



Cartography M.Sc.

Master thesis

The Cartographic Visualization of Processes and Changes:

“Case study of changes over the years
in the city of Vienna”

Tea Muraj



2023

Statement of Authorship

Herewith I declare that I am the sole author of the submitted master's thesis entitled:
"The Cartographic Visualization of Processes and Changes: Case study of changes over the years in the city of Vienna"

I have fully referenced the ideas and work of others, whether published or unpublished.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

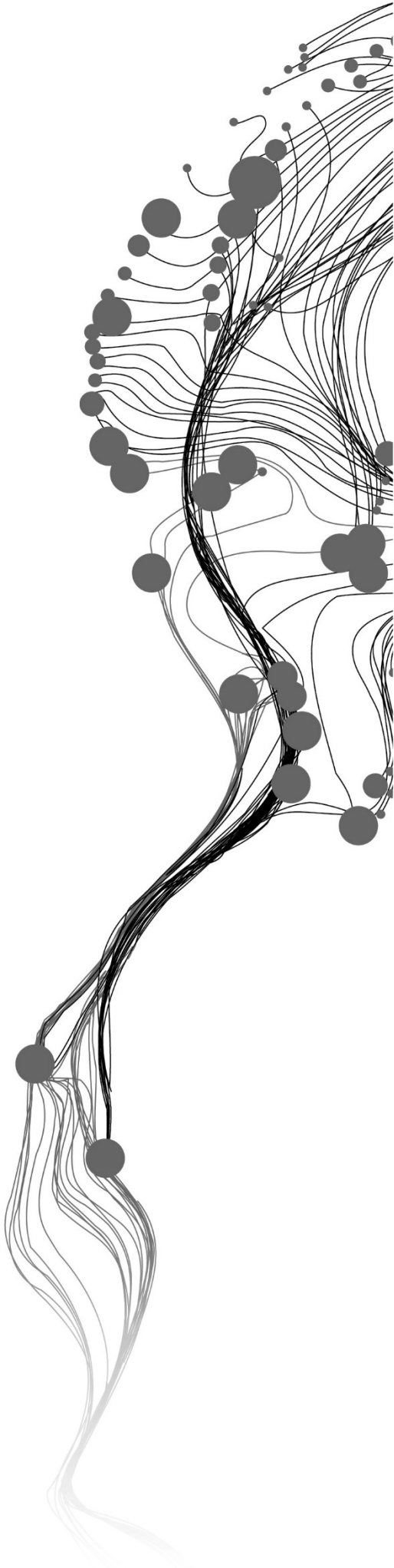
Vienna, 07.09.2023

Tea Muraj

The Cartographic Visualization of Processes and Changes: “Case study of changes over the years in the city of Vienna”

TEA MURAJ
SEPTEMBER, 2023

SUPERVISOR:
Prof. Dr. Franz-Benjamin Mocnik



The Cartographic Visualization of Processes and Changes: “Case study of changes over the years in the city of Vienna”

TEA MURAJ

Enschede, The Netherlands, September, 2023

Thesis submitted to the Faculty of Geo-Information Science and Earth
Observation of the University of Twente in partial fulfilment of the
requirements for the degree of Master of Science in Geo-information Science
and Earth Observation.

Specialization: Cartography MSc

SUPERVISOR:

Prof. Dr. Franz-Benjamin Mocnik

THESIS ASSESSMENT BOARD:

Prof. Dr. Menno-Jan Kraak (Chair)

Dr. Nianhua Liu (TUM) (Reviewer)

DISCLAIMER

This document describes work undertaken as part of a programme of study at the Faculty of Geo-Information Science and Earth Observation of the University of Twente. All views and opinions expressed therein remain the sole responsibility of the author, and do not necessarily represent those of the Faculty.

ACKNOWLEDGMENTS

First and foremost, I want to express my sincerest gratitude to Professor Franz Benjamin Mocnik for supervising me throughout this thesis. Thank you for giving me the trust to ask and share anything on my mind during our meetings and for the trust to work from afar. You have been truly inspiring.

Furthermore, I want to thank Professor Barend Köbben and Professor Menno-Jan Kraak for being so welcoming and supportive during our journey at the "University of Twente". Additionally, a very big thank you to Juliane Cron, for being the best coordinator this program can wish for and for being so heartwarming, kind, and supportive.

It has been an incredible journey and it has been an honor to have lived and shared it with my fellow future cartographers. These two years would have not been the same without them.

ABSTRACT

This thesis delves into the dynamic evolution of the city of Vienna followed by an exploration of visual representations. By including and creating different representations of maps and diverse visualisations, this study reveals the world of the process, changes and transformation that have shaped Vienna's urban landscape over time. Using the power of cartographic tools and design techniques, this research illuminates the historical and contemporary dimensions of Vienna's urban growth. This thesis gives a holistic view of the city's growth by bridging the gap between different analysis and artistic interpretation. The resulting synthesis contributes to a larger discussion on the function of visual representation in comprehending urban development, and fusing process and change in the world of cartography.

Table of Contents

ABSTRACT.....	1
INTRODUCTION.....	6
1.MOTIVATION AND PROBLEM STATEMENT	7
2.RESEARCH IDENTIFICATION	7
2.1. RESEARCH OBJECTIVES.....	7
2.2. RESEARCH QUESTIONS:	8
2.3. METHODS ADOPTED:	9
2.4. INNOVATIONS INTENDED	9
2.5. RELATED WORK.....	9
2.6.STRUCTURE AND FRAMEWORK	11
3.PROJECT SETUP.....	12
3.1. METHODOLOGY	12
3.2. PLANNED SCHEDULE OF THE PROJECT	13
3.3. RISKS AND CONTINGENCIES.....	13
3.4. RESOURCES REQUIRED.....	14
CHAPTER I:.....	16
VISUALISATION, PROCESS AND CHANGE	16
1.LITERATURE REVIEW.....	16
1.1. WHAT IS CHANGE?.....	16
1.2. WHAT IS A PROCESS?	19
1.3. WHY DO MAPS CHANGE?.....	21
1.4. REPRESENTING MAPS THROUGH CHANGE AND PROCESS.	23
1.5. TRANSFORMATION OF CITIES.....	25
1.6. CHANGE IN A CITY	27
1.7. VISUALIZATION IN CARTOGRAPHY AND URBANISM	28
1.8. VISUALIZING CHANGE AND PROCESS.....	29
CHAPTER II:.....	32
VIENNA'S HISTORY AND CITY	32

TRANSFORMATION.....	32
1.CARTOGRAPHY AND URBANISM	32
2.HISTORY AS A PROCESS OF CHANGE.....	34
3.VIENNA’S HISTORY AND HOW HAS IT CHANGED THROUGHOUT THE YEARS	35
CHAPTER III:.....	37
THE PART OF THE STUDY.....	37
VIENNA AS A REPRESENTATION FOR DEPICTING CHANGE AND PROCESS.....	37
1.VISUALIZATION METHODS AND REPRESENTING CHANGE.....	37
2.VISUALIZING AND REPRESENTING CHANGE IN VIENNA.....	41
CHAPTER IV:.....	51
CONCLUSIONS AND RECOMMENDATIONS	51
CONCLUSIONS	51
RECOMMENDATIONS.....	54
REFERENCES	56
APPENDICES:.....	59

List of Figures

Fig. 1: map of vienna, showing the different changes throughout the years (suitner j., 2020).....	12
fig. 2: the occurrence of change	18
fig. 3: process described in a visual form	20
fig. 5: process diagram explained	21
fig. 4: change and process	23
fig. 5: change, process and time.....	24
fig. 6: visualization techniques in cartography inspired by jacques bertin, 1984	38
fig. 7: ways to visualize and represent change and process.....	40
fig. 8: timetable with specific changes that occurred in vienna	41
fig. 9: vienna's major processes	42
fig. 10: early map of vienna's development.	43
fig. 11: map of vienna during the year 1890.	44
fig. 12: nowadays situation of vienna's transformation.	45
fig. 13: layering method of showing all changes that have occurred in different years.....	47
fig. 14: areas in vienna that are currently experiencing change.....	48
fig. 15: an approach by using different visualization elements to represent change visually.....	49
fig. 16: a simpler approach to visually represent change over time.	59
fig. 18: vienna's change between 1920 and 1945.	61
fig. 19: vienna 1960 and 1990 growth situation	62
fig. 20: expected changes to occur in the city of vienna by year 2030.....	63
fig. 21: heat map, highlighting future changes in 2030 vienna.	64

List of Tables

tab. 1: table of the planned thesis schedule	13
--	----

INTRODUCTION

The centre and city of Vienna display a real history of transformation. Every street, building, and space depicts a progressive narrative that has evolved over time. This thesis walks through Vienna's urban story using the compass of cartography. Maps are used as guides to enlighten the way through the complex environment of change and development that has defined this metropolis.

Cartography in this case is treated as the art of mapping and used as a tool for understanding historical references and changes that have occurred in an urban matter. A city unfolds through growth, transformation and renewal.

Three related stages make up and give shape to the projects. In order to learn more about Vienna's past, it is important to first unravel the past and delve into historical records and maps. These maps will serve as a way to reveal the times when the city's foundations were established and its contours were beginning to take shape. At the same time, focusing on the nowadays situation of Vienna's and city's developments is important for this part of the study.

In the second part, Vienna is depicted as a very solid ground that depicts development and growth. Through modern cartographic techniques, the development is documented by outlining the buildings, evolving spaces, and landmarks that reflect the passing of time.

This research aims to enrich the field of cartography by integration both traditional and modern cartographic techniques, as well as speculative representation. This presentation of maps documenting developments and changes, aims to speculate new perspectives in cartography, urban studies and design.

Let the map serve as your compass, the past as your guide and the future as the horizon to begin this journey. On the following pages the history of Vienna is revealed layer by layer, map by map.

1. Motivation and problem statement

Visualization provides ample opportunities to explore, portray and convey a particular concept or idea. It can be argued that technology and the burgeoning proliferation of information have drastically transformed the landscape in recent years, rendering it easier to visualize and depict anything (Wada et al., 2022). Maps offer cognitive advantages by enabling data interpretation as they relate to a specific representation. The field of map visualisation requires clarification regarding existing techniques (Oeltze-Jafra et al., 2020). The challenge lies in controlling and representing this type of visualisation. Visualising individual parts is already complex, but representing a city's processes and changes poses an even greater difficulty.

Maps have always been effective representations of visualisations, with numerous variations in how to depict and present a given subject matter. In current urban design practices, the map is a valuable tool for recording reality and facilitating decision-making. Its usefulness is dependent on its perceived objectivity. When contemplating cities, complexity is often the initial thought that springs to mind. At the same time, various groups and individuals hold differing perceptions in this area. Cities undergo significant development, and even the smallest alteration can have a substantial effect on space and people. These changes and impacts are rarely apparent as they occur, but instead manifest over extended periods. Ultimately, the question arises as to how we should depict and depict this particular transformation. As this study aims to exemplify a concept, Vienna will be used as an example. This is an important aspect of the study. The focus lies on the processes and changes in cartography and how to represent them visually.

2. Research Identification

2.1. Research Objectives

The thesis aims to objectively investigate various methods of visualising change and transformation in maps, examining techniques which best represent visualisation in a case study. The thesis aims to objectively investigate various methods of visualising change and transformation in maps, examining techniques that represent visualisation in a case study.

For this part the study incorporates a range of fields including cartography, urbanism, psychology, and design to explain the process and change approaches.

The study is guided by two central research questions to support the conclusive thesis:

O.1. Understanding the meaning of process and change, by discovering how it relates to urban life and cartography.

O.2. Observing different visualisation methods and approach the techniques that represent change and process better.

The outcomes of this investigation can aid the field of cartographic visualisation by serving as a guide for designing diverse and fitting representations on maps.

2.2. Research Questions:

RQ1.1.: How can processes and changes be effectively identified and distinguished?

RQ1.2.: What are the various visualisation methods employed in the field and how do they differ from one another?

RQ1.3.: Which visualisation methods are most suitable for specific types of cases or scenarios?

RQ2.1.: Which specific visualisation methods yield superior results in terms of representing data, and what are the key considerations for constructing a well-visualised map?

RQ2.2.: Which conceptual frameworks and methods are commonly employed to describe processes and changes?

RQ2.3.: How do different visualisation methods interact within the field of cartography?

RQ3.1.: What are the effective techniques for visualising processes and changes on a map?

RQ3.2.: What role does time play in accurately representing processes and changes on a map?

RQ3.3.: What specific design approaches are utilised in urban settings for visualising processes and changes?

2.3. Methods Adopted:

In this study, a systematic literature review is chosen as the primary research method. This approach allows a closer examination to the different ways in which information is presented on maps in the field of cartography.

The next part of the research focuses on a fundamental aspect: how to represent processes and change on maps. This specifically brings focus on how to visually represent things that change over time or across different areas. In doing so, the contribute might bring valuable insights to the field of cartography and help improve the way we present dynamic information on maps, and specifically bring more attention in including abstract themes, like change and process.

Finally, the research will be concluded by presenting innovative ways to show the changes and transformations that have taken place in Vienna. These new ways of visualising data are intended to provide a clearer understanding of how Vienna has evolved over time.

2.4. Innovations Intended

This project is dedicated to the development of innovative cartographic techniques tailored to the visualisation of distinct map elements, while addressing the intricacies associated with their thoughtful design. Given the variety of approaches available to communicate these methods, our primary goal is to create a wide range of patterns that can be used in different applications. This deliberate effort will not only enhance the effectiveness of the visualisation, but also take its usability and compositional combined with the ideas of change and process.

2.5. Related Work

It has been shown that the use of cartographic maps to evaluate data with respect to location offers cognitive benefits. The term "map-like" in visualisation refers to

techniques that incorporate cartographic map elements in their display of abstract data. The field of map-like visualisation is vast; however, there is currently no comprehensive classification of the methods in use. **(Hogräfer, M., Heitzler, M., Schulz, H. J., 2020)** The authors present a hierarchical classification of techniques based on the distinction between imitating and symbolizing maps.

(Kraak, 2005) provides an insightful observation on the use of maps for visualizing spatial data. Maps play a crucial role in processing spatial data. They aid in revealing and understanding spatial distributions and relationships through visual representation of data. Recent innovations, such as exploratory data analysis and scientific visualization, have made a significant impact on the field. Firstly, visualization enables the display of spatial data in cases when well-designed maps are not feasible. Secondly, analysis can be performed through visualization. Thirdly, exploration of data can be undertaken through visualization. In this way, visualization facilitates interaction and data exploration through specific animations or views. "Visualising Strategic Change."

