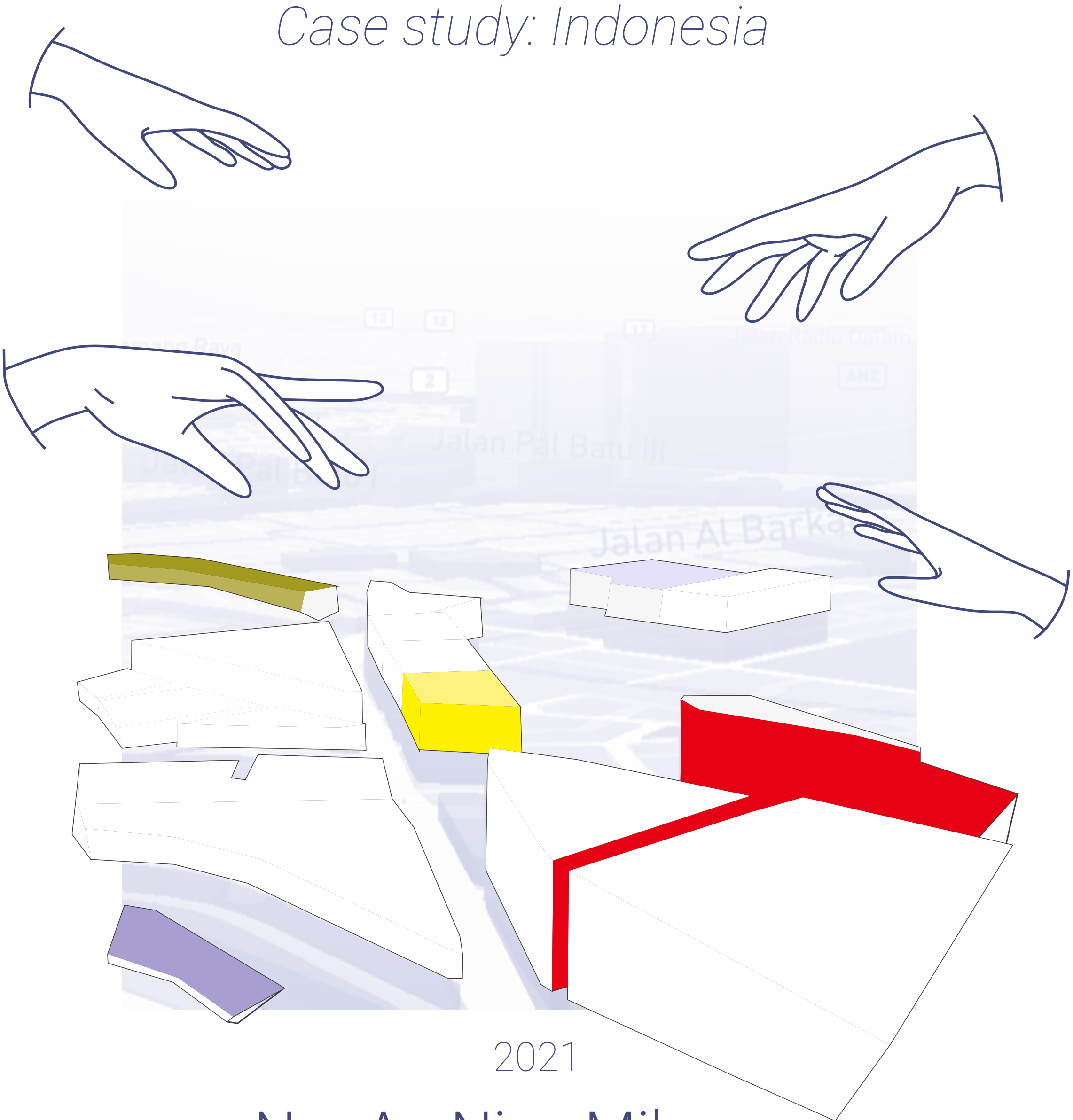
Master thesis in Geomatics for the Built Environment

DESIGNING USER EXPERIENCE (UX) TO SUPPORT PUBLIC PARTICIPATION IN SPATIAL PLANNING

Case study: Indonesia



2021

Nur An Nisa Milyana

TU Delft

MSc thesis in Geomatics

Designing user experience (UX) to support public participation in spatial planning

Nur An Nisa Milyana

July 2021

A thesis submitted to the Delft University of Technology in partial fulfillment of the requirements for the degree of Master of Science in Geomatics

Nur An Nisa Milyana: *Designing user experience (UX) to support public participation in spatial planning* (2021)

The work in this thesis was carried out in the:

Delft University of Technology

Supervisors:	Mr.dr. Hendrik Ploeger
	Dr.ir. Bastiaan van Loenen
Co-reader:	Prof.dr. Willem Korthals Altes

This research was supported by:

Indonesia Endowment Fund for Education

Abstract

In modern-day spatial planning, the implementation of public participation has increased to find a balance between two major actors: the government as the powerholder and citizens as the individual affected by planning decisions. Cities are required to redefine their public participation strategies by adopting modern tools to increase their citizen's satisfaction regarding the spatial planning process. This challenge has made geographic information system (GIS) technologies invaluable to enhance the place-making process by allowing citizens to express their needs and preferences.

On the other hand, developing GIS technology with design or hierarchy left unchecked, could cause usability problem to the user. GIS technology would end up running into an unnavigable ocean of buttons and maps, resulting in users can easily get lost and become frustrated. Therefore, User Experience (UX) can become integral for engaging users with spatial planning products and effectively meeting their aspirations.

This thesis aims to develop a User Experience (UX) design guideline together with a mockup design and apply it as a web-based GIS prototype. The focus of the study will be on spatial planning practice in Indonesia. The User Experience (UX) design guideline named '4PHASE toolkit' was made with several design phases: Phase 1: Define, Phase 2: Design, Phase 3: Build, Phase 4: Test. The first phase is related to top-down studies about participation in spatial planning process both in general and case study, resulting with the Actor-Network (ANT) diagram for conceptualizing user roles, participation tasks, and space-time setting during the participation. The second phase is related to the design process of the UX starting from building persona, creating user flow, sketching wireframes, and designing interfaces - resulting with the proposed mockup of 4D Musrenbang. The third phase is the development of the prototype based on the mockup design using HTML, CSS, and Javascript to add functionalities to the web. At last, Phase 4 is testing the prototype with real actors who share similar traits with the Persona. Based on the user tests, the prototype itself is considered as good, with usability score of 71%. Overall, this thesis project has successfully created three main products: The 4PHASE toolkit, a mockup, and a geo-web prototype.

Acknowledgement

This thesis research represents the culmination of one tough year graduation trajectory, which represents my passion in design and mapping, and as the requirement for the degree of Master of Science in Geomatics, at Delft University of Technology. It would not be possible to complete this study without the financial support from LPDP, the Ministry of Finance, Indonesia. I am also very grateful to have the pleasure of working with many talented and kind people, some of whom I would like to thank especially here.

First, I would like to thank my supervisors, Hendrik Ploeger and Bastiaan van Loenen. It was a challenging time for me as the pandemic hit right when I started this thesis project - while at the same time also try to keep my family safe at the same time. I am immensely indebted to both of you for your trust and patience, and most important, for being my supervisors. I would also thank Agung Indrajit for inspiring me, and kind enough to let me explore more in-depth about 4D PUPM during my thesis project.

Second, I would like to thank my strong family for all the love and support. As the first in the family who's able to go to and study in the university, this degree is special for both of you.

Second, I would like to thank all of my friends here in Delft and some who already went back to their countries. Thank you for the being with me as I experienced my first time living abroad, and sharing fun experience while having a love-hate relationship with Dutch strong wind. I hope we can meet again soon.

At last I want to thank myself for being strong even when it feels like falling apart. I hope you keep being strong until the end, and I wish you a bright and colorful future.

Nur An Nisa Milyana
Delft, July 2021

Contents

List of Figures

List of Tables

Acronyms

4D PUPM 4D Open Spatial Information Infrastructure

ANT Actor-Network Theory

Bappeda *Badan perencanaan pembangunan daerah* / Local development planning agency

CSS Cascading Style Sheets

GIS Geographical Information System

HTML HyperText Markup Language

KDB *Koefisien Dasar Bangunan* / coefficient of the building

KLB *Koefisien Lantai Bangunan* / coefficient of the floor

KB *Ketinggian Bangunan* / building's height

KDH *Koefisien Daerah Hijau* / coefficient of the green area

Musrenbang *Musyawarah perencanaan pembangunan*

Musrenbangdes *Musrenbang Desa* / Village-level Musrenbang

Musrenbangcam *Musrenbang Kecamatan* / District-level Musrenbang

NGO Non-Governmental Organization

PPGIS Public Participation Geographical Information Systems

RDTR *Rencana Detai Tata Ruang* / Detailed Urban Space Spatial Plan

RRR right, restriction, and resposibility

RPJP *Rencana Pembangunan Jangka Panjang* / Long-term National Development Plan Strategies

RPJM *Rencana Pembangunan Jangka Menengah* / Medium-term National Development Plan Strategies

SII Spatial Information Infrastructure

RKP *Rencana Kerja Pemerintah* / Government Work Plans

UX User Experience

UI User Interface

Chapter 1

Introduction

Following the emerging advancements in Geographical Information System (GIS) technologies, several new modern tools have emerged to facilitate geo-enabled citizen participation using maps for communicating spatial planning issues. In addition to modern participation tools, the innovation of GIS technologies with Web 2.0 introduces many geo-web applications that could enhance government-citizen interactions and spur social innovation during the participation. However, while geo-web technologies are emerging trends in this area, there is still a lack of user consideration during the design process. This situation motivates this thesis research to conceptualize the User Experience (UX) design method and build a geo-web prototype as a precedent in helping to stimulate better usability for future geo-web participation tools.

This chapter introduces the intersection of three research domains: participation in the spatial planning process, GIS, and UX. It also explains the relevance of the thesis to the case study area, Indonesia. Additionally, it shares the research questions and methodologies used and tailored in this work.

1.1 Background

The living environment that people experience every day is shaped by the individual (Thwaites, 2001). Each of these individuals can describe places that they enjoy by memories of what they store. In the context of this research, the place is conceptualized as a static artefact in a state of becoming, which means it could constantly be shaped through physical changes for various reasons, including spatial planning actions (Dovey, 2009). Without any individual's involvement, these changes could be viewed as threats that may destroy the existing individual value and perspective of a place. To minimize these threats, modern-day spatial planning requires sensitivity to find a balance between developing or changing the existing living environment while maintaining the individual's perspective. As a result, public participation has increased in the decision and policy-making process for spatial planning projects.

