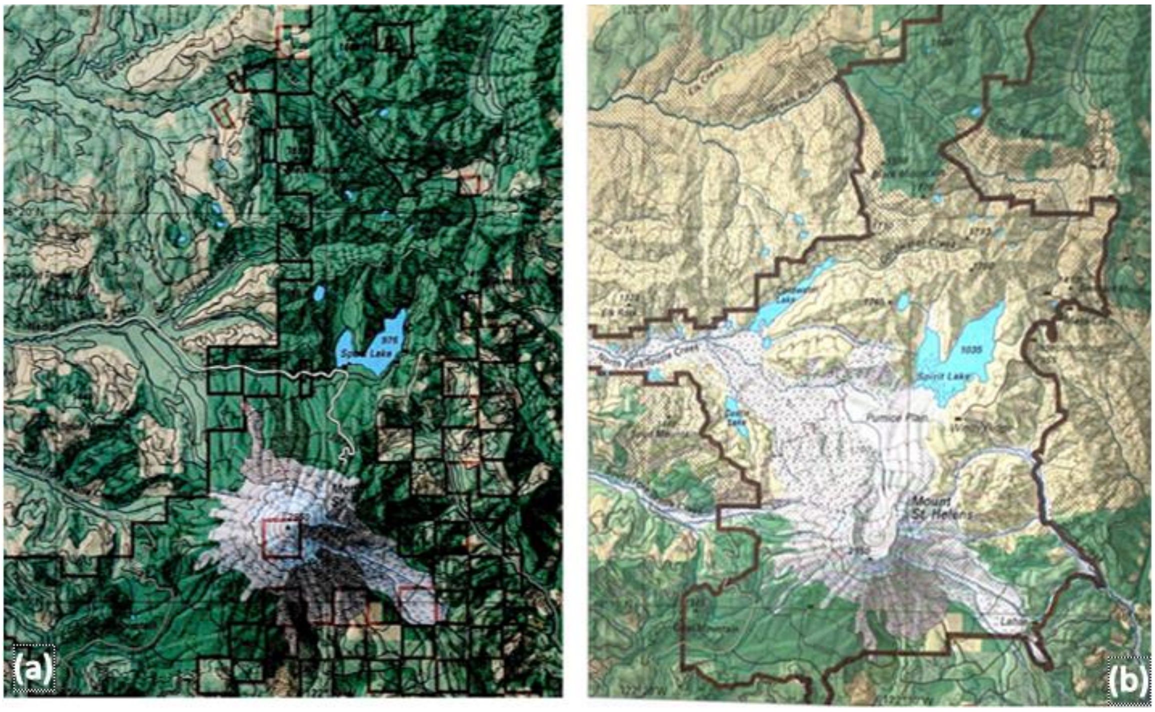



Figure 2.2 Mount St. Helens before (a) and after (b) the eruption in a topographic map [3].

Besides maps, also satellite images and aerial photographs are used to present the landscape change in 2D in a visual way. An example is the visualization of “Madrona Marsh “ [4]. The Madrona Marsh in the city of Torrance in the region of Southern California looked like before and after a string of storms (see figure 2.3). Many people find aerial photographs easier to understand than maps, possibly because these photographs provide more clues about the landscape. People with low map-reading skills tend to prefer photorealistic landscape visualizations (Schroth, 2010). Aerial or panoramic photos not only bring out the participants' local knowledge, but also give the participants a sense of familiarity and help to make comments about the landscape (Schroth et al., 2011).

[4] https://www.skyladderdrones.com/projects/2d-mapping_madrona_marsh/ (last access: 24 July,2021)


Figure 2.3 Madrona Marsh before and after a string of storms [4].

Also, visualization examples exist where the landscape change is shown in more than one map, simply by adding a map overlay, by highlighting and by using transparency to show different stages. An example for this is the "renaturation of the Lippe in Paderborn-Sande" [5] where in the first map (a) the development of the Lippe with its profile cut deep and the floodplain can be seen, wherein in the second map (b) an overlay is used. With the help of the overlay, user's get new information as about the renaturation and bed evaluation. In the third map (c), the authors added another overlay for humidity and roughness (see figure 2.4).

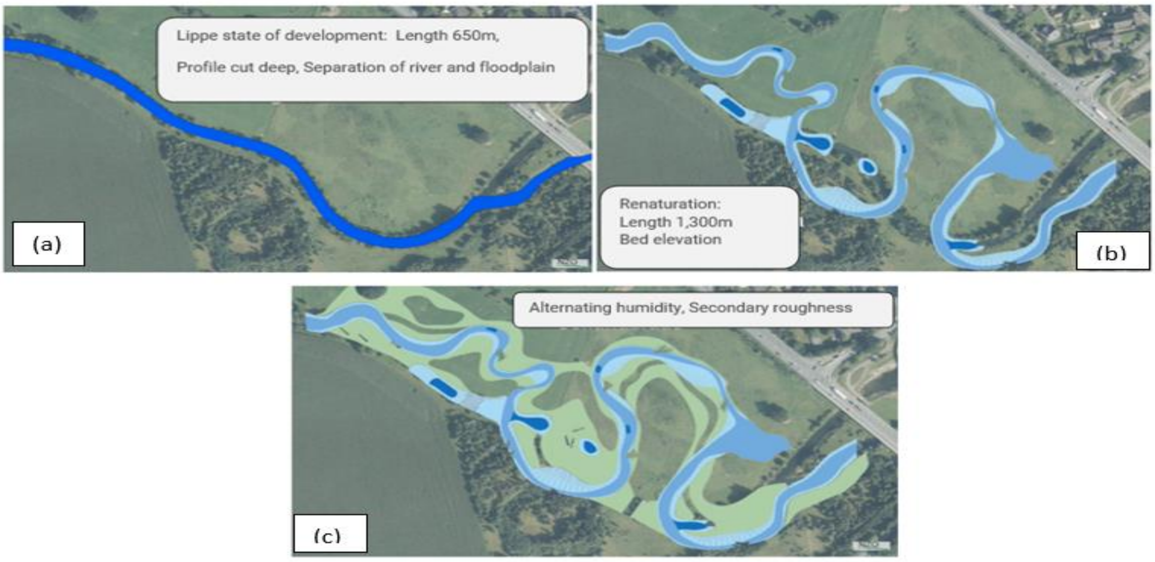



Figure 2.4 Renaturation of the Lippe in Paderborn-Sande [5].

[5] https://www.wilde-lippe.de/lippe-renaturierung/massnahmenbeschreibung/ (last access: 24 July,2021)

In total, eleven examples have been analyzed, Table 2.1 gives an overview of all examples and the visualization method used to visualize the landscape change.

| | Name of the Example | 2D map (s) | 2D satellite image (s) or aerial photographs | Animation | Overlay | Highlighting | Time Series |
|---|---|---|---|---|---|---|---|
| 1 | Explosion in Beirut | x | x | | | | |
| 2 | Nuremberg | x | x | | x | | x |
| 3 | Munich | x | x | | x | | x |
| 4 | Waldkraiburg | x | x | | x | | x |
| 5 | Neckarland and Swabian Alb | x | | x | | | |
| 6 | Renaturation of the Lippe | | | | x | x | x |
| 7 | Madrona Marsh | x | x | | | x | x |
| 8 | Mount St. Helens | x | x | | | | |

Table 2.1 Analyzed examples from visualization of landscape changes in 2D.

The example of "Beirut" [6] shows the big explosion in the Lebanese capital. To show the landscape changes, aerial photographs and satellite images are used in accordance with 2D maps to show the city in ruins before and after the big explosion in the Lebanese capital.

In the case of "Nuremberg" [7], landscape changes occur in different places such as: Port, Central Station, City Center, Castle, Main Market, Nuremberg. The changes can be clearly seen in the development of construction and nature. In the case of the Port, four satellite images are displayed showing the changes that have taken place over the years. With the help of a time series, users can understand information about the city and the years of change.

[6] https://www.maz-online.de/Nachrichten/Bildergalerien/Explosion-in-Beirut-Luftbilder-zeigen-die-Stadt-in-Truemmern (last access: 24 July, 2021).
[7] https://www.ldbv.bayern.de/vermessung/luftbilder/archiv.html (last access: 24 July, 2021).

In the "Munich" [8] example, satellite imagery and times series are used. The Frauenkirche, Central station, Sendlinger Tor are the places where landscape changes are shown between the years 1963-1978-2009. The changes appeared in the great development in construction as well as in nature.

In the "Waldkraiburg" [9] example, the visualization methods used are the presentation of satellite imagery, times series and overlay. Landscape changes appeared during these years 1963 1977-1994-2009. The changes could be seen more during 1963 and 2009 in greenery and construction.

In the examples of "Neckarland"[10], Saxon Switzerland, and the Swabian Alb, topographic maps (ATKIS data) were scanned, georeferenced, edited and used as map base.

In the example of "Lippe Paderborn Sande" [5] the landscape change is shown with more than one map by adding a map overlay, highlighting and using transparency to show the different stages.

To sum up, the following methods have been used individually or in combination in different 2D visualizations.

- 2D map (s),
- 2D satellite image (s) or aerial photographs,
- Animation,
- Overlay,
- Highlighting,
- Time series.

### 2.1.2 Visualization of Landscape Changes in 3D

Landscape visualizations are specific forms of geo-visualization, which can also represent the visual landscape in perspective 3D views and with varying degrees of realism (Egberts & Bosma, 2014). According to Egberts & Bosma (2014), 3D visualizations are flexible and effective media for conveying complex spatial or geographically-based information to a varied audience. They also convey the so-called "effective" qualities; these are characteristics that make viewers experience emotions towards the environment, such as excitement, fear, attraction.

Bogucka & Jahnke (2018), describe the landscape change of the "Royal Castle in Warsaw"[11] that has been visualized using the Space-time cube. The Space-time cube can be viewed on a

[8] https://www.ldbv.bayern.de/vermessung/luftbilder/archiv.html (last access: 24 July, 2021).
[9] https://www.ldbv.bayern.de/vermessung/luftbilder/archiv.html (last access: 24 July, 2021).
[10] https://learn.opengeoedu.de/monitoring/landschaftstrukturmasse/forschungsbeispiele/landschaftsveraenderung (last access: 24 July, 2021).
[11] Bogucka, E., & Jahnke, M. (2018). Feasibility of the Space–Time Cube in Temporal Cultural Landscape Visualization (last access: 24 July, 2021).

3D globe (Caesium). Cases of utilize for progressed space-time visualization strategies are directions of moving objects as well as occasions, which are happening at distinctive places and at distinctive times (see figure 2.5).

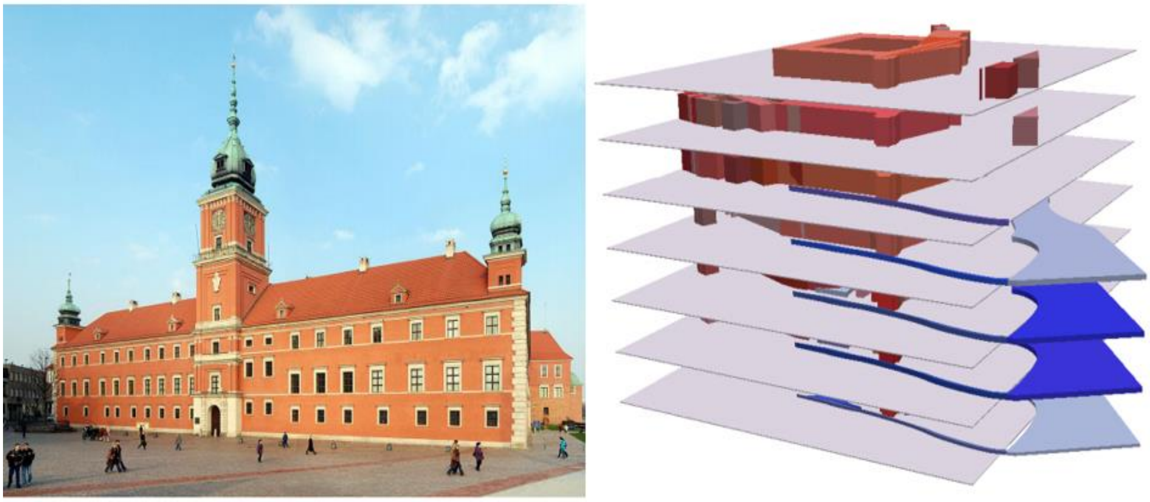


Figure 2.5 The model of the space time-cube for landscape changes depiction of the Royal Castle in Warsaw [11].

Popelka & Brychtová (2011) use five visualization components to precise the spatial-temporal change within the "City of Olomouc"[12]. Textual information, historical and contemporary photographs, georeferenced historical maps overlaid over a current orthophoto, a 3D map and a photorealistic model are used (Popelka & Brychtová, 2011). According to Popelka & Brychtová (2011) changing the transparency of the old maps, the historical situation can be directly compared with the modern situation (see figure 2.6).

[12] Popelka, S., & Brychtová, A. (2011). Olomouc Possibilities of Geovisualization of the Historical City (last access: 24 July, 2021).

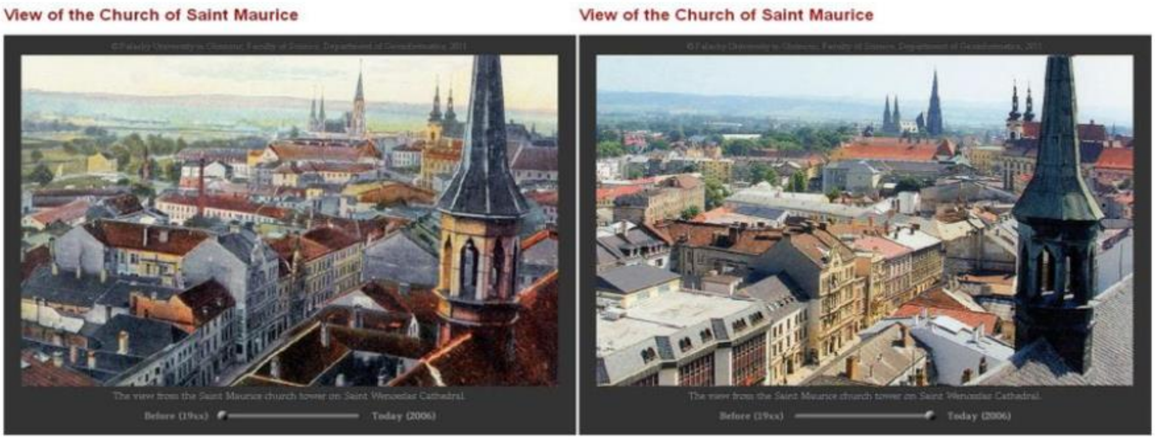



Figure 2.6  Flash application for comparing two images from different time periods [12].

Figure 2.7  Flash application for comparing two images from different time periods [12].

A large number of historical maps, prints, and paintings exist of the “Honselaarsdijck palace” [13] and its surrounding landscape. The static images offer only a limited degree of interactivity and perspective (see figure 2.8). From digital color-prints of historical drawings and paintings, some relevant topographic information about the outward building and garden appearance of the Palace Honselaarsdijck estate is extracted. Historical maps and paintings can be upgraded to a 3D virtual environment.

[13] Houtkamp, J., & Kramer, H. (2014), Visualization of Place and Landscape (last access: 24 July, 2021).

Figure 2.8 Palace Honselaarsdijck in year of 1683 and 2008 [13].

In example of village “Shimo-Okubo” [14] located in Japan, Onitsuka et al. (2018) visualized the landscape change by using drone images and arranging them in an animation

Parts of the “City of Presov”[15], Sekcov have undergone major changes over the past 50 years. Created virtual city 3D models help to better understand morphological and also functional changes in the city. With the help of times series, a 3D city model city of Sekcov the changes in land use and new construction sites (apartment blocks, schools and other facilities - presented in a different color) from 1959 to 2012 have been visualized.

The authors of the “Usti”[16] example focus on landscape reconstruction and created a database of vanished municipalities in the Usti region. Besides aerial images, chronicles, historical photographs, old maps are used as the main visualization component. The old maps provide a huge amount of information about the historical landscape. The Usti project shows that georeferencing, vectorizing and change analysis can lead to impressive results. All Changes can be presented as values of area changes, classic printed maps, or web mapping applications (Popelka & Brychtová, 2011).

[14] Onitsuka, K., Ninomiya, K., & Hoshino, S. (2018). Potential of 3D Visualization for Collaborative Rural Landscape Planning with Remote Participants (last access: 24 July, 2021).
[15] http://web.science.upjs.sk/hofierka/projekty/vega3_results.html (last access: 24 July, 2021).
[16] Cajthaml, A. J., & Pacina, D. J. (n.d.). Using of Old Maps within Landscape Changes Analysis (last access: 24 July, 2021).

The visualization examples that have been found and analyzed within the thesis are summarized in table 2.2.

| | Name of the Example | 3D map (s) | Photorealistic | Animation | Overlay | Highlighting | Time Series | Orthophoto | Textual info. |
|---|---|---|---|---|---|---|---|---|---|
| | | | 3D model | | | | | Aerial images | |
| 1 | Kyoto, Japan | x | x | x | | | | x | |
| 2 | 3-D city models for the Sekcov area | x | x | | | x | x | | |
| 3 | Royal Castle in Warsaw | x | | | x | x | x | x | |
| 4 | City of Olomouc | x | x | | x | | x | x | x |
| 5 | Palace Honselaarsdijck | x | | | | | x | x | X |
| 6 | Usti region | x | | | | | x | x | X |

Table 2.2  Analyzed examples from visualization of landscape changes in 3D.

To sum up, the following methods have been used individually or in combination in the different reviewed 3D visualizations.

- 3D map (s)
- Photorealistic 3D model
- Animation
- Overlay
- Highlighting
- Time Series
- Orthophoto | Aerial images
- Textual information

### 2.1.3 Visualization of Landscape Changes in 4D

Objects of more than three measurements can be utilized to show geographic wonders that happen in space, time, and scale. An example of a visualized landscape change in 4D is “The Stolen Heart Video Map”[17]. The example uses 3D objects with interactive projected layers (animation) on top of a 3D model to show time periods. The Stolen Heart Video Map applied aerial views of Berlin's city center from 1933 to the present day. The video content is incorporating archival images and topographic time-lapse elements (see figure 2.9).

Figure 2.9 Stolen Heart Video Map projection (left), extract of Berlin city center with projected orthophoto (right) [17].

Another example of a visualized landscape change in 4D is “The Berlin Wall” [18], an animated story projected on top of a 3D model (see figure 2.10). The Berlin Wall story combines text, audio, and small details like moving planes, and the line of change of the wall to visualize the event.

[17] https://segd.org/stolen-heart-video-map (last access: 24 July, 2021).
[18] https://cartographymaster.eu/general-news/student-story-berlin-wall-an-animated-story-on-a-3d-model/ (last access: 24 July, 2021).

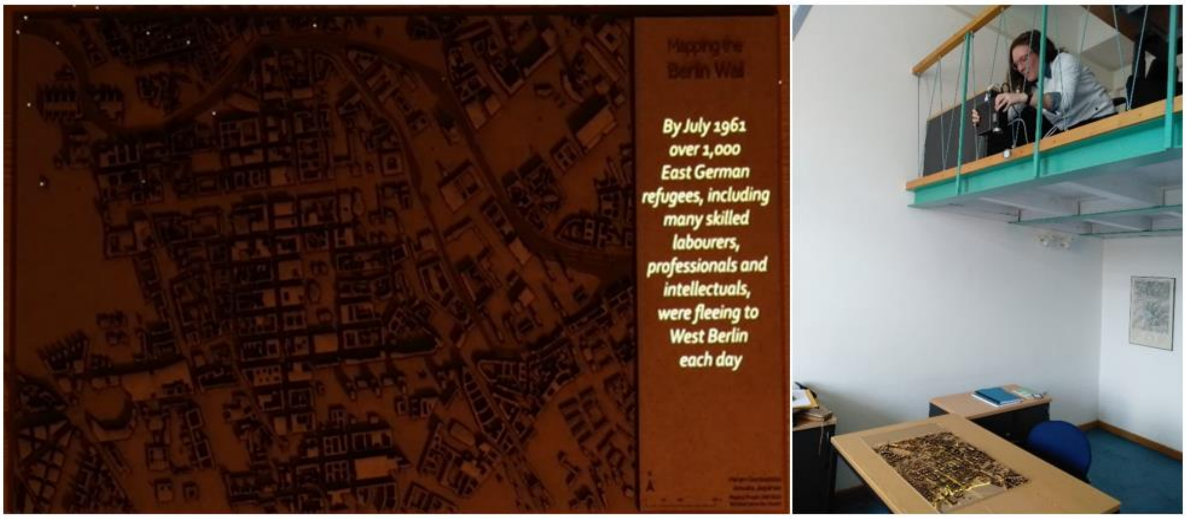



Figure 2.10 The Berlin Wall project [18].

Appleton & Lovett (n.d.) describe a visualization of a landscape change in 4D in “White Bastion fortress, Sarajevo”[19]. The 4D virtual presentation displays the historical development of this cultural heritage object through storytelling combined with interactive 3D models of the Bastion in various time periods. The “White Bastion” [20] fortress story combines time series of aerial photographs, interactive 3D models, and information about new buildings or demolitions (see figure 2.11).

Casein an example showing the change of the” City of Verona” [21], historical aerial photographs are used with dense image matching algorithms to realize 3D models of the city in different years. The models are used to study the urban development of the city and its changes through time.