"Visualizing Strategic Change: The Role and Impact of Process Maps as Boundary Objects in Reorganization" may bear resemblance to our selected topic. Fenton highlights the strength of process mapping, which is highly flexible and can integrate with other tools. This study incorporates process maps, which are dynamic and changeable **(Fenton, E. M., 2007)**. Additionally, process maps can become a knowledge repository and signify the sustainability of the change program. While process maps may be effective tools, their usefulness is dependent on the abilities of their users, unforeseen circumstances (such as the need for intermediate success stories), as well as broader organizational, technological, and cultural factors.

The objective of this study is to also examine urban cartography as a central topic of discussion. Indicators of a city's performance, data-driven solutions, and information-sharing platforms are increasingly accessible and have the potential to play a critical role in comprehending and governing intricate urban systems. Our cities face strain in an increasingly urbanized world, and planners, decision-makers, and communities must be ready to adapt to the challenges. **(Pettit C., Lieske S. N., Jamal M., 2017)**. As a consequence, effective communication of these urban

processes and transformations will rely on appropriate methods of representation and visualization.

2.6 Structure and Framework

2.6.1. Introduction

This section serves as the central foundation of the study, providing a detailed description of objectives accompanied by a compelling rationale. It also sets out the research objectives and questions that underlie the nature of the research. In this way, not only clarity and common understanding are ensured, but also a solid foundation on which to build the entire research project is created.

2.6.2. Literature Review

Literature searches are of paramount importance in the context of this study. It acts as an intellectual gateway and introduces a wealth of terminology used to describe different aspects of change and processes. Beyond a mere exploration, this section provides a comprehensive overview of the conceptual landscape and provides a solid ground for future research studies related developments and changes in cartography.

2.6.3. Methodology

After exhaustively researching the existing literature, the path of developing the methodology is embarked. This phase is characterized by the creation and refinement of various visualization techniques. These techniques improve your ability to understand, evaluate, and systematically organize the design expressions. This methodological journey embodies the practical translation of theoretical insights into tangible tools for research and investigation, and marks an important turning point in the research and results. The commitment is not only to advance knowledge, but also to empower the research community with innovative approaches to representation.

2.6.4. Results

The Findings section has proven to be the focus of the research and carries the weight of the efforts. In this comprehensive chapter, all the data evaluated and considered are presented in a visual format, revealing the results to receive an

objective analysis. The goal is to extract meaningful insights from all information collected and explained. Through this process, the contribute is done mostly to the body of knowledge, and also to the broader discussion of our research subject.

In the final section of the research, detailed overview is provided in the last section of the study. Here the threads of the research journey are adjusted into a coherent narrative that summarizes all the findings. In addition, an insightful feedback is provided on the overall findings, focusing mostly for consideration of change and process within the broader of academic and practical context. This section therefore serves as the culmination of the academic inquiry, inviting others by reflecting on structuring the foundations that are already laid.

3. Project Setup

3.1. Methodology

In this study, the main research approach is to take a detailed look at different ways of displaying information on maps. The goal is to classify these methods, understand where and how they are used, and assess their impact on map quality and cartography in general.

Following this exploration, taking a look at Vienna's history and recent changes is quite important. The goal is to understand how various processes shaped Vienna into its current form. Thinking of it as a retrospective that combines change, history, and urban planning to paint a complete picture of Vienna's transformation. All this

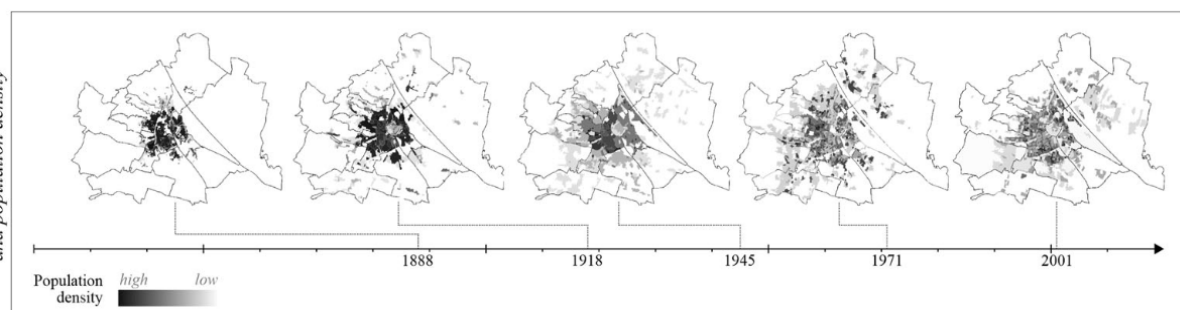
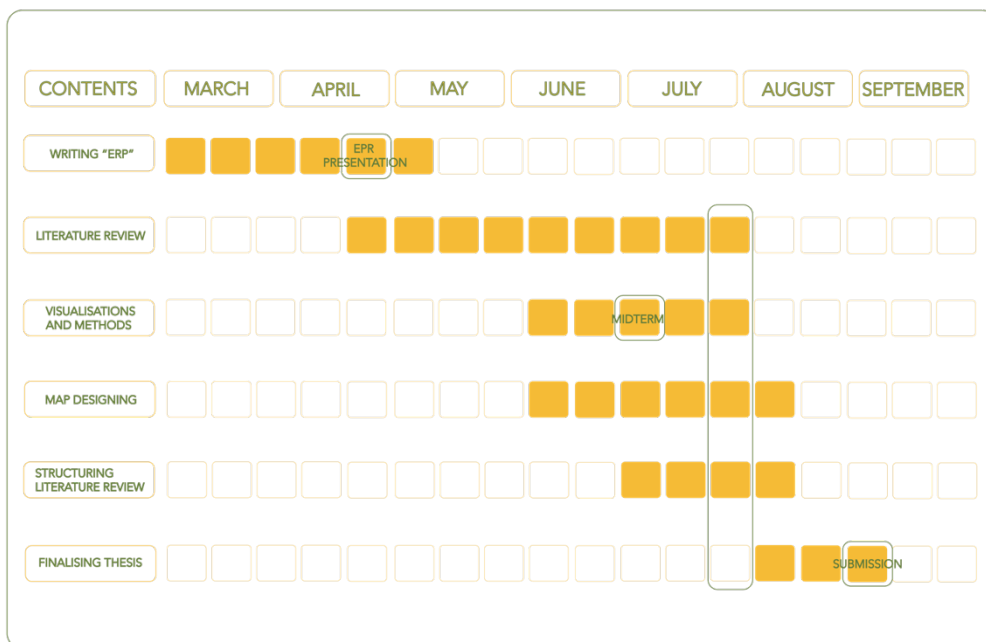


Fig. 1: Map of Vienna, showing the different changes throughout the years (Suitner J., 2020)

knowledge has been applied to the field of cartography. Considering ways to visually represent the changes that are uncovered, is important to note that the data is taken from different maps of Vienna in different years. All areas and details are carefully outlined, ensuring rendering accuracy and precision. It shows how different disciplines such as history, urban planning and cartography can work together to create a map that vividly tells the story of Vienna's development.

3.2. Planned Schedule of the Project

The projected timeline for the project can be found in the structured table below. To ensure close oversight and consultation throughout the paper, insightful meetings are scheduled. These meetings provide a valuable opportunity to review and discuss project progress, foster effective collaboration, and ensure that the work is running smoothly.



Tab. 1: Table of the planned thesis schedule

3.3. Risks and Contingencies

At the core of this research is a unique focus on:

Evaluating the effectiveness of design visualization. The main goal is to decipher the complexity of process and change, unravel their fundamental properties, and explore new ways of visually communicating them. The beginning with a

comprehensive presentation of the wide range of visualization and illustration techniques that emerged as a result of our extensive research.

The city of Vienna turns out to be an exemplary canvas for this exploration. Vienna's recent history has been characterized by great changes, making it an ideal background for diverse visual representations. Ready to make a transformative impact on design practice, these reimagined visualization techniques offer an innovative way of representing a variety of events intertwined with the multitude of processes and changes that occur in cities.

However, it is important to recognize that mapping these complex processes and changes can pose subtle challenges as the exact methods of their implementation are not yet fully understood. This highlights the dynamism and evolution of the research in navigating the fields of design, visualization and representation within the ever-changing urban landscape.

3.4. Resources Required

3.4.1. Resource Utilisation and Methodology

Important data about the city of Vienna will be used as a key resource when developing the visualization for this study. This data set contains important maps and historical timelines of important changes in the city.

3.4.2. Literature review and research approach

The literature review plays a central role in creating the foundation of this study. Dr Franz Benjamin Mocnik, the supervisor, is the main contributor to this topic. It is important to note that there is no plan to conduct interviews or user studies on this particular topic.

3.4.3. Software and hardware

In terms of the tools and technologies that we will be used in this study, mainly involves the use of the Adobe Pack for visualisation purposes. However, the flexibility about incorporating alternative software such as ArcGIS and QGIS, depending on the evolving needs and progress of the study. During this phase, data will be collected from various maps of Vienna, by outlining and layering the newly

generated maps. For this part Illustrator will be used to assemble all the layers together and work on them.

3.4.4. Financial considerations

No funding is required at this stage of the project.

CHAPTER I: VISUALISATION, PROCESS AND CHANGE

1. LITERATURE REVIEW

1.1. What is change?

Change is constantly happening all the time and in general the overall idea of change in the academic practice is not indeed that fragmented. All of the disciplines and practices that seem to exist have an only partial of different kind of reviews for this matter. There seems to not be a specific map that concludes all these fields together, for a better understanding, and it must be considered that all these different perspectives range of different understandings. This chapter will introduce a multidisciplinary approach into explaining the topic of change. A different of viewpoints will be demonstrated form different kinds of fields like art, demography, economics, education, politics, global environmental change, industrial change, organizational change, psychology, to mention just a few. (Bammer, 2015) explains that this type of approach is expected to enrichen the different perspectives to be

demonstrated while exploring some similar points of intersection, if there will be any. Generally, in this case the expectation is also the diversity this part will offer, as grouping them in different categories or discipline based is not the focus.

In politics, **(Carnell, 2015)** sees change as quite challenging due to the fact that making that change happen in a specific government brings a lot of risks. In this case the art of negotiation and compromise is included as a key ingredient. But the different processes and transformations that are happening in this case, successful or failures, still lead to change fatigue.

When it comes to global and environmental change, the uncertainty about the long-term direction and details that are required is seen as quite difficult. In this case change is feared, in a sense of how it will affect to humans and the actions that they will take. Working carefully with the complexity that the unknown brings, will help identify and understand approaches to make change more effective (Stafford, 2015). But as a result, change still cannot be stopped, as it is natural for it to occur. And as Professor Rune Todnem has specified, change is nothing to be protected from because it is part of life.

War is also influenced a lot by ideas about a specific change. **(Wesley, 2015)**, considers three competing schools of thought. "Teleology" provides an optimistic view, seeing the world on a solid trajectory to becoming more peaceful, based on the power of rational thought and behaviour. "Cyclicity" argues that the constant pressures for change on internal and external state relationships result in a perpetual cycle alternating between relative peace and widespread war. "Episodes" focuses on the complexity and unpredictability of changes in relationships between nation states, as well as conditions that result in inertia and inability to respond flexibly when new conditions for war arise.

Change is a central consideration in sociology and sociologist **(Browne, 2015)** provides an overview of change in different perspectives. Two important focuses in this part relate a lot to the double character of society as it is in fact made up of the actions of individuals and it extends to which of these individual actions are constrained by what society allows. The approach of this interaction explains the ability of various groups within society to

control and modify their lives and also the difficulties of making change happen. It safe to mention that social movements are widely directed by the promotion of change and the resistance to it.

Other disciplines and platforms like, industry, media, internet and psychology are very simplified in the sense of using creativity and powerful messages that tend to exploit basic human needs, like security, love and belonging. Internet and media are well known a huge platform for free expression of the change that is occurring. **(Madigan, 2015)** brings focus in this part that the change might have a better stable ground. Controlling this change that is being influenced and represented has its own difficulties as it is a topic for a lively debate.

Change also navigates with difficulties of understanding, direction and assessing change in a high pressure and evolving world of intelligence, as Grant Wardlaw describes. He raises three questions that are quite interesting and important, not for the intelligence growth, but all the fields that exist:

- a) What Change is necessary?
- b) How and how much the intelligence world has actually changed?
- c) Whether this change has been effective?



Fig. 2: The occurrence of Change

The general understanding about change management, and the resistance to change are complicated by the specifics of the context. At the same time, both fundamental change and the capacity adaptation are required to address those specific changes that are seen as threats or issues.

The field of biology can relate to change as quite natural, and change is viewed as inevitable. Biologist (**Bromham, 2015**) describes the evolution of change in humans as quite important. Knowing these types of changes that have occurred is essential to humans and it created a connection with the changing biological world. But in this part, the outcome leaves quite the interpretation. Relevant data can be interpreted in multiple ways, which are open to modification as the disciplinary field of biology is constantly changing itself. There are constant analyses, new ideas and findings.

In demography, the change is as a consequence of human decisions, which in fact are shaped by the overall society. Researcher (**McDonald, 2015**) explains that change in demography is about not only how and why populations change, but also the consequences of change, especially repercussions for public policy.

When we talk about economy, structural change and climate change, (**Butler, 2015**) mentions a common theme of all three like growing interest in causality, moving beyond simply accepting and describing change to understanding its economic determinants. In economy, this is lately seen as quite a big shift, due to the fact that the determinants of change were therefore outside the domain of economics.

1.2. What is a process?

Processes form a family, but by considering some cases as essential, will create a good picture of the structure that these processes have. (**Munsat, 1969**) admits that there are several properties of processes which any analysis of the structure of a process must take into account. Processes take time, it can be interrupted or completed. Processes can proceed at a normal or abnormal rate. At the same time, it is possible to break processes up into stages. In this case one can ask at what point the process has been reached at a particular time. This technically does not mean that process comes into pieces of puzzle that are already broken apart. The process can be considered a "natural one" and it seems that every process consists of four stages and parts:

1. An initial state (object or stuff)

2. An event or activity
3. An episode
4. A product or result (which is sometimes a state)

These so-called stages must be present in order for a process to occur. The logic of process can be conceptualized within these specific stages. A process can take time in virtue of there being an activity or an event involved, and when we speak about a process being interrupted, we might refer to the activity not culminating in the episode. The things which "undergo" processes are the elements of the first point, "a thing or an object". The normal or abnormal rate refers to the time taken or the activity to culminate in the episode (not the "activeness" of the activity, though this is no doubt related to the rate at which it reaches its culmination). And lastly, to reverse a process is to end up, via a process, where you started via an activity which is roughly the original activity or the original activity backwards.