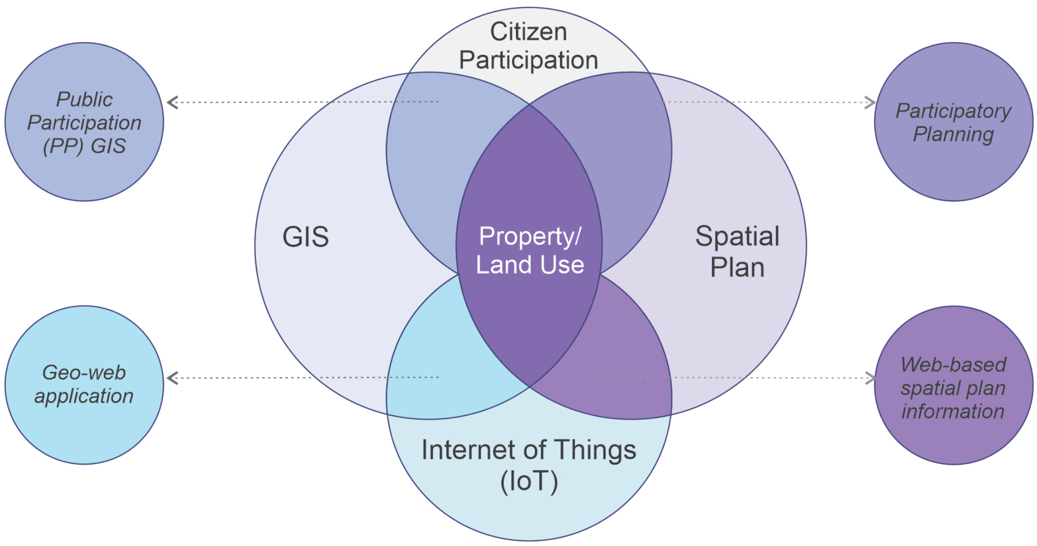


Figure 1.1: The intersection of citizen participation, GIS, and spatial plan

Public participation is essential to provide interaction between two sides: the government as a spatial planning expert and the individual affected by planning decisions (Faehnle, 2014). Cities are required to redefine their public participation strategies by adopting modern tools, such as GIS. Therefore, it has made GIS technologies become invaluable to the experts to enhance the placemaking process by allowing citizens to express their needs and preferences. Figure 1.1 visualizes how the intersection of these three domains (citizen participation, GIS, and spatial plan) has expanded the placemaking process in participation. Due to the increasing use of IoT devices, web-based GIS, namely geo-web, is often used to foster citizen participation in the spatial planning process.

1.1.1 Why is geo-participation tools needed for the spatial planning process?

The technical barriers of participation have been reduced with the increased access to GIS technologies and the Internet, offering wider-scale spatial data generation by citizens. Explicitly, it has set out some benefits of good participation (Involve, 2005), such as:

- To understand humans' values, needs, and preferences by communicating with them. It also could enhance the effectiveness of service provision and decision-making.
- To understand humans' values, needs, and preferences by communicating with them. It also could enhance the effectiveness of service provision and decision-making.
- To involve people in decisions that affect their lives. Moreover, participation can increase the legitimacy of those decisions among the participants.
- To become effective, in which some public services of the government need an active participation process.

In the context of the spatial planning process, geo-participation is introduced as the umbrella term for participatory approaches using geospatial information and techniques (Pánek, 2016). This term is not new, considering the development of GIS in the participation process has existed since the 1960s with mental maps for collecting information of geographic areas through human perceptions (Sieber, 2006; Pánek, 2016). More recently, local governments follow these practices to understand public opinions better and enhance public participation in the spatial planning process.

In urban planning cultures, two sides will get the benefit from using participatory approaches: the government and the citizen. The government strives to find ways to influence all stakeholders that involve during development projects. On the other hand, participation methods promote sharing citizens' experiences and behavior concerning their living environment. Several new GIS technologies can become an important communication instrument between citizens as the inhabitants and the government as the planners using geo-participation tools and approaches.

Furthermore, the advancement of modern geospatial tools can make the participation process more democratic than the traditional approach due to its freedom from the limit of time and place and its potential to reach large numbers of participants. These tools offer varied opportunities for the citizens to understand a city's transformation better through spatiotemporal or 4D visualization. These visualization components are relevant to visualize and analyze the impacts of the choices made during the consultation process.

1.1.2 Bridging participation, spatial planning, and GIS with User Experience (UX)

Advances in GIS technologies have fundamentally transformed how communication using GIS is about producing maps and using them. As visualized in Figure 1.2, adding participation into map use has added third-dimensional space to the cartography from private (map use for a personal goal) to the public (map use for reaching a wider audience). Thus, GIS applications should provide higher human-map interaction so the users can manipulate a map in a substantive way (MacEachren and Taylor, 1994).

Despite the massive advancement of GIS applications, the number of studies regarding how 3D geo-visualization can be a communication platform for citizens to express their opinion is relatively low. Kramers (2008) stated that many users are unable to handle mass functionalities provided by GIS applications.

Consequently, many functions provided in GIS applications are not suitable for most users, primarily because of not including the profiles of future users in the development process (Kramers, 2008; Resch and Zimmer, 2013).Regardless of the potential of this tool for leveraging ideas, the further concern is how to deal with the uncertainty of cartographic design and simplification of spatial knowledge from a wide variety of users (Rinner and Bird, 2009). Involving users in GIS within the planning decision system has increased the complexity of spatial information products (spatial property and zoning maps). For example, drawing a proposed development may generate a conflict if the geometric features interpret a different understanding of what could be built in a specific area (Elwood, 2010).

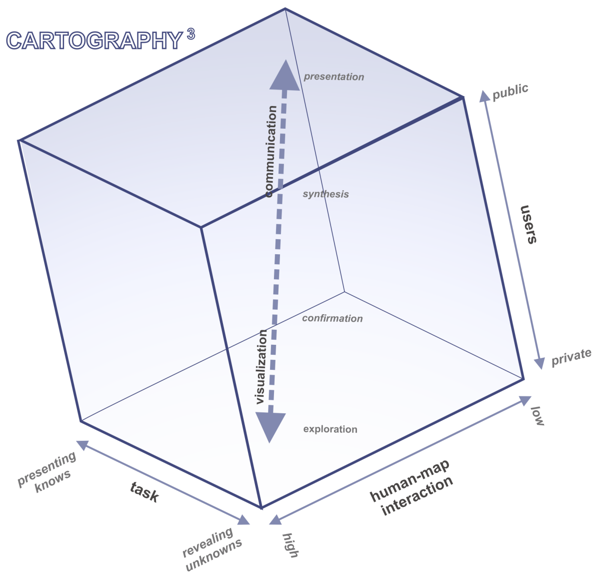


Figure 1.2: Cartographic cube: the complexity of human-map interaction - adapted from (MacEachren and Taylor, 1994)

If the design or hierarchy is left unchecked, GIS technology could run into an unnavigable ocean of buttons and maps, resulting in users can easily get lost and become frustrated. Hence, the implementation of GIS for delivering spatial plans should be more user-friendly, increasing the accessibility and ability of various actors to use and understand it. At its core, UX could help the spatial planning experts to make this spatial information to become more humane. UX is a process of enhancing user satisfaction by improving the overall experience provided in the interaction between the user and the product (Adikari et al., 2011). Therefore, UX can become integral for engaging users with spatial planning products and effectively meeting their aspirations.

1.1.3 Motivation and relevance to the case study: Indonesia

The concept of participation has become the cultural feature of Indonesian identity, which constructs the traditional social mechanism community in seeking mutual assistance (Bowen, 1986). This spirit of community involvement has also incorporated into the spatial planning process in Indonesia using a bottom-up approach, namely *Musyawarah perencanaan pembangunan* (Musrenbang), as the traditional tools to the participatory planning process. As technology development is used as political communication, several modern tools have emerged in becoming an area for digital participation. Among them, 4D Open Spatial Information Infrastructure (4D PUPM), developed by Agung Indrajit, is the modern-day participation tools that implement a 3D city model for monitoring spatial planning implementation through a participatory process.

This thesis project investigates how to design UX for the geo-web applications to support public participation in the spatial planning process. The research will develop a UX design guideline together with mockup designs and implements as a geo-web application prototype. The focus of the study will be on spatial planning practice in Indonesia. The research builds on the work of 4D PUPM by Agung Indrajit as the initial design.

1.2 Research Question

This research aims to enable interactive geo-web application as a two-way communication platform in the spatial planning decision-making process using a UX approach. Furthermore, the implementation and evaluation resulting from the final result could act as a design guideline for similar participatory geo-web applications in spatial planning process.

The main research question for this thesis is:

How to design a User Experience UX for geo-web applications to support public participation in spatial planning processes?

To be able to answer the main research question, a set of sub-questions has been established. The sub-questions are categorized according to the aspect of the research they are relevant for:

SRQ-1 What is the role of public participation in the spatial planning process in theory?

SRQ-2 What is the role of public participation, as applied to the spatial planning process in Indonesia, and how can this be improved using 4D PUPM?

SRQ-3 To what extent can the user experience design bring added value for public participation in the spatial planning process?

SRQ-4 What are the requirements for UX for implementation in 4D PUPM?

SRQ-5 How can these UX requirements be implemented to increase public participation in the spatial planning process in Indonesia?

SRQ-6 How do users assess the added value in the specific case of spatial planning in Indonesia?

1.3 Methodology

Bearing in mind the complexity of overarching participatory planning procedures using geo-web, this thesis research adopts a mixed-method approach for answering the main and sub-research questions by combining theoretical and empirical research elements. The mixed-method, in this case, provides complimentary in-depth knowledge to address such a heterogeneous iterative approach that encompasses the UX design process.

Therefore, the choice for the methods leans towards an interdisciplinary approach, thus inquiring about participation, spatial planning, and GIS as the social construct for application design. The interdisciplinary research findings are then clustered into the UX design framework to design a geo-web application, referred to as 4PHASE (Chapter 3). This framework is later applied and tested to the case study area, which is Indonesia. Overall, the process of establishing and testing 4PHASE will be as follow:

1. Literature review: A combined theoretical analysis with a study of real case study experiences explores the existing participatory process in spatial planning and UX design principles.

2. Simulation-based process: The simulation-based design process is empirical-based research, which helps to see whether the 4PHASE design framework could be implemented in the selected case study area. This later will be resulting in a mockup design and a geo-web prototype.

3. User session: During the user session, several participants from different backgrounds are invited to check the usability benchmark of the new design.

1.4 Scope of The Research

This project's scope is primarily based on spatial planning users in Indonesia, especially users of 4D PUPM. This research is focusing on user experience on selected user types and datasets. When designing a platform, several considerations mainly focus on the user and the context of use (Robin and Chisnell, 2008). Further constraints for the design also originate from the spatial planning and geo-information literature backgrounds that are to be provided. In the following section, I will elaborate on several constraints that have emerged from the analysis – leading to several technical factors that should be considered.

1. Context of spatial planning and geo-information.
   Having defined participation activities that the multiple users will likely perform, I have derived the human-to-GIS connection for participatory planning purposes, including the detailed model using the ANT diagram to standardize what participation tasks should exist and who can participate during the process. However, for this research, the literature backgrounds concentrate on the holistic approach of spatial planning and GIS, meaning that these two things are studied toward knowledge-based studies in a broad perspective. Also, the spatial planning context leans toward participation during plan formulation and its integration with GIS to manage citizen-government interaction. Since the main research question strongly focuses on the design context, measuring the performance in the spatial planning process and the quality of spatial information being used are not discussed.

2. Legal and technical aspects of the case study.
   While the theoretical research is heavily constructed from a broad sense of studies, the implementation of the design is mainly covered from the legal and technical frameworks specified to the case study location, Indonesia. It could be assumed that participation is a familiar concept for people who live in Indonesia, as the Indonesian legal frameworks clearly state its citizens' rights and obligations to participate in the spatial planning process actively. Furthermore, the technical aspect is also heavily based on Indonesia's chosen traditional and modern participation tools: Musrenbang and 4D PUPM. Due to this, implementing the design concept (4PHASE) and selecting intended actors can be varied depending on what frameworks of spatial planning process exist in the specific countries.