Figure 2.11 Sample images of the time series: 1954, 1981, 1997 [21].

[19] Rizvić, S. (2018). Chapter 5. A 4D Virtual Presentation of the White Bastion Fortress in Sarajevo (last access: 24 July, 2021).
[20] Appleton, K., Lovett, A., Sünnenberg, G., & Dockerty, T. (2002). Rural landscape visualization from GIS databases: A comparison of approaches, options and problems (last access: 24 July, 2021).
[21] Adami, A. (2015). 4D city transformations by time series of aerial images (last access: 24 July, 2021).

In total, five examples have been found and analyzed. A summary of the found visualization is shown in table 2.3.

| | Name of the Example | 3D Model | Aerial/Satellite Images<br>Historical/Archival Images | Animation | Overlay | Virtual Reality | Time Series |
|---|---|---|---|---|---|---|---|
| 1 | White bastion fortress in Sarajevo | x | x | x | x | x | |
| 2 | Verona city | | x | | | | x |
| 3 | Berlin Wall | x | | x | x | | x |
| 4 | Stolen Heart Video Map | x | x | x | x | | x |

Table 2.3 Analyzed examples from visualization of landscape changes in 4D.

To sum up, the following methods have been used individually or in combination in the different 4D visualization.

- 3D model (physical)
- Aerial/satellite images or historical/archival Images
- Animation
- Overlay
- Virtual reality
- Time series

### 2.1.4 Visualizations in Virtual, Mixed and Augmented Reality

Eve (2018) agreed that the prospect of recreating a historic environment with virtual reality (VR) techniques is so enticing. Augmented reality (AR) is a way of combining digitally created content with the real world and also it is a part of the wider concept known as mixed reality (MR). Mixed reality is generally approved as a way to seamlessly combine our perception of the real world with digital or created elements. Eve (2018) furthermore described the term augmented reality as a combination of the real scene viewed and a virtual scene generated by the computer in which the virtual objects are superimposed on the real scene.

In an interactive environment, the maps are mostly arranged within an animation. An example is described by Houtkamp et al. (2014) in the project "Things have changed" [22]. The VR visualization is created using topographic maps made in 1900 and 2006 in a region in the

[22] Houtkamp, J., de Boer, A., & Kramer, H. (2014). Visualization of Place and Landscape (last access: 24 July, 2021).

southern part of the Netherlands. Navigating the environment, viewers become aware of the effects of landscape features on their viewing points. The animations of the historical and current landscape are juxtaposed and presented to the user together with a 2D route map for navigation purposes (see figure 2.12).

The immersive visualization offers the user the opportunity to explore the transformation from a landscape to a small-scale urbanization and natural habitats in a characterized modern landscape from large-scale, man-made interventions.


Figure 2.12 Topographic maps in the time series: 1960, 2006 [22].

For the "Rome Reborn project" [23], a virtual reconstruction was created of the entire city of ancient Rome. The primary objective was to spatialize and present information and theories on how the city looked at that moment in time; and, the secondary aim was to make available the sources of archaeological information and the speculative reasoning supporting the digital reconstruction. The Rome Reborn project includes high quality graphics, precise textures as well as environmental elements (animated bodies of water, fog, clouds), to create a more attractive, immersive experience for the users (see figure 2.13 and 2.14).

[23] https://www.romereborn.org/content/colosseum-district (last access: 29 July, 2021).

Figure 2.13 A Digital Model of Ancient Rome 1 [23].

Figure 2.14 A Digital Model of Ancient Rome 2.0 [23].

Case study of the “Royal Castle in Warsaw”[24], Poland has undergone many transformations in its appearance during its existence period since the fourteenth century till nowadays. the primary objective was to explore the visual design aspects of the space-time cube in mixed reality (Jahnke et al., 2019). Royal Castle in Warsaw includes map elements implemented in the MR space-time cube hologram: 3D space-time cube, Interactive map legend, landscape features, text, time subintervals (see figure 2.15).

[24] Turchenko, M. (2018). Space-Time Cube Visualization in Mixed (https://cartographymaster.eu/wp-content/theses/2018_TURCHENKO_Thesis.pdf) (last access: 24 July,2021).

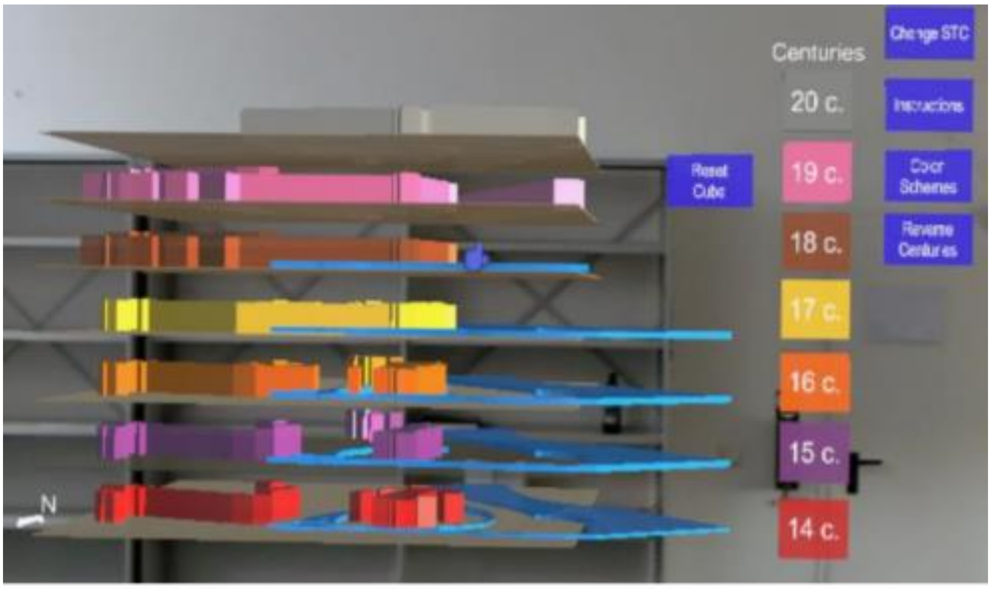



Figure 2. 15 Spacing of the time subintervals [24].

Table 2.4 summarizes the findings of the found and previous described examples.

| | Name of the Example | 3D Model | Aerial/Satellite Images / Historical/Archival Images | Animation | Overlay | Time Series |
|---|---|---|---|---|---|---|
| 1 | Netherlands | x | x | x | | x |
| 2 | Rome Reborn, 2012 | x | | x | | x |
| 3 | Royal Castle in Warsaw | x | x | | x | x |

Table 2.4 Analyzed examples from visualization of landscape changes in virtual, mixed and augmented reality.

- To sum up, the following methods have been used individually or in combination in the different Virtual, Mixed and Augmented Reality visualization: 3D models
- Photorealistic images
- Space-time-cube
- Higlighting
- Time series

### 2.1.5 Summary: Methods Used for Visualizing Landscape Changes

All above-described visualization methods have been used individually or in combination in an example. The analysis of the different examples gave knowledge of where it is necessary to use an overlay or highlighting option something in a projection to better visualize the landscape change. When dealing with important information or objects, overlay or lighting raises users' attention to the information or object. The time series method can be emphasized. It is a specific way of analyzing a sequence of data collected over a time interval. Most examples to show changes over different years use times series as a time series helps users understand the underlying causes of trends or patterns over time and predict everything from the landscape change report from year to year (Block, 2006). The combination of a 3D model and a time series provides a compelling level for landscape changes. In visualizing changes in the landscape, virtual reality, mixed and augmented is a way to combine digitally created content.

Time series analysis is a specific way of analyzing a sequence of data collected over an interval of time. In other words, time is a crucial variable because it shows how the data adjusts over the course of the data as well as the final results. Time series forecasting is part of predictive analytics. Time series help users understand the underlying causes of trends or patterns over time. Likewise, time series analysis is ideal for landscape changes, helping people predict everything from year starting landscape change report to future years. (Blok, 2006)

Aerial images are widely used to distinguish differences such as changes resulting from natural disasters and the reconstruction of buildings (landscape changes). Aerial images can detect landscape changes by taking the same scene at different times (Han et al., 2019). Also, aerial photographs record a lot of detail even in the relatively low contrast range.

Animation overlays and highlighting are elements that can be added at will when visualizing animation landscape change.

## 2.2 Narration of Landscape Changes

Woodfin et al. (1999) described the term landscape narratives as the interaction and reciprocal relationship that develops between landscape and narrative.

Visualized information is information converted into a spatial form and therefore, in principle, suitable for current spatial analysis techniques (Mocnik & Fairbairn, 2018). The narrative function of the text is aiming to draw the reader into a shared involvement experience or a concrete story. Often these relate to personal encounters, in some cases incorporating direct dialogue (Latifa & Manan, 2018).

A narrative text is a series of written events that are significant. A story tries to solve important, problematic events or entertain its readers. Readers generally tend to observe a text in five unique dimensions which are: place, cause, time, cause and effect, and character(s). The descriptive text focuses on the use of plain text attributes, forms, and constructs that classify or categorize events, objects, and characters. (Latifa & Manan, 2018)

Herman (2001) defined narration as the representation of the motion within coordinates, coordinates of space, and time. Reading the story Herman suggested interpreting it with horizontal and vertical movements and narrative events of the text. The horizontal narrative axis through the coordinates of space and textual time includes the linear movement of the characters. While the vertical axis includes space and time. A narrative may be a semiotic representation of a series of related events in a transient and casual way. Narratives can be built employing an assortment of semiotic media: composed or talked dialect or images. Narrative structures may be more expansive in artistic texts, but narrativization is one of the foremost common ways of establishing order and a viewpoint on experience (Daniels, S. et al, 2012).

Therriault & Raney (2007) state that more theoretical concepts are represented in expository text, allowing for the elucidation of new information, e.g., by explanations, justifications, and persuasions. Through its narrative and descriptive functions, the text provides the narration of stories, but through exposure, it can also give imagination; may represent action over time.

Mapping narratives comes with its challenges to break the narratives into pieces of places to resolve the complexity in identifying their actual location. In addition, mapping narratives can be particularly challenging as geometry and geography will need to be linked. Caquard & Cartwright (2014) found that landscape narratives tend to be conceived primarily in terms of literal storytelling. Mapping narratives can have a double purpose: exploring the geographical structure of a story and the impact of stories on the production of places (Caquard, 2013).

Recent technological progressions have also modified the connections between maps and narratives. Places showing up in narratives, such as books and historical archives, can presently be found and mapped automatically (Crampton, 2009).

Landscape changes are often simply described with texts and supported by some photographs. Within cartography, the fundamentals have been described on how the texts can be mapped.

### 2.2.1 Storytelling in Cartography

The concept, the focus of the story, which enhances the ability of maps to communicate the same information in the narrative text on a map was developed by (Mocnik & Fairbairn, 2018). The focus of the story provides a more dynamic representation of important elements in the narration of a story by applying the structural elements of the text versions of a story. The essence of representations that use the concept of storytelling means describing what is important to the story and eliminating redundancies. However, as the story unfolds, the map and its elements may change over time.

Mocnik & Fairbairn (2018) depict, maps are great at representing geographic space, but texts have a more grounded affordance of telling a story than maps. Telling stories is, in any case, important to create information more personal and to capture the map user’s attention. Storytelling describes a communicative process that passes on a story in an arrangement of events. Caquard (2013) describes the concept of ‘storytelling’ as a form of spatial expression that demonstrates personal environmental experiences and contributes to creating a sense of place.

According to Boer et al. (n.d.), a story consists of two types of events: the presumed and inferred events, such as expectations and imaginations, and the explicitly presented events. The plot of the story includes explicitly presented events, but also non-digestive visual and audio materials that are not part of the story, e.g., background music.

Poletti (2011) describes seven essential components to digital storytelling: points and perspectives, drama, emotion, economics, rhythm, voice gift, and quality soundtrack. Perspective helps to 'realize' history; the point of view makes it easy to personalize the story; the drama element helps the audience perceive the structure of the point of view powerfully and not casually. Emotion takes the place of holding the listener's attention. Perspective and emotion give context to the influence of the narrator's voice gift in telling a story.

Narrative components are inalienably incorporated in every printed or digital cartographic product. Nevertheless, they have been dismissed or ignored in most map concepts. In today's cartography, narrating is basically accomplished by story maps where users get additional context-based, narrative information as clarified in Graham et al. (2014). Gershon et al. (2001) emphasize that user's way better memorize stories than pure facts. At the example of a hostage-taking scenario, they provide a story script that, first gives an outline of the scene, then zooms into certain locations while highlighting entities and adding contents. Gershon et al. (2001) also promote the use of metaphors such as a comic-like presentation.

Storytelling is a centuries-old tradition of describing events in such a way that the audience is able to create mental images. Storytelling is known as a vital form of communication. However, digital media presents new opportunities in storytelling for the purpose of education, entertainment and marketing (Levine, 2011). The process to tell stories from data should start with data exploration followed by story formulation, and then telling the story. Lee et al. (2015) summarized the three broad phases in the "Visual Data Story Process (VDSP)" (see figure 2.15).

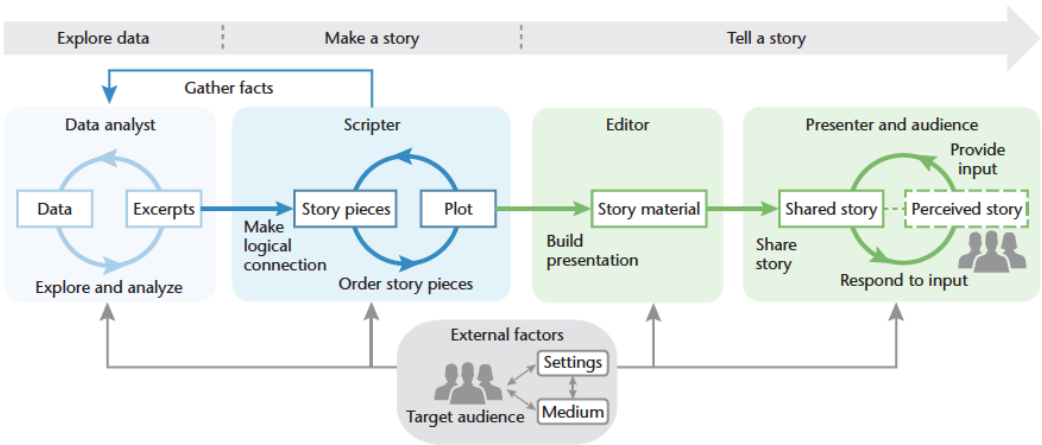



Figure 2.16 The process of storytelling process by data (Lee et al., 2015).

The three fundamental stages are: Explore the data, make a story and tell a story. The methods aren’t linear: a few of the parts have to be repeat recursively. A story can be separated into four stages: data analyst, scripter, editor and presenter.

### 2.2.2 Spatialization of Textual Descriptions

Information visualization is an interdisciplinary research field in which cartographic efforts have mainly addressed the handling of geographic information. Several cartographers have recently been involved in efforts to extend geographical principles and cartographic techniques to the visualization of non-geographic information. Information visualized is information turned into spatial form and therefore, in principle, amenable to current spatial analysis. (Skupin & Fabrikant, 2003)

Stanford (2012) defines narrative most simply as the representation of movement within the coordinates of space and time. Depending on the characteristics of a data set, very different approaches can or must be pursued in order to turn source data into a visual form.

Skupin & Fabrikant (2003) stated that there are significant differences in how structured, unstructured, and semi-structured data may need to be processed before visualization techniques can be applied. Spatialization does not mean the erasure of time from space. A case from Joseph Frank, who, in his influential essay, "Spatial Forms in Modern Literature," argues that avant-garde narrative techniques in modern literature created an illusory effect of contemporaneity and unity (Frank, 2005). On the contrary, for Kristeva, spatialization constitutes the text as a surface or verbal place in which space and time, synchrony and diachrony, function as coordinates for the textual activity.

Kristeva's spatialization of the word has potential applications for narration. Defining narration as movement representation through space and time in both axes. The one (horizontal) referring to the movement of characters within their fictional world; the other (vertical) referring to the "motions" of the writer and the reader in relation to each other and to the text's intertexts. (Stanford, 2012)

Spatialization can go beyond these methods by facilitating some new readings of the story that might not otherwise exist. Instead, they initiate stories narratives themselves "told" by the reader. According to Wise et al. (1995), the purpose of text visualization is to spatially transform textual information into a new visual representation that reveals thematic patterns and relationships between documents in a similar if not identical way to how it is perceived natural world.

As stated by Wise et al. (1995), the primary requirements of a text processing engine for information visualization are:

1) the identification and extraction of essential descriptors or text features,

2) the efficient and flexible representation of documents in terms of these text features,

3) subsequent support for information retrieval and visualization.

The notion of spatialization of information is indicating systematic mapping of the information onto the spatial and temporal domains.

Spatialization and storytelling are important for the thesis because by understanding the location and dimension of objects through spatialization non-spatial information is mapped into the spatial. While storytelling was used to display the change of landscape using elements and methods to illustrate the importance of changing the landscape.

# 3 Methodology

The methodology chapter represents the research approach and the workflow chosen to pursue the research goals. As it was stated in the introduction chapter, the main motivation is to demonstrate how the existing textual information of a landscape change can be transformed into an attractive narrated and animated story in a 3D model. To define the scope of the thesis, the research focuses on the potential of the storytelling approach in a 3D environment in order to depict landscape changes. Figure 3.1 represents the research workflow.

## 3. 1 Overview of the Research Workflow

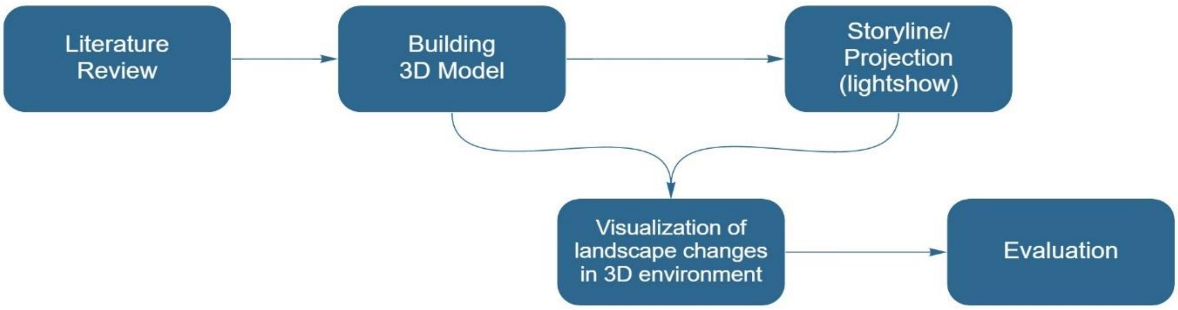



Figure 3.2 Research workflow.

The research workflow consists of four main phases: (0) Literature review; (1) Building a 3D model; (2) Creating the Storyline based on textual descriptions and projection (light show); and (3) Evaluation. Within Phase 2 it has also been researched which other storytelling elements (maps, pictures, audio) could be used in order to visualize the landscape change.

The fundamental phase of the research began with a review of existing examples or projects visualizing landscape changes in different environments and literature about storytelling in cartography. The aim was to find visualization methods and techniques to present landscape changes, having the case study area and the existing textual descriptions of the landscape change of the City of Pristina in mind. The phases 1, 2 and 3 will be described in detail in the following subchapters.

## 3.2 Research Workflow Phases

### 3.2.1 Phase 1: Building a 3D Model

This phase describes the methodology for developing and creating the 3D model, integrating the selected techniques into it, and making it functional for the use as a basis for the projection and the final user study. Building a 3D model requires three steps with further sub-steps. Before the printing of the model can be performed, it needs to be clear which objects should be printed. Therefore, the main objects of the 3D model need to be identified based on the available textual descriptions about the landscape change.

The textual data collection contains four further steps:

- Identifying the landscape change in general and find out which objects have been involved (influenced the change or have been influenced by the change),
- Analysis of various book sources
- Selection of information based on interest criteria,
- Highlighting method for summarizing information.

After the main objects have been identified, the printing material and scale needs to be defined. The printing material and consequently the available 3D printer influences the scale of the 3D model. To define the best scale of the 3D model, the following sub-steps are necessary:

- Selection of the printing material and calculation of the dimensions of the 3D model basis plate (width, length and height).
- Selection of the printing material and calculation of the dimensions of the identified objects (width, length, and height),

As soon as the printing material and object dimensions are decided, the creation of digital model of the object can start. Until the final base plate and the objects are physically printed, the following steps need to be performed:

- 3D modeling of objects based on dimensions at a given scale,
- Preparation of 3D printing machine parameters,

Further details about the model for the case study area are presented in chapter 4.3: Crafting the 3D Model.

### 3.2.2 Phase 2: Creating the Storyline with Projection

As mentioned before, the visualization of the landscape change should combine a physical 3D model and a digital projection (lightshow) on top of it. In order to visually tell a story of a landscape change, several multimedia elements have to be combined. These elements can be text, animation, graphics (photographs, maps), and sound. To combine all the multimedia elements in a projection, the following steps are required:

- Selecting the textual data that describe the landscape change,
- Identifying further elements that are available and beneficial for the projection and illustration of story (cadastral maps, orthophotos, sound, images),
- Conceptualizing the storyline and creating storyboards, decide when which multimedia elements should be used to visualize the landscape change,
- Sequencing all elements together in an animation.
- Checking the Beamer requirements and final projection.