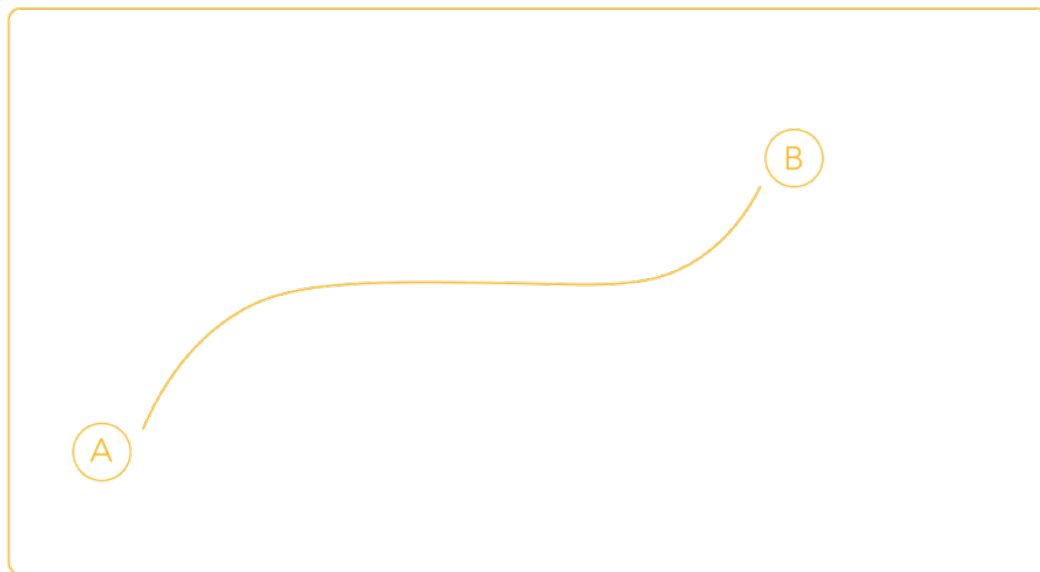


Fig. 3: Process described in a visual form

What distinguished processes from non-processes is the applicability of these concepts. Processes involve a very definite direction in a special or particular manner toward a specific end. "Process" is a teleological concept.

(Muller, 2021) describes that process can actually be rather abstract. In our day-to-day life we use process as a way of working. "A process is an activity which takes place over time and which has a precise aim regarding the result to be achieved. The concept of a process is hierarchical which means that a process may consist of a partially ordered set of subprocesses." Considering that this word is used a lot, it technically results that people view it quite differently. In some other cases process is seen with different attributes that consist of "the purpose' what is to be achieved, the structure of how this will be achieved, "the rationale" of the reason behind the process, "the roles" that are present, what responsibility and criteria is associated, and lastly "the ordering" that includes the phasing or sequence in application. It describes the essentials of the purpose, structure, rationale, roles and timing, leaving plenty of implementation freedom. The power of a process is its abstraction, which enables its application in a wide range of applications, by tailoring its implementation to the specific application.

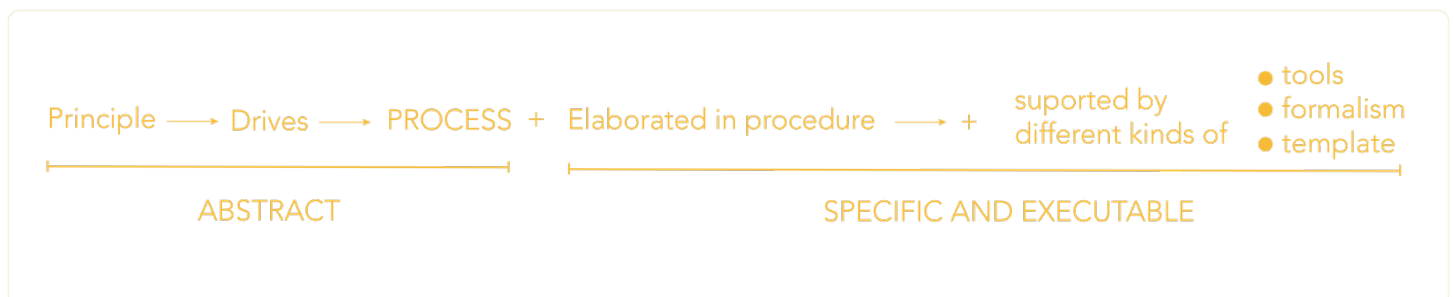


Fig. 5: Process Diagram explained

1.3. Why do maps change?

Prof Arup Dasgupta, gives a very compelling definition, As how mapping becomes ubiquitous, cartography as a craft needs to take into account the vast amounts of constantly updated information. While this presents an entirely new set of challenges for the cartographer, it also provides new opportunities for visualising the world around us.

Hans-Peter Brondmo, Vice-President and head of new product innovation for Nokia HERE has explained that a map is really just a way to guide one through his or her life. This is the reason why "Nokia" is aiming in representing maps that would model the real world, one that can actually show where one is in an accurate 3D representation.

People have wanted to draw and show maps of the world for a really long time, and it is a bit hard to know exactly when it started, but the Greeks played a big part in making maps better. Aristotle thought the earth was round, and Eratosthenes worked out how big it was and drew lines on the map to show where everything was. Ptolemy made a special book of maps with names, directions and symbols on them. These things are still used in maps today. Over time, people have used new technology to make better maps. Now maps can be interactive, which means you can choose how you want to use them. The main aim is still the same, to show the world in a way that is much easier for people to understand.

The most important question that is quite heard in the world of cartography is if maps are related to specifically science, technology or art? On one hand, there are aesthetic maps which convey nothing as a map, while on the other there are very informative maps presented crudely in clashing colours, unnecessarily bold fonts and clumsy patterns. Erwin Josephus Raisz was the first one to admit that cartographers are both scientists and artists (**Raisz, 1938**). A lot of others seem to agree at this remark, like Ed Parsons. He also explains that today is mostly artistic, as the science and technology are being replaced by technology and it is in fact quite easy to "manipulate" algorithms and information due to advanced software of nowadays. It is important to also mention how now the cartographer more than ever must use their judgment to choose the appropriate techniques to communicate their intended purpose. Of course, today, designing for the dynamic medium of a display screen, the range of techniques has hugely expanded".

Prof Menno Kraak, agrees with Raisz's statement. Kraak states that technology in fact is affecting on maps resulting of the same kind. And in this case the art of design plays the role into making all these maps to display some type of usability and appreciation of the map. He continues to add and emphasize the importance of the

triangle, science-technology-art, since it brings different areas together for a better interaction and results in maps.

1.4. Representing maps through change and process.

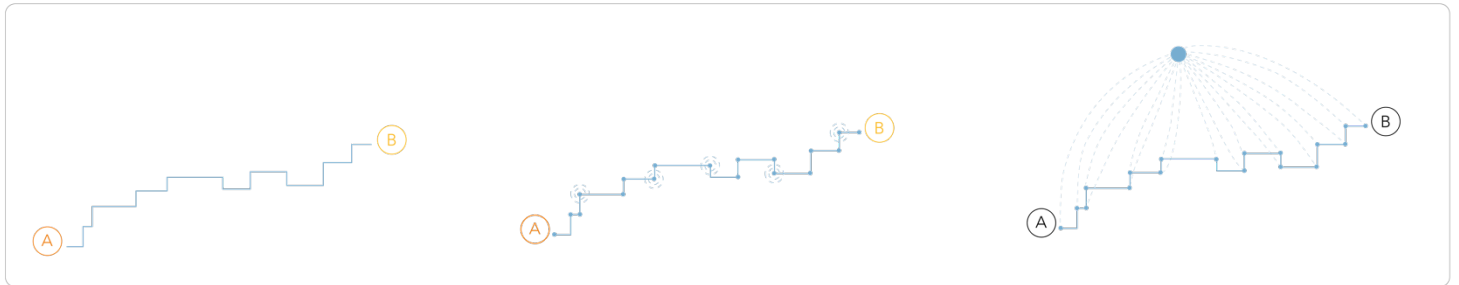


Fig. 4: Change and Process

As discussed in previous chapters, change and progress differ from each other. Despite varying perspectives, some theories sensibly complement each other. Change can be constantly ongoing or still undergoing, and many see it as a process or a series of changes. Technically, this is not the correct terminology as a process can continue indefinitely without a specific conclusion. Even a single change can be considered a process, as many events occur during the change. This produces a process that includes the specific change. Time is itself a process and continues to move forward. While time progresses, a series of events occur which impact our space and time, leading to changes that affect our lives. However, visualizing this ongoing change through mapping is challenging as not all events are observable to the human eye or noticed in real life.

When we involve time in this case it becomes a bit more complicated. Time has never been identified in physics, but the most important thing to include and mention is that nothing actually affects time, but certain things affect our perception of time. Time marches on at a steady pace or rate. The greatest mystery of time is that it just flows. We cannot describe time as change, it is actually just a dimension that allows for change, representing a potential for change.

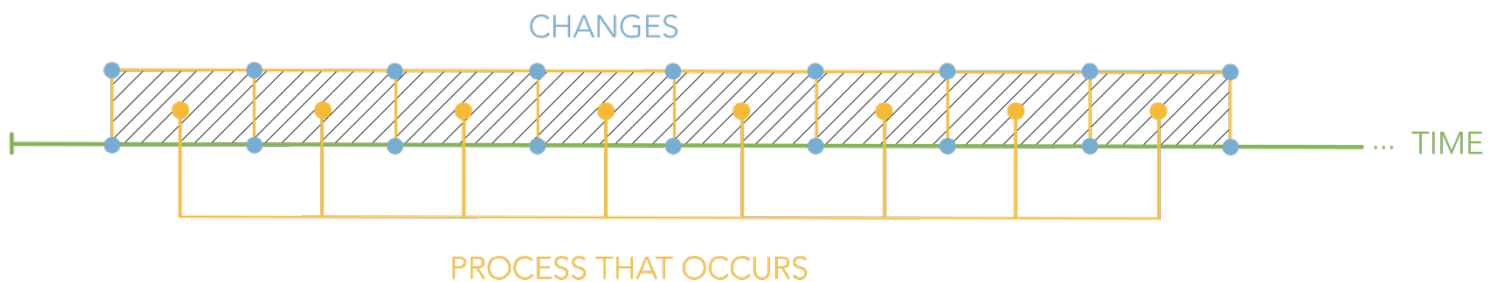


Fig. 5: Change, Process and Time

Science lacks a definite answer, and even Einstein, when prompted, simply replied, "time is what clocks measure!" This response is not precisely informative or could even be considered evasive. Although it's a concept that's well-known, accurately defining it has proven to be an elusive task. Nevertheless, it does point to the problem of trying to define time as a noun when it is better described as a verb. Time is not a human construct nor a force exerted on things. Time is an action we perform. Time is akin to motion through the spatial dimension, but through the temporal dimension. Thus, we traverse the spatial dimension and time through the temporal dimension.

There are three useful techniques for illustrating change on maps.

Firstly, the "percentage change", method illustrates shifts over time by showing the difference between values as a percentage of the original value. This is shown using shaded maps, allowing the extent and direction of change to be quickly and easily identified.

Secondly the "Actual Change" approach highlights changes by showing the numerical difference between quantities. A graph is used to visually communicate these differences, with larger shapes, indication more significant changes.

In addition, the ability to seamlessly "switch views and layers" allows the comparison of different years for the same variable. This interactive feature allows observers to examine how the graph evolves over time, helping to identify patterns and trends.

This particular facet of the study places a particular emphasis on the process of layering different data sets, as outlined earlier in the methodology. The focus part

of the exploration revolves around the representation of change through the strategic use of layers, which was identified a "switch views and layers".

The main strategy that is used is the application of layered data to visualise change. This approach will allow a possibility to utilize the layering techniques that are offered, enabling a proper way to describe and communicate change in a comprehensive and insightful way. By using this method, exploring this wide range of possibilities and using different ways to represent aspects of change in maps, will acknowledge many visualisation possibilities.

1.5. Transformation of cities

Another aspect of the literature examines urban change from a different point of view. Historical figures such as Weber, Du Bois, and Drake and Cayton have conducted statistical analyses on urban social change. More recently, researchers have focused on studying the statistical properties of neighbourhood's appearance. Urban planners such as Rapoport and Lynch pioneered efforts to measure neighbourhood aesthetics, and contemporary social scientists have built on their work. The link between the physical environment and social behaviour has been widely discussed and researched. A notable quote by Winston Churchill, "we shape our buildings, thereafter they shape us," captures the long-held belief that all lives are influenced by the built environment. This belief can be traced back to the Renaissance, when Alberti argued that beauty had the power to disarm anger and reduce violent crime. This concept foreshadowed the City Beautiful movement, which advocated for aesthetically pleasing cities to cultivate better citizens. In summary, the relationship between the physical environment and social behaviour has been the subject of extensive discourse and research. From ancient architectural beliefs to modern empirical studies, there is a wealth of knowledge about how our environment shapes us and influences our behaviour.

Architectural theorists have diverse perspectives on what constitutes beauty in a space, and empirical research has explored statistical properties of urban change and neighbourhood appearance. Despite the challenges of data collection, efforts have been made to quantify and understand the impact of the built environment on society. However, architectural theorists have different opinions on what constitutes

beauty in a space. Ebenezer Howard promoted the combination of urban and rural elements in Garden Cities, while Le Corbusier envisioned cities as functional "machines for living." Frank Lloyd Wright offered an alternative approach with his Broadacre City, which aimed to provide lighter, freedom of movement, and spatial freedom for a more civilized society. Early attempts to quantify neighbourhood appearance relied on visual perception surveys, where individuals were asked to rate or compare images. These surveys provided the first maps of cities based on perception and evaluation, albeit at lower resolutions. However, the manual nature of data collection limited the scope and scalability of these methods.