3. Selection of design choices and functionalities.
   The research's main goal lies in seeking UX design conception for creating collaborative two-way interaction in geo-web applications. Consequently, the goal "two-way" influences the design and functionality consideration concerning several points: 1) design an interface that is accessible for different types of users' backgrounds and skills; 2) ensure that each user can easily contribute during the participation process; 3) provide easy-to-use and user-friendly functions for all users. Moreover, the final output, the prototype, demonstrates the aspects from the intended design and is used to test the whole participation design conception. Due to time constraints, several technological aspects like the database system and the error-proofing functionalities are not described.

1.5 Outline

The outline of this thesis is organized as follows:

Chapter 1 introduces to the motivation and background of the research and provides the research information, problem statements, and research methodology.

Chapter 2 explores and analyze the core foundation of spatial planning process with the help of acgis technologies based on literature studies, resulting with the ANT diagram to map the user roles and task capabilities during participation process.

Chapter 3 established the design steps related to User Experience, resulting with the proposed toolkit named 4PHASE toolkit.

Chapter 4 focuses on defining user roles and participation tasks to the case study: Indonesia. This chapter is the implementation of Phase 1: Define, resulting with the ANT diagram based on both traditional Musrenbang and 4D PUPM.

Chapter 5 focuses on making a suitable design which consists of persona, user journey, wireframes, and interface. This chapter is the implementation of Phase 2: Design, resulting with the mockup design of 4D Musrenbang.

Chapter 6 focuses on building a prototype which consists of data preparation, data visualization, and map functionalities implementation. This chapter is the implementation of Phase 3: Build, resulting with the prototype design of 4D Musrenbang.

Chapter 7 evaluates the prototype by inviting several users that have similar traits with the intended actors. The user test consists of three tests, such as: task-based test, persona validation test, and semi-interview.

Chapter 8 provides the conclusion, limitations, and future works of this thesis research.

Chapter 2

Making Sense of Participation in the Spatial Planning Process with the Help of GIS

This chapter presents a top-down research approach using the literature review related characteristics and components of participation in spatial planning and GIS as the participation platform. The conclusion of this chapter defines the roles and participation tasks of GIS to facilitate participation in the spatial planning process.

2.1 Theoretical Background of Participation in the Spatial Planning Process

In its original sense, the term spatial planning is described by Keeble (1969) as: "the art and science of ordering the use of land and siting of buildings and communication routes to secure a maximum practicable degree of economy, convenience, and beauty." From the definition, the root of spatial planning shapes the place of human activities such as houses, offices, retails, and agriculture to ensure harmony among them. Moreover, this process is also approaching within a broader social scale, which means engaging multiple actors through several planning products such as design, land use allocation, and policy-making (Healey, 2003; Morphet, 2010). According to (Banfield, 1959), the process of spatial planning consists of five steps: 1) Definition of problems and/or goals, identification of alternative plans, 3) evaluation of alternative plans, 4) implementation of plans, 5) monitoring of effects of plans. Due to the continuation of the steps, these processes could be simplified into three phases, such as 1) Plan Formulation, 2) Plan Implementation, and 3) Plan Monitoring and Evaluation (Banfield, 1959; Kato and Ahern, 2008).

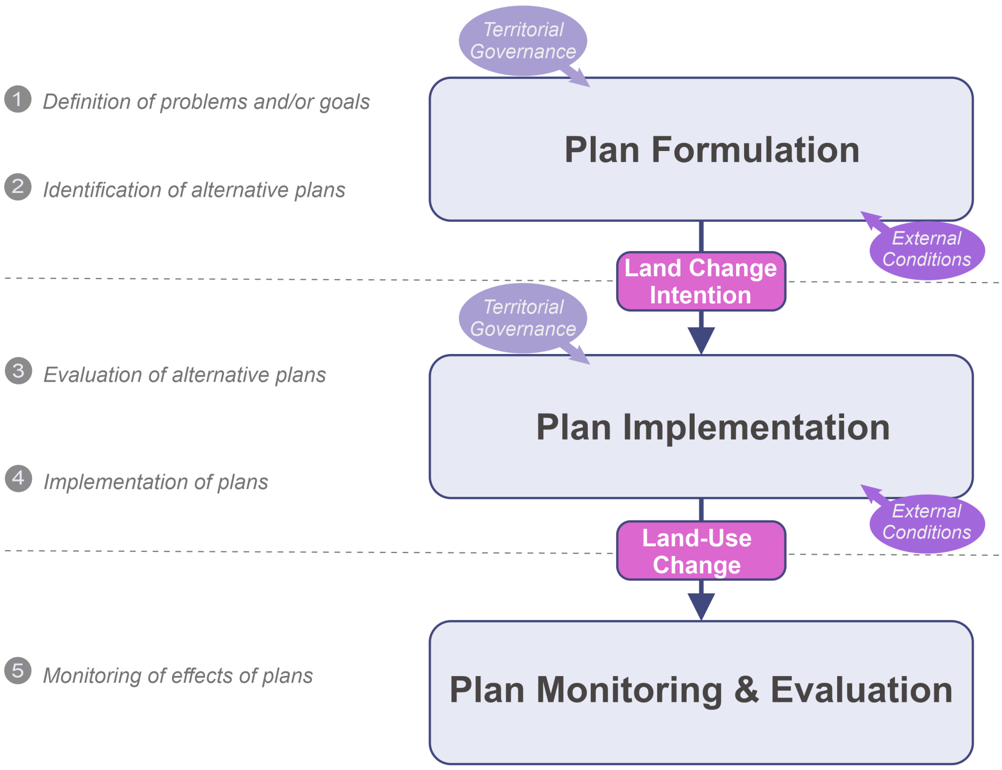


Figure 2.1: The spatial planning process with the impact on land change (Banfield, 1959; Kato and Ahern, 2008; Hersperger et al., 2018)

However, these classic spatial planning steps are rarely conducted for local planning intentions (see Figure 2.1). It is partly due to several agreements of public and political supports (Kinzer, 2016; Hersperger et al., 2018). Hersperger et al. (2018) complements these steps by adding three components: territorial governance, external conditions, and land change intention. During the plan formulation, land change intention is expressed in a map and/or text describing the development visions, such as land-use and density plan, infrastructure plan, and other strategic projects. Then, land use intention is sustained by the territorial governance process, which refers to the formulation of planning policies. On the other hand, external conditions can also affect plan formulation and implementation beyond territorial government arrangements, commonly based on joint participation agendas. During plan implementation, these components lead to land-use change in which later the effect and the efficiency will be monitored during plan monitoring and evaluation step.

Even though public participation is considered desirable action to support collaboration in the planning process, it also causes tension between lobbying interests in territorial governance arrangements and citizen participation agenda as the external conditions (Hersperger et al., 2018; Loonen, 2020). This collaborative turn creates a paradigm shift from focusing on political economy and urban management impact into how citizens come to comprehend the quality of their living environment (Healey, 2003; Loonen, 2020). This shift could be seen with a participation activity involving stakeholders at an early stage in the decision-making process. However, there is no guideline to design participation in the spatial planning process, sustaining how participation flow happens, who has the right to participate, and what happens after the participation ends. Therefore, it is crucial to draw up designs and tools to safeguard good participation in the spatial planning process.

2.1.1 Organizational perspective on participation: the role and activity

The emerging variations of participation make it difficult to determine who could participate during the decision-making process of spatial planning (Pettersson et al., 2017). By nature, the process of participation involves different stakeholders from various backgrounds and types of knowledge. Brown et al. (2016) describe stakeholders as those who affect the decision and who are affected. These stakeholders consist of actors who have similarities in skills or power positions to influence the decision significantly. Still, it is important to note that each involved actor has their unique perspectives towards the issue. Therefore, when managing various types of perspectives, those should be constructed into meaningful knowledge to ensure the effectiveness of the process.

In the democratic world, one of the critical points is that people's power could lead to a more robust decision-making process, making it essential to choose whether citizens should be involved during the spatial planning process and how much they could contribute to the result (Mapuva, 2015). Reducing the isolation of the spatial planning process from the non-government stakeholders is the answer to bring comfort, creating a more unrestrained conversation between stakeholder parties (Carver, 2003; Mapuva, 2015). One way to achieve this is by generating a spirit of trust and cooperation from all participants. As a result, citizens should feel that they can produce their visions and ideas for their living area and see some of these come to fruition. However, one practical issue for citizens to participate in is that the participation process is often limited to public hearings, mainly focusing on the analogue form of participation, making citizens only able to comment on the ideas presented (Carver et al., 2001; Carver, 2003). What is worse is that this issue often de-motivating the participants leading to them end up being unengaged with the process. To avoid these problems, good participation tools and structures are necessary. At last, we should realize that involving multiple stakeholders is not a trivial task; therefore, it is highly valuable to make the best design process to achieve effective and democratic participation.

2.1.2 Measuring the level of participation

Accessing the voices of crowds should be considered as a way to collect opinions on some issues. As the planning character is future-orientated, information on current developments should be given greater prominence at the city level. Crowd-sourcing can be a fast and direct way to create commitment amongst experts and the public in general. It also provides a sense of commonness, which impacts turning collaborative turn into planning strategies with social context (Healey, 2003; Loonen, 2020).

Participation, especially in spatial development, augments citizens' power by taking an active role in the planning process. The pioneer of citizen participation starts with Arnstein (1969). She elaborates the types of participation into a ladder metaphor called Ladder of Participation, consisting of eight different levels, dividing them into three groups of degrees or intensities. On the other hand, McCall (2003) refined this ladder to specify participation based on four task intensity levels. As visualized in Figure 2.2, McCall's ladder level starts from the second degree of Arnstein's ladder, which is degrees of tokenism.

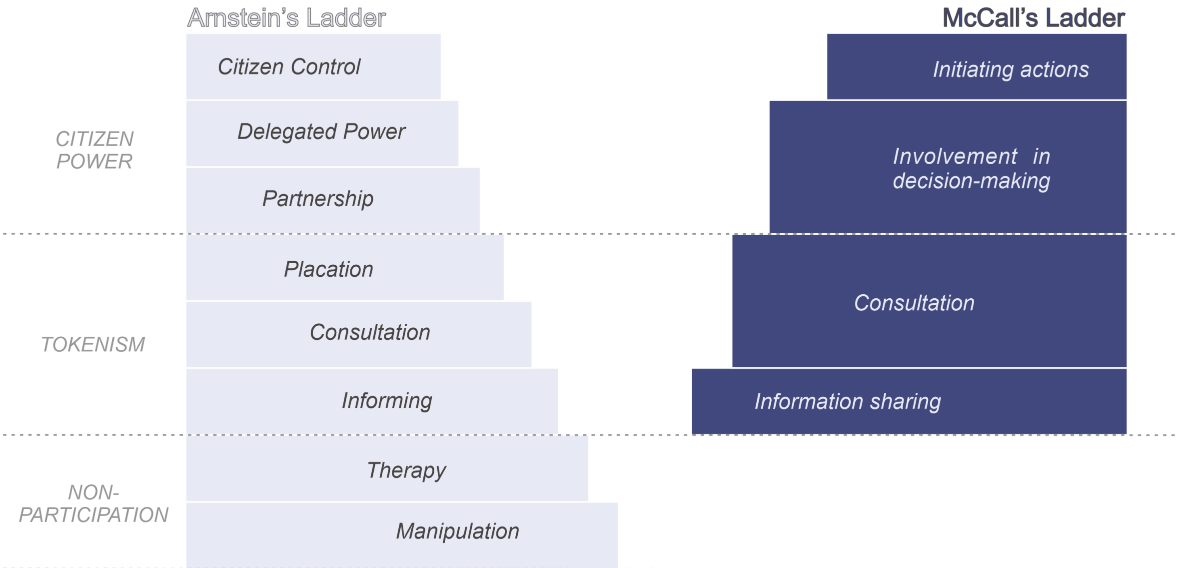


Figure 2.2: The ladder of participation - adapted from Arnstein (1969); McCall (2003)

Arstein's Ladder: The ladder starts from the bottom of the ladder, manipulation and therapy, which is seen as non-participation. To this degree, participants can only get information from the powerholders without allowing them to be involved. In the middle part (informing, consultation, and placation) is degrees of tokenism, in which participants can speak their opinion. However, they have no power to enforce their opinion to be considered by the powerholders – thus, it does not assure that the status quo can change (Arnstein, 1969). Finally, at the top of the ladder are partnership, delegated power, and citizen control as degrees of citizen power. It illustrates that the participants now have the ability to influence the decision-making process. In this case, there is still a distinction between these three top participation levels. Partnership and delegated power provide more active participation from specific population groups, so the decision comes from the majority (Arnstein, 1969). Meanwhile, in citizen control, the powerholder gives full participation to the individual citizens, and these individuals have power to the end decision (Arnstein, 1969; Carver et al., 2001).