Further details on the projection are presented in chapter 4.5: Creating the Projection.

### 3.2.3 Phase 3: Evaluation

After the 3D model and the projection are finalized, phase 3 focusses on the evaluation of both components. Expert feedback will initiate a discussion revealing and contrasting the advantages and disadvantages of the model and the projection. It will give insights on how the visualization of a landscape change for a city in such an environment is perceived.

To complete the research study, human participation is required. The evaluation will therefore be done in person. The 3D model and the projection need to be arranged like in an exhibition. Participants will be asked to complete a first questionnaire with general questions about their profile, background and knowledge concerning landscape changes and visualizations. After filling the background information questionnaire, the participants will explore the exhibition one by one, means the model and the projection will be shown and they will listen to the story of the landscape change. Upon completion of the entire story, an interview with an accompanying questionnaire will be conducted.

Methods of evaluation

To complete the research study, human participation was required (Suchan & Brewer, 2000). Kveladze et al. (2019) identified qualitative methods such as questionnaires, think aloud, interviews, and focus groups as techniques used in the evaluation of cartographic products. Due to the exploratory and descriptive nature of this research, qualitative methods were selected to capture the experience of the participants effectively. The techniques are questionnaires, and interviews with audio-recorded post-experience. The method of questionnaires is an easy and efficient way of collecting certain information from participants. Easy to use in the sense that they do not require special skills by the participants and efficient because they can be used to collect quantifiable and discrete data. Collecting information on the profile (e.g., age, occupation) of the experiment's participants is fast and precise (Suchan & Brewer, 2000). Therefore, the questionnaire method was chosen to evaluate the effectiveness of visualizing landscape changes in the context of storytelling. Interviews have been used to interact with participants and to get insights into participants opinions, feelings, behaviors and experiences. Besides, the strategy of interviews does require great listening, locks in, and asking abilities of the interviewer (Gill et al., 2008).

Further details on how the evaluation has been conducted are presented in chapter 5.

# 4 Case Study

This chapter discusses the thesis workflow in detail. As case study for the visualization of a landscape change, the Mother Teresa and Zahir Pajaziti Boulevard in Pristina, Kosovo between 1893 and 2018 has been selected. After introducing the case study area, it will be described how the 3D model has been created. Afterwards, it will be explained how the textual information describing the landscape change have been collected, analyzed and composed to create a story out of it. Finally, the composition of the storytelling elements into the lightshow projection will be described.

## 4.1 Mother Tereza and Zahir Pajaziti Boulevard in Pristina

The practical implementation of the methodology is based on the case study of the Mother Tereza and Zahir Pajaziti Boulevard in Pristina, Kosovo (figure 4.1). The Mother Teresa Boulevard is the main square among four squares that are positioned in the same place and connected to each other. So, in addition to Mother Teresa, there are also Zahir Pajaziti, Skenderbeu, and Ibrahim Rugova squares. Due to its history, artistic values, and symbolic meaning, the Mother Teresa Boulevard is considered as one of the most important pedestrian streets in the City of Pristina. (Gashi, 2020)

Pristina is characterized by its archaeological heritage from the times of Illyrians, Dardanians, Romans, Byzantines, Serbs, and Ottomans. The territory of the Mother Tereza and Zahir Pajaziti Boulevard includes cultural monuments and buildings with a combination of elements of neo-renaissance, neo-baroque, and new art (figure 4.2). Pristina which after the Second World War remained under the territory of Yugoslavia, was built and was destroyed several times in the name of progress and prosperity, striving hard to acquire influences from neighboring countries. This process was also used under the name of modernity and construction of a new identity, namely the modern identity in Kosovo. Cities of Kosovo, up to the late 40s retained their medieval structure and began to change dramatically. (Sylejmani, 2010)

The Mother Tereza and Zahir Pajaziti Boulevard is a good example of this kind of landscape changes depiction, as it has undergone many transformations in its appearance during its existence period from the year 1893 till today (figure 4.3). Pristina's dramatic change came in the name of modernization and rapid social change. As a result of strengthening the workforce, opening factories, promoting education and employment in various administrative positions, the city population began to grow significantly. New city centers with a number of large public buildings have been constructed, new tourist centers have been developed, and all this together represent an important turning point in terms of shaping a new reality, that of new public and modern life. Thus, the central new part of the City of Pristina, the Mother Tereza and Zahir Pajaziti Boulevard, has been considered as a perfect use case for achieving this thesis goals.


Figure 4.1 Mother Tereza and Zahir Pajaziti Boulevard in Pristina, Kosovo.[25]

Figure 4.2 Mother Tereza and Zahir Pajaziti Boulevard and adjoining buildings nowadays.[26]

[25] Orthophoto from 2018 (last access: 20 September, 2021). from http://geoportal.rks-gov.net/).
[26] Orthophoto from 2018, in orange Boulevard of Mother Teresa & Zahir Pajaziti (last access: 20 September, 2021). from http://geoportal.rks-gov.net/).

Figure 4.3 Marshall Tito Street in 1893.[27]

## 4.2 Textual Data Collection

The narrative function of the text is aiming to draw the reader into a shared involvement experience or a concrete story. Through its narrative and descriptive functions, text furnishes the recounting of stories, but through exposition, it can also furnish imagination; it can represent action through time (Mocnik & Fairbairn, 2018). The textual data collection for the Mother Teresa and Zahir Pajaziti Boulevard in Pristina features four main steps:

1. Searching in different books to find an overview of landscape change in general, and based on the books of Sylejmani (2010) and Gashi (2020), 10 relevant objects (monuments, buildings) have been identified that explain the change in a specific time period in an excellent way.
2. The 10 monuments found in the books of Sylejmani (2010) and Gashi (2020), represent the core of the storyline. The next step is the detailed recherché to all 10 buildings to gather the most important facts about their change and how they shaped the landscape of the City of Pristina. A categorization of the facts is needed.
3. The story of all 10 monuments is following the same storyline and is based on the following facts:

- Year of construction,
- Year for remodeling,
- The main characteristics of the monuments,

[27] Gashi, S. (2020) Pristina a unique monograph of the past of the city, history, tradition, culture and its people (last access: 20 September, 2021).

- Architect or designer,
- How it is used the monuments.

4. Based on the above facts, the analysis of textual data is done simply using the highlighting method. With this method, the emphasis is made on the main point or idea thus continuing through each paragraph and section of the book.

Below are two figures showing how the highlighting method has been applied.

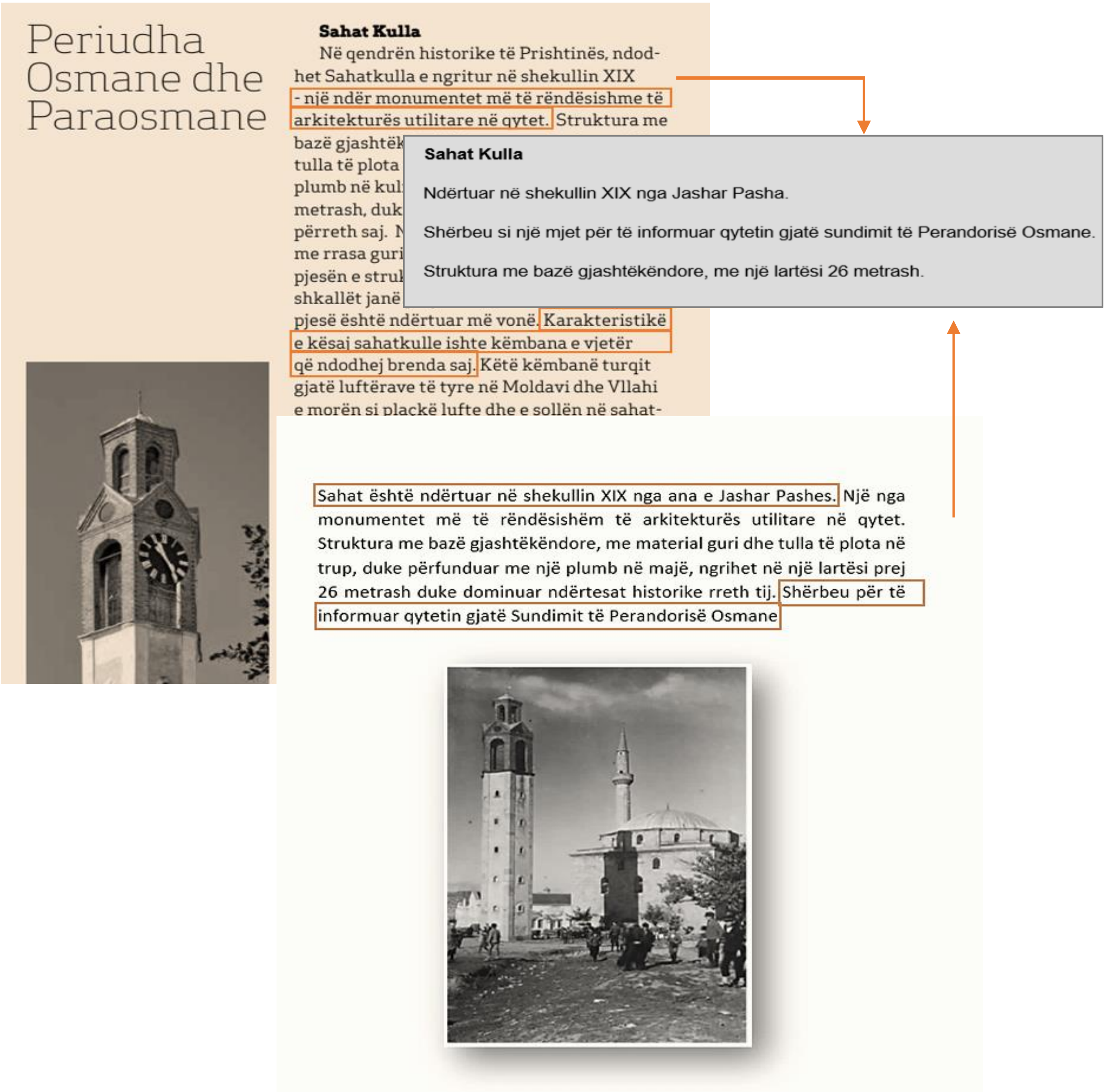



Figure 4. 4 Collection and Categorization of textual data.

The 10 cultural-historical objects for Mother Teresa and Zahir Pajaziti Boulevard are the National Theater, the Union building, the statue of Skanderbeg, Ibrahim Rugova, the Government, the Assembly, the Qarshia Mosque, the Monument of Unity and Brotherhood, the Museum of Kosovo and the Clock Tower.

## 4.3 Crafting the 3D Model

The previously selected 10 objects need to be modeled before they can be printed in 3D. Chapter 4.3.1 describes the steps performed to model the objects and chapter 4.3.2. describes how the 3D printing was performed.

### 4.3.1 Modelling the Cultural Historical Objects

The software Sketchup was used to model the 10 cultural-historical objects for the Mother Theresa and Zahir Pajaziti boulevard. The steps performed in Sketch-up are:

- Geo-location**:** The selection of the space or region we want to model. Based on the selection of space we have a satellite map were based on it we continue with the next step (see figure 4.5).
- Vectorization: of objects in the selected space (see figure 4.6).
- 3D model: Modeling objects in 3D based on the height of objects. Pulling a 3D shape from a face. Height of the objects are taken from google map 3D where the accuracy is approximately to 20-30 cm (see figure 4.7).
- Design: Some of the objects are in different shapes where more time, focus and drawing precisely should be devoted (see figure 4.8).

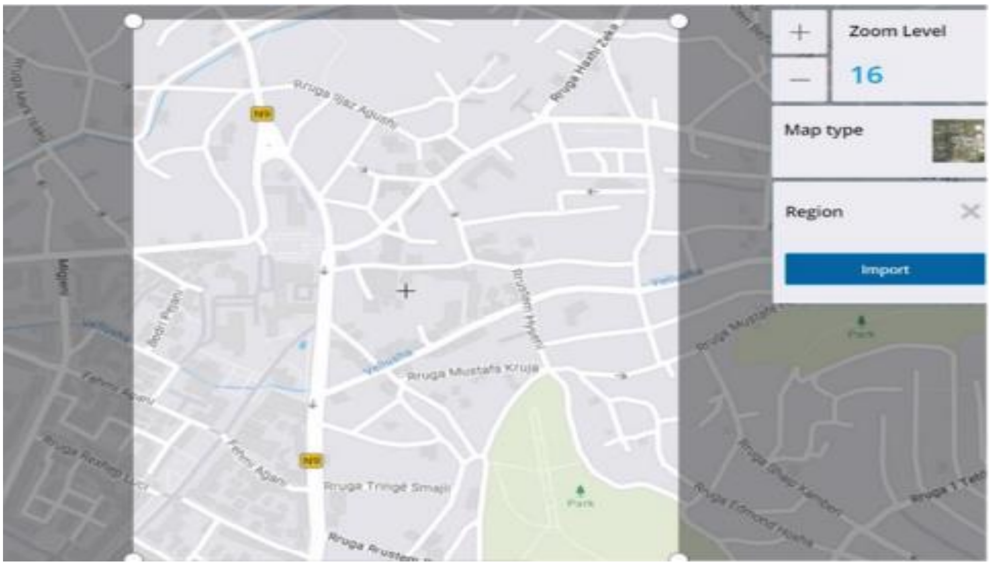



Figure 4.5 Geolocation of the region.

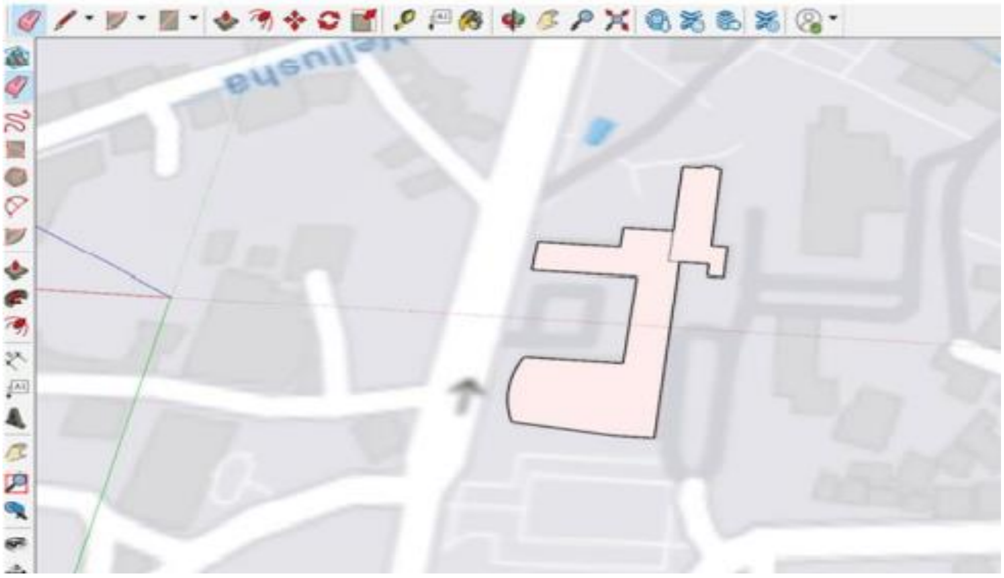


Figure 4.6 Vectorization of the objects in the selected region.

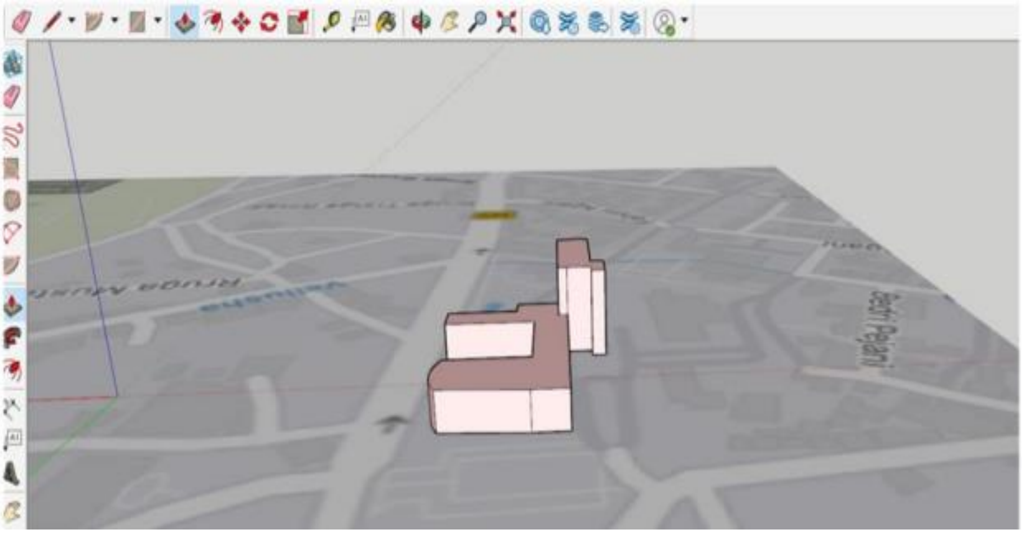


Figure 4.7 Modeling objects in 3D.

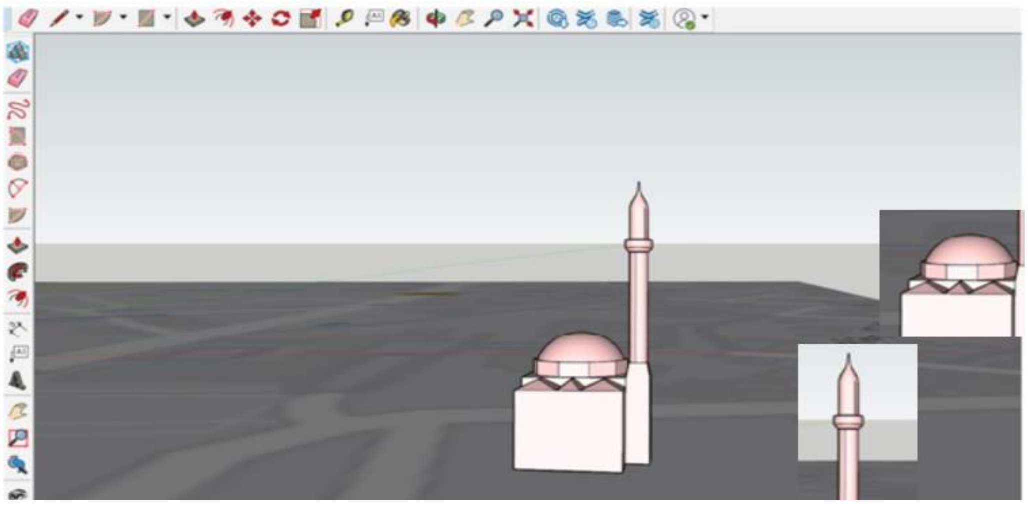


Figure 4.8 Design the objects precisely.

### 4.3.2 Printing the 3D Model

Cura 3D is an open-source slicing application for 3D printers. It takes a 3D model and slices it into layers to create a file known as G-Code. Three basic stages are needed to prepare the files for 3D printing.

- ❖ Modeling: SketchUp has its own file format. The format enables the printer to open, edit, save, and export the files from the application.
- ❖ 3D file export: Once the model is created, it then needs to be exported as either an STL or OBJ dataset. These are the file formats that are recognized by Cura.
- ❖ Slicing file export: The STL or OBJ file can then be imported into the Cura software where it is sliced and outputted as G-Code (see figure 4.9). This G-Code is just a text document (in essence) with a list of commands for the 3D printer to read and follow such as hot-end temperature, move to the left this much, right that much etc.

The application of Cura slices 3D models. It interprets the 3D STL or OBJ files into a format that the printer can understand. Cura 3D takes the 3D model and works out how those layers are put on the print bed and makes a set of information for the printer to take after—layer by layer. Cura creates information for the 3D printer. They are called G-Code, a text report that closes with the file expansion g-code. This code can alter fan speeds, layer heights, and hot-end temperatures at different points.

```
G28 XY
G0 X50
G92 E0
G1 F200 E-1
G28 Z;Home
G92 E0
G1 F200 E-1
G29
G1 Z15.0 F6000 ;Move the platform down 15mm
G92 E0
G1 F200 E-1
```

Figure 4.9 G-Code.

Two tables 4.1 and 4.2 are presented below. Both tables display the process of modeling the 10 objects in two different scales (1: 500 and 1: 250). For these two scales (1: 500 and 1: 250) analysis was made for the height of each object where it would match the streets and the selected frame.