Just like architects argue that the appearance of cities shapes society, many social scientists contend that societal factors determine the changes in the physical city. **(Burgess, 1925)**, for example, according to his model of neighbourhood change, inner zones expand outward as the city grows. While overall city expansion drives this process, individual neighbourhoods may experience physical transformations.

They offer a vision of urban life often shrouded in nostalgia for the "lost world", the rural world of the small-scale individual "community" rather than the impersonal, large-scale and heterogeneous world of the city. In the 1920s, Chicago in the United States became the centre of an alternative urban analysis tradition shaped by ecological analogies, Darwinian competitiveness, and a market economy. The city suffered successive waves of emigration in, leading to the view that the dominant processes of were those of invasion, succession, and domination. Then, **(Wirth, 1938)**, writing in Chicago, took the theme of urban planning as a way of life and saw it as the result of changes in the size, density, and heterogeneity of the city.

Collectively, these processes create greater complexity and scale in urban life and change social relationships from those based on acquaintance and intimacy to those of an objective and formal nature.

During the 1970s, the dominant "ecological model" was repeatedly attacked for being perceived as flawed in its approach, and in the 1970s new forms of analysis emerged, influenced both by Weberian, represented by urban management and Marxist theory **(Pickvance 1976, Castells 1977a, Harloe 1977, Saunderrhls 19 1981)**. Much of the earlier theory was dismissed as "ideological" and the focus

shifted from quasi-biological metaphors of process to an analysis of power, political processes, and economic determinants of urban systems. The growing identification of the agency's role through social movements also links with this structural orientation. This was initially expressed in the class movements of, but expanded to recognize the importance of both gender and ethnicity in as the basis for campaigning and fighting over the shape and direction of the city.

The 1980s and 1990s saw a new emphasis on the empirical analysis of both global and local changes. This led to studies of economic restructuring and deindustrialization and the changes this brought about in the spatial and social structure of the city (**Smith, 1980**). For a time, the neo-Marxist school of regulation provided much of the framework for the study of cities that explored the cumulative patterns and nature of social regulation. These s are thus largely written as the transition from "Fordism" to post-Fordism and define urban employment and unemployment and urban labour force change (**Massey 1984, Bluestone and Harrison 1986**). Then in the 1980s, the role of consumption rather than production as a major influence on the shape and form of the city began to take on greater importance. Diversity rather than convergence became a major theme in urban studies when it adopted a postmodernist-influenced analysis more than (**Soja 1989, Johnson 1994a, Watson and Gibson 1995**). Most postmodernist analysis of America has focused on Los Angeles, now considered the quintessential postmodern city, rather than Chicago or New York (**Dear, 2000**). As a result, studies and analyses have moved from grand narratives to stories that are more reflective of the diversity of urban experiences shaped by context and scenarios of urban development and change. Although we live in in an increasingly globalized world, locality retains a strong influence on the shape of 's daily life.

1.6. Change in a city

Cycles of change in the morphology of cities, have an historical dimension related to the courses of historical events that, with their strength and impact, influence the change in past and present morphological conditions, as well as a range of thoughts about the future. These historical flows are generally not closely related to urban morphology, except in rare cases (**Gauthez, 2004**). Dynamic effects in space tell about the alienation of flows and the nature of their internal events, which are usually indifferent to the implications and causal points of their ideas, interests, and goals,

affecting the state of the morphology of cities both partially and as a whole. The cycle between causes, influences and consequences of change will be explained in relation to the city and specific effect that it has. The cycles of change, with their quantitative and qualitative expression in time and space, therefore the expression/form and the objective and visual representation of this abstract form can be expressed and represented in many ways.

When a change occurs in the urban structure, its occurrence is tied to a specific spatial-temporal framework. Change is caused by the impact of effects that can be observed, measured, perceived. Change has a beginning, stages of development, and an end. All changes begin, develop, that end have their own causes, reasons, and consequences. This is the most logical and visible form of change (**Bammer, 2015**). Behind this obvious form, there are less obvious and seemingly much more illogical flows of change about what exists and what is defined as an existing condition. Impact parts are identified by their nature and type. Without this basic definition, it is impossible to understand where the change comes from, what its consequences are, and whether it makes sense. There is no change without a cause, reason, effect and consequence, whether we know and understand them or not. Causes, reasons and consequences of changes and how the change itself has occurred will be understood not only as a matter of causes, reasons and consequences of changes, but also in our ability to understand and recognise them (**Gauthiez, 2004**). In this relationship, known and unknown, comprehensive and incomprehensible, have all the other relationships that reflect the transformation of urban reality, first through the spatial and temporal dimensions, then the other.

1.7. Visualization in Cartography and Urbanism

Using maps to visualise information has always been an important way to understand geography. This means that looking at maps helps us understand and study different places and how they are connected. Some researchers believe that maps are not just pictures, but also tools that help us learn about and analyse geography. Other researchers have agreed with this idea too.

The new computer tools we have now make it possible to do more things with maps and interact with them in different ways. This is important because it's a big change

from how we used maps before. Different experts have different ideas about what "visualisation" means when it comes to maps (Rhind, 1989). This becomes a bit challenging since different cartographers have different opinions. Technically, visualisation is not just about making maps, but also about using them to talk to other people. Some people think that visualisation is the same as studying maps, but it is believed that visualisation is about how maps are used. Using maps is like moving around in a three-dimensional space. David Rhind proposes three parts about this topic: (1) using maps for yourself or sharing them with others, (2) using maps to find new information or show information we already know, and (3) using maps where we can change them a lot or where we can't change them much.

What cartographers understand by visualisation and how we react to it the development of the view beyond mapping is critical to the possibilities of mapping will be at the beginning of the 21st century. Cartography is at a crossroads, in limbo uncertain between references to geography and references to other "cartographies".

David Rhind states that teachings, between centuries-old traditions and the "threat" of geographical information systems (GIS) that will replace the mapping we know are among the requirements skilled technologists capable of creating competitive mapping systems and requirements uses our cognitive knowledge to evaluate whether the system we are building is working jobs.

Visualisation is important for making maps and working with other people who study geography. It can help us understand things better and work together (Rhind, 1989). This is really important, but there are even bigger benefits. Visualisation can make cartography more exciting and relevant to other subjects. It can help us solve important problems that involve different subjects working together.

1.8. Visualizing Change and Process

Based on the direct visualisation from two- and three-dimensional databases, new possibilities in change representation result. They can be divided in traditional cartographic and computer-aided animated visualizations. Traditional cartographic representations have the following limitations: They are static: situations can be

reproduced, but processes and changes can hardly be presented directly. They are isolating: only a limited number of objects with their attributes and their spatial, causal and functional relations can be shown, otherwise their legibility and differentiation is seriously affected. They can only be presented in one preselected way: in a single cartographic representation only a certain aspect of data and their attributes can be shown.

Cities expand through intricate mechanisms influenced by their vast size, societal structures, economic frameworks, geopolitical contexts, and technological advancements (Hall, 1998). In response to successive waves of technological innovation, cities have extended outward from compact cores, initially as linear transit-oriented settlements and later as sprawling automobile-centric environments. Alterations in industries have also played a significant role; outmoded factories have often shuttered, leaving behind soil and groundwater contamination. The hazards linked to redeveloping such polluted "brownfield" sites have prompted developers to favour undeveloped "greenfield" areas on the outskirts of urban areas (Suzuki, 2013). The persistent growth of urban populations further propels city expansion. Interestingly, even cities experiencing stagnation or declining populations, such as certain aging industrial cities, continue to sprawl outward.

For more than five decades, the field of computer graphics and visualization has been centred around urban environments since the inception of computers. Initially employed to depict the inner workings of machines, computer graphics rapidly transitioned into simulating diverse processes and representations. Starting in a two-dimensional context and later progressing to three dimensions, early visualizations of buildings and landscapes were manually plotted using plotters or cathode-ray tubes. Early attempts from the mid-1960s aimed at utilizing line printers to overlay symbols, generating the illusion of raster maps. The true convergence of computer memory with graphics emerged in the early 1980s during the micro-revolution, marking the genuine initiation of urban visualizations. This surge occurred largely from two fronts: applications of Computer-Aided Design (CAD), emphasizing precision, and applications of video games, prioritizing realism often through illusions and approximations.

In the domain of urban models, there are now two distinct traditions. City models tend to visually depict iconic representations rooted in architectural conventions, emphasizing the aesthetic manipulation and urban planning. On the other hand, urban models, though often interchangeable with city models, stem from an emphasis not on representation but on the structure and processes that encapsulate ideas about how cities function. These models may present their outcomes as maps or even in three-dimensional formats if representation is a concern, yet their focus on simplifying reality diverges significantly from city models, which embody the notion of a virtual city. Geographical Information Systems (GIS) intersect both types, but even within this realm, the emphasis leans more toward representation. Remarkably, as explored in the forthcoming challenges section, there is a multitude of opportunities to integrate city models into urban models and vice versa, amalgamating these distinct traditions and enriching representation through functional simulation, as well as enhancing functional simulation through representation.

CHAPTER II:

VIENNA'S HISTORY AND CITY TRANSFORMATION

1. Cartography and Urbanism

Encouraged by the increasing acceptance of evolutionary perspectives in planning, researchers are increasingly looking to history to better understand the places they are studying. However, historically contextualizing urban development can be quite challenging (Suitner, 2020). Urban history is often a vast and disorganized body of literature that is difficult to navigate, and language barriers can further complicate matters. This is especially true for urban planning history, as historic studies face difficulties in a discipline that is primarily focused on the future and practical applications. As a result, past land management decisions, previous developments, and institutional changes are often not thoroughly reviewed or systematically analysed. In most cases, a city's urban planning historiography consists of a varied but fragmented collection of studies, with a focus on certain phases or policy areas

that the city is well-known for. This lack of comprehensive research makes it a matter of chance for historically informed approaches to planning research to be successful.

Cartography, also known as map making, has always been a crucial tool in representing spatial concepts throughout history. From ancient times where maps were engraved on clay tablets and cave walls, to the modern era where maps have evolved to creatively showcase various types of information, they have served as invaluable resources (**ArchDaily, 2023**). Kaley Overstreet explains that these visual representations allow us to gather insights on population sizes, historical occurrences, cultural transformations, and weather patterns, ultimately helping us gain a deeper understanding of our world and the impact we have on it. Some of the earliest known maps can be traced back to approximately 17,000 BCE. These maps consisted of visual representations depicting constellations, geographical elements such as mountains and rivers, and other physical markers that assisted people in traveling from one place to another. Around 600 BCE, the Babylonian World Map was created, which is considered to be the first depiction of the earth based on the knowledge available at that time.

Ancient civilizations, including the Greeks, started utilizing paper maps for navigation, relying on observations made by explorers and mathematical calculations. These maps held great significance as they portrayed Greece as the central point of the world, encompassed by vast oceans (**Overstreet, 2023**). Subsequently, maps began depicting two major continents, Asia and Europe, largely influenced by literary works authored by Greek philosophers. It was crucial for these civilizations to depict the world around them, and they also dedicated their attention to representing their cities through alternative forms of mapping. Quite often, they utilized various types of maps to carefully plan out entire future towns.

Among these techniques, the "Nolli" map holds significant importance as it allows for a comprehensive understanding of spatial flow within a city. The very first "Nolli" Map was crafted by Italian Architect Giovanni Battista Nolli, who the map is named after. In 1736, Pope Benedict XIV entrusted "Nolli" with the task of creating the most precise plan of Rome ever drawn. The objective was to gain insights into how the space could be divided into distinct areas to effectively plan for future expansion and meet public needs.

2. History as a process of change

History is the study of how things develop over time. This covers a wide range of topics such as empires, languages, concepts, technology and attitudes. Despite the inevitability of change, there are aspects that persist. The study of both changes and continuity is fundamental to the study of history. Historians seek to understand the changes in societies and cultures as well as the elements that persist. By analysing these dynamics, historians can gain a deeper insight into the complex nature of human existence.

Understanding cities as dynamic processes intertwined with biophysical patterns of change and transformation requires new frameworks for thinking. Behaving as complex dynamic systems, cities show similarities to ecosystems, where periodic collapses and disturbances are crucial elements that drive innovation, transformation and evolution.

Resilience, encompassing persistence, adaptability and transformability, represents vital capabilities of living systems:

- i) Resist collapse and maintain essential functions,
- ii) adapt to changing conditions through learning and self-organisation, and
- iii) apply foresight and anticipation to proactively transform socio-ecological systems, enhancing their health and ability to respond wisely and creatively to disturbance and change.

'Change' means a discernible departure from an earlier state. Change refers to modifications or shifts observed in societies, cultures, political systems or other dimensions of human experience over time. Various factors such as technological advances, natural disasters, conflicts, social movements and economic progress can trigger change. Its effects can be both positive and negative, affecting individuals and communities in different ways.

In the realm of history, change tends to unfold gradually over long periods of time, making it difficult to pinpoint an exact moment of transformation. This makes it

easier to select two different historical moments for comparison. For example, the 2nd century AD can be compared with the 4th century AD, or 1600 with 1900.

Nevertheless, instances where a striking and abrupt change occurs at a particular point in history, often triggered by a single event, are commonly referred to as 'turning points' in history. Not all elements change over time; certain aspects persist over long periods of time, even into the present day.

'Continuity' refers to elements that remain relatively unchanged over time. These include enduring traditions, cultural principles or political frameworks that persist despite changes that may occur in other areas. Continuity provides a sense of permanence and a link with the past, influencing the development of societies and cultures over time.

In this role, it is imperative to examine both change and continuity over time and to attempt to provide explanations for these phenomena.

3. Vienna's history and how has it changed throughout the years

Urban transformation has undergone significant changes over the last 50 years. As the field of urban transformation continues to expand, its various manifestations have become more complex. Johannes Suitner, brings a lot of focus in Vienna's urban history, its richness and extensively researched subject. Understanding its evolution from an ancient Roman settlement over 2,000 years ago to its current status as a networked central European metropolis is a challenging task. Vienna serves as a prominent case study in urban planning, often cited as an esteemed example of 'good planning'. However, there are only two comprehensive works that provide an overview of Vienna's urban planning history.