McCall's Ladder: The first step of the ladder is information sharing, where the citizen and power-holders engage in one or two-way communication to gather information such as a status report or baseline surveys, although the topic is pre-determined by the powerholder. At the second step, consultation, the citizen can choose which case should be prioritized; however, the powerholder pre-defined lists of cases before the discussion then controls all analyses. The third step is the involvement in decision-making, where both citizen and powerholder jointly identify what should be prioritized, conduct analysis, and implement plans. This third ladder is in line with partnership and delegated power on Arnstein. Lastly, the top of the ladder is initiating actions, where citizen-owned everything or self-mobilization. This highest level implies that citizen conducts the whole participation process from the beginning until the without any facilitation or mediation from the powerholder. This tallest ladder reached a similar level with the highest Arnstein's ladder – therefore, this participation activity is still considered rare (McCall, 2003).

2.2 GIS, Public Participation GIS (PPGIS), and Geo-web

Over the last decade, technological advancements like GPS and virtual globes have facilitated the collection of crowd-sourced spatial data and the dissemination of spatial information (Goodchild, 2013). These rapidly available technologies have opened a window of opportunity to combine public participation and GIS for a citizen-oriented spatial planning framework. As a result, the concept of Public Participation Geographical Information Systems (PPGIS) has emerged in the spatial planning domain as the collaborative approach to link participation and spatial information by involving non-expert stakeholders in the decision-making process (Ghose, 2007; McCall and Dunn, 2012). Overall, the overarching goal of this PPGIS concept is giving empowerment tools for citizens by enabling them to use the tools of decision-makers to influence events that could affect their local environments (Corbett and Keller, 2005).

With the recent development of Web 2.0, further development of PPGIS has opened new ground for citizens to critically communicate and express their location-specific opinions in the form of a map. As a result, the merging of the Internet with GIS has gradually grown into a medium that provides the broadest sense in various participation activities and sectors of society involved. In this respect, several web-based GIS platforms, called 'geo-web', have reduced technical barriers for a layperson to create maps and spurred various activities that generate geospatial information (Sieber et al., 2016). Moreover, modern participation intrinsic to geo-web differs from traditional PPGIS practices – as it often involves a larger scale. Thus, it has brought a paradigm shift of how citizens could engage with spatial planning issues and policy-making processes.

2.2.1 The ideal GIS to support participation

Despite all possibilities offered by GIS, much of the criticism laid at the door of GIS still exist, such as most spatial data comes from the hands of powerholder and the user needs to be technology-savvy to use the platform. Geo-web should not be a technical gimmick – instead, it should unpack the theories of participatory planning into a practical solution while also fulfilling the efficiency and transparency of a good decision-making process. Hence, it would be a pity considering the connectivity provided by the Internet with the increasing use of GIS is very much keeping with the realization in reaching consensus on spatial issues in a geographical sense. The view of GIS technologies has changed from being a simple data provider to being a medium for the transferal of spatial knowledge. With this in mind, we might ask what an ideal GIS would be like to support participation in the spatial planning process? Kingston (2011) explains such platform includes as follow:

- Good quality and unbiased information, which allow users to understand complex problems and explore those topics in-depth as they wish.
- The ability for users to add their information to the foreground knowledge, discuss with others, and form a consensus.
- The participation process is not time-limited as the traditional public meetings are, although it should be limited to a certain period to fit with the planned schedule.
- The ability to ease data processing means the data contributed by users could be displayed back instantaneously.
- The ability for users to examine spatial data involved in the decision being taken and further to this - also to manipulate the data to gain 'what if' scenarios affected by the decision.
- The ability for users to reach the decision and submit this decision to see feedback and reasons for the final choice.

2.2.2 Could GIS increase the level of participation in the spatial planning process?

When comparing participation in general with the traditional spatial planning process by its nature, the root of participation is viewed as being bottom-up. In contrast, the planning process led by the government could be viewed as top-down. Conversely, although GIS is originated from the bottom-up approach, the spatial data is predominantly owned and controlled by the government, making it difficult for non-government actors to represent their knowledge within the GIS framework (Kingston, 2011). This condition tends to make GIS to be about disseminating spatial data in a very top-down process. While GIS makes it possible to access spatial data publicly, it still requires specific skills to operate this system entirely.

However, the development of PPGIS does offer an opportunity to shift this into a bottom-up process. With a user-friendly platform design, PPGIS can be a handy tool that acts as a place to allow citizens to fully engage with the decision-making regarding spatial plan at whatever spatial scale is relevant for them (Innes and Simpson, 1993; Kingston, 2011). Therefore, the development of PPGIS technologies allows the public to have a higher degree of participation. Furthermore, it is possible to reach the citizen power level of Arnstein and McCall ladder using easy-to-use and straightforward platforms like geo-web (Kingston, 2011).

Although many governments have incorporated geo-web technologies for their e-governance purposes, there are still limited functions offered to do decision-making procedures. Most of the time, users can only perform address look-up or download maps of proposed city projects (Christodoulou et al., 2004). Therefore, it is necessary to outline how to develop a good platform design for geo-web applications by providing the necessary tools and a better understanding of user's knowledge and skill.

2.3 The Human-to-GIS Connection

PPGIS plays a paramount role in the spatial planning process, facilitating spatial plan visualization through interactive maps and analytical capabilities to mediate the process (Ballatore et al., 2020; Aguilar et al., 2021). Moreover, these mapping tools are also claimed to increase engagement and participation in the spatial planning process both in public and private contexts (Sieber, 2006; Rinner and Bird, 2009). By exploring the theory of PPGIS, the conceptualization of geo-web as participation tools in the spatial planning process is created to build a conceptual network diagram that consists of participation task capabilities, space-time settings, and user roles.

Participation task capabilities.
Based on the literature reviews, several researchers have listed the desired task capabilities of PPGIS application as a spatial planning tool. After that, the tasks are matched with the intended user's skill to see their participation activities throughout the application. The participation tasks are shown in Table 2.1.

Participation Tasks		Source
Data Input	To enhance the user's spatial cognition during participation, there is a need for data input creation and manipulation, such as annotating locations, marking spots, adding simple sketches, and importing spatial data.	Eikelboom and Janssen, 2017 Vonk and Ligtenberg, 2010 Zenghong et al., 2012
Visualisation and Consultation	To facilitate seamless participation activities, there is a need to balance the visualized data input, e.g. limiting the number of layer maps, providing guidance for map visualisation being displayed, and navigating the user to the located problems.	Dias et al., 2013 Shrestha et al., 2018

Spatial Analysis	To support scenario planning process, several embedded GIS functionalities such as map overlay and spatial analysis are needed.	Eikelboom and Janssen, 2017 Flacke and De Boer, 2017
Database Management	To document participation activity, data management should enable the re-use of spatial information, e.g. integrating spatial information via database, enable handling large datasets.	Van de Ven et al., 2016 Vonk and Ligtenberg, 2010
Validation	To check whether the correctness of imported spatial data, there is a need for data validation before, during, and after the participation process.	Van de Ven et al., 2016 Vonk and Ligtenberg, 2010 Indrajit, 2019 Akbar et al., 2020

Table 2.1: Participation task capabilities of GIS

Space-time collaboration setting.
In the modern-day spatial planning process, it is essential to note that multi-users interaction through an application could be differentiated based on the space-time collaboration setting (MacEachren and Taylor, 1994; Aguilar et al., 2021). In general, participatory collaboration is usually conducted through typical face-to-face interaction in the same space and time. However, due to the increasing ability of GIS technologies, there is a growing interest in supporting multi-users collaboration in different space-time settings (Figure 2.3). (Isenberg et al., 2011) visualize four space-time setting for collaboration in the planning process:

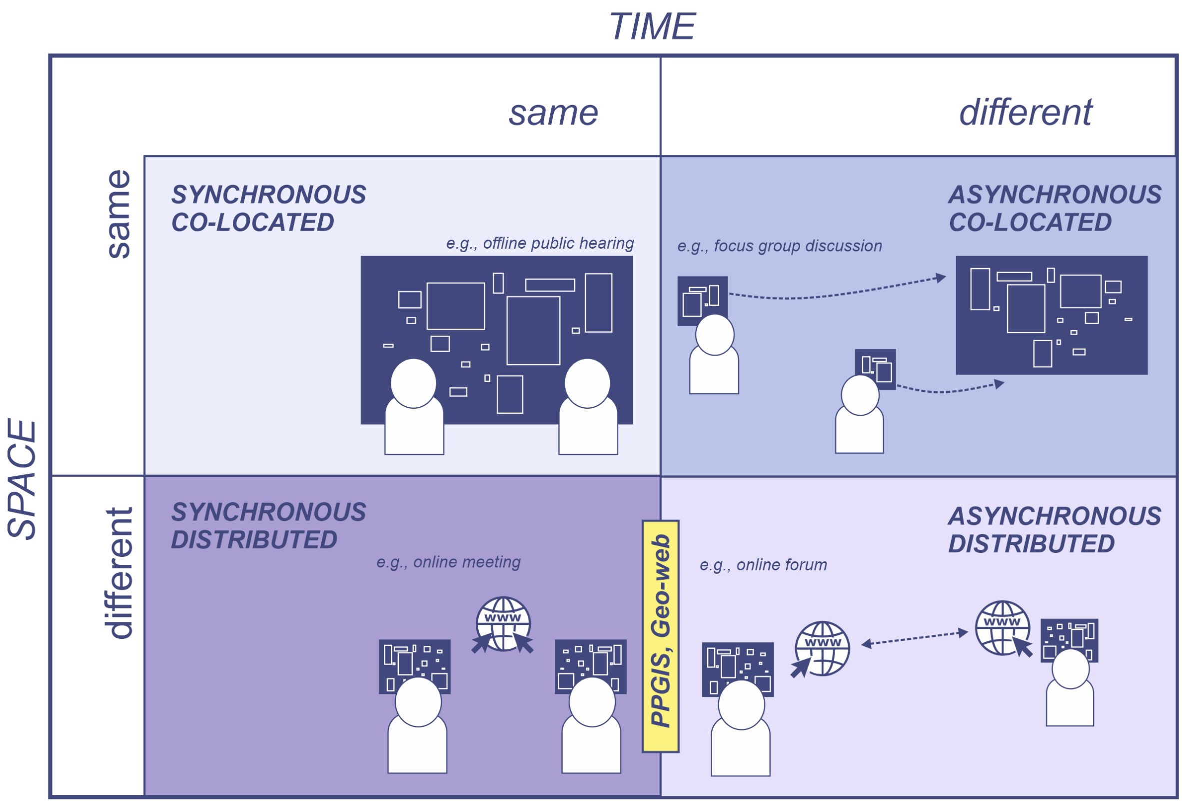


Figure 2.3: Space time collaboration setting - adapted from (Isenberg et al., 2011)

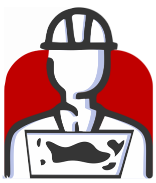
1. Co-located synchronous: The collaboration happens between multi-users in the same space and at the same time.
2. Co-located asynchronous: The collaboration happens between multi-users in the same space but at different times.
3. Distributed synchronous: The collaboration happens between multi-users in different spaces but at the same time.
4. Distributed asynchronous: The collaboration happens between multi-users in different places and at different times.