Table 4.1 presents the objects in the scale 1: 500, where the minimum objects are reasonable (8,4,20mm), while the maximum objects have a dimension of142,264,50mm. Road model displayed at a scale of 1: 500 acquire dimensions (1.50cm * 1.25cm). The second table 4.2 presents the models at a scale of 1: 250, where the minimum objects are with dimensions 16.8,40mm and the maximum objects with dimensions 284,528,100mm. An underlying wooden base plate, of the roads displayed at a scale of 1: 250 would have a size of 3.00cm * 2.50cm).

| | | Dimension of reality (m) | | | Scale 1:500 | | | Dimension on map (cm) | | | Dimension on Cura Software (mm) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Objects | X | Y | Z | (X/500)*100 | (Y/500)*100 | (Z/500)*100 | X | Y | Z | X | Y | Z |
| 1 | National Theater | 31 | 78 | 30 | (31/500)*100 | (78/500)*100 | (30/500)*100 | 6.2 | 15.6 | 6 | 62 | 156 | 60 |
| 2 | Union | 30 | 28 | 19 | (30/500)*100 | (28/500)*100 | (19/500)*100 | 6 | 5.6 | 3.8 | 60 | 56 | 38 |
| 3 | Skanderbeg | 4 | 2 | 10 | (4/500)*100 | (2/500)*100 | (10/500)*100 | 0.8 | 0.4 | 2 | 8 | 4 | 20 |
| 4 | Ibrahim Rugova | 4 | 2 | 10 | (4/500)*100 | (2/500)*100 | (10/500)*100 | 0.8 | 0.4 | 2 | 8 | 4 | 20 |
| 5 | Government | 40 | 70 | 71 | (40/500)*100 | (70/500)*100 | (71/500)*100 | 8 | 14 | 14.2 | 80 | 140 | 142 |
| 6 | Assembly | 71 | 132 | 25 | (71/500)*100 | (132/500)*100 | (25/500)*100 | 14.2 | 26.4 | 5 | 142 | 264 | 50 |
| 7 | Qarshise Mosque | 21 | 20 | 45 | (21/500)*100 | (20/500)*100 | (45/500)*100 | 4.2 | 4 | 9 | 42 | 40 | 90 |
| 8 | Brotherhood and Unity | 2.5 | 3 | 17 | (2.5/500)*100 | (3.5/500)*100 | (17.5/500)*100 | 0.5 | 0.7 | 3.5 | 5 | 7 | 35 |
| 9 | Museum of Kosovo | 39 | 25 | 29 | (39/500)*100 | (25/500)*100 | (29/500)*100 | 7.8 | 5 | 5.8 | 78 | 50 | 58 |
| 10 | Clock Tower | 5 | 5 | 26 | (5/500)*100 | (5/500)*100 | (26/500)*100 | 1 | 1 | 5.2 | 10 | 10 | 52 |

Table 4. 1 Dimension of reality, map and Cura, scale 1:500.

| | | Dimension of reality (m) | | | Scale 1:250 | | | Dimension on map (cm) | | | Dimension on Cura(mm) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Objects | X | Y | Z | (X/250)*100 | (Y/250)*100 | (Z/250)*100 | X | Y | Z | X | Y | Z |
| 1 | National Theater | 31 | 78 | 30 | (31/250)*100 | (78/250)*100 | (30/250)*100 | 12.4 | 31.2 | 12 | 124 | 312 | 120 |
| 2 | Union | 30 | 28 | 19 | (30/250)*100 | (28/250)*100 | (19/250)*100 | 12 | 11.2 | 7.6 | 120 | 112 | 76 |
| 3 | Skanderbeg | 4 | 2 | 10 | (4/250)*100 | (2/250)*100 | (10/250)*100 | 1.6 | 0.8 | 4 | 16 | 8 | 40 |
| 4 | Ibrahim Rugova | 4 | 2 | 10 | (4/250)*100 | (2/250)*100 | (10/250)*100 | 1.6 | 0.8 | 4 | 16 | 8 | 40 |
| 5 | Government | 40 | 70 | 71 | (40/250)*100 | (70/250)*100 | (71/250)*100 | 16 | 28 | 28.4 | 160 | 280 | 284 |
| 6 | Assembly | 71 | 132 | 25 | (71/250)*100 | (132/250)*100 | (25/250)*100 | 28.4 | 52.8 | 10 | 284 | 528 | 100 |
| 7 | Qarshise Mosque | 21 | 20 | 45 | (21/250)*100 | (20/250)*100 | (45/250)*100 | 8.4 | 8 | 18 | 84 | 80 | 180 |
| 8 | Brotherhood and Unity | 2.5 | 3 | 17 | (2.5/250)*100 | (3.5/250)*100 | (17.5/250)*100 | 1 | 1.4 | 7 | 10 | 14 | 70 |
| 9 | Museum of Kosovo | 39 | 25 | 29 | (39/250)*100 | (25/250)*100 | (29/250)*100 | 15.6 | 10 | 11.6 | 156 | 100 | 116 |
| 10 | Clock Tower | 5 | 5 | 26 | (5/250)*100 | (5/250)*100 | (26/250)*100 | 2 | 2 | 10.4 | 20 | 20 | 104 |

Table 4.2 Dimension of reality, map and Cura, scale 1:250.

Table 4.3 shows the time needed and the material consumed for printing the 10 objects in the scale 1:500.

| Name of building | Time consuming | Material consuming |
| --- | --- | --- |
| National Theater | 10h 17min | 20 gram |
| Union | 6h 48min | 19 gram |
| Skanderbeg | 5min | 0.05 gram |
| Ibrahim Rugova | 5min | 0.05 gram |
| Government | 26h 38min | 17 gram |
| Assembly | 16h 20min | 93 gram |
| Qarshia Mosque | 4h 25min | 17 gram |
| Brotherhood and Unity | 15min | 0.08 gram |
| Museum of Kosovo | 14h 43min | 48 gram |
| Clock Tower | 1h 18min | 2 gram |

Table 4.3 Objects with the required time and material.

Figure 4.10 shows the printer that is used for printing the 10 building objects.

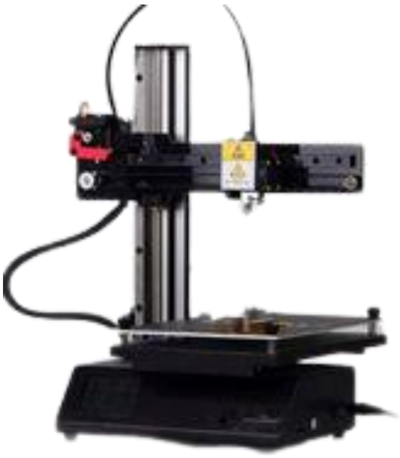


Figure 4.10  3D printing machine and the PLA material.

The parameters for every single object to be printed must be characterized inside a single sketch. Parameters cannot be characterized in one sketch and utilized to make expressions in another sketch. Figure 4.11 shows the general parameters of 3D printing machine.

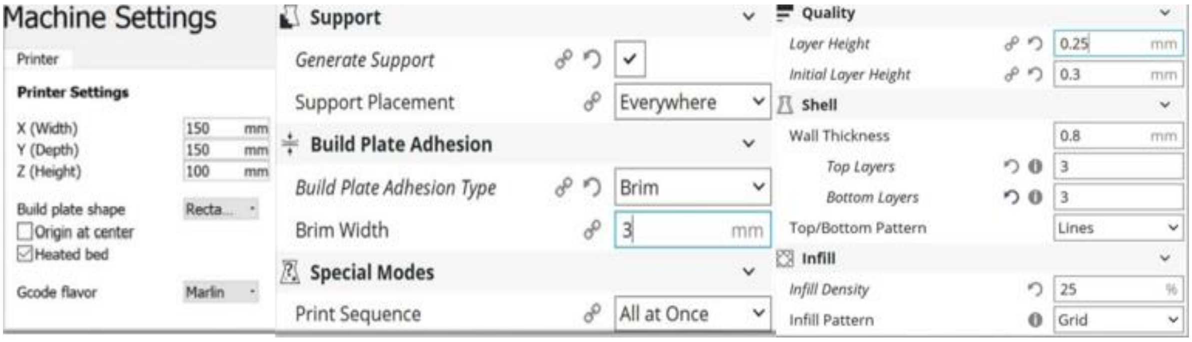



Figure 4.11 3D Machine settings and parameters.

Before sending the objects to the 3D printer, the material in which the objects should finally be printed was selected. For the 10 objects printed for the case study, PLA material (Polylactic acid) was used. PLA is a filament for 3D printing Gembird, 1.75 mm, transparent. PLA material is easy to print with. It has a lower printing temperature, and it doesn't warp as easily, meaning it doesn't require a heating bed. Another benefit of using PLA material is that it doesn't give off an off-putting odor during printing. Another engaging perspective of PLA is it's accessible in an endless abundance of colors and styles. The 3D printing of the Museum of Kosovo building used 22 grams of PLA yarn with 20% filling. Calculations for an object with twice larger dimensions will use twice as much material, meaning between 66g-70gram PLA fiber yarn. But if the quality is different the consumption of the material will change. Quality filling with 40% makes buildings stronger, so as a rough estimate, the expected weight of the Museum of Kosovo will be increased.

After the material was chosen, the printer was set up (see figure 4.12).

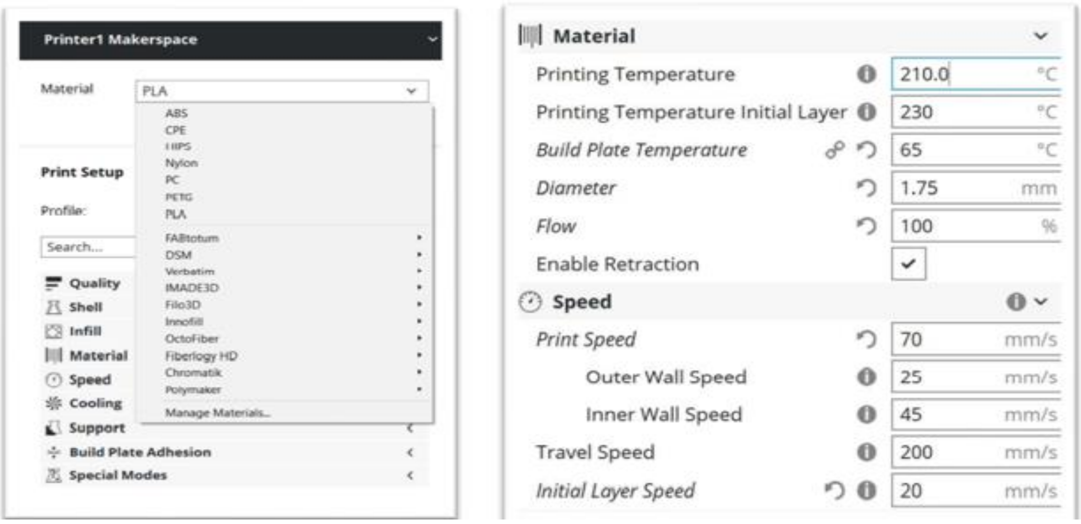



Figure 4.12 Print set-up.

In the following, all 10 objects that have been printed with PLA in 3D, the time needed and the costs are shown (figure 4.13).

Skanderbeg statue

**Time specification**

| | | |
|---|---|---|
| Inner Walls: | 00h 00min | 9% |
| Outer Wall: | 00h 00min | 41% |
| Retractions: | 00h 00min | 21% |
| Skin: | 00h 00min | 1% |
| Skirt: | 00h 00min | 15% |
| Travel: | 00h 00min | 12% |

**Cost specification**

| | | | |
|---|---|---|---|
| PLA: | 0.05m | 0g | € 0.00 |
| Total: | 0.05m | 0g | € 0.00 |

Ibrahim Rugova statue

**Time specification**

| | | |
|---|---|---|
| Inner Walls: | 00h 00min | 9% |
| Outer Wall: | 00h 00min | 41% |
| Retractions: | 00h 00min | 21% |
| Skin: | 00h 00min | 1% |
| Skirt: | 00h 00min | 15% |
| Travel: | 00h 00min | 12% |

**Cost specification**

| | | | |
|---|---|---|---|
| PLA: | 0.05m | 0g | € 0.00 |
| Total: | 0.05m | 0g | € 0.00 |

Brotherhood & Unity

**Time specification**

| | | |
|---|---|---|
| Outer Wall: | 00h 04min | 57% |
| Retractions: | 00h 01min | 20% |
| Skirt: | 00h 00min | 5% |
| Travel: | 00h 01min | 17% |

**Cost specification**

| | | | |
|---|---|---|---|
| PLA: | 0.08m | 0g | € 0.00 |
| Total: | 0.08m | 0g | € 0.00 |

Union

| Time specification | | |
|---|---|---|
| Infill: | 00h 48min | 16% |
| Inner Walls: | 00h 31min | 10% |
| Outer Wall: | 01h 02min | 21% |
| Retractions: | 00h 02min | 1% |
| Skin: | 02h 10min | 43% |
| Skirt: | 00h 01min | 1% |
| Travel: | 00h 25min | 9% |

| Cost specification | | | |
|---|---|---|---|
| PLA: | 5.74m | 17g | € 0.00 |
| Total: | 5.74m | 17g | € 0.00 |

Clock Tower

| Time specification | | |
|---|---|---|
| Infill: | 00h 08min | 10% |
| Inner Walls: | 00h 14min | 19% |
| Outer Wall: | 00h 32min | 42% |
| Retractions: | 00h 07min | 9% |
| Skin: | 00h 07min | 9% |
| Skirt: | 00h 00min | 1% |
| Travel: | 00h 07min | 9% |

| Cost specification | | | |
|---|---|---|---|
| PLA: | 0.75m | 2g | € 0.00 |
| Total: | 0.75m | 2g | € 0.00 |

Assembly

| Time specification | | |
|---|---|---|
| Infill: | 07h 34min | 41% |
| Inner Walls: | 01h 39min | 9% |
| Outer Wall: | 03h 17min | 18% |
| Skin: | 04h 33min | 25% |
| Skirt: | 00h 03min | 0% |
| Travel: | 01h 10min | 6% |

| Cost specification | | | |
|---|---|---|---|
| PLA: | 31.34m | 93g | € 0.00 |
| Total: | 31.34m | 93g | € 0.00 |

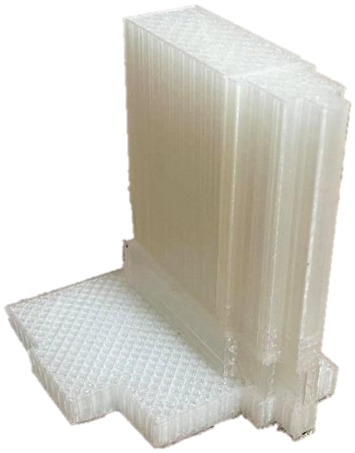
## Government

**Time specification**

| | | |
|---|---|---|
| Infill: | 00h 48min | 16% |
| Inner Walls: | 00h 31min | 10% |
| Outer Wall: | 01h 02min | 21% |
| Retractions: | 00h 02min | 1% |
| Skin: | 02h 10min | 43% |
| Skirt: | 00h 01min | 1% |
| Travel: | 00h 25min | 9% |

**Cost specification**

| | | | |
|---|---|---|---|
| PLA: | 5.74m | 17g | € 0.00 |
| Total: | 5.74m | 17g | € 0.00 |



## Museum of Kosovo

**Time specification**

| | | |
|---|---|---|
| Infill: | 07h 34min | 41% |
| Inner Walls: | 01h 39min | 9% |
| Outer Wall: | 03h 17min | 18% |
| Skin: | 04h 33min | 25% |
| Skirt: | 00h 03min | 0% |
| Travel: | 01h 10min | 6% |

**Cost specification**

| | | | |
|---|---|---|---|
| PLA: | 31.34m | 93g | € 0.00 |
| Total: | 31.34m | 93g | € 0.00 |

## Qarshia Mosque

**Time specification**

| | | |
|---|---|---|
| Infill: | 01h 01min | 23% |
| Inner Walls: | 00h 32min | 12% |
| Outer Wall: | 01h 07min | 25% |
| Retractions: | 00h 02min | 1% |
| Skin: | 01h 17min | 29% |
| Skirt: | 00h 01min | 1% |
| Travel: | 00h 23min | 9% |

**Cost specification**

| | | | |
|---|---|---|---|
| PLA: | 5.60m | 16g | € 0.00 |
| Total: | 5.60m | 17g | € 0.00 |

National Theater

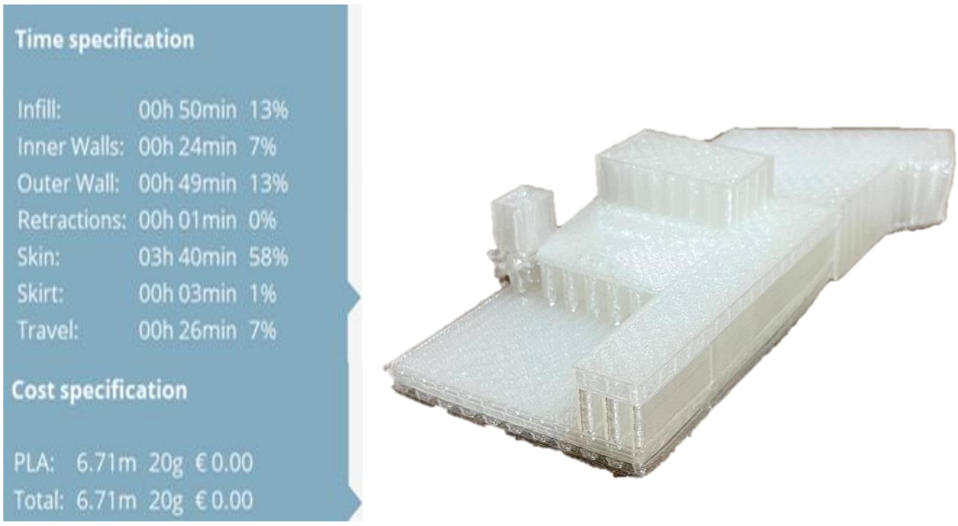



Figure 4. 13 Objects with detailed information about the time and material required.

All the 10 printed building objects in white PLA will be placed on top of a wooden base plate that shows the road network of the case study area. The road modeling was done with the help of ArcGIS. Initially, the roads were vectorized in their current state with an overlay of the orthophoto from 2018 (see figure 4.14). The road model has a scale of 1: 500 and a dimension of 1.50cm * 1.25cm. The road network is engraved into the wooden base plate. The carving was realized with a 3D printing CNC machine.

Figure 4. 14 CNC engraving road modeling.

## 4.4 Preparation of Additional Datasets

The geodata used to support the case study and tell the story of the landscape change were provided by the Kosovo Cadastral Agency. The database contained cadastral maps of the year 1893 (see figure 4.15), orthophotos of the year 2001 (see figure 4.16), 2004 (see figure 4.17), 2009 (see figure 4.18), 2012 (see figure 4.19), 2018 (see figure 4.20).

The Kosovo cadaster has many data deficiencies, a lot of data are missing including parcel boundaries and number of parcels.

The graphical cadastral data of cadastral plans between 1958 and 1999 are located in Serbia, wherein in 1999[28]the entire cadastral archive was taken. Therefore, the ability to place multiple cadastral maps for the selected part of the case study was small for the purpose mentioned above. All cadastral maps and orthophotos were classified according to their time attributes and the location framework that was defined as the case study. A new orthophoto from 2021 is existing, but not yet published on the portal of the Kosovo cadastral agency and could therefore not been used within the case study. Below, table 4.4 shows an overview of all collected data that will be used for the case study.

| Data | Author | Year |
|---|---|---|
| Cadatral Plan | Kosovo Cadastral Agency | 1894 |
| Orthophoto | Kosovo Cadastral Agency | 2001 |
| Orthophoto | Kosovo Cadastral Agency | 2004 |
| Orthophoto | Kosovo Cadastral Agency | 2009 |
| Orthophoto | Kosovo Cadastral Agency | 2012 |
| Orthophoto | Kosovo Cadastral Agency | 2018 |
| Border of Prishtina | Kosovo Cadastral Agency | 2018 |
| Textual Data | Sanije Gashi | 2020 |
| Textual Data | Sherafedin Sylejmani | 2010 |
| Textual Data | Municipality of Prishtina | 2018 |
| Textual Data | Fjollë Caka | 2019 |
| Archival Images | Sanije Gashi | 2020 |
| Archival Images | Sherafedin Sylejmani | 2010 |

Table 4.4 Data collected for the case study.

[28] Kurteshi, M. (2017). Krijimi i gjeoportalit në funksion të kadastres në Kosovë [Bachelor dissertation, Pristina University] (last access: 20 September, 2021).

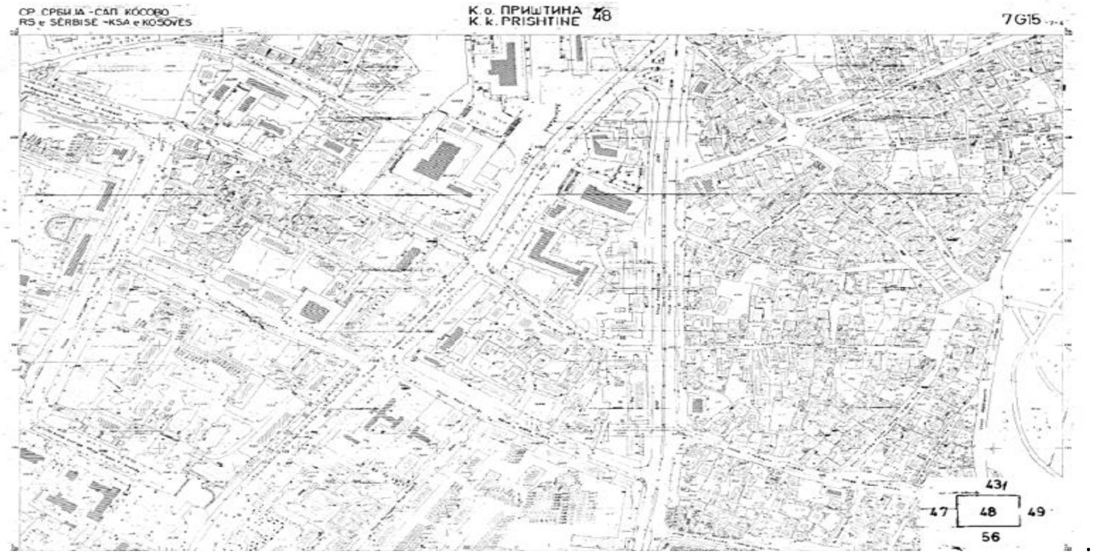



Figure 4.15 Cadastral map in 1893 with sheet binding 48.