This overview begins in the 1820s, a period that marks the beginning of modern planning history in Vienna. It highlights the First and Second World Wars as key historical junctures that brought about significant changes in the political, social and economic dimensions of urban development (**Suitner, 2020**). During the 19th century, Vienna underwent a rapid and well-planned transformation from a congested walled city to a modern metropolis. This transformation was initiated by the central government. In 1857, Emperor Franz Joseph ordered the demolition of Vienna's fortifications, paving the way for the expansion of the city into the area

previously occupied by the old walls and surrounding open spaces known as the glacis. Viennese planners devised an extensive system of boulevards along the former defensive lines, known as the "Ringstrasse". The "Ringstrasse" was 2.5 miles long and 185 feet wide, lined with new public buildings and privately financed apartment blocks.

Viennese planners made further improvements in the late 19th century. The addition of the "Ringstrasse" to the city brought a different way of organising the city. By the outbreak of the First World War in 1914, Vienna had become a much more attractive city. But the war brought drastic changes. The city faced a severe housing shortage as soldiers returned from the army, married and started families, while refugees from the former Empire poured into the city. The post-war Austrian constitution granted Vienna the status of a province, giving it considerable powers and resources. The Socialist Party used public funds to build 63,924 low-cost housing units, addressing the housing shortage and improving living conditions for tenement dwellers.

CHAPTER III:

THE PART OF THE STUDY

VIENNA AS A REPRESENTATION FOR DEPICTING CHANGE AND PROCESS

1. Visualization methods and representing change

Cartography has undergone significant changes during the 1990s due to rapid technological advances and new scientific concerns related to data exploration and analysis. Despite the current focus on using interactive map displays for visual thinking, the main use of cartography by students still revolves around visual communication (Orford, S., Dorling, D. and Harris, R., 2003). With the rise of computerized and web-based cartography, more people now have the ability to create maps, making it crucial to emphasize the fundamentals of cartography. The production of a well-designed map that effectively communicates factual information and supports queries such as "what is?" or "where is?" is becoming

increasingly important as both the scientific and social communities demand faster access to geographically referenced data.

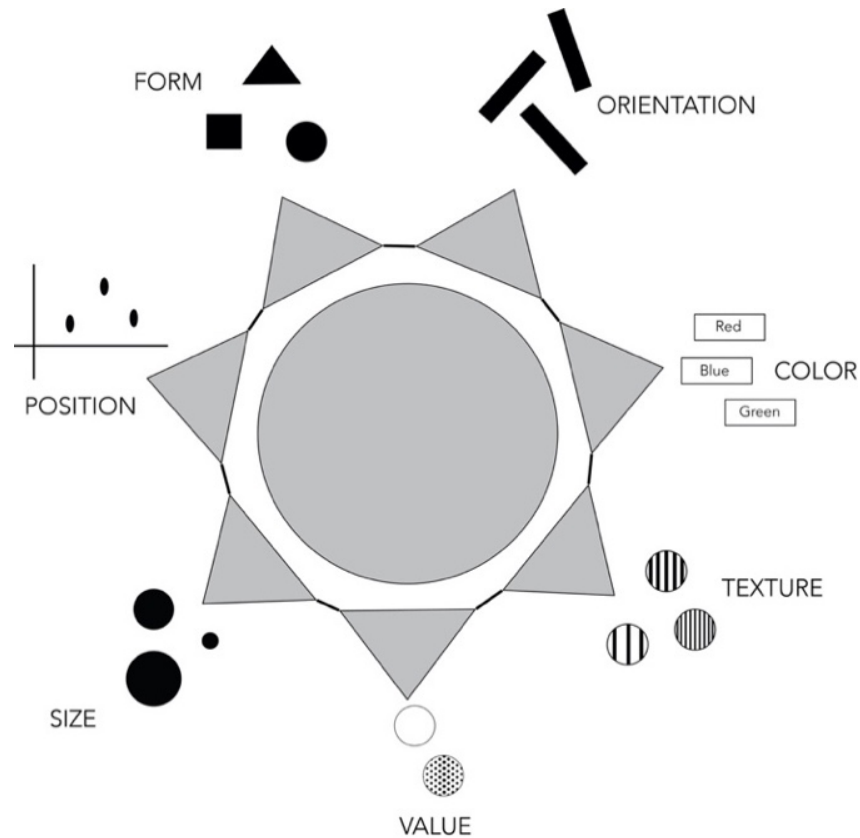


Fig. 6: Visualization techniques in cartography inspired by Jacques Bertin, 1984

When discussing cartography and its concepts on visualization, objective evaluations should be used. It is critical to note that cartography has changed significantly in the 21st century. It now navigates between geography and other mapping sciences while balancing tradition with the rising influence of GIS. This form of technology is redefining traditional cartography, putting it at a crossroad. It is worth noting that cartography has also become a space for free expression. In 1953, visualization served as a purely fundamental geographic tool. Philbrick would later suggest that visualization should be viewed as a geographic research or spatial analysis tool. In a scientific research context, DiBiase proposed a framework for

considering geographic visualization that encompasses all aspects of map usage. The evolution of terminology across various domains, including visualization and cartography, allows for greater scope to improve and enhance methods of representing maps and utilizing visual aids in a more subjective manner.

The visual Variables of Jacques Bertin, created elements in a constructed view of the supposed reality. Specific types of cartographic symbols have functional association with specific types of data (**New York University, 2017**). Understanding Bertin's visual variables and their visual variables functions help map authors choose effective schemes among the wide range and confusing symbols available, but violations of these function assignments lead to confusion and misunderstanding.

Bertin said he recognized two types of visual variables: Retinal and location variables. Its two position variables are the familiar horizontal and vertical axes of scatterplots and other his two-dimensional data plots. For maps based on a rectangular projection, these axes correspond to latitude and longitude. Bertin's interests extended beyond cartography and planning, address and network diagrams, and maps of various kinds.

Today the world of visualization has changed a lot, considering with how the technology has improved its use. There is a wide range of ways to express map design, and it is necessary to say that maps are becoming less boring, but that does not mean that a particular way of representing data will be the same for other representations too.

For this study, it is important to know how to visualize change and process in maps. This representation works for different data visualization, depending on the size of the data is and also about the quality of the data. It makes sense for the visualizations not to be so complicated, as this makes maps unappealing and difficult to read. The designs works better if they are combined with each other, or used as stand-alone graphics. Change and Process turned out to be quite difficult in explanation, but they can be visualized very easily, depending on the data available.

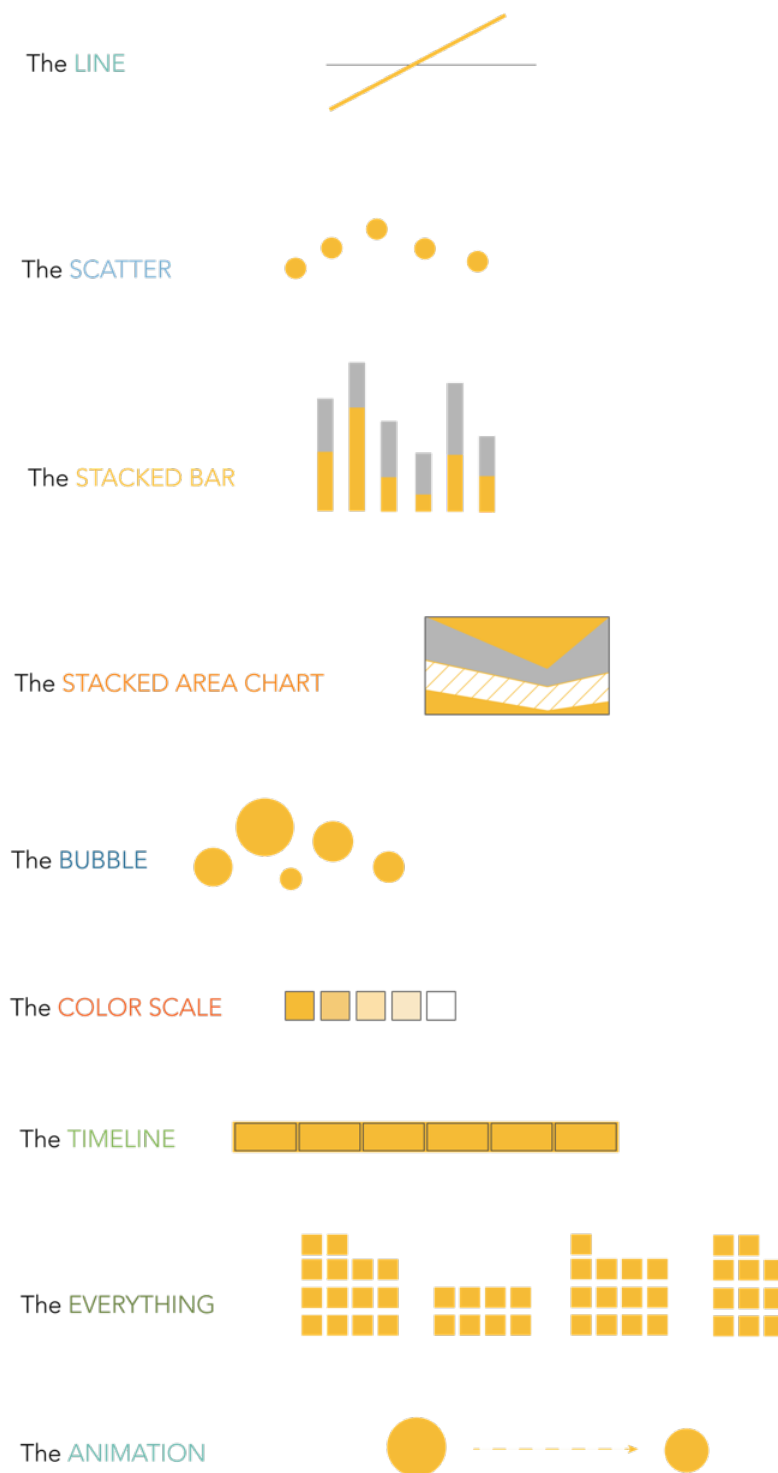


Fig. 7: Ways to visualize and represent Change and Process

2. Visualizing and representing change in Vienna

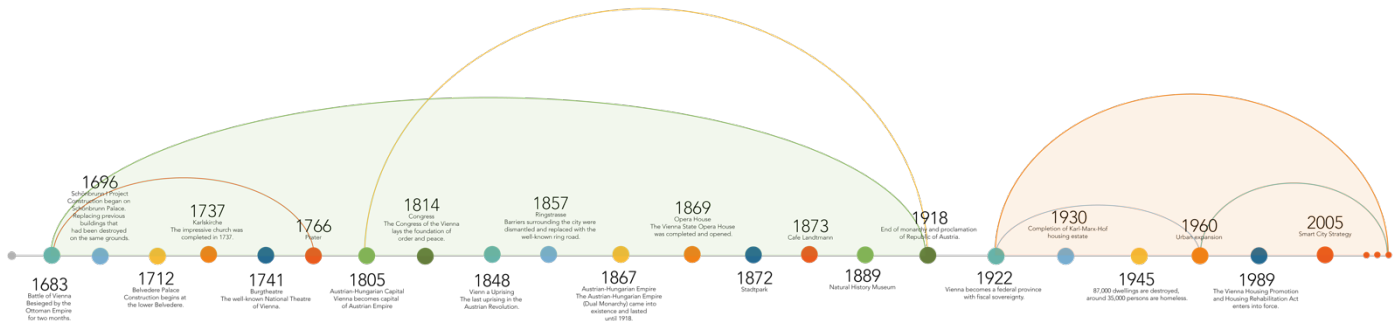


Fig. 8: Timetable with specific changes that occurred in Vienna

The created timetable serves as a comprehensive chronicle of the City of Vienna's historical evolution, encapsulating pivotal moments and transformative processes that have shaped its trajectory over the years. Through a meticulous arrangement of years and corresponding events, this visual representation offers an insightful journey into the city's dynamic history.

Within this chronology, two distinct periods emerge as profound milestones, exerting a profound influence on the lasting change. These periods stand to confirm that Vienna has the ability to adapt and reinvent itself in response to the challenges and opportunities that define its progress.

The first phase of transformation occurred as a landmark moment, characterized by a series of events that spurred unprecedented growth and development. It marks the city's transition from its historical roots to a modern metropolis, marked by architectural masterpieces, cultural flourishes, and a diverse wave of influences. The strategic urban planning and innovation initiatives of this period laid the foundations for Vienna's emergence as a global centre of innovation and creativity.

The crucial second period, by contrast, emphasized Vienna's resilience in the face of adversity. Amid external pressures and changing global dynamics, the city has undergone a profound reassessment of its identity and priorities. This period is symbolic of Vienna's ability to turn challenges into opportunities for innovation. As urban planners and civic leaders collaborate to address emerging needs, the city has undergone a paradigm shift in governance and infrastructure. This transformational

journey, driven by the spirit of adaptation, has resulted in a more inclusive and sustainable urban environment.

In summary, the meticulously crafted timetable not only offers a chronological tapestry of Vienna's past but also spotlights these two remarkable phases that have left an indelible mark on the city's character. These periods underscore Vienna's legacy as a dynamic and resilient urban centre, embodying the profound interplay between historical continuity and visionary change.

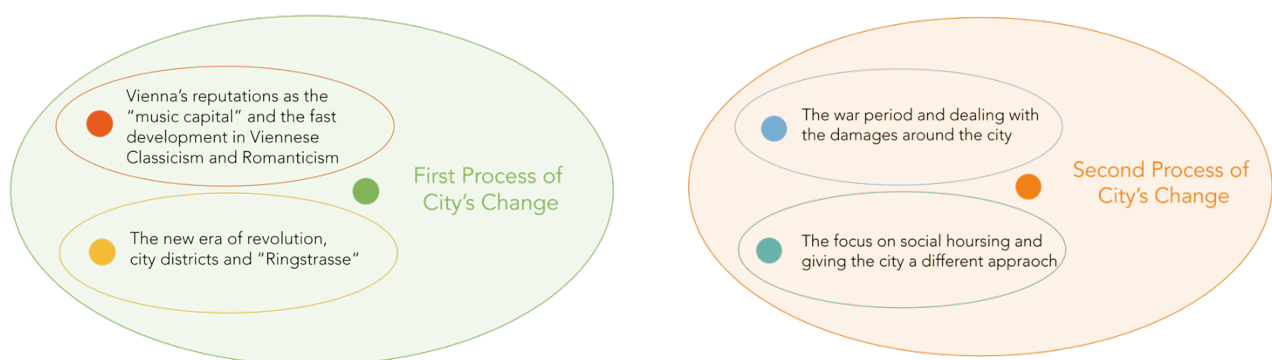


Fig. 9: Vienna's major Processes

The timetable provides an initial means of visualizing historical events and recognizing change as a key aspect. As a result, it allows us to better perceive the city's approach and the complex processes of change. In this context, 'process' refers to the various strategies, decision-making processes and events that have influenced Vienna's transformation in different contexts and time periods.