In terms of the space setting, traditional participatory planning uses 'co-located' due to the need for face-to-face interaction, such as group discussion and consultation using sketches and paper-based mapping (Isenberg et al., 2011; Aguilar et al., 2021). However, this space is shifted from a place to a digital environment by using GIS applications and the Internet. Therefore, the space setting of participation becomes 'distributed' (see Figure 2.3) (Maceachren and Brewer, 2004; Aguilar et al., 2020).

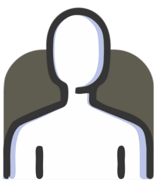
However, for the time setting, traditional participatory planning can happen in both 'synchronous' and 'asynchronous' depending on how long the collaboration is conducted (Aguilar et al., 2021). This happens due to the form and flow of information are categorized temporally, which creates three possibilities: 1) sequential interaction with only one participant talking at the time, 2) simultaneous interaction with multiple participants talking at the same time, and 3) mixed participation with one participant controls the visualization, and other can communicate verbally (Oviatt et al., 1997; Maceachren and Brewer, 2004).

The intended actors and user roles.
The user role is indispensable when discussing GIS as participation tools. The involvement of the user determines what kind of spatial data could be derived. Each user has a different role depending on the background of the intended actors. In the concept of GIS application, four main groups of the intended actors can be identified (Aguilar et al., 2020, 2021). In the end, these intended actors are divided into three groups of user roles, such as 1) Contributor, 2) Validator, and 3) Mediator (Aguilar et al., 2020; Akbar et al., 2020).

Planning actor
The planning actors are defined as the professional in spatial planning studies, whether they have a GIS application background or not. Therefore, they are interested in mainly spatial planning problems instead of supporting technology for addressing them.



GIS actor
The GIS actors are professionals or highly skilled individuals in the application of GIS technologies. They may have some knowledge of spatial planning; however, their focus should be on exploiting GIS capabilities.



Layperson
A layperson is referred to an individual without specialized knowledge in spatial planning or GIS. This user is usually referred to as the local citizen with knowledge and experience in a specific location.

Intermediary
The intermediary is referred to an individual who helps facilitate and navigate the participation activity. This user type should have a knowledge background both in GIS and spatial planning.

2.3.1 The network of human-map interaction in participatory GIS

The modern situation in human-map interaction in participatory GIS blends the deposition of the participation task layers with the decision-making mechanism of the spatial planning process. The research conceptualized the relation of human-map interaction in GIS using the ANT diagram by (Latour, 1996) and further developed Cvetinovic et al. (2017) for spatial planning context. The ANT diagram emphasizes the connection between human and non-human actors to examine how spatial planning participation is manifested (Latour, 1996; Latour and others, 2005; Gad and Bruun Jensen, 2010; Cvetinovic et al., 2017).

In this research, ANT is applied not as a theory but as a method to treat all human-map entities symmetrically within the platform (Latour and others, 2005). This research develops the ANT diagram based on the intended actors as the human actors with GIS application as the non-human actors into two natures: nature of tasks and nature of roles. Following the circumstances found through in-depth research on Section 2.3, the empirical and theoretical key points are structured using dynamic perpetual networking (see Figure 2.4) in the following way:

1. Nature of tasks.
   To answer how participation in GIS operates, this research proposed the nature of networks consisting of participation tasks as the hierarchical circle loop starting from the outer layer as 'Data Input' to the inner as 'Validation'. Moreover, each task is filled with the space-time setting to see whether the participation flow is 'synchronous' (same time) or 'asynchronous' (different time).

2. Nature of roles.
   The nature of roles is displayed to maximize all stakeholders' involvement during the participation process. These stakeholders' involvement could act as the individual state or group state, depending on their initial motive to join. By nature, each actor brings new information during the discussion process based on their background of knowledge and skills – thus, splitting it into three information products: spatial plan products, map layer, and local spatial knowledge. These actors and their products are then situated to the loops of the nature of tasks in a perpetual networking condition. The final product that reaches the loop's core is considered the final output from the participation process. At last, each loop is highlighted to conclude what kind of user roles and which actors should be involved in each participation task.

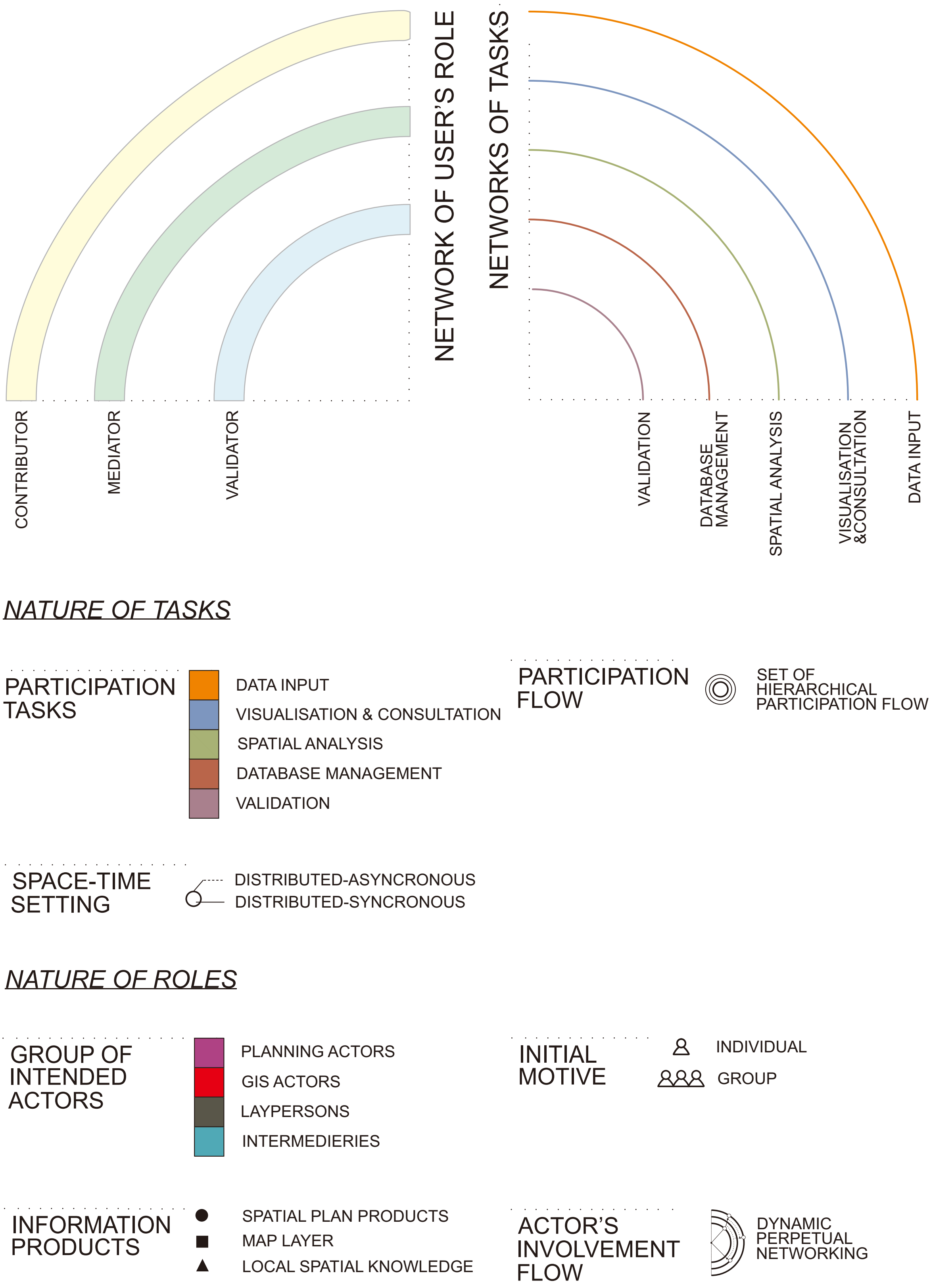


Figure 2.4: Conceptualisation of human-map interaction in participatory GIS using the ANT diagram - adapted from (Cvetinovic et al., 2017)

Chapter 3

Establishing UX Design for Geo-web Applications

This chapter provides empirical review based on literature as well as further design considerations in the field of UX design. Based on the theoretical perspective, several potential benefits from incorporating UX design to geo-web applications are discussed. Additionally, this chapter also shares the best way to visualize 3D maps for participation purposes and how the visualization affects the motivation and contribution of users during the process. At last, this chapter explains 4PHASE design toolkit as the proposed design approach for designing geo-web as an active participation tools.

3.1 Understanding User Experience for Geo-web Perspective

Despite the massive advancement of geospatial web-based applications, the number of studies regarding the technology's usability is relatively low. Kramers (2008) shows that many users cannot handle mass functionalities provided by geo-web applications. Tech-savvy users can use the provided functions well; however, less tech-savvy users may struggle to connect their daily lives with the same screen-afforded applications like geo-web. In the worst case, users may find themselves lost and unable to use the applications successfully. Consequently, many functions provided in technology-oriented GIS approaches are not suitable for most users, primarily because of not including the profiles of future users in the development process (Kramers, 2008; Resch and Zimmer, 2013).

At the same time, web designers also struggle to consistently predict what kind of information might be necessary to specific user groups in specific situations. Getto and Moore (2017) stated that digital technologies become more pervasive, meaning that relationships between users and technologies become increasingly complex and unpredictable. Because of the pervasiveness, visualization becomes too open to diverse, especially for novice users who want to visualize their personal information (Morrison and Arnall, 2011; Getto and Moore, 2017). Unfortunately, most users involved in the design process are invited too late to influence the final platform design. Therefore, the advancement for geo-web purposes should further reflect on the ambient nature of visual information in user's daily lives. Due to this ambiance, it is crucial to further examine the user characters and the mediated composition and communication contexts.