Figure 4.16 Orthophoto 2001 in ArcMap software together with layer view.


Figure 4.17 Orthophoto 2004 in ArcMap software together with layer view.


Figure 4.18 Orthophoto 2009 in ArcMap software together with layer view.


Figure 4.19 Orthophoto 2012 in ArcMap software together with layer view.


Figure 4.20 Orthophoto 2018 in ArcMap software together with layer view.

In the data processing phase, the orthophoto and cadastral plan were georeferenced. With the help of orthophoto and cadastral plan, the background of the storyline can be determined. The georeferencing process included the selection of the orthophoto (2001, 2004, 2009, 2012, 2018) and the cadastral plan (1893) and in addition geographic information so that the mapping software (ArcMap) could "place" the orthophotos and cadastral plan in its appropriate real-world location. This process was completed by selecting pixels in orthophotos and cadastral plans and assigning them with geographic coordinates. The respective coordinate transformations were from FryRef30 to KosovaRef01.

| **Name:** | **FryRef 30** | **KOSOVAREF01** |
|---|---|---|
| **Year of defining:** | 1924 | 2001 |
| **Period of utilization:** | 1924-2001 | 2001-ongoing |
| **Datum:** | Harmannskögel | ETRS89 |
| **Ellipsoid:** | Bessel 1841 | GRS 80 |
| **Map projection** | Gauss–Krüger | Gauss–Krüger |
| **Projecting zone:** | 7th | 7th |
| **Width of the zone:** | 30 | 30 |
| **Prime meridian:** | Greenwich | Greenwich |
| **Central meridian:** | 210 | 210 |
| **Origin of latitude:** | Equator | Equator |
| **False easting:** | 500000m | 7500000m |
| **False northing:** | 0m | 0m |
| **Scale factor:** | 0.9999 | 0.9999 |
| **Length units:** | Meter | Meter |
| **Origin of elevations:** | Mareograph “Molo Sartorio” – Trieste, Italy | Mareograph “Molo Sartorio” – Trieste, Italy |

Table 4.5 Coordinate systems of the Republic of Kosova (Idrizi et al., 2009).

## 4.5 Creating the Projection

The APPENDIX I contains the general chart showing the structure of the story that guides the prototype. The structure of the storyline features four main phases:

Phase 1 is the introduction of the City Pristina. The data presented are the city border, and archival images of Pristina. While displaying all information about the city, voice is included as well as a background melody. In the beginning of the story, the border with the magnification method is displayed where the displacement process is. It consists of two steps: zoom in and zoom out. It starts with enlarging the border together with brief information about old Pristina with element of audio and archival images.

Phase 2 is showing the evolving city with the help of a cadastral map, in this case the cadastral plan of 1983.

Phase 3 is showing the evolving city with an orthophoto. The main feature in this phase is the time line divided into five phases. Five different years of the landscape change are presented.

Phase 4 is highlighting the 3D building objects. The 10 historical monuments are displayed with features from the fact structure and accompanied with archival images.

The projection was created with the software Adobe After Effects. Creating the projection started with uploading the data to Adobe After Effects and creating the story script at the top. All collected data was imported: cadastral plans, orthophoto, border, textual data, archival images, audio, and melody and the story was realized based on the structure of the storyline (APPENDIX I).

Figure (4.21) shows the step where the yellow objects are placed. All objects are synchronized, based on the year of the object they are displayed one by one.

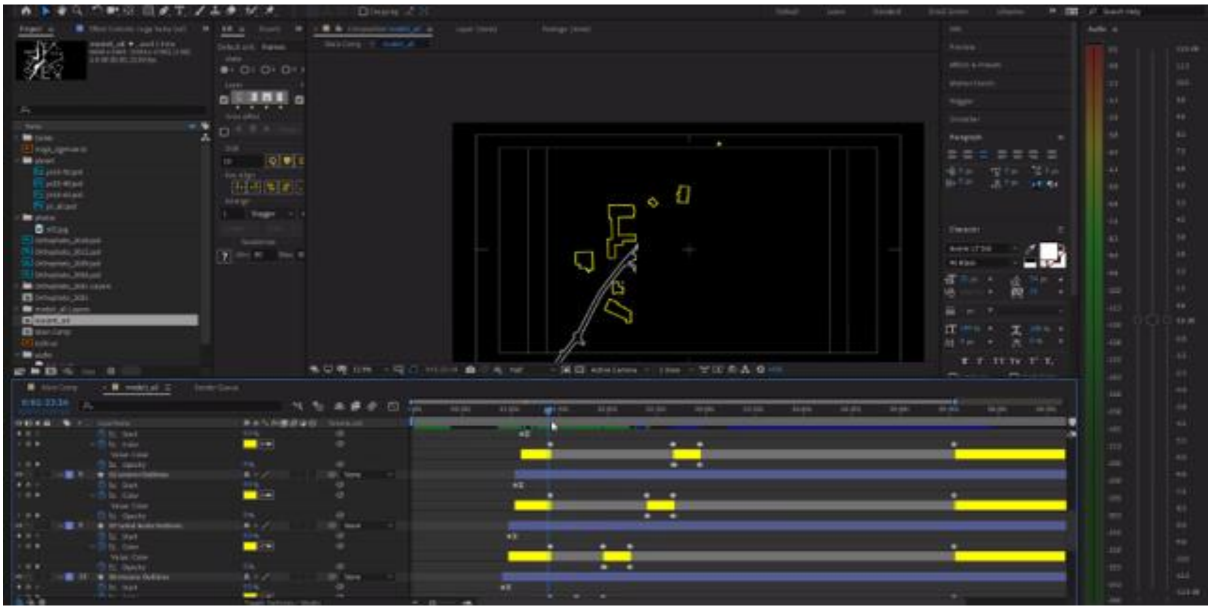


Figure 4.21 Elaboration of the first phase: Introduction.

Figure (4.22) shows the step where the combination of sound and text elements is done.

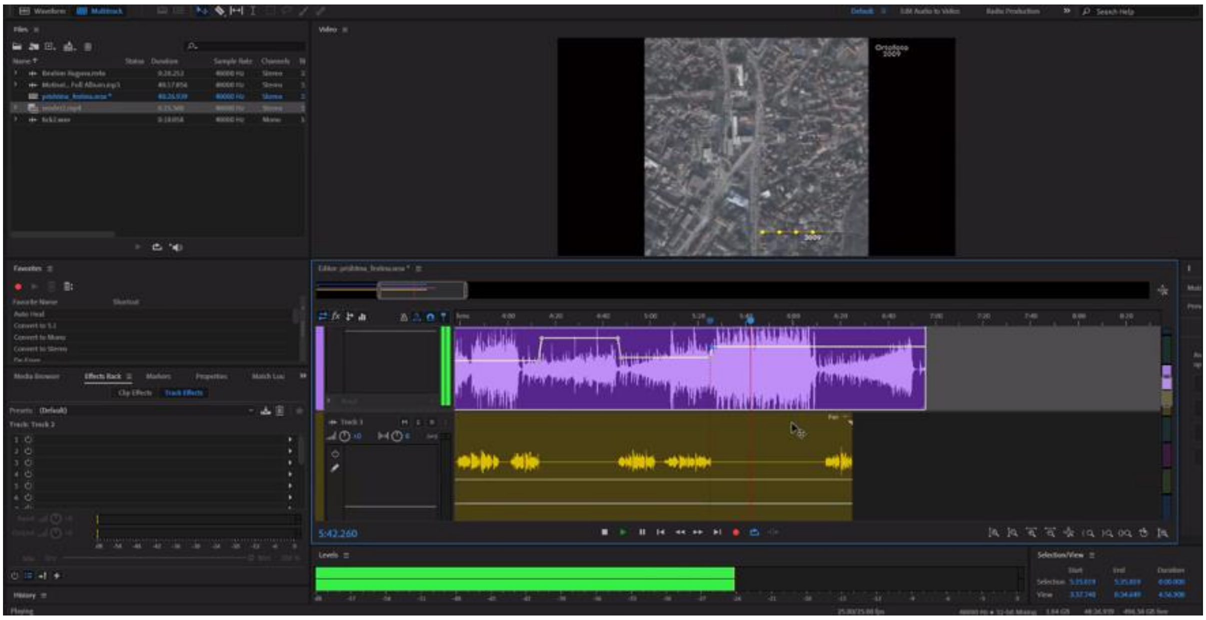


Figure 4.22 Elaboration of the third phase: evolving city by orthophoto.

Figure (4.23) shows the final stage of the animation. At this stage, it is checked whether all the elements are fitted, and making sure that there is no empty space between stages.

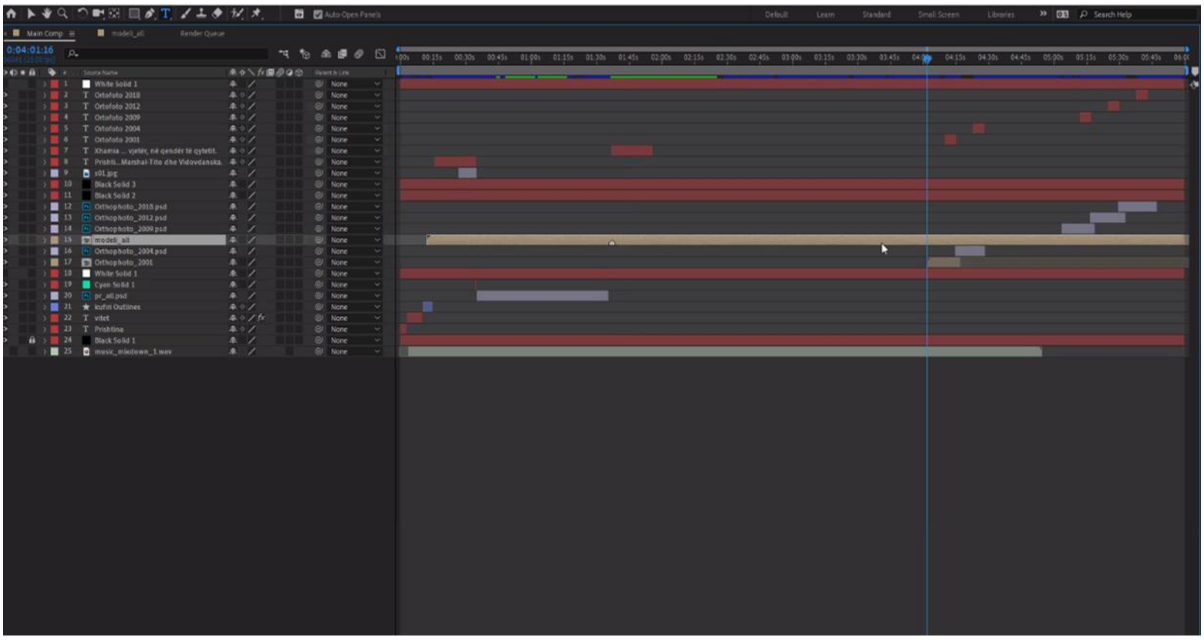


Figure 4.23 The appearance of the animation in the final stage.

The whole story was in Albanian, there were 10 paragraphs with information for each building and 2 paragraphs with information about Pristina where they appear at the beginning and end of the animation. A total of five orthophotos and a cadastral map are presented.

Also, the sound and text elements were attached to the paragraphs, where the sound presentation was for additional information about streets and buildings, while the text was presented giving the main features of the building and roads.

After finishing the animation, the whole story was projected as a lightshow on top of the 3D model with the 10 historical buildings. This final result will be explained in detail in the next chapter 5.

# 5 Results and Discussion

This chapter outlines the principal results of the research, analyzes how the research objectives were addressed, and answers the research questions formulated in chapter 1.2.2.

The first subchapter 5.1 describes the final practical result and addresses research objective I. Chapter 5.2 approaches research objective II. The set-up of the user study and information about the study participants are given. The user study results of the questionnaire and the interview will be discussed in detail.

## 5.1 The Prototype

A prototype of a 3D model with a projection on top of it was developed within this thesis. The case study tells the story of the landscape change in the City of Pristina using the storytelling approach in a 3D environment. The key element of the visualization is a timeline. The types of media to be used and animated are cadastral maps, orthophotos, texts, graphics, and background sound.

The main landscape change has occurred from 1893 until 2018 is Marshall Tito Street where it has been transformed into the main squares of the City of Pristina. At the location of Marshall Tito Street are now the Zahir Pajaziti Square and the Mother Teresa Boulevard.

In the City of Pristina are many objects that have an old history and are important, but finally 10 historical buildings have been selected due to the framework defined by the thesis. The 10 buildings have been mentioned in the available texts describing the landscape change of the City of Pristina. Each of these buildings represents a story in itself. During the years 1893-2018, all buildings were constructed, rebuilt and served for certain works.

The projection starts with animated numbers counting down from 1893 to 2018. The first element of the time line is the presentation of the cadastral map of 1893. The cadastral map has been selected to be presented as it is the only one given from 1893. In 1893 there was no orthophoto since the realization of orthophotos in Kosovo began in 2001.

As orthophotos have the positive attributes of a photograph such as details and timely coverage, the orthophoto’s from 2001, 2004, 2009, 2012 and 2018 have been used later in the timeline. The voice was used in for narrating the main information for all the 10 buildings. In addition to the voice, the spoken text was also displayed in a shorter version in a reserved section on the 3D model. Objects and roads are colored with different colors (yellow, white) in order to draw the participant's attention to important information in a text. Yellow is displayed when objects and roads are shown one by one with the most important information. While the white color appears when all objects and roads are displayed at the beginning.

For the 3D model two materials were used, the PLA material for the creation of the 10 buildings and the wooden material for the presentation of the roads including the boulevard. The reason for this combination was that the cadastral map and orthophotos can be visible on top of the transparent PLA material and will also be visible on top of the wooden material.

In the following, all stages from the realization of the prototype will be shown. These stages are the sequences taken from the animation.

As already described above, the projection starts with an animation counting the years from 2018 and stops in 1893 on top of the wooden model. The animation directly in the beginning of the story was chosen as it attracts the participant's attention and inform about the beginning of the landscape change (see figure 5.1).


Figure 5. 1 Animated numbers.

The animation continues with the presentation of the Kosovo border using zoom in and zoom out. The zoom in and out method was used to bring the Kosovo border over a certain time interval and to provide clarity to the participants about the location of the selected location in the storyline. After showing the country border, Kosovo's capital, Pristina, is introduced. The most important information about Pristina is displayed through text elements as well as narrated with voice (see figure 5.2).

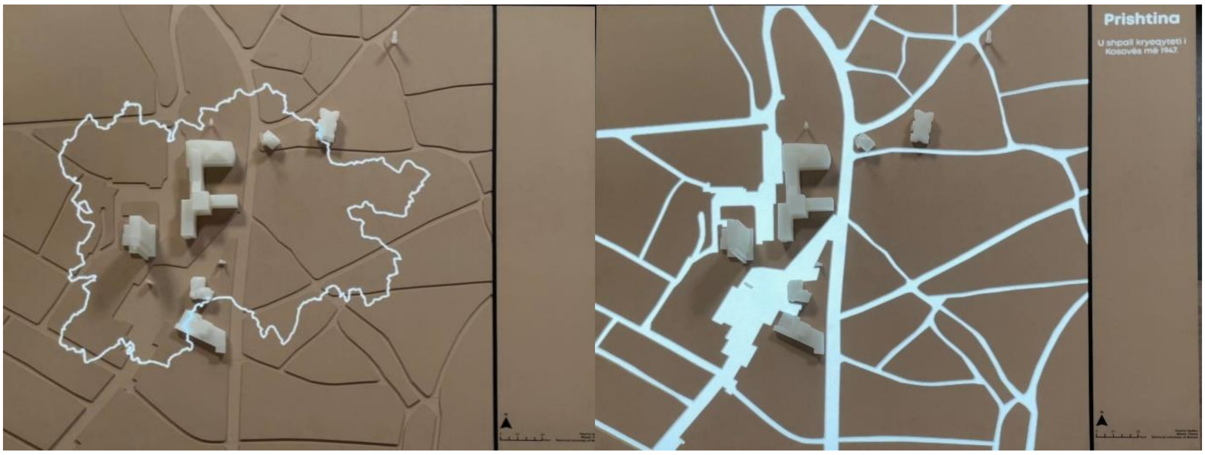



Figure 5.2 Presentation of the Kosovo borders.

The following sequence is the presentation of the cadastral map of 1893and continues with highlighting Marshall Tito Street and the 10 buildings presented in the 3D model. The selection and combination of white and yellow color was done for reasons of transparency in the wood material (see figure 5.3).

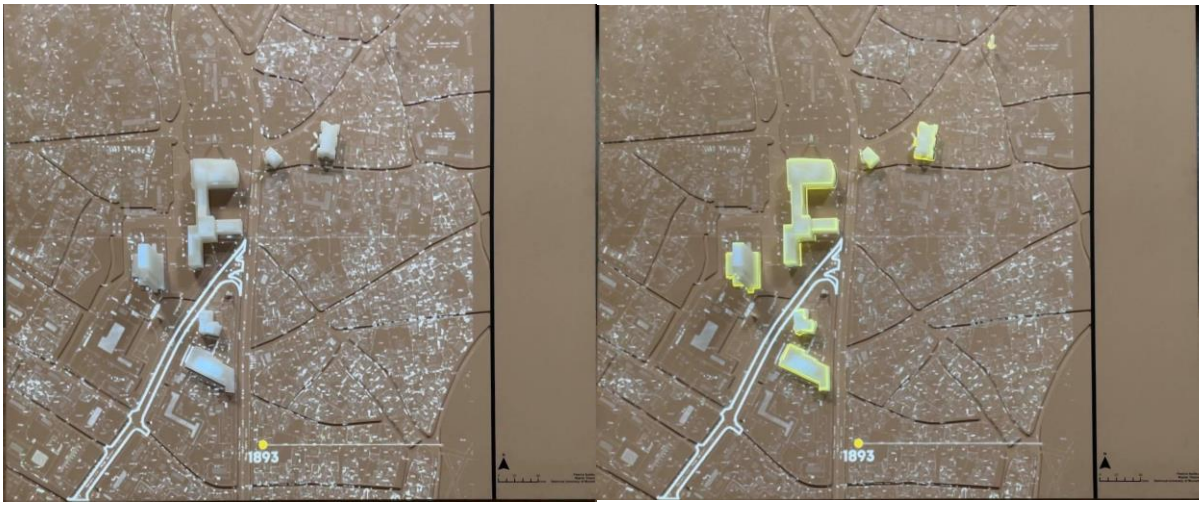



Figure 5. 3 Cadastral map in 1893 with highlighted buildings and street.

The next sequence highlights the 10 selected objects without the cadastral map in the background. The sequence starts with information on the features for each object and archival images displayed on the right side of the 3D model. Text is always supported by voice. The landscape change from Marshal Tito Street to Mother Teresa and Zahir Pajaziti Boulevard is narrated (see figure 5.4).


Figure 5.4 Information on the objects.

The following sequence is the presentation of orthophotos from 2001 to 2018. From the orthophotos, the landscape changes can be visually identified as the main changes are narrated and highlighted (see figure 5.5).


Figure 5.5  Orthophotos from 2001 to 2018.

The projection finishes with an orthophoto from 2018 and information about Pristina today given by element of voice. Finally, all roads today and the ten (10) objects are highlighted (see figure 5.6).

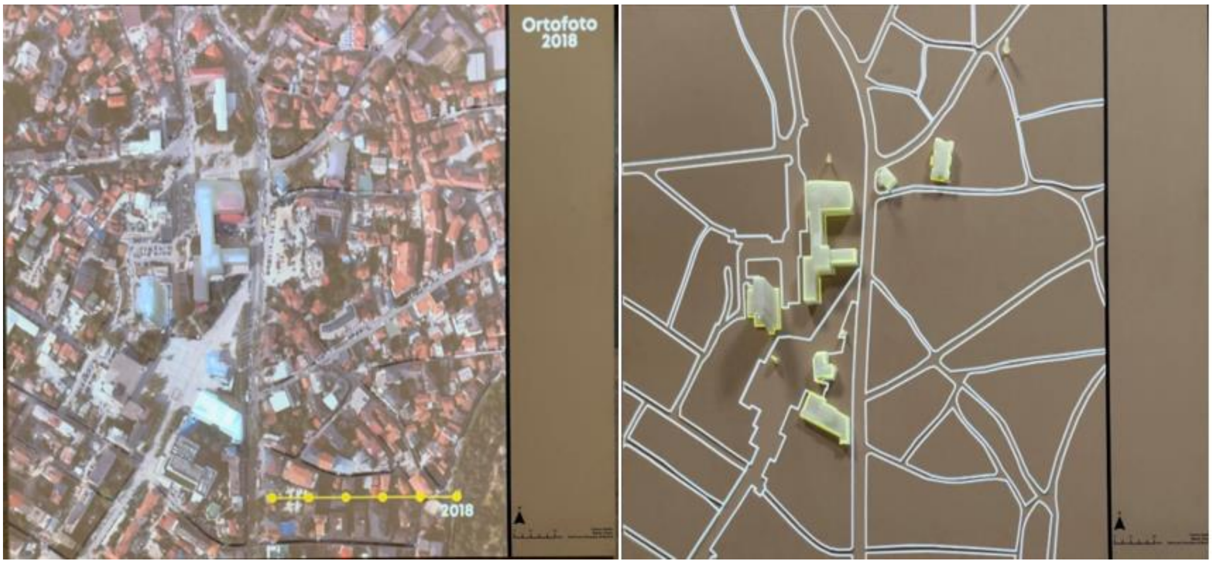



Figure 5. 6 Final sequence of the projection.