It is a comprehensive approach that combines theory, research, and a foundational timetable. This time framework is mainly to understand the city's evolution. The timetable isn't just a visual aid, it is the backbone that holds valuable insights from both theory and real-world observations. This timetable captures the rhythm of changes and transformations that have shaped Vienna's urbanism. This part will become quite helpful in creating various maps and visualizations illustrating these



Fig. 10: Early map of Vienna's development.

changes and processes. The maps and visualizations will vividly show how Vienna has evolved over time. This synergy between theory, research, and the timetable forms

a comprehensive narrative that tells the story of Vienna's transformation in a way that's both clear and insightful.



Fig. 11: Map of Vienna during the year 1890.

When discussing visualisation and identifying an appropriate method to depict a specific representation, objectivity should be a top priority. Various ways to represent data and visualise it have been previously discussed in this study. Change can also fluctuate immensely. Maps of the city of Vienna are displayed, illustrating the city's progression over time. In this instance, the visualization of buildings over various years effectively demonstrates how the density and quantity of buildings reflect the changes that have taken place and the expansion of the city.

This has been one of the most common and easiest ways to depict change. In a way all that is happening in this kind of visualisation is mainly a representation of the real-life situation. This part of visualisation also was the first part of this study, as by outlining the buildings in different years included the data collection for this study.

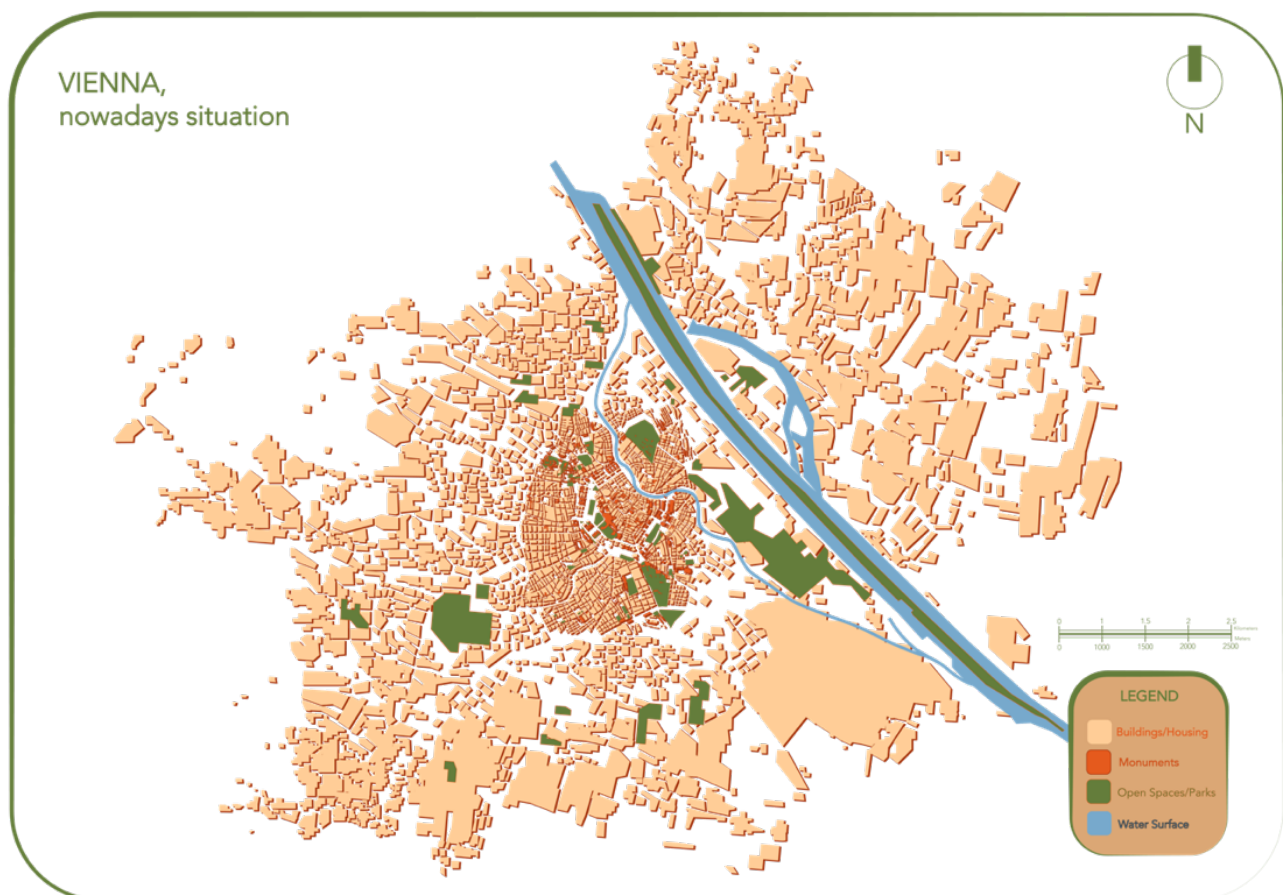


Fig. 12: Nowadays situation of Vienna's transformation.

This aspect of visualisation demands greater attention, as over time changes may become harder to detect. For instance, when there was less construction, such as during the 1890s, comparing the map from that era to the present day reveals significant change that has transpired. However, when comparing recent years alone, layering them together is necessary to avoid difficulty in discerning differences. The process of detecting the change could prove somewhat time-consuming, in such instances, combining maps might be the optimal solution.

For this issue, which may not be very significant, utilising colour schemes and layering changes could be an ideal approach to demonstrate the alteration. In this case, the following map, figure 13, is still quite straightforward, as it employs lines and areas as fundamental methods of visualisation. Furthermore, the maps exclude space for additional elements and animations to be included, if this map be researched or incorporated into some form of evaluation.

Experimenting with visualization and design is paramount in the field of cartography. Cartographers have the ability to transform complex geographic information into easy-to-understand maps, and the visual and design choices they make have a profound impact on how people perceive and interpret that information. Through experimentation, cartographers can discover innovative ways to effectively communicate spatial data, improving clarity and usability for different audiences. This process allows to discover new perspectives, refine the beauty of maps, and adapt to evolving technological tools. Ultimately, the importance of experimentation in cartography lies in its ability to push boundaries, foster creativity, and ensure that maps remain powerful tools for communication and understanding in an ever-changing world.

Representing processes can be challenging, as they are often more complex than we realise. Technical term abbreviations should be explained upon first use. It is important to ensure objectivity and logical progression in the representation. The best way to represent a process as data is through a timetable, which can include all events or episodes that led to change. The use of layering maps and various graphics, such as lines and polygons with different shapes and colours, can enhance

the representation. And as long as they are used in a manner that respects all cartographic concerns, there will be no correct or incorrect approach.



Fig. 13: Layering method of showing all changes that have occurred in different years.

Integrating different design elements to represent specific materials always creates the right visualization. When working with maps and finding the right approach to visualizing processes and changes, the components and symbols shown in Figure 7, to be central and very helpful.

The visualisation table starts with very common ways of actually representing data. The scatterplot, the stacked bar chart and the area chart are very common in cartography and especially when it comes to presenting data. In the case of Vienna,

since the data was mostly done through layering and just going through different years and tracking the change of the city through the buildings, this part was much more challenging to do as it requires more data to work. The same goes for "The Everything", as it shows data for every point, but unfortunately it takes up far too much space. "The scatter" and "bubbl" shapes are also quite good for showing areas where changes have occurred, and they are also quite common.

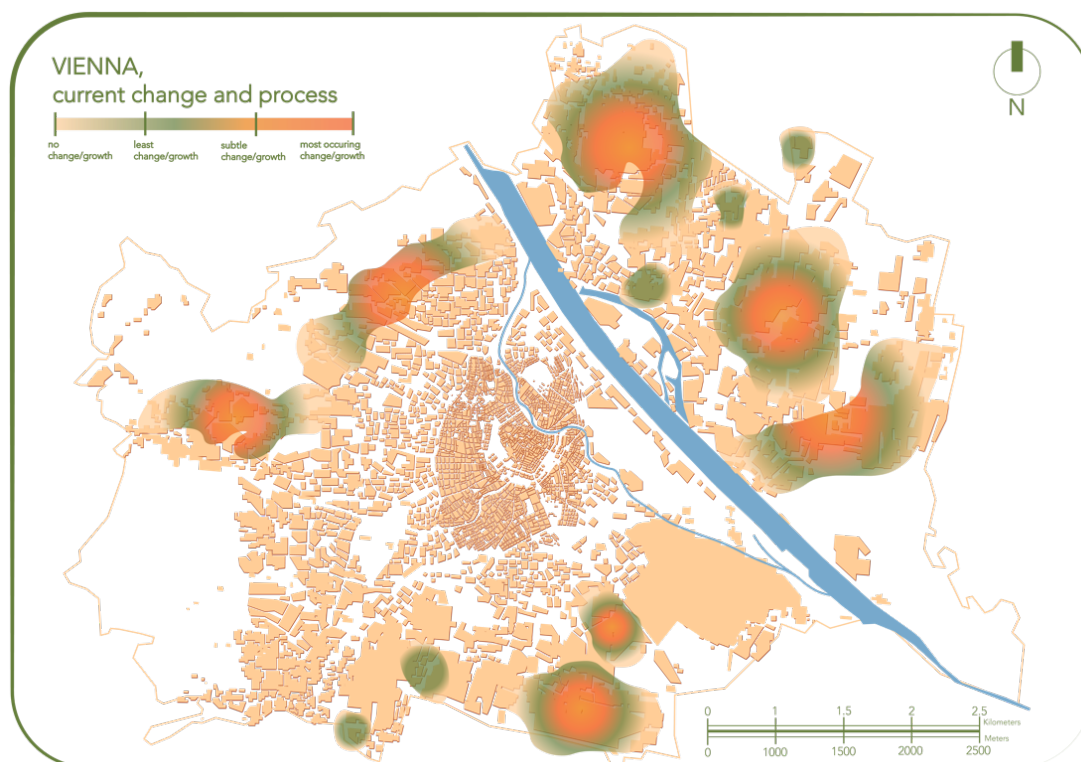


Fig. 14: Areas in Vienna that are currently experiencing change.

The timeline that results from the study works best if it is followed by another type of visualisation. "The colour scale" has been used quite a lot in this study because colour is used to show change trends. "Animation" can be quite tricky at the end, but it can work very well with different graphics and then just put them together like a video.

In the previous chapter, we explored diverse methods of visualizing change and process in maps, recognizing that the choice of symbology plays a pivotal role in effectively conveying information. The visualization of change can take multiple

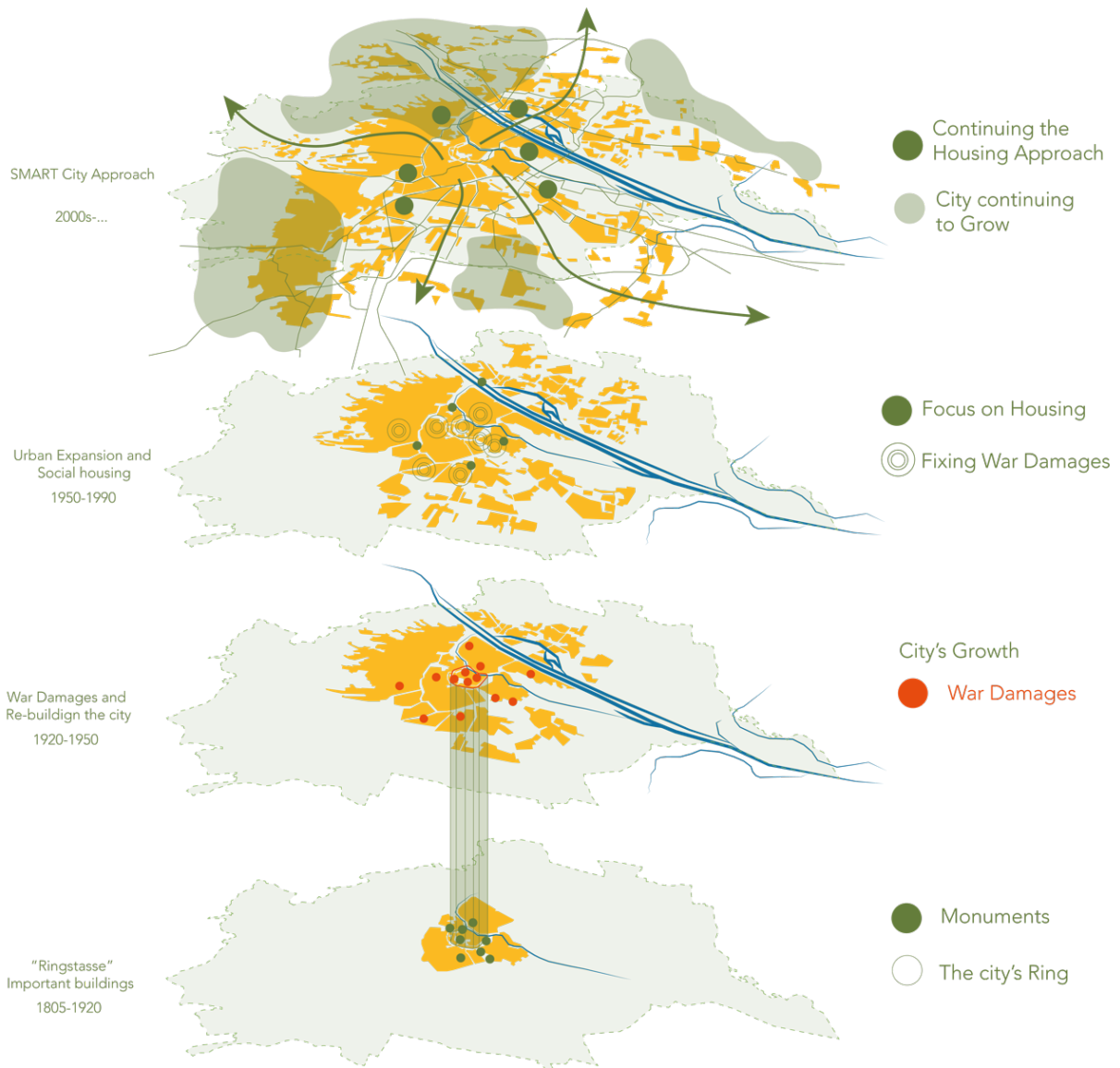


Fig. 15: An approach by using different visualization elements to represent change visually.

forms, each offering unique insights into the underlying data. These options include representing change as a percentage change, illustrating it through actual values, or

employing diagram views that facilitate a seamless transition between different states. The selection of the most appropriate visualization technique hinges upon the specific characteristics of the data and the desired communication of information.