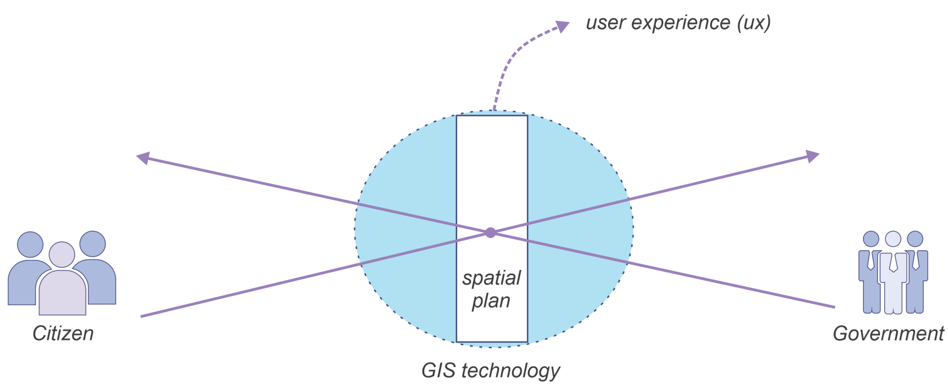


Figure 3.1: Involving UX geo-web as the with participation tools in spatial planning process

Therefore, the call for research on integrating GIS and UX concepts is essential to properly visualize spatial planning information in a user-friendly interface to easily engage users from both citizen and government groups with the resulting maps (Figure 3.1). In this case, involving the Geomatics knowledge in UX design guideline development is needed to achieve a user-friendly geo-web application.

Due to the growing profession in the geospatial industry, user experience and user interface design (referred to as UX/User Interface (UI)) must engage stakeholders through spatial information projects (Haklay, 2010) The UX/UI describes a set of guidelines and workflows for critical thinking about designing and using an interactive product (Garret, 2011). Although UX and UI complement each other, they are not the same due to their focus difference between interaction and interface. User Experience (UX) tackles interaction issues before, during, and after using the website. Therefore, the usability of an interface is part of the user experience, which means that a good user experience cannot be achieved by good usability alone (Adikari et al., 2011). The interface is what the product looks like at the end, referring to the website's appearance.

3.2 Reflection on the current trends of citizen participation using 4D visualisation

In recent years, there has been an increase in the appearance of multidimensional spatial data visualization to support citizen participation activity. In this case, a web-based GIS application, known as geo-web, is often used to facilitate the citizen participation process, making it possible to connect multiple users to virtually share their opinions. Traditionally, most geo-web applications use 2D maps to simplify the living environment visualization that the user experiences every day (Resch and Zimmer, 2013). However, some researchers argue that 3D maps can significantly improve the understanding of non-expert users and increase spatial cognition (Kramers, 2008; Resch and Zimmer, 2013). Nevertheless, both 2D and 3D are complementary representations to facilitate participation in the spatial planning process.

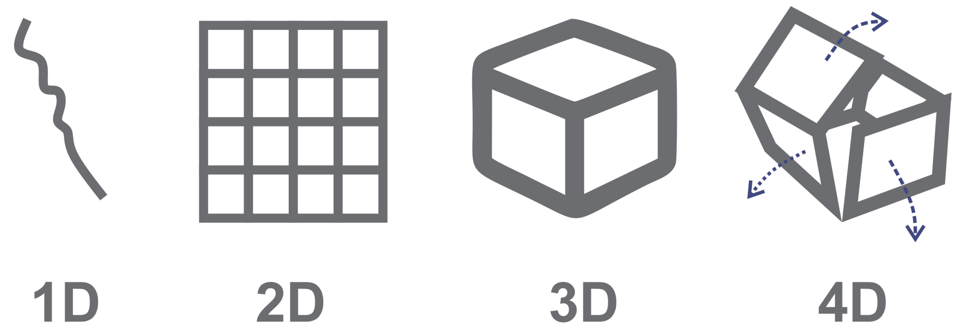


Figure 3.2: Multideminsonal visualisation of spatial information

In terms of leveraging 3D maps to foster citizen participation, previous research shows that using 4D maps (3D + time) to visualize the dynamic spatiotemporal phenomena during the process is very beneficial (Stellingwerff and Kuhk, 2004; Lafrance et al., 2019; Laksono and Aditya, 2019). The 4D map has multiple benefits, such as allowing spatial planning products (zoning map and the representation of buildings) to have better dynamics and harnessing the time aspect as the crucial aspect for successful participation in the spatial planning process (Nabatchi, 2012). This becomes the main reason for both the initial 4D PUPM and the proposed design are developed using a 4D geo-web mapping environment.

3.2.1 Best visualization to stimulate participation

In Section 3.1, contradictory statements concerning the possible benefits of geo-web application with the multi-user understanding of the platforms were mentioned. The contradictory in the current geo-web applications might disturb the level and the equality of participation. When multiple users participate equally during the discussion process, every group type of users has the same opportunity to contribute to knowledge construction, to give or request explanations, and to use and refine their skills (Webb, 1996).

If the level and the equality of the participation are not maintained, the participation process might suffer from two debilitating effects: social loafing and the free-rider effect. Social loafing is the phenomenon of a user who tends to be less effort to achieve a goal when they work in a group compared to working alone (O'Donnell and O'Kelly, 1994). This phenomenon could gradually increase and become a free-rider effect (one or several users of a group contribute so little to the participation process), causing the result to be misleading and unfair (O'Donnell and O'Kelly, 1994; Salomon and Globerson, 1989). To solve these effects, constructing a better way to visualize ideas from the users could be a common ground for the transmittal of information that significantly reduces the risk of confusion when understanding spatial information. However, this solution also raises questions about the best visualization technique to stimulate active participation with the users. Furthermore, there has been a heavy debate about how complex or simple the visualization should be.

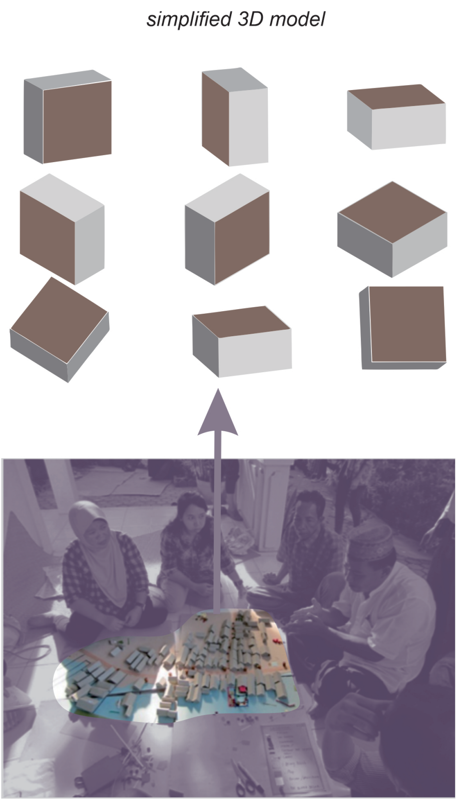


Figure 3.3: Simplified 3D visualization to stimulate active participation

Based on Section 2.2, it is discovered that geo-web has an ability to stimulate the temporal and sensory experience of place and to be able to interact within it over the Internet. Along with the smart cities agenda, there has been an expansion of advancement in detailed 3D physical asset representations of the city on geo-web or usually described as digital twins. Cities are complex, and he complexity in design is very subjective. While participatory mapping activities such as sketching can be easy to implement using 2D map, the story will differ when we implement it on 3D map. Not everyone can draw the visualization of their houses in 3D; thus, it requires special skills that belong to specific users.

While skilled participants appreciate traditional drawings, unskilled participants is more familiar using easy-to-use representation (Sawczuk and Nicholson, 1992). Some researchers also have been reported that when laypersons are exposed to an architect's drawing, the visual representation becoming has little meaning as they could not understand what was represented (Harrlichack, 1993). Kaplan et al. (1989) argue that a simplified model (Figure 3.3) could parallel the user's cognitive structure and reduce the total load to the processing system. In order to grasp a large type of users to participate and avoid social loading and the free-rider effect during the process, there is a need to simplify the complexity of spatial information provided in the geo-web application.

Figure 3.4: Caption

3.3 The 4PHASE toolkit: UX Design Guideline for Geo-web

For the reproducibility of the implementation, this research seeks a way to create a UX design strategy scheme in building geo-web applications for participation purposes. This design structure is provided to give a guideline so that geo-web could accommodate and facilitates active participation from multi-stakeholders in a two-way communication. In this research, the UX design strategies would be called as 4PHASE toolkit. Toolkit itself means as the style guide templates to help to maintain the consistency of participative and user-friendliness of geo-web applications. The 4PHASE toolkit consists of four phases of the design method, such as:

PHASE 1: Define.
The first phase is based on the theoretical background of the spatial planning process and citizen participation. This research conducts a top-down approach using the literature review's related characteristics to establish the initial requirement and procedure for intended actors, user roles, and task capabilities through the geo-web application.

PHASE 2: Design.
The second phase translates the previous result into a conceptual UX design to establish a design guideline to facilitate the interaction and participation process through a geo-web application. Geo-web as a digital mapping can be complex due to the unique spatial information representations that can be displayed, linking the platform to the spatial cognition to scale the human mind with its digital representation. Thus, UX design can help create efficient and effective user guidelines flow before, during, and after accessing the interface. In this phase, five steps should be conducted to design an interface: 1) building Persona, 2) constructing the 5E model, 3) creating Wireframes, and 4) implementing the design as an Interface. The result of this phase will be a mockup consisting of design elements of the platform. However, this mockup is not yet including functional elements. For instance, when users click on the selected buttons, the download of ".txt" file will indicate the completion of the access process.

PHASE 3: Build.
The third phase focuses on filling the proposed mockup with real map datasets and exploring the function element in a geo-web application. The end result is a prototype, which demonstrates the realistic front-end web experience with real datasets in 2D and 3D. This prototype will be built based on the current web environment (HyperText Markup Language (HTML), Cascading Style Sheets (CSS), and Javascript) combining with tile set visualization. However, some functions might not be implemented as a prototype due to technical difficulties and time constraints.

PHASE 4: Test.
The last phase focuses on evaluating the platform's usability. The user session is done by doing the task-based performance and persona validation test. The user session will lead to two results: 1) the initial status benchmark compared to the final design and 2) several comments about the participation process's experience through the prototype. This means that both qualitative and quantitative elements will be assessed. For quantitative research, a time-based mission will indicate how long the user can complete specific tasks. The user also will be asked to rate their experience while using the prototype quantitively. As for qualitative research, a semi-structured interview is be conducted to elaborate on several issues that the users find and some improvements to solve those. Finally, the result will be reviewed by creating a usability metric based on the observed behavior of each user.

Chapter 4

Defining the Role of Participation to Indonesia's Spatial Planning Process

This chapter is the simulation-based process of PHASE 1, presenting an empirical-based research approach using the literature review related characteristics and components of participatory planning in the case study location, Indonesia. In addition, this chapter aims to implement human and GIS connections using the ANT diagram that is proposed in Chapter 2. Finally, the conclusion of this chapter defines the roles and participation tasks of GIS to facilitate participation in the spatial planning process based on two participation tools in Indonesia: Musrenbang and 4D PUPM.

4.1 Analysis of Participation Mechanism in Indonesia's Spatial Planning Process

The spatial planning process in Indonesia is conducted through the top-down hierarchy from national, provincial, and local government levels based on Law No. 26/2007. Each government level is required to provide spatial plans with different levels of detail. The planning product itself is divided into two categories: normative and thematic (Figure 4.1) (Law No. 26/2007, 2007).