The animation is seven minutes long. The text written and spoken is in Albanian language, because the user study participants will be free to speak and give feedback in Albanian language. Details about the study participants, how the evaluation was conducted and how the user evaluated the prototype, are given in the next chapter.

## 5.2 The User Evaluation

This chapter now presents the outcomes of the user's participation in the evaluation of the prototype: questionnaire and interviews responses. At the latter part of this chapter, both the quantitative and qualitative analyses are combined to derive insights.

The experiment began on 1st September 2021 and ended on 3rd September 2021. Participants were approached via email. In the email the reason of the experiment was stated. In order to efficiently manage the participants schedule, users were asked to select a convenient day and time. A maximum of 8 slot per day were available to be selected, from 9am-4pm and each user's had maximum 1 hours available for visiting the exhibition, questionnaire and interview. An email is sent a day before the experiment, which included the exact location of the experiment and the time allocation. In conducting the experiments for this research, it was fundamental to inform the participants what they would do, how the experiment would be carried out in all possible phases, and the possible consequences. Prior to the start of each experiment, consent forms were presented to each participant. Participants were also informed that they could decide to discontinue the experiment at any time without stating their reason and request that their collected data will be excluded from the research. They were informed how the collected data will be processed. When a user's participation was completed, 15 minutes continued for a break to allow to prepare for the next user.

### 5.2.1 The Exhibition Setup

An exhibition prototype was installed in the amphitheater of the University of Pristina. To evaluate the prototype created with the case study, participants are invited to visit the exhibition and give feedback and comments. During the user test, participants could ask questions or got help when needed. The study was anonymous and not monitored. The time required to answer each question about the story as well as the time and self-exploration notes was determined by the experimenter. The participant had to fill in the first form with some general questions about their profile as well as questions about previous knowledge concerning the changes that have occurred in Mother Teresa and Zahir Pajaziti boulevard. After entering and filling in personal data in the first form, users were asked to explore the exhibition themselves one by one.

The exhibition prototype included the wooden base plate with the 3D models of the buildings with the dimensions of 1.50m * 1.25m * 0.80m. To use the selected area with the 1: 500 ratios, the projector holder was 4 m and 30 cm high (see figure 5.7). For the case study, the following equipment was available:

- Video projectors ACER X1323WH to project the lightshow.
- Anker Sound Core 2 Portable for the sound (voice and music).

Figure 5.7 Filling the questionnaire on the left, exhibition prototype on the right.

### 5.2.2 Participants

The user test was conducted among users with different professional backgrounds and different prior knowledge. Overall, there were twenty (20) participants, ranging in age from 20 to +60, with 55% between 20 and 40 years old, and 45% between 41 and +60 (see figure 5.8). Participants came from a variety of professional backgrounds, such as Cartography, Geodesy, Architecture, Geology, Graphic, and Structural engineer (see figure 5.9). The geodetic background was the most recurring and accounted for 45% of all participants, while the cartography background accounted for 15% of all participants (see figure 5.10). From the difference of profession, age and knowledge, the reactions and feedback for the 3D model were different from each other. From the difference in profession, age, and knowledge, the reactions to the 3D model were different from each other. Geodesists in the 20-30 age group were more enthusiastic when they saw the 3D model as they had never seen such an appearance before. While the participants with the profession of architecture were more familiar with 3D models and looked at the 3D model in detail.

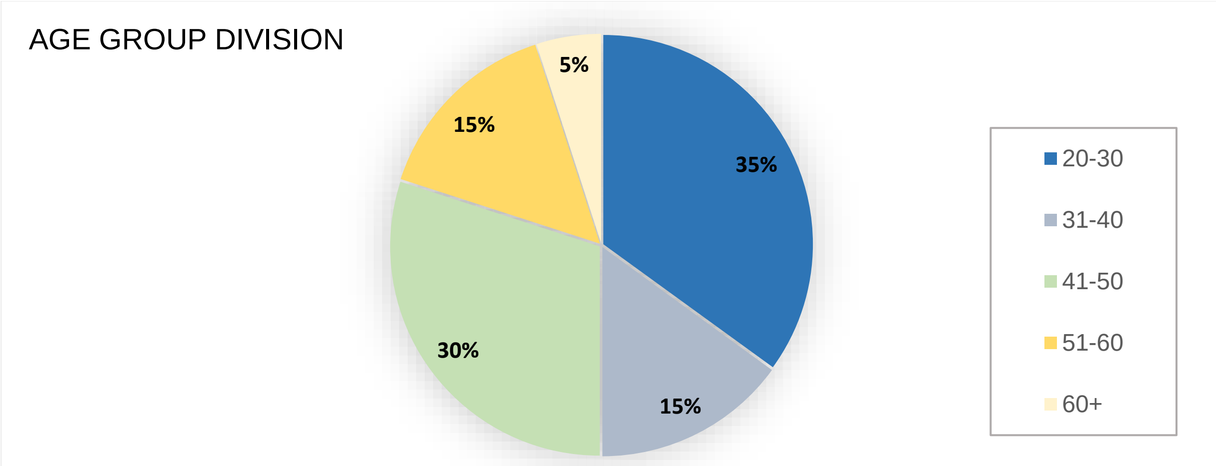



Figure 5.8  User's age group.

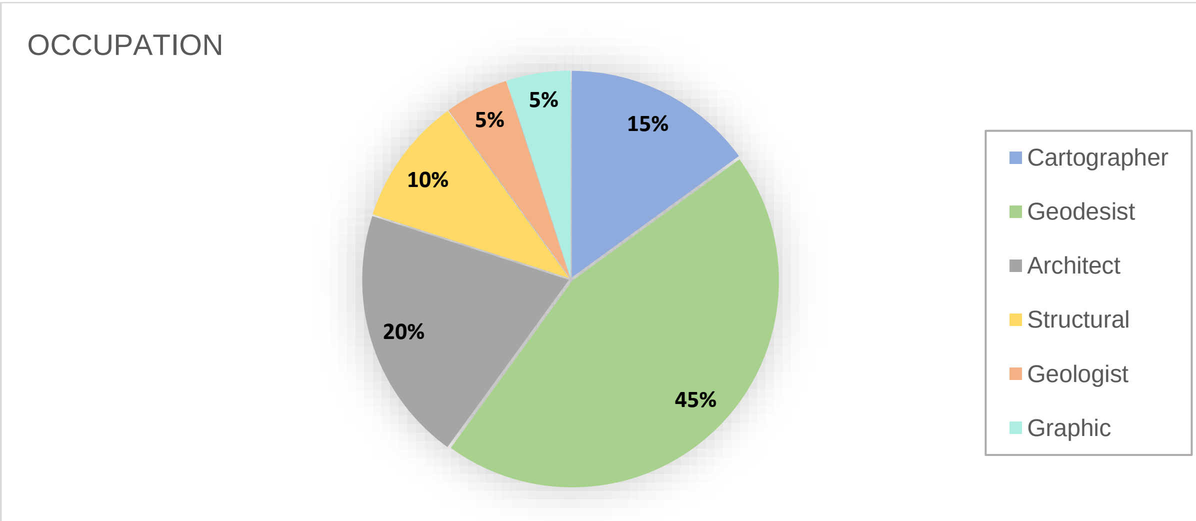



Figure 5.9  User's occupation.

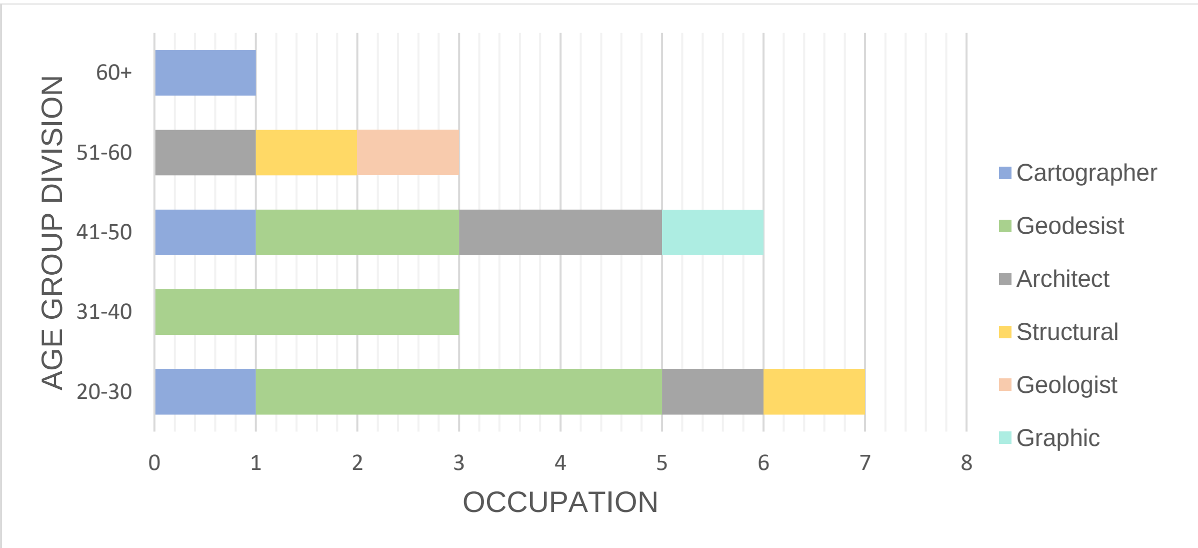



Figure 5.10  User's age group and their occupation.

Benefiting from the diversity of participants in the evaluation lead to a number of positive outcomes, such as feedback and a lot of support. From this support and feedback, the goal of many participants was to enable the display of the entire case study in the public interest or to develop stronger processing similar to this prototype.

If there were a larger number of historians, then maybe a more curious analysis between historians and geologists would have been possible. Based on (Cronon, 1992) the curious analysis between historians and the geologist would be because geologists record and analyze changes in the earth's landscape, where the data contained within the earth tell a history of centuries of change, some of them catastrophic dramatic. Despite historians are concerned with the narrative and past events related to the changing landscape (Cronon, 1992).

### 5.2.3 Analysis of the Questionnaire Responses

Evaluation was divided into two parts, a questionnaire and an interview. The questionnaire and the interview template can be found in Annex II and Annex III.

In order to answer the research question under objective II, it was necessary to first ask the users about their experience and knowledge about the landscape changes taking place in the case study area. Besides, it was necessary to know if they had prior experience in landscape visualization in any environment.

According to the responses related to the participants' profiles (age and highest completed degree), four participants in the age of 20 to 30 have completed a bachelor degree Three of the participant finished geodesy and one of the participants finished bachelor in department structural. While three of this age group have completed a master's degree in cartography. Three from the age of 31 to 40 have completed the master's degree and are geodesist by profession. Six participants in the age group 41 to 50 have completed master's degrees and doctoral degrees in several disciplines as geodesist, architect, graphic and cartographer.

Three participants in the age group 51 to 60 years have completed their doctorate and are with occupation as structural, architect and geologist. And finally, a participant with an age group of +61 has completed his doctorate as a cartographer.

To summarize, seven participants completed a doctoral degree in geodesy, cartography, structural engineering, architecture and geology. Nine have completed a master's degree in occupation of geodesist, Architect, Cartographer, Graphic and Architect. While four have completed a bachelor's degree and by profession are geodesist and structural (see figure 5.11).

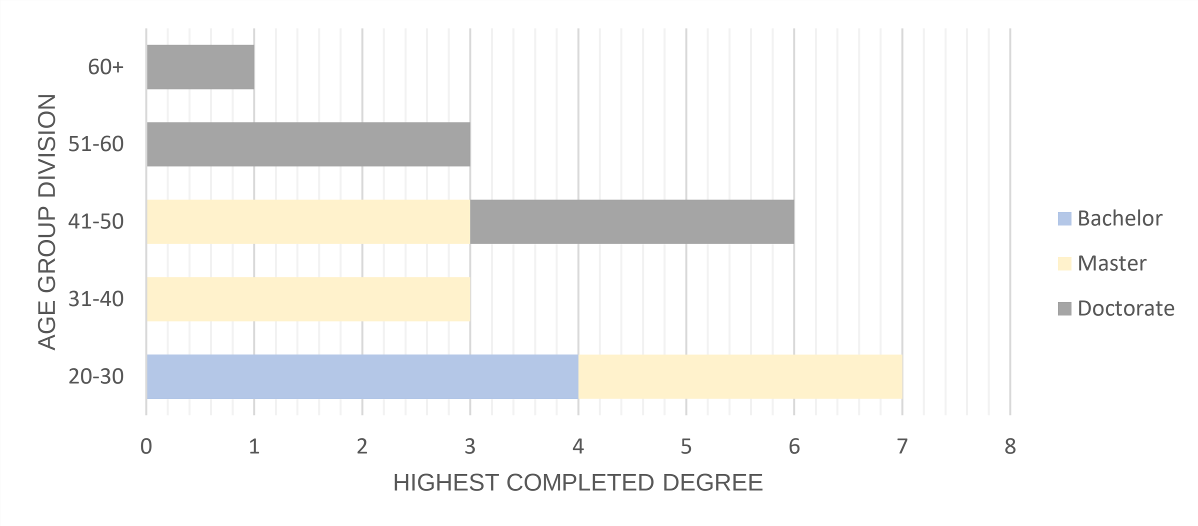



Figure 5.11  Age group division with highest completed degree parameters.

Question 1.6 asked the participants if they know any cultural monuments at Mother Theresa and Zahir Pajaziti boulevard in Pristina. Fourteen (14) out of twenty (20) participants stated that they are having previous knowledge of the cultural monuments while six (6) out of twenty (20) were without prior knowledge. Most of the participants without prior knowledge belonged to the youngest age group from 20-30. This was due to the fact that the younger participants do not live in the city of Pristina and do not have ample information about the cultural monuments (see figure 5.12).

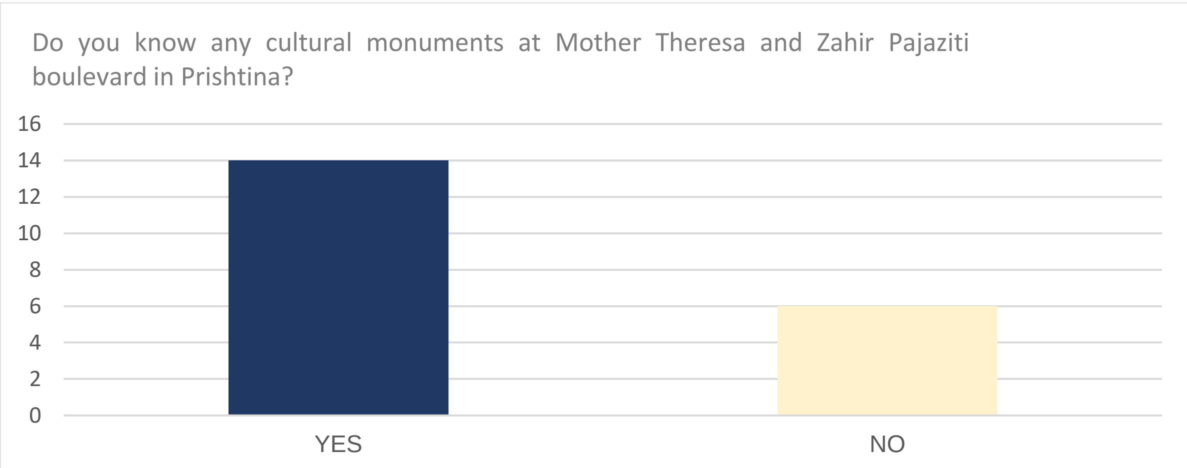



Figure 5.12  User's prior knowledge for cultural monuments.

Participants with the profession of structuralist, geologist, graphic artist, surveyor and some architects had not worked with 2D, 3D, 4D, or with virtual-, mixed-, and augmented reality before. Participants belonging to the architecture profession replied that they did not work with methods of the latest technology due to their age and qualification (see figure 5.13).

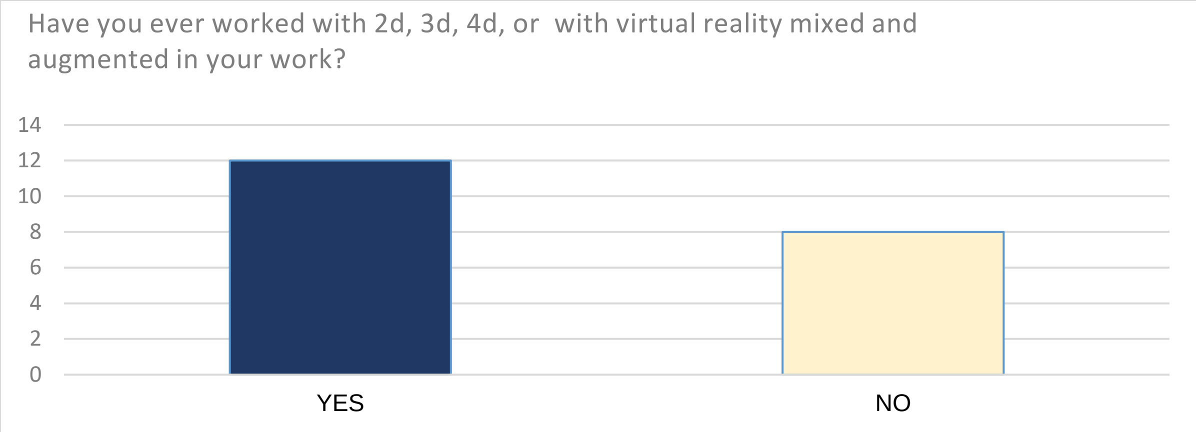



Figure 5.13 User's prior experience.

Question 1.7 asked the participants how informed they feel about the main monuments on Mother Teresa and Zahir Pajaziti Boulevard in Pristina. Three (3) of the twenty (20) who participated in the study were very informed, nine (9) were informed, five (5) less informed and three (3) neutral. The participants who felt very informed were citizens of the City of Pristina and therefore had ample knowledge of the changes that took place. The age group from 31-50 felt informed (see figure 5.14).

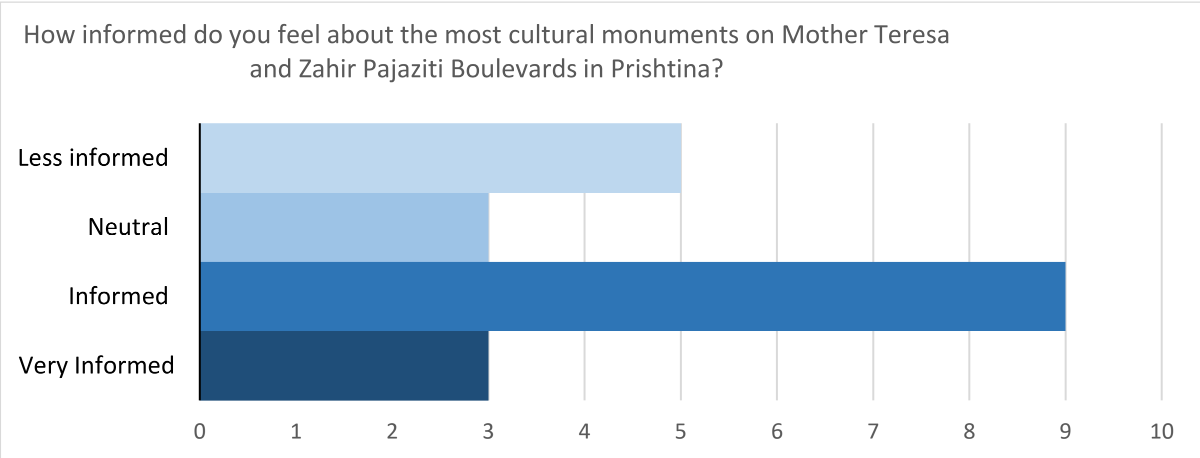



Figure 5.14 User's prior knowledge for cultural monuments in boulevards.

As mentioned above, all the participants were professors or assistants working in the University of Pristina, but with different occupation such as Cartographer, Geodesist, Structural, Architect, Geologist and Graphic. Those who had an occupation as Cartographer and Geodesist, twelve (12) were familiar with visualizing landscape changes with the help of a map while users with occupation as Structural, Architect, Geologist and Graphic (8) had no prior knowledge in visualizing landscape changes with the help of a map (see figure 5.15).