In the field of cartography and geospatial visualization, the importance of experimentation and exploration of different design approaches cannot be overstated. The landscape of visualization techniques is vast and diverse, offering a plethora of tools, styles and methods for representing change and process in maps. To truly harness the power of visual communication, it is essential to embrace a spirit of experimentation. By systematically testing and iterating different design choices, from color schemes and symbology to layout and interaction, we can discover the optimal means of presenting complex data. This process enables us not only to select the most effective visualizations, but also to uncover insights that may have remained hidden under a less appropriate design. In an evolving field where new techniques and technologies are constantly emerging, a willingness to explore and adapt is key to pushing the boundaries of map-based communication.

CHAPTER IV: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Throughout this research, innovative approaches to representing change and process in urban environments, with a particular focus on Vienna have been explored. This research has highlighted the significant potential of integrating change and process visualisation into cartography, offering new perspectives for understanding dynamic urban landscapes. The maps have demonstrated different techniques for representing these complex phenomena, shedding light to the complicated aspects of change and process. However, it is important to recognise that the visualisation of change and process remains a diverse and evolving field, ready for further exploration. While significant progress has been made in

understanding process and associated change, it is clear that there is still much to explore and discover. Researchers in the field are encouraged to build on this study, expanding its scope and delving deeper into areas that are in need of additional exploration. This study is therefore an invitation to further research, encouraging collaboration and the pursuit of a fuller understanding of the subject.

The selection and creation of visualisations requires a considerable amount of time and thought. This study has also highlighted the challenges inherent in working with visualisations, including the selection of appropriate symbols, colours and shapes.

The maps that were produced are selected as the most effective means of presenting data within the city of Vienna. However, it's important to recognise that these choices may be significantly different for other cities and research contexts, potentially leading to different results and design approaches.

In summary, this study was designed to achieve two specific key objectives, each designed to illuminate the complexities of visualising change and processes within urban environments and cartography, with a particular focus on Vienna. Reflecting on the focus of this research, it is evident that these objectives have been met.

RQ1. Understanding the meaning of process and change, by discovering how it relates to urban life and cartography.

Aim 1 was to explore the fundamental concept of process and change, with a particular focus on their interrelationship within urban life and the field of cartography. Throughout the course of this study, this part was achieved by examining the nature of process and change in different domains. The research uncovered the complicated links between these phenomena and urban life, creation connection with Vienna.

In essence, the research provided an understanding of process and change, demonstrating their importance in the shape of urban cities over time. By including these concepts with cartography, we have not only broadened the scope of the study, but also introduced a novel approach to mapping historical and contemporary change in Vienna. It was important to integrate different fields and incorporate

historical and temporal dimensions to enhance the study, ultimately contributing to a more comprehensive representation of Vienna's evolving urban narrative.

RQ2. Observing different visualisation methods and approach the techniques that represent change and process better.

Aim 2 focused on a comprehensive review of the existing literature on visualisation methods, with a particular emphasis on identifying techniques that excel at effectively representing change and process. In pursuit of this objective, we systematically examined a wide range of visualisation approaches and analysed their applicability to the complex context of Vienna's urban dynamics.

The study considered different visualisation methods and assessed their suitability for representing change and process in Vienna. This objective served as a critical foundation, guiding our selection of the most effective techniques for creating maps that accurately depict the city's transformation over time. It allowed us to make informed decisions about the symbols, colours and shapes that would best encapsulate Vienna's evolution.

Overall, Objective 2 was instrumental in refining the cartographic representation approach, which offers the ability to choose the methods that are most in harmony with Vienna's unique urban history.

In the field of cartography, it is important to recognise that it is a discipline that seamlessly weaves together elements of art, technology and design. Cartographers are not simply mapmakers, but multidisciplinary artists, technologists and designers with a unique ability to communicate complex information in a visually engaging way.

However, to harness the full potential of cartography and create maps that resonate with the complexity of our world, it is imperative to take a holistic approach. By incorporating fields such as urban studies and history into our cartographic endeavours, we unlock a wealth of knowledge and insight that enriches the storytelling power of maps.

With each passing moment, cities are being reshaped by economic shifts, cultural movements, technological advances and demographic trends. In this ever-changing

landscape, we must embrace the impermanence of urban life and the fluidity of cartographic representation. Maps become a reflection of the times, capturing the essence of cities in their current state, while acknowledging the echoes of history and the potential trajectories of the future. As we navigate the interplay between time and cartography, we should remember that our maps not only depict space, but also encapsulate the profound histories of cities, their enduring transformations, and the existence of humanity. Through the lens of time, maps become vibrant narratives of urban evolution, transcending the limitations of static imagery to offer a dynamic and holistic representation of our ever-changing world.

Recommendations

Based on the study of visualising change and process in cartography, it is clear that the process of selecting appropriate visualisations, symbols, colours and shapes can be time-consuming and challenging. Adopting an iterative design process, prioritising a user-centred approach with stakeholder involvement, making data-driven decisions for appropriate visualisations, understanding colour theory and symbol selection principles, considering contextual variations in different cities and studies, conducting usability testing for refinement, creating documentation with best practices, keeping up to date with cartographic tools, fostering collaboration, remaining adaptable to evolving techniques.

It is important to note that this study can be used for different types of work. The fact that the introduction of a very abstract topic like change and process shows how much a cartographer can do with visualisations. As mentioned above, change and process is quite interdisciplinary, so it is important to encourage collaboration between cartographers, urban planners, designers, data scientists and social scientists. This collaboration could be broader and more stable given their expertise, which gives a higher percentage for the end results to be more precise.

Studies work much better when there is continuous experimentation. The same situation is recommended for this study, as exploring new methods and technologies can provide richer insights into the complex world of urban change and processes, or any kind of change that occurs. In a way, everything around us is changing without

people being aware of it. So, it is important to know the situation of this change and its process and how it affects our lives.

For this specific study, the urban transformation and historical changes over time were used as a better way to work with the city of Vienna. For other cities, the results may be different depending on how the researcher wants to visualise the maps. For example, if the existing data is much larger and collected in different ways, the historical part and urban transformations might not be the best way to visualise it. The maps might work better by expressing change and process through percentages or a larger number of graphs. It is also very important to mention that experimenting and seeing what works best for the data should be kept in consideration, as it is very important.

Integrating the visualisation part of change and process into cartography might become quite effective if researchers continue to contribute in this idea. It is very important to acknowledge the efficiency that visualisation brings. Enhancing this part and contributing as much in this field, will enrich and communicate the power of maps and how much they can offer.

In conclusion, this study has embarked on an exciting journey towards redefining the boundaries of cartography by introducing change and process visualization into its repertoire. This research serves as an invitation for future endeavours, inspiring scholars to push the boundaries of knowledge and contribute to the evolving landscape of urban visualization and cartography.

References

- 1) Robertson, P. K., 1988. Choosing data representations for the effective visualisation of spatial data. Proceedings, Third Int'l Symposium on Spatial Data Handling, 243–252. Sydney, Australia.
- 2) Robinson, A. H. and Barbara Petchenik, 1976. The nature of maps; Essays Towards Understanding Maps and Mapping. University of Chicago Press, Chicago.
- 3) Papp-Vary, A., 1989. The Science of Cartography, in Rhind, D. W. and Taylor, D. R. F. (eds.), Cartography, Past, Present and Future. Elsevier, London.
- 4) Friedhoff, R. M. and Benson W., 1991. Visualisation: The Second Computer (Volume 33, 1991, Pages 247-307). Chicago, Illinois.
- 5) Kraak M. J., 2005. Visualizing spatial distributions. In P. A. Longley, & [et al] (Eds.), Geographical information systems: principles, techniques, management and applications: abridged (pp. book 49-65, cd-rom 157-173). Wiley.
- 6) Wada K., Wallner G., and Vos S., 2022. Studying the Utilization of a Map-Based Visualization with Vitality Datasets, by Domain Experts. Basel, Switzerland.
- 7) Tobler W., October 1979. Transformational View of Cartography, Article in Cartography and Geographic Information Science. California, United States.
- 8) Hölscher K., and Frantzeskaki N., 2021. Perspectives on urban transformation research: transformations in, of, and by cities. Rotterdam, The Netherlands Caquard S., January 2018. Cartography and Art. Montreal, Canada.
- 9) Hogräfer M., Heitzler M., Schulz, H.J., 2020. The State of the Art in Map-Like Visualization.
- 10) Suitner J., 2020. Vienna's planning history: periodising stable phases of regulating urban development, 1820–2020. Vienna, Austria.
- 11) Franz, Y., 2015. Gentrification in Neighbourhood Development: Case Studies from New York City, Berlin and Vienna. s.l.:s.n.
- 12) Ferdinand Reimer, U. K., 2020. The Viennese Building Stock from 1920 to 2018: a Prototype Model. s.l.:s.n.
- 13) Muller, G., 2011. What is a Process?. s.l.:s.n.
- 14) Roth, R. E., 2020. Cartographic Design as Visual Storytelling: Synthesis and Review of Map-Based Narratives, Genres, and Tropes. s.l.:s.n.

- 15) Gilles Duranton, D. P., 2013. The growth of cities. s.l.: s.n.
- 16) World, G., 2013. Changing maps to map changes.
- 17) Publishing, T.-C., n.d. Dynamic Maps: Showing Change over Time (GIS and Spatial Analysis). [Online].
- 18) Cities, R. B. a. L., 2015. Cities in numbers: how patterns of urban growth change the world.
- 19) Skupin, A., 2002. On Geometry and Transformation in Map-Like Information Visualization.
- 20) Stanislav Frangeš, M. L. V. P.-P., n.d. CURRENT CHANGES IN CARTOGRAPHIC VISUALISATION.
- 21) Scott Orford. Danny Dorling, R. H., 2003. Cartography and Visualization.
- 22) Bammer, G., 2015. An Approach to Understanding Change. In G. Bammer (Ed.), Change: Combining Analytic Approaches with Street Wisdom (pp. 3–16). ANU Press. <http://www.jstor.org/stable/j.ctt16wd0cc.5>
- 23) Eigner, P., n.d. The growing city: Vienna on the eve of the First World War-how the city changed. [Online] <https://ww1.habsburger.net/en/chapters/growing-city-vienna-eve-first-world-wa>
- 24) FLOWINGDATA, 2010. 11 Ways to Visualize Changes Over Time – A Guide. [Online] <https://flowingdata.com/2010/01/07/11-ways-to-visualize-changes-over-time-a-guide/>
- 25) Brinch, S., 2020. What we talk about when we talk about beautiful data visualizations. In M. Engebretsen & H. Kennedy (Eds.), Data Visualization in Society (pp. 259–276). Amsterdam University Press. <https://doi.org/10.2307/j.ctvzgb8c7.22>
- 26) Ricker, B., Kraak, M.-J., & Engelhardt, Y., 2020. The power of visualization choices: Different images of patterns in space. In M. Engebretsen & H. Kennedy (Eds.), Data Visualization in Society (pp. 407–424). Amsterdam University Press. <https://doi.org/10.2307/j.ctvzgb8c7.30>
- 27) Derudder, B., Timberlake, M., & Witlox, F. (2 (Eigner, n.d.) (FLOWINGDATA, 2010)010). Introduction: Mapping Changes in Urban Systems. Urban Studies, 47(9), 1835–1841. <http://www.jstor.org/stable/43079841>
- 28) Sabine Kraft, Anna Aichinger, Zhen Zhang: 2016, „The Transformative Powers of the Cities “, Editorial, in: Planetary Urbanism: The Transformative Power of Cities, Aachen 2016, S. 5–9, hier S. 5

- 29) Programme, U. N. H. S., n.d. World Cities Report 2022 Envisaging the Future of Cities, s.l.: s.n.
- 30) Hunter M., Soro A., Brown R., Enhancing Urban Conversation for Smarter Cities – Augmented Reality as an enabler of digital civic participation (IxD&A, N.48, 2021, pp. 75 - 99). Australia.
- 31) Wahl C. D., 2020. City as Process Breakdown & breakthrough in Socio-Ecological-Systems. Design for Sustainability <https://designforsustainability.medium.com/city-as-process-394ffce9cc57>
- 32) Vienna and Paris, 1850-1930: The Development of the Modern City (pp. 4-5) (Online)http://mprapeuro.weebly.com/uploads/2/9/3/0/29308547/vienna_paris_documents.pdf
- 33) Robinson J., 2005 "Inventions and Interventions: Transforming Cities-An Introduction" (Urban Studies, Vol. 43, No. 2, pp.251-258, February 2006)
- 34) Leitner M., Bутtenfield P. B., "Cartographic guidelines on the visualization of attribute accuracy" (Department of Geography and Anthropology, pp. 184-1991)
- 35) Jiang, B., 1996 "Cartographic Visualization: Analytical and Communication Tools" (Article in Cartography Vol.25, No2, pp. 2-10) Roth E. R., 2017, "Visual Variables" (Chapter, University of Wisconsin–Madison, USA, pp. 1-11)
- 36) Stojanović V., 2015. "CAUSES AND CONSEQUENCES OF THE CYCLE OF CHANGES IN URBAN MORPHOLOGY: Urban Theory and Practice" (Article, pp.38-43)
- 37) Oberholzer C., Hurni L., 2000 "Visualization of change in the Interactive Multimedia Atlas of Switzerland" (Volume 26, Issue 1, 1 February 2000, Pages 37-43)
- 38) Orford, S., Dorling, D. and Harris, R., 2003 "Cartography and Visualization" in Rogers, A. and Viles, H.A. (eds), The Student's Companion to Geography, 2nd Edition, Part III, Chapter 27, pp 151-156, Blackwell ISBN 0-631-22132-8
- 39) Suzuki, Hiroaki, Robert Cervero, and Kanako Iuchi, 2013. "Transforming Cities with Transit: Transit and Land-Use Integration for Sustainable Urban Development". Washington, DC: World Bank. DOI: 10.1596/978-0-8213-9745-9. License: Creative Commons Attribution CC BY 3.0.