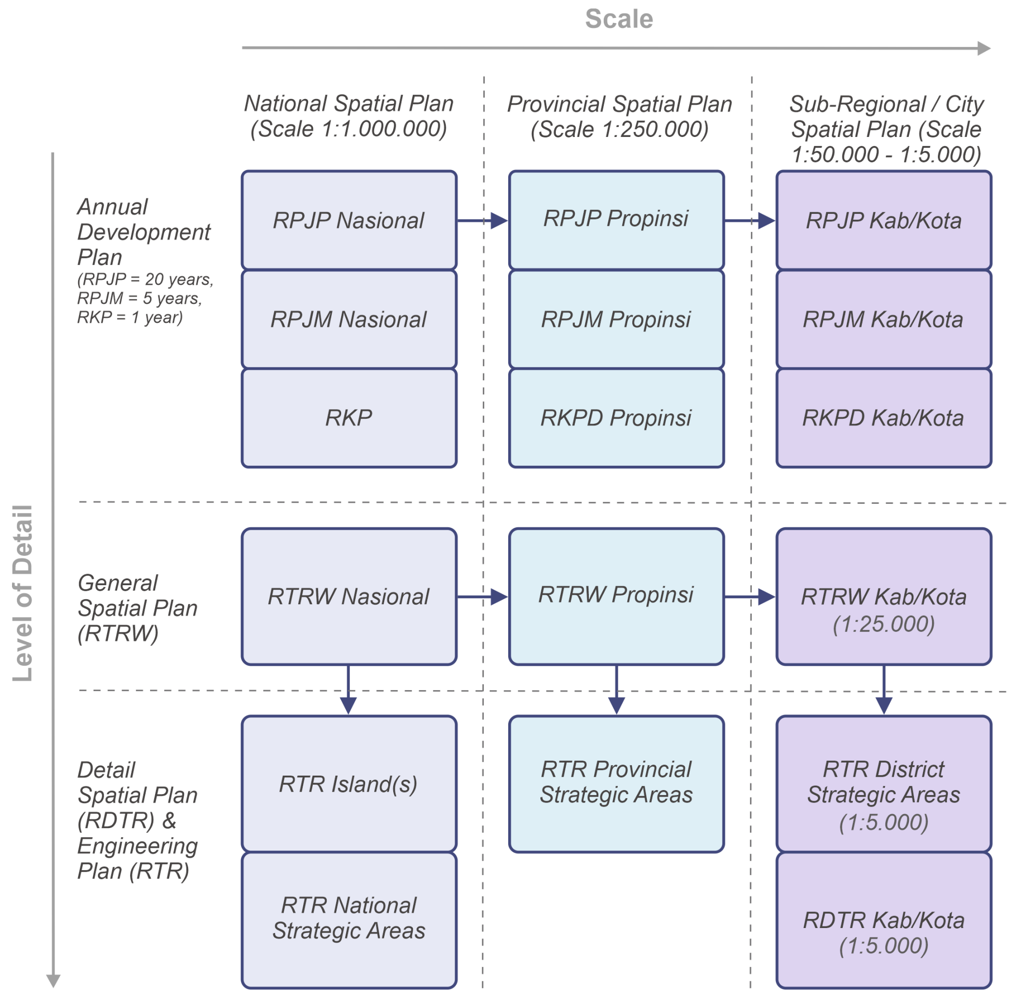


Figure 4.1: The hierarchy of spatial planning process in Indonesia (Law No. 26/2007, 2007; Hudalah, 2010)

The normative planning deliverable contains the legal power and its obligation for both government and citizens to the formulated plan strategies, consisting of three annual development plan strategies: 1) long-term strategies for 20 years period (*Rencana Pembangunan Jangka Panjang* / Long-term National Development Plan Strategies (RPJP))) medium-term strategies for 5 years period (*Rencana Pembangunan Jangka Menengah* / Medium-term National Development Plan Strategies (RPJM)), and yearly strategies (*Rencana Kerja Pemerintah* / Government Work Plans (RKP)). Meanwhile, the thematic planning deliverable contain the general and detailed spatial plans with level of detail starting from the national to the city level (Law No. 26/2007, 2007; Hudalah, 2010).

Indonesia's planning process consists of three stages: the plan-making process (*perencanaan tata ruang*), the utilization of space (*pemanfaatan ruang*), and controlling the space development (*pengenalian pemanfaatan ruang*) ((Law No. 26/2007, 2007)). The first stage, the plan-making process, establishes several spatial plan deliverables in multi-levels of detail from national to district level. The sharing information of this stage is supported by Government Regulation 15/2010, which instructs local governments to develop a zoning map and Spatial Information Infrastructure (SII) to support sharing planning deliverables from the national to the city level. According to the regulation, the zoning map should contain the function of land/area, urban infrastructure, and the intensity of each zone, such as *Koefisien Dasar Bangunan* / coefficient of the building (KDB), *Koefisien Lantai Bangunan* / coefficient of the floor (KLB), *Ketinggian Bangunan* / building's height (KB)), and *Koefisien Daerah Hijau* / coefficient of the green area (KDH). In this case, spatial representation using GIS tools is used to describe the current land use and determine the land allocation to the specific land parcel.

The second stage, the utilization of space, is implemented through managing land information based right, restriction, and resposibility (RRR) for the use of the land permit. This stage still has a strong relationship with Government Regulation 68/2010, which stated SII itself should present the current land use and zoning plan that can be accessed by all stakeholders, especially for issuing the land permit. Furthermore, the visualization and the quality of spatial information are specified in Government Regulation 8/2013.

At last, in the third and last stage, controlling the space development, the government must monitor and evaluate the use of space to prevent and solve irregular activity that is considered as zoning regulation violations.

4.1.1 Public participation in Indonesia

The driving forces of Indonesia's spatial planning system come from the formal-institutional forces and the informal-cultural forces. While the top-down governmental structures and legal frameworks formalize the formal-institutional forces, the informal-cultural forces associate with the bottom-up native culture, which constructs traditional participatory discussion mechanisms in customary practices of consensus decision-making (referred to as *musyawarah*) (Bowen, 1986).

As a result, the law has encouraged citizens to participate in the spatial planning process. The participation itself is stated in Government Regulation 68/2010, which stated in Art.2 that 'citizens contribute to the process of the plan-making process (*perencanaan tata ruang*), the utilization of space (*pemanfaatan ruang*), and controlling the space development (*pengenalian pemanfaatan ruang*) based on their legal rights and obligations'. It is stated through Art.9 that in spatial planning, the citizens have rights:

(a) to give an opinion about zoning directions and/or regulations, permits, incentive and disincentive distributions, as well as the imposition of sanctions;

(b) to participate in monitoring and supervising the implementation of the spatial plan that has been determined;

(c) to report to the government agencies regarding an alleged violation of the space utilization implementation in comparison to the spatial plan;

(d) to report the irregularities from official statements regarding the development process that is considered violating the spatial plan.

Concerning the citizens' obligation, the law gives the government the mandate to provide citizens with roles and services to deliver their information. According to Art. 13, participation mechanisms from 'the citizen can take form in information delivery, oral suggestions, and writing opinions through various media platforms (print, electronic media, and seminars)'. Also, the participation mechanism can be carried out by individuals, organizations, and professionals (Government Regulation 68/2010, 2010).

4.1.2 Musrenbang: traditional participation tools for the spatial planning process in Indonesia

The traditional form of bottom-up level participation on the first stage of the Indonesia planning process is actively seen through Musrenbang (*Musyawarah*: community building, *perencanaan*: planning, *pembangunan*: development). Based on Law No. 25/2004, Musrenbang is a multi-stakeholder participatory planning process aiming to negotiate, reconciliate, and harmonize differences between government and non-government stakeholders to reach collective consensus on development priorities.

The process starts from the level of the village, district, city, to province. It is usually conducted by Non-Governmental Organization (NGO), researchers, or the local government advocating land ownership that belongs to several local communities. Finally, the outcome will be sent as input for *Badan perencanaan pembangunan daerah* / Local development planning agency (Bappeda) to assign resources to each neighborhood depending on the available funds based on their needs (Mohamed and Solo Kota Kita, 2012).

Before the design process, we need to understand the stages of traditional Musrenbang. Based on Law No. 25/2004, Musrenbang aims to draft the annual work plans (RKP Desa) and annual budget preparation (APBD Desa). The two most common participation activities of Musrenbang are participatory mapping and participatory budgeting. The activities consist of sharing information resources and sharing local spatial knowledge by creating a neighborhood-level map and socio-spatial discussion (Mohamed and Solo Kota Kita, 2012; Akbar et al., 2020).

Throughout Musrenbang, the citizen gains a sense of duty to discuss the planning process based on their priorities. However, it is important to note that this process can only be effective if a facilitator fills the knowledge gap about spatial information and spatial planning to the public (Akbar et al., 2020). Therefore, both the importance of information access and capable facilitator are essential to the succession of the participation mechanism.

Figure 4.2: Participatory planning activities using 2D and 3D maps through Musrenbang (Mohamed and Solo Kota Kita, 2012)

4.1.2.1 Musrenbang workflow

The driving force dualities of the spatial planning process in Indonesia is heavily perceived through Musrenbang workflow (Figure 4.3). The process starts from the community's local priorities – continues with the combination of time and/or land provided by the community and external resources (construction materials, heavy equipment, or investment fund) provided by the government. Each area's urgency is deliberated through a bottom-up community meeting, combined into an annual city plan. However, not all issues would be included at the end of the process (FPPM, 2008). From January to May, several levels of Musrenbang will start from the *Musrenbang Desa* / Village-level Musrenbang (Musrenbangdes), *Musrenbang Kecamatan* / District-level Musrenbang (Musrenbangcam), then continue to the city, province, and national level. The investments are primarily from the government, but they can also agree to request additional funds from external such as through public-private partnerships (FPPM, 2008; Nurmandi et al., 2015).