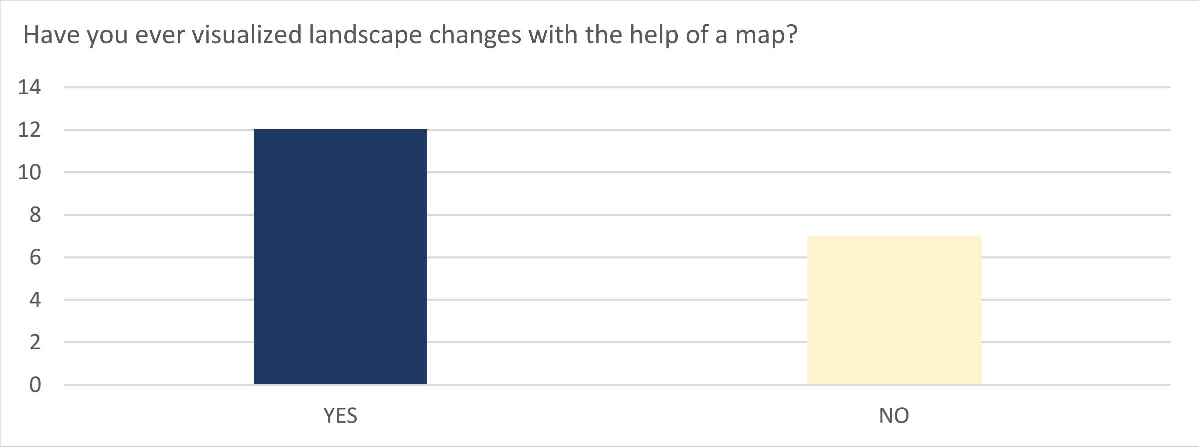



Figure 5.15  User's experience knowledge about landscape change visualization.

The participants who had an occupation as Cartographer and Geodesist (12) represent the landscape changes with the help of a map. Most of the participants practiced working with 2D and 3D visualizations (see figure 5.16). One participant with a profession in geodesy and in the age group of 20-30 gave the following comment:

*"Technology has advanced a lot in recent years. With these methods we have many opportunities for use and development".*

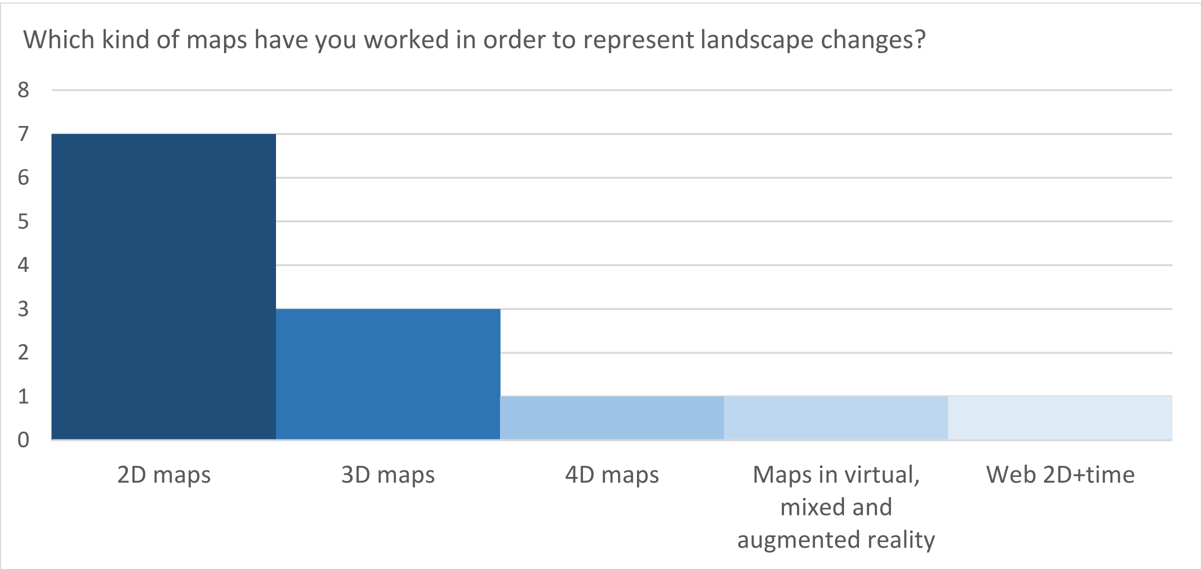



Figure 5.16  User's responses on question: Which kind of maps have you worked to represent landscape changes.

### 5.2.4 Analysis of Interviews Responses

Following the questionnaire, an interview with each participant was conducted. The interview was used to get insights on the user's perceptions. Users were asked to give feedback on their impression for the model itself and its features.

Almost all user's, nineteen (19) rated the impression of the model itself and its features as "excellent" while one (1) user rated it as "good" (see figure 5.17).

The following comment has been given by one participant in the interview:

*"It is very interesting and very accurate. The reason for the reply "good" is since I am an architect by profession and I have traveled a lot outside Kosovo, I am aware of 3D models that represent the change of a place or a storytelling with time-series for a certain event. The advantage of the models I have seen is that they have used a larger space and have displayed more objects, more animation."*

Overall, most participants had comments to share about the model itself. They found the combination of a 3D model with the projection as very interesting and informative. According to these users, four (4) of them preferred a different scale of the model and seeing more buildings.

A user said: *"I was happy when I saw all the animations. I was born and raised in Pristina, every piece of information was accurate and reminded me of the past. The model looks quite interesting and very informative. Regarding the scale, I must emphasize i would prefer different scale in order to have 30% more objects."*

Most of the users, fourteen (14), gave feedback regarding the impression of the prototype. Most of the users liked the preparation of the 3D buildings, the narration and visualization of the changes with the help of a timeline, the combination of the orthophoto and the audio, and the combination and synchronization of the text part with the visual effects and animation. During the interviews, the users mentioned that the incorporation of the light source coming from the projector was exciting. The participants stated that the model looked accurate, informative and attractive to them.

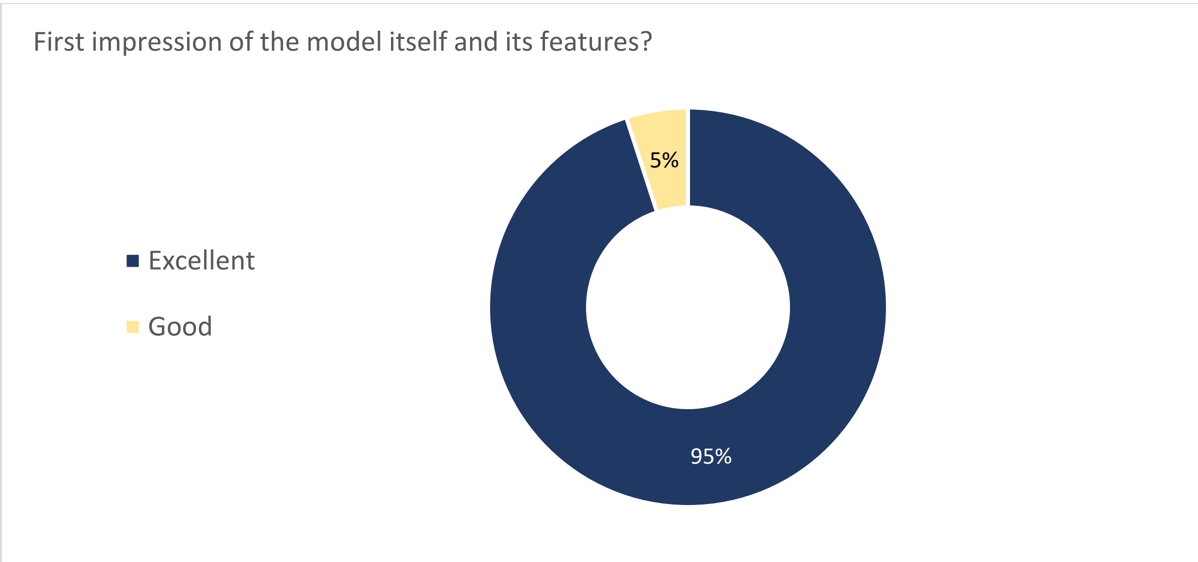



Figure 5.17 User's first impression.

Most users, sixteen (16), "strongly agree" with the meaning of the information presented in the prototype. Three (3) were "neutral" in understanding information about the City of Pristina. Participants with "neutral" answer would like to see more information about the city in general, not just about the chosen location. A user does not agree with the presentation of road information as the road information was only displayed for the selected location (see figure 5.18).

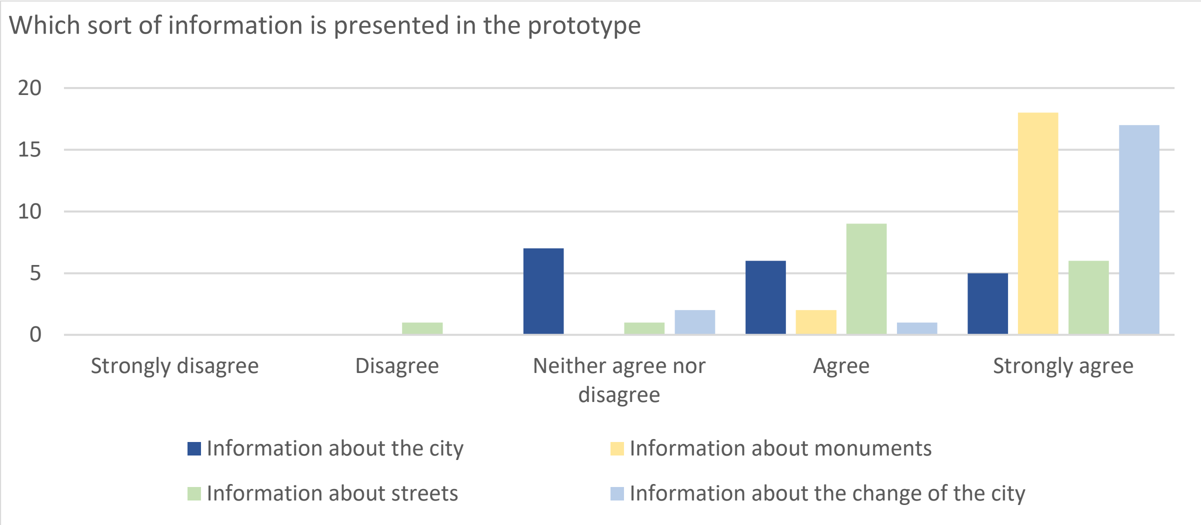



Figure 5.18 Information presented in prototype.

Most of the user's, sixteen (16), think that each element of the animation/projection helps understanding the landscape change (see figure 5.19). Three (3) were "neutral", one thought it doesn't help understanding the change.

Seventeen (17) users responded that the audio element helped "very much" understanding the landscape changes while two (2) were "neutral". Ten (10) users concluded that cadastral map "very much" recognize the landscape changes of Pristina, at the same time six (6) users thought "neutral" and one (1) "not at all". All the users, twenty (20) agreed that the orthophoto is a huge help in understanding the changes that occurred in Pristina.

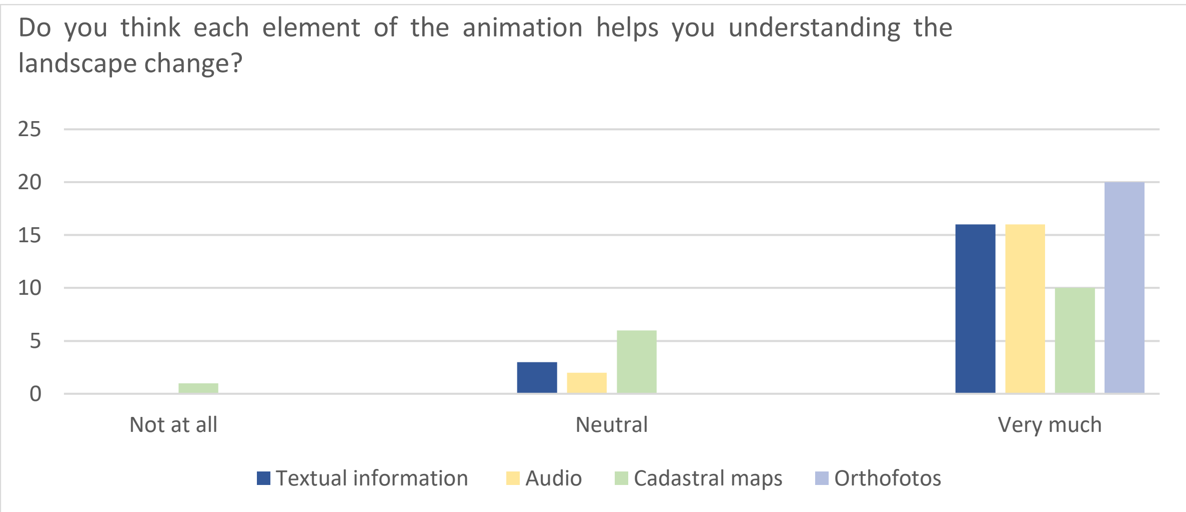



Figure 5. 19 Responses regarding the understanding of the animation.

(17) out of (20) users stated that they would create a similar prototype and the possible change of landscape would be street B in the city of Pristina, the city of Prizren and the area of Camp Bondsteel in Ferizaj.

Overall, most of the readers could not pick one element. They found it hard to decide on either the audio and the text information of the story or the orthophoto and 3D buildings but rather went for both elements. According to these users, ten (10) of them, selected audio and twelve (12) textual information. Fourteen (14) of the users were "neutral" about the selection of the 3D buildings also thirteen (13) were “neutral” about choosing more orthophotos (see figure 5.20)

*“Prizren falls in the middle in the first place, but any city would be good decision. Any area of the center and outside the center would be of interest, it would be good to place in museums, schools. I would select Prizren since I was born and raised and I very much hope to see a prototype with a different theme or the same, would be of great interest to me, but every city would be pleased to have such a prototype.”*

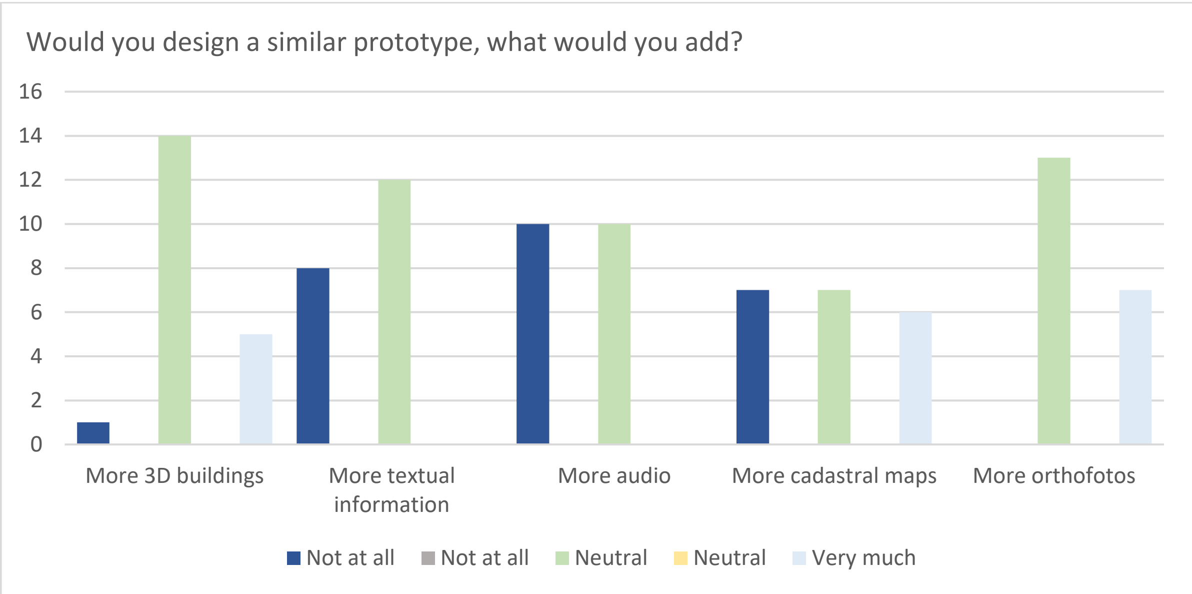
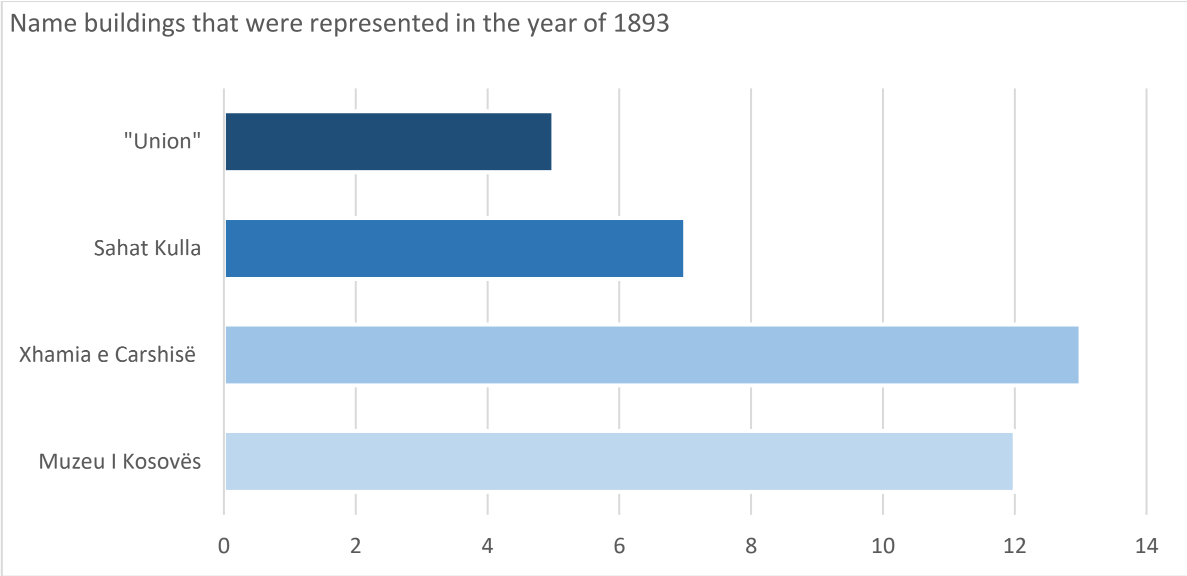



Figure 5.20 User’s suggestion for similar prototype.

The questions 2.9 and 2.10 (figure 5.21) referred to the memory of the users, the process that are taking place to acquire, store, retain, and later retrieve information. The correct answers to the questions asked are Museum of Kosovo, Carshia Mosque and Clock Tower, but most users had the correct answer for only two of the objects. Eighteen (18) users marked the Museum of Kosovo and sixteen (16) marked the Mosque of Carshia. A very small number of users, two (2) gave the correct answer for the third object displayed in 1893.



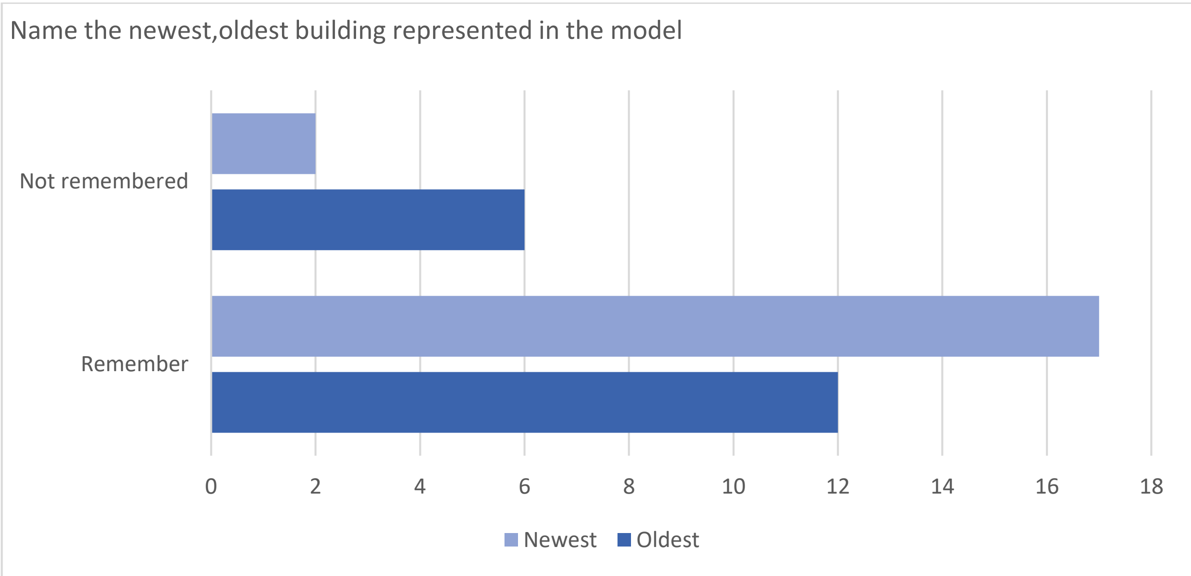




Figure 5.21 Memorization during the animation.

Most users, eleven (11) rated the difficulty level for reading the textual information as "easy". For five (5) of the users the level was "moderate" while for the other users four (4) it was "difficult". All these four users were in the group age 51-60. Their feedback was that they would prefer the time during the display of information to be longer as they could not concentrate on all details. It can therefore be argued that users in the age between 51-60 need longer to absorb, process, and remember new information (see figure 5.22).