Appendices:

VIENNA'S DEVELOPMENT

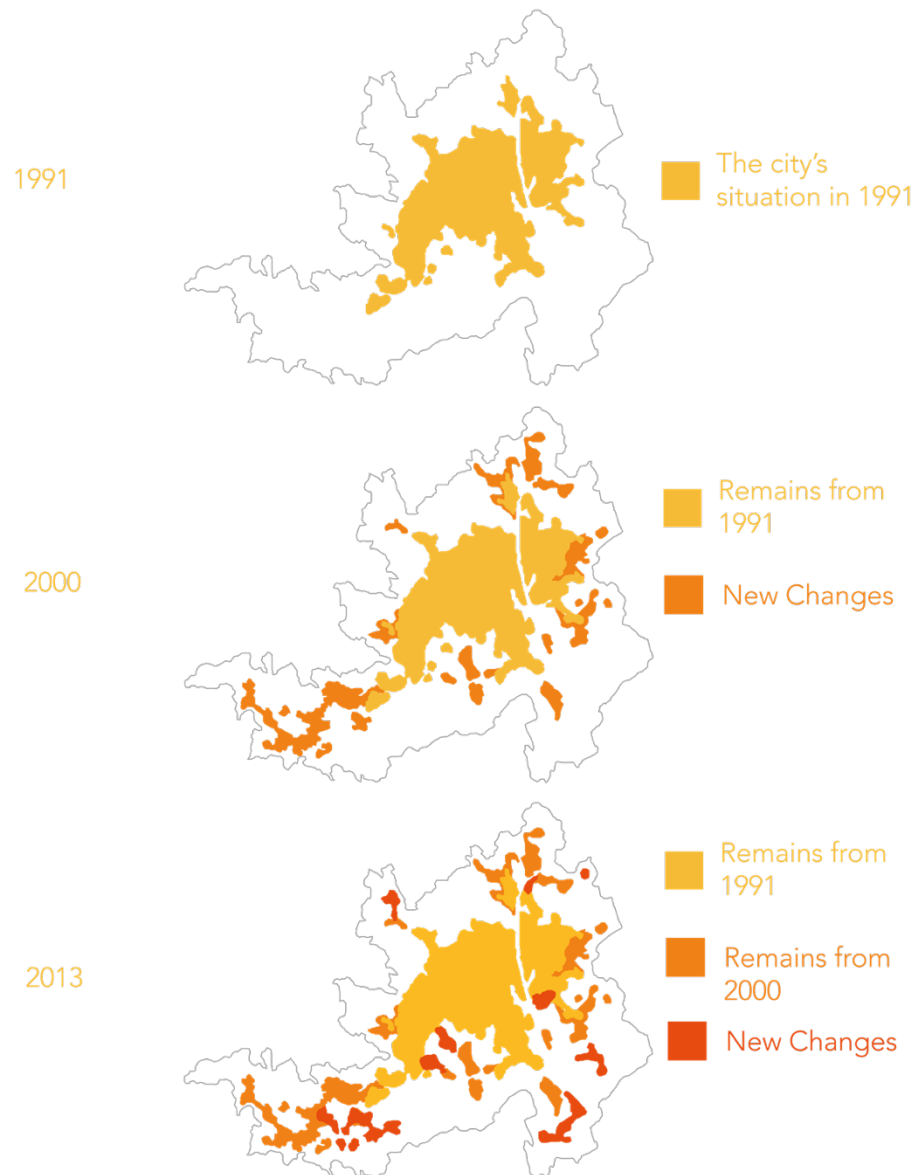


Fig. 16: A simpler approach to visually represent change over time.



Fig. 17: Map of Vienna during 1900s.

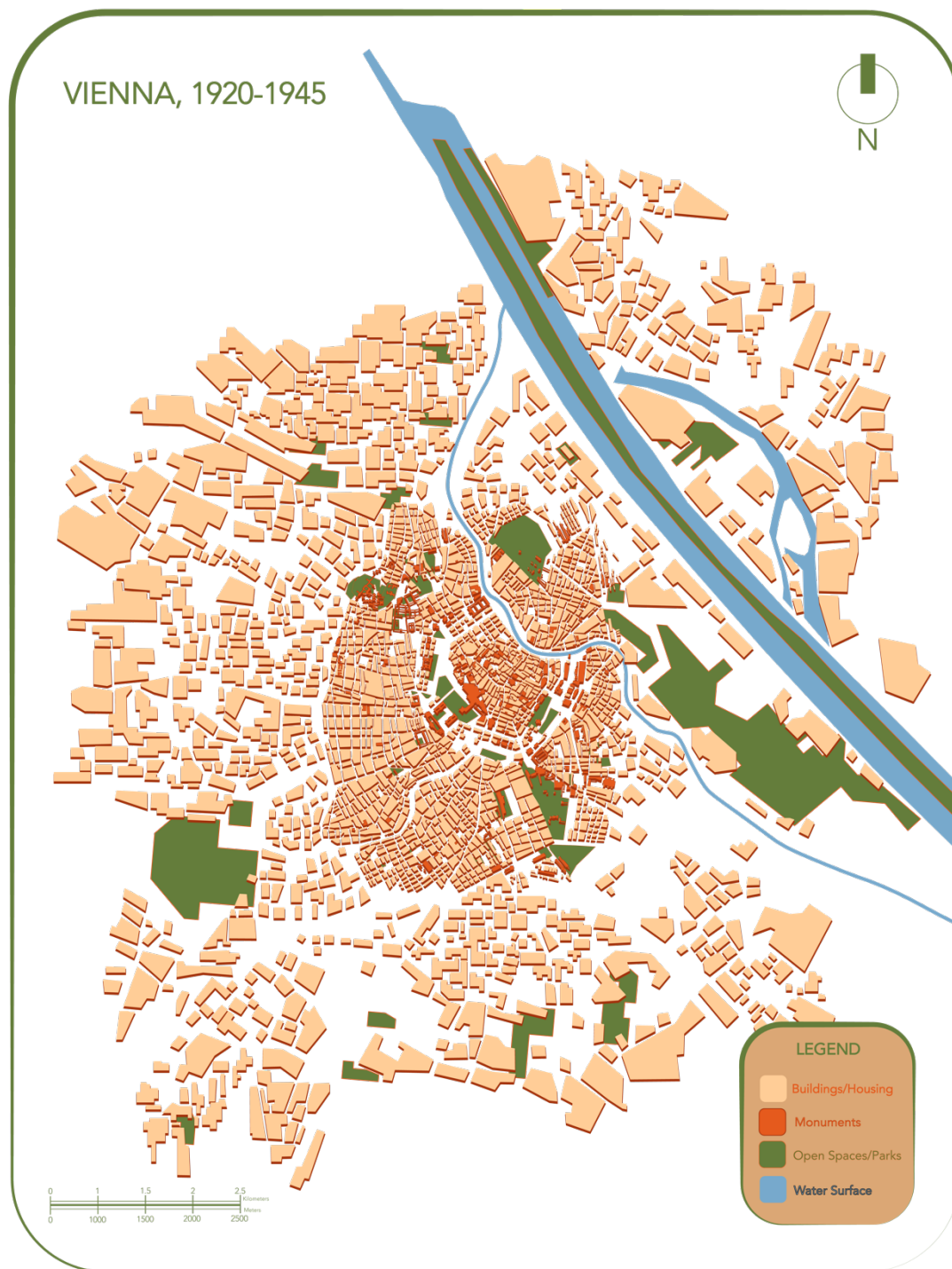


Fig. 18: Vienna's change between 1920 and 1945.

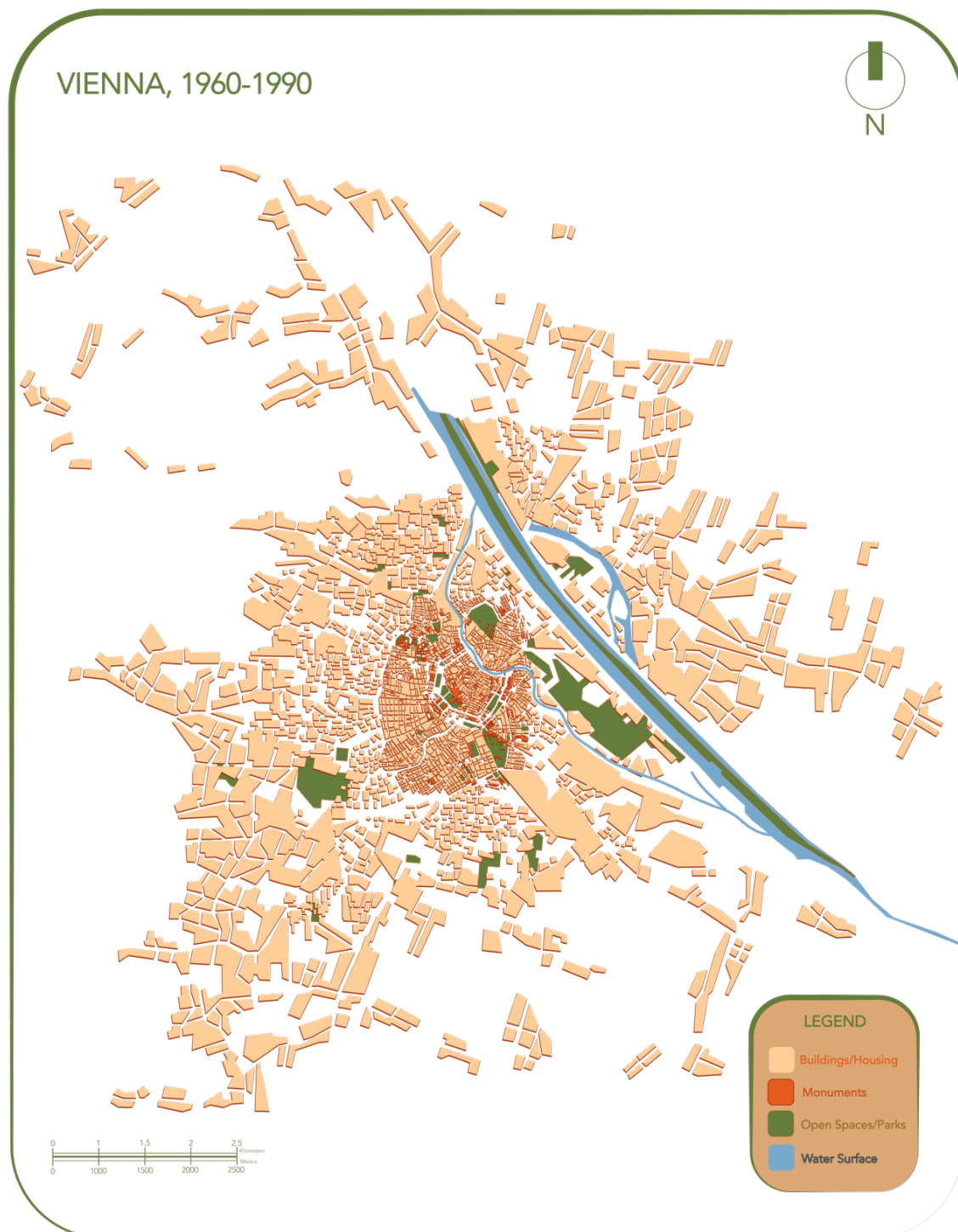


Fig. 19: Vienna 1960 and 1990 growth situation



Fig. 20: Expected changes to occur in the city of Vienna by year 2030.

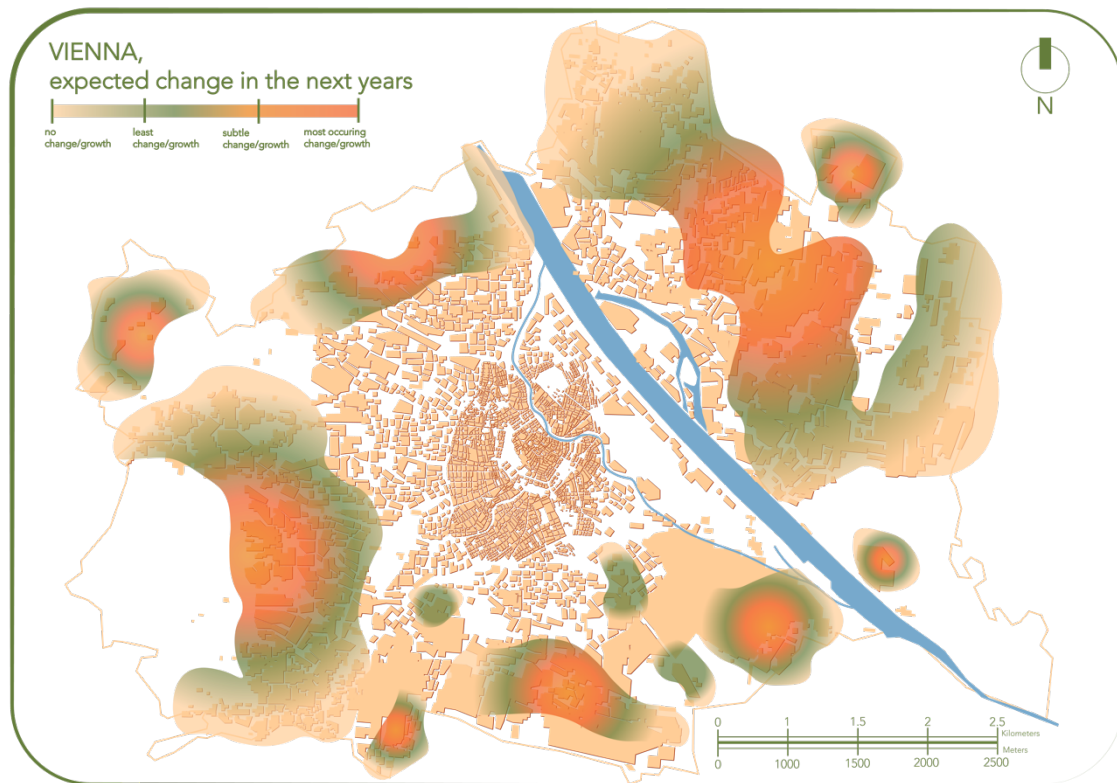


Fig. 21: Heat Map, highlighting future changes in 2030 Vienna.