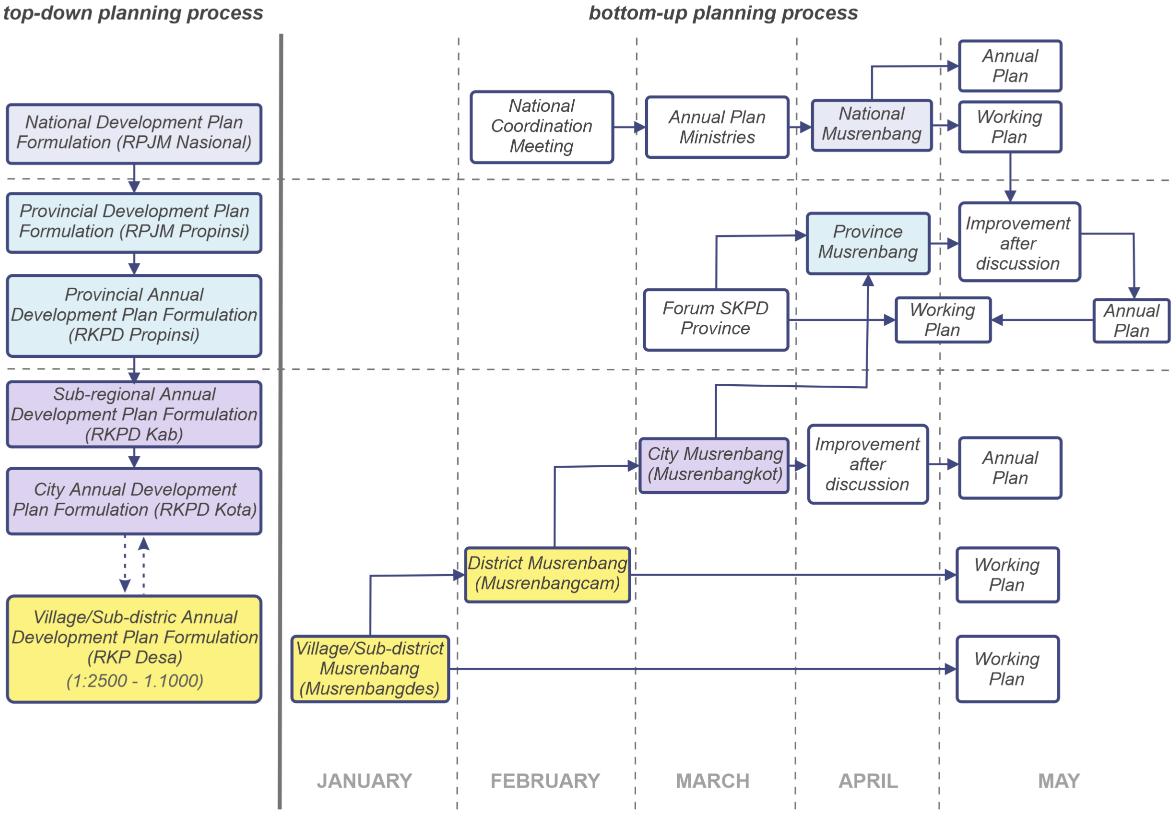


Figure 4.3: Mechanism of Traditional Musrenbang - adapted from (Law No. 25/2004, 2004; Nurmandi et al., 2015)

As visualized in Figure 4.3, started from January, both neighborhood units and the local government create the initial proposal to select the highest priority development plan with the most realistic budget for the year. The priority is usually by ranking the order of importance for village activities proposed based on the area's existing problem. This initial proposal from Musrenbangdes is then processed to the district level Musrenbangcam) (FPPM, 2008). During this time, the head of the neighborhood (*Ketua RT/RW*) is invited to be present at an open meeting with other stakeholders such as local NGOs, researchers, and mass media to ensure the openness of future planning's decision (Sindre, 2012). However, most of the time, Musrenbangdes and Musrenbangcam are combined in one large forum due to time constraints. For example, in Merjosari village, Malang, a drainage construction project resulted from Musrenbangcam with a total budget of around Rp. 300.000.000 is provided through a partnership with the local government and the World Bank (Nurmandi et al., 2015).

From March to May, Bappeda as the local government collected the proposals from multiple districts and discussed the budgeting and technical issue with other government agencies. In summary, it would be included as an annual city plan. However, not all the proposals would be included in an annual city plan. The government agencies usually determine the priorities according to planning criteria listed in the long-term plan (RPJM), annual plan (RKP), the local zoning plan (*Rencana Detai Tata Ruang* / Detailed Urban Space Spatial Plan (RDTR)), or other national plan priorities. However, these planning criteria are not open access to the previous stakeholders involved. Due to this, there are some concerns that Musrenbangdes and Musrenbangcam do not guarantee the participants would have the right to shape the planning decision (Sindre, 2012; Sopanah, 2012; Buckwalter, 2014).

4.1.2.2 The actors of Musrenbang

Different various stakeholders were involved in each of the hierarchy depending on the area level. Since the research focuses more on village and district level (Musrenbangdes, Musrenbangcam), I identify several actors based onMusrenbang's stakeholder matrix by Akbar et al. (2020) then classify them into three different groups: 1) government agencies, 2) village, district elites, 3) non-government groups. The matrix describes each actor's potential interests and influences toward the participation process during the process of traditional Musrenbang, which later could potentially causing gaps and conflicts among actors.

STAKEHOLDERS GROUP	ACTORS	INFLUENCE			MOTIVATION	CONTRIBUTION	POTENTIAL CONFLICTS
		IMPACT	INTEREST	INFLUENCE			
Government agencies	*Bappeda* (Regional Development Planning Agencies)	Low	Low	High	The plans produced in Musrenbang are crucial for achieving the regional planning target	Developing standard operational procedure (SOP) for annual planning practice	Delaying the SOP process through planning time plans
	Dinas Pemberdayaan Masyarakat Desa (Village Community Empowerment Department)	High	High	High	The plans produced in Musrenbang are essential to achieve their work performance /targets	Developing standard operational procedure (SOP) for village budget policy	Delay in issuing the Regent's Regulation about Village Budget Policy
	Pendamping Desa (Village Supervisor)	Medium	Medium	Low	Working under Ministry of Village, Underdeveloped Area, and Transmigration (Kemendes PDTT)	direct supervision; source of information; drafting village document plans	Lack of skills/capacity for supervision; not cooperate well with various stakeholders
Village, district elites	*Camat, Kades* (Head of District, Village)	High	High	Medium	As the performance indicator of trust and reputation among citizens	deciding Musrenbang schedule; source of information; making sure that decision made through consensus	Manipulating decisions; only inviting or favoring specific groups
	Kepala RT/RW (Head of Neighborhood)	High	High	Medium	Making sure concerns from the locals are heard and followed-up; get trust from citizens	Schedule the neighborhood meeting; involving all impacted groups; articulate the neighborhood's interests well.	Manipulating decisions; only inviting or favoring specific groups; conflicts with other stakeholders
Non-government groups	*LSM di Desa* (Local NGOs)	Low	High	Low	Obtain the latest information about the development, to get involved in the projects	Identify real problems /needs; proposing ideas and solutions	Conflicts with other stakeholders
	Masyarakat Umum (Local Citizens)	Low	High	Low	As the media to fight for citizens' interests; obtain latest information about the development; to get involved in the projects	Identify real problems /needs; proposing ideas and solutions	Lack of knowledge about Musrenbang and spatial planning procedures

Table 4.1: Stakeholders matrix of Musrenbang actors' influence - adapted from (Akbar et al., 2020)

As explained in Table 4.1, the government agencies have better spatial planning skills to formulate the development planning documents and provide spatial data. However, they often do not understand the current geographical condition of the discussed area, making them lack knowledge of how reliable and accurate the spatial data that they provide. In several Musrenbang cases, both government agencies and village, district elites significantly influence the participation process. It is interesting to note that village, district elites are based on the community election and do not work under the government. The village, district elites have better knowledge about the current geographical locations due to their working duties in visiting neighborhoods. Therefore, during Musrenbang process, they often play a vital role in controlling the discussion, and their opinions are often agreed upon by participants (Akbar et al., 2020). In terms of the non-government groups, they have more extensive knowledge of the area as they spend most of their daily activities there. Despite the fact that their influence are relatively low, they have a solid local spatial knowledge and can recognize the exact location of each house, who the owners are, and what they do for living.

4.1.3 4D PUPM: modern participation tools for spatial plan monitoring in Indonesia

Local citizens' involvement in monitoring and evaluating the implementation of urban plans is mentioned in Government Regulation 68/2010 Art. 2 and Art. 9, which then details by Government Regulation 15/2010 describing the conformance approach of plan monitoring in Indonesia. The approach begins with the participants examining conformity with each zoning's actual function to the zoning regulation. If the participants find any inconsistency, they can submit reports to the authority to validate and check the permit over the suggested land (or property).

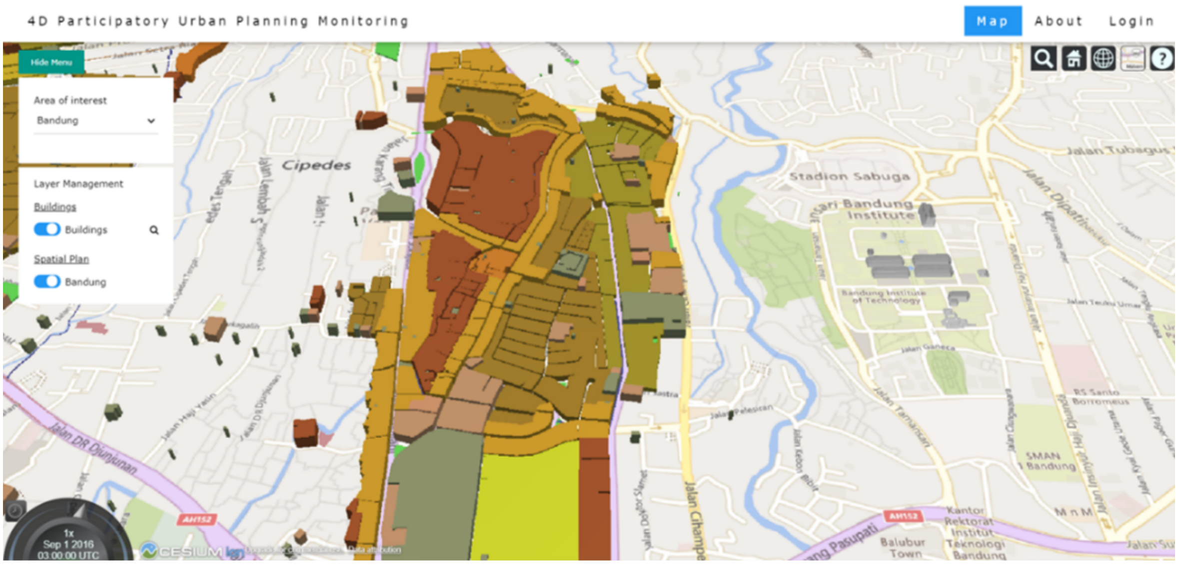


Figure 4.4: The interface interface of 4D PUPM

As the modern-day participation tools, 4D Open Spatial Information Infrastructure (4D PUPM) works as a geo-web application developed by Indrajit (2019) to monitor spatial planning implementation through a participatory process. This application shows 3D spatial zoning in provincial (RTRW) to city level (RDTR) to help a better understanding of the spatial properties of the urban objects (Figure 4.4). The platform works under the national mapping agency named Geospatial Mapping Agency (refers to BIG) and can be accessed on: https://tanahair.indonesia.go.id/pupm. It was built as an integration platform to the spatial planning deriverables by harnessing local spatial knowledge from citizens and other private sectors to gain 4D (3D + time) spatial information. The spatial information available on 4D PUPM are the 3D buildings and 3D spatial plans of two cities in Indonesia: Bandung and Jakarta.

4.1.3.1 4D PUPM workflow

The workflow of 4D PUPM mainly focusing on enabling two-way information flow, facilitating data collections between contributors and validators to collect, and verifying local spatial knowledge on the implementation of spatial plans. The local spatial knowledge is then fostered as a unique description of land or space attached to the provided 3D buildings.

The participations activities provided in 4D PUPM platform itself consisting of three primary monitoring workflows as follow:

1. Accessing 3D spatial plan models and 3D buildings
2. Comparing actual conditions with the 3D building by updating the attribute table to the selected land (or properties)
3. Modifying existing 3D building information by providing the current image of the actual building
4. Verifying the inputted local spatial knowledge from the contributors and updating those to the database.

4.1.3.2 Actors of 4D PUPM

The user's roles of 4D PUPM are divided into three types: 1) contributor attribute, 2) contributor geometry, 3) validator. In order to gain access to the functionalities, at first, a new user needs to sign up based on one of these three roles. Then, the task capabilities and the flow of web pages depend on the picked role.

USER ROLES	ACCESS	GENERATE/UPDATE		VALIDATE