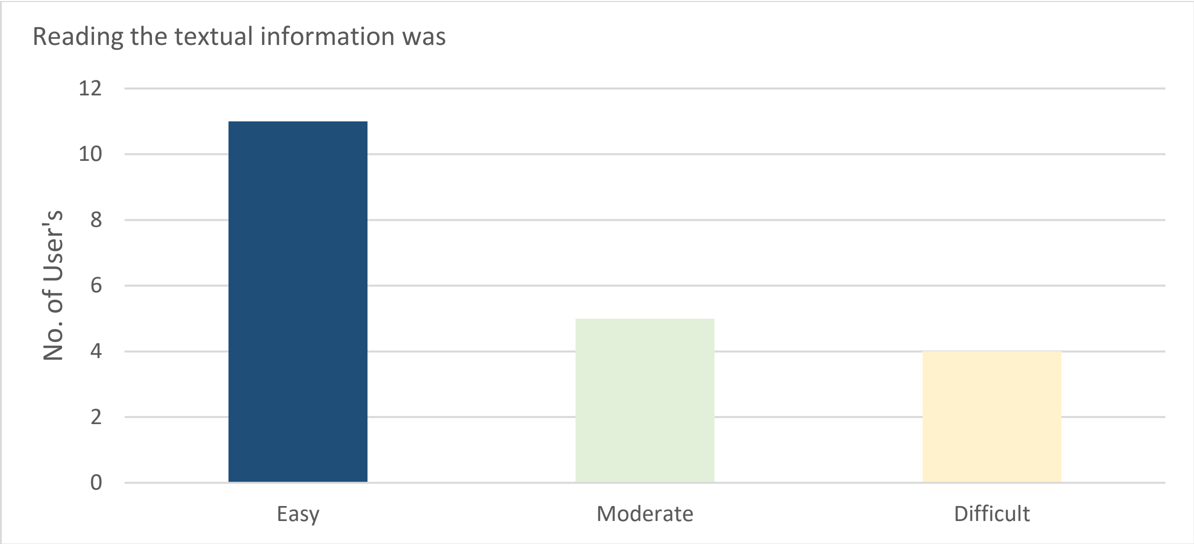



Figure 5.22 User's difficulty level.

Seventeen (17) users consider the combination of textual information with audio as "very useful". While three (3) users consider the combination of textual and audio information “useful”. As mentioned earlier in figure 5. 22 users in the 51-60 age group (3 of 4) here suggested (see figure 5.23).

*“If I had more time to focus on textual data and audio, I think I could understand better.”*

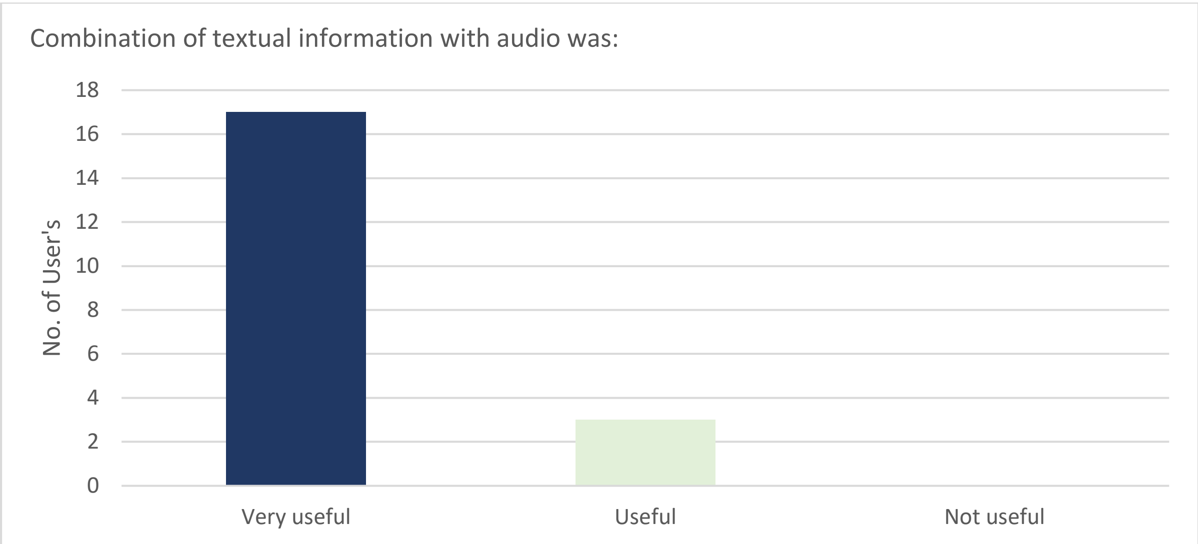



Figure 5.23 Combination of audio with textual information.

As shown in figure 5.24 most users, fifteen (15) consider the combination of textual information with the cadastral plan as “useful”. While five (5) of the others thought “moderately useful” and "slightly", "useful". There were some feedbacks from users who thought it was “less useful”. Their feedback was that if there were more cadastral maps followed over the years then the difference would be greater and the combination with textual information would be more appropriate.

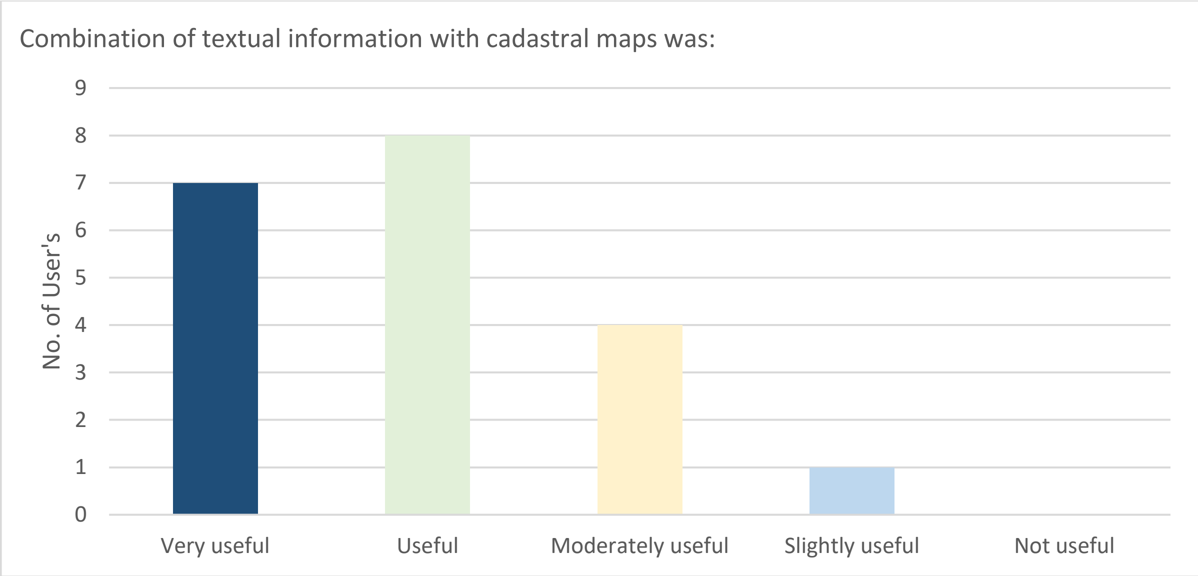



Figure 5.24 Combination of textual information with cadastral maps.

Combining textual information with orthophotos was beneficial for all users (see figure 5.25). Although it has been noticed that orthophotos change over the years in terms of resolution and the perspective of photography. In Kosovo, the realization of the orthophoto is not done every year because it has a high cost, but during the past years there were not many changes in many parts of the country.

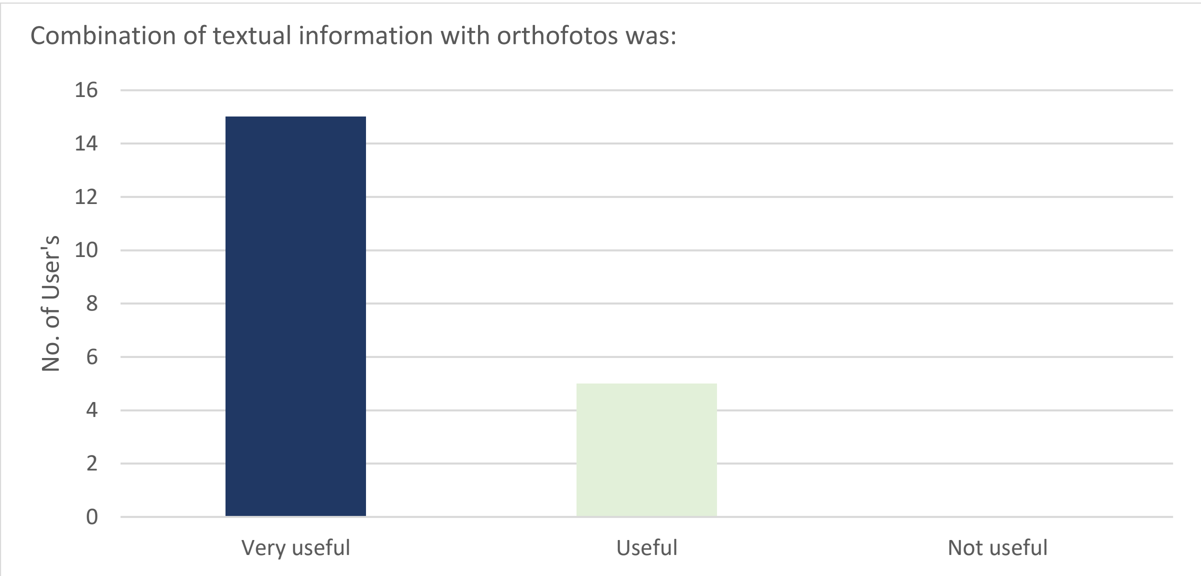



Figure 5.25 Combination of textual information with orthophoto.

# 6 Conclusion and Outlook

Pristina the case study, is an exceptional and favorable example of this kind of landscape changes depiction. Pristina is a city that has undergone many transformations in its appearance during its existence period from the year 1893 till nowadays 2021.

The methods and techniques used apply to the city of Pristina and are a recommendation for similar cities that have overcome a similar landscape change, but not for cities or areas that have a different type of landscape change. A concrete example would be the presentation of the change of landscape in mountainous areas, then it is completely opposite from the case study in Pristina as there is a lack of buildings in mountains areas.

As stated in Chapter 1 this thesis aims to investigate how textual descriptions about landscape changes can be transferred and communicate in a 3D environment using the storytelling approach. This overall objective can be divided into two sub-objectives:

I. Visualization of textual descriptions using storytelling method.

II. Evaluation of the effectiveness of the visualization (3D model and projection).

Two research objectives, each containing three sub-questions, were formulated in Chapter 1. In order to achieve these objectives all of research questions were answered in detail in their respective chapters, and are now discussed one by one. Afterwards, possible improvements of the methodology are described in outlook chapter.

## 6.1 Visualization of Textual Descriptions Communicated in a 3D Model

Through the visualization of textual description, storytelling aims to represent landscape change in action through time and to draw attention to the participant.

Landscape changes in books are discovered year after year describing specific information about altered landscape changes describing the characteristics of landscape changes based on single objects.

Multimedia is the key element of interactive storytelling that can be used to represent and transfer textual descriptions in a spatial model. Time series, maps, texts, audio, and photos can be combined in an animated story and projected on top of a 3D model. Individual elements can appear at a certain time in the animation. The text is one element in the narrative approach and mainly supports the visualization by providing additional information on the most important landscape changes with the categorization of features. The text provides the narration of the stories, but through exposure, it can also give imagination; may represent action over time.

To create a 3D model, data sets are needed, to visualize landscape changes the animation is needed, while to make the scenario structure, we need 10 selected objects. The scenario structure contains 4 main phases. The 3D model sequence with the time series element perfectly conveys the aspect of explaining landscape changes.

## 6.2 Evaluation of the Visualization

To test the effectiveness of the visualizations, research objective two was elaborated upon. The required elements for the answer of the research question (II-a) are: text, audio, cadastral maps, and orthophotos, archival images.

According to the user test, a majority of users found the combination of textual descriptions an attractive solution for describing the landscape changes. Some of the users considered the combination as a result achieved by the great development of multimedia technology. All of the elements have the same weight to tell the changes in the City of Pristina. On one hand, users' respond to a combination of cadastral plans with textual descriptions differs from the other combination elements.

The time series elements helped users see the visualization of changes through the time approach in storytelling. With this element, the emphasis is made on the main point or idea thus continuing through each specific year by giving new information for landscape changes.

The user test, as described in chapter 5, showed that there are many factors that change each other's participants' response. During the evaluation the influencing factors were: occupation, age group and living area. From these factors it can be concluded that work experience and older age groups have more work experience in visualizing landscape changes.

The use of cadastral maps and orthophotos to show the landscape change was considered as beneficial. The user impression of the 3D model was inspiring. Participants commented that the combination of the wooden plate with translucent colored buildings was appropriate as the presence of elements such as orthophotos and cadastral maps could be easily identified and analyzed.

Also, during the interviews, participants who had not seen such a model were surprised and excited when they saw that the light source coming from the projector on top of a wooden plate. Overall, users stated that the model looked accurate, attractive, and the combination of materials was pleasing.

## 6.3 Limitations and Future Research

This chapter reviews the experiences gained from user participation and summarizes aspects that may need to be revised and improved in future research.

Using the City of Pristina as a case study area within this thesis is an encouraging example for applying the storytelling method in a 3D environment for creating an attractive visualization of landscape changes. Pristina is a city that has undergone many transformations in its appearance during its existence period from the year 1893 till 2021. The methods and techniques used in this case study and applied to the City of Pristina can be used and are recommended for similar cities that have overcome a similar landscape change. However, it is not clear yet what needs to be added or changed for other cities or areas that have undergone a different type of landscape change.

In the case of Pristina, the data collection was difficult as the textual data existing was very rare. Two books were found and analyzed. Within these two books the landscape changes over the years were explained for the most important historical and cultural objects. If more data and literature explaining the change of the city would be available. Then the projection would incorporate more details and maybe the selected location would be bigger or in another part of the city.

The user evaluation produced positive results. All users considered the prototype as a needed visualization. By using elements as voice, text, maps and images, the attention of the participants was guided to parts of the model where participants found the information faster and efficient. Similarly, by using the highlighting option and animation, the storyline could be easily understood by the participants.

In case of a future continuation of the thesis case study, another scale and consequently adding more 3D models might suggested. Additionally, the evaluation should be performed with further participants.

The implementation of this idea in another city would be the determination of the smallest scale so that the space is larger and the presentation of the elements would happen more often. Frequent animation presentations would make storytelling more realistic and more emotional.

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# APPENDIX I: Structure of Storyline

| Phases | | | Data | Author | Year of Data | Next Steps | Details |
|---|---|---|---|---|---|---|---|
| 1' Phase | Introduction of Prishtina | Music | - | - | - | | ---- |
| | | Borders | Kosovo Geoportal | Kosovo Cadastral Agency | 2019 | Animation | Showing Borders of Kosovo and then zooming into Prishtina Bordes |
| | | Textual Data | Prishtina Monograph | Sanije Gashi | 2010 | | Short Introduction of Prishtina and Boulevard |
| | | Picture | My Prishtina | Sherafedin Sylejmani | 2015 | | Two Pictures of Prishtina and Boulevard |
| | | | | | | | |
| 2' Phase | Evolving City by Cadstral Map | Cadastral Plan | Kosovo Cadastral Agency | | 1957 | Vectorization | Overlay and highlighting the objects. |
| | | | | | 1980 | Vectorization | |
| | | | | | 1995 | Vectorization | |
| | | Textual Data | | | 2010 | Vectorization | Showing how many objects are build and how many of them |
| | | | | | 2015 | Vectorization | are restructured |
| 3' Phase | Evolving City by Orthophoto | Orthophoto | Kosovo Geoportal | Kosovo Cadastral Agency | 2001 | Animation | showing orthophoto year by year. |
| | | | | | 2004 | | |
| | | | | | 2009 | | |
| | | | | | 2012 | | |
| | | | | | 2015 | | |
| | | | | | 2018 | | |
| | | Textual Data | Kosovo Cadastral Agency | | 2010 | Animation | Details about the year of the othophoto. |
| | | | | | 2015 | | |
| 4' Phase | 3D Objects | Textual Data | Carshia Mosque | Sanije Gashi and Sherafedin Sylejmani | 1393 | Animation | Short Information about each object. |
| | | | Museum of Kosovo | | 1885 | | Each object will be described when it was built,where is located |
| | | | Clock Tower | | 1900 | | what are the main features or the characteristics of the buildings? |
| | | | Union | | 1927 | | |
| | | | Government Building | | 1980 | | |
| | | | Assembly of Kosovo | | 1948 | | |
| | | | Brotherhood and Unity | | 2010 | | |
| | | | Theater of Kosovo | | 1999 | | |
| | | | Skanderbeg | | 2010 | | |
| | | | Ibrahim Rugova | | 2012 | | |
| | | Picture | My Prishtina | Sherafedin Sylejmani | 2015 | Animation | The pictures of the building will be included. Every time that the |
| | | | Prishtina Monograph | Sanije Gashi | 2010 | | the object will change also the pictures will. Old pic for buildings. |

# APPENDIX II: Questionnaire

## USER'S PROFILE

1.1 Which age group do you belong to?

- ☐ 20-30
- ☐ 31-40
- ☐ 41-50
- ☐ 51-60
- ☐ 60+ years

1.2 What is your highest completed degree?

- ☐ Bachelor
- ☐ Master
- ☐ Doctorate
- ☐ Other ________________________________

1.3 What is your occupation?

- ☐ Cartographer
- ☐ Geodesist
- ☐ GIS professional
- ☐ Historian
- ☐ Other, please specify: ______________________________

1.4 Have you ever worked with either 2D, 3D, 4D or in virtual, mixed and augmented reality at your job? Please explain your experiences shortly (incl. the device you were using).

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

1.5 Have you ever heard about the landscape changes in Pristina between 1995 and 2021?

☐ Yes

☐ No

If yes, what landscape changes do you know? Please list and/or describe them briefly.

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

1.6 Do you know any cultural monuments at Mother Theresa and Zahir Pajaziti boulevard in Pristina?

☐ Yes

☐ No

If yes, which cultural monuments in Mother Theresa and Zahir Pajaziti Boulevard do you know? Please list the monuments.

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

1.7 How detailed informed do you feel about the most cultural monuments in Mother Theresa and Zahir Pajaziti boulevard in Pristina?

| Very informed | Informed | Neutral | Less informed | Not informed |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

1.8 Have you ever visualized landscape changes with the help of a map?

☐ Yes

☐ No

If yes, with which kind of maps have you worked in order to represent landscape changes?

☐ 2D maps

☐ 3D maps

☐ 4D maps

☐ Maps in virtual, mixed and augmented reality

☐ Other, please specify: ________________________

# APPENDIX III: Interview

2.1 What is your first impression of the model itself and its features?

| Bad | | Good | | Excellent |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

Do you have any comments you would like to share about the model itself (e.g., scale)?

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

2.2 What did you like about the prototype the most?

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

2.3 Which sort of information is presented in the prototype?

| | Strongly disagree | Disagree | Neither agree nor disagree | Agree | Strongly agree |
|---|---|---|---|---|---|
| Information about the city | ○ | ○ | ○ | ○ | ○ |
| Information about monuments | ○ | ○ | ○ | ○ | ○ |
| Information about streets | ○ | ○ | ○ | ○ | ○ |
| Information about the change of the city | ○ | ○ | ○ | ○ | ○ |

2.4 From your perspective, how useful would you consider storytelling in a 3D environment for describing and visualizing landscape changes?

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

2.5 How do you think each element of the animation helps you understanding the landscape change?

| | Not at all | | Neutral | | Very much |
|---|---|---|---|---|---|
| Textual information | ○ | ○ | ○ | ○ | ○ |
| Audio | ○ | ○ | ○ | ○ | ○ |
| Cadastral maps | ○ | ○ | ○ | ○ | ○ |
| Orthophotos | ○ | ○ | ○ | ○ | ○ |

2.6 Please mark one number in the continuum for each question that best represents your experience.

Reading the textual information was:

| Easy | 1 | 2 | 3 | 4 | 5 | Difficult |
|---|---|---|---|---|---|---|
| | | | | | | |

I consider the combination of textual information with audio as:

| Very useful | 1 | 2 | 3 | 4 | 5 | Not useful |
|---|---|---|---|---|---|---|
| | | | | | | |

I consider the combination of textual information with cadastral maps as:

| Very useful | 1 | 2 | 3 | 4 | 5 | Not useful |
|---|---|---|---|---|---|---|
| | | | | | | |

I consider the combination of textual information with orthofotos as:

| Very useful | 1 | 2 | 3 | 4 | 5 | Not useful |
|---|---|---|---|---|---|---|
| | | | | | | |

2.7 If you could design a similar prototype, what would you add?

| | Not at all | | Neutral | | Very much |
|---|---|---|---|---|---|
| More 3D buildings | ○ | ○ | ○ | ○ | ○ |
| More textual information | ○ | ○ | ○ | ○ | ○ |
| More audio | ○ | ○ | ○ | ○ | ○ |
| More cadastral maps | ○ | ○ | ○ | ○ | ○ |
| More orthophotos | ○ | ○ | ○ | ○ | ○ |

2.8 Can you remember the buildings that were represented in the year of 1983? Please encircle the buildings that were shown.

☐ Museum of Kosovo

☐ Carshia Mosque

☐ Clock Tower

☐ "Union"

☐ Government of Kosovo

☐ Assembly of Kosovo

☐ Brotherhood and Unity

☐ Skanderbeg

☐ National Theater of Kosovo

☐ Government

☐ Ibrahim Rugova

2.9 Name the oldest building represented in the model. Can you remember when it was built?

Name: ________________________ Year: ________________________

2.10 Name the newest building represented in the model. Can you remember when it was built?

Name: ________________________ Year: ________________________

2.11 Can you imagine a similar application visualizing a landscape change (a 3D model with an animation on top of it) for a different area?

☐ Yes

☐ No

If yes, which area and possible landscape change do you have in mind?

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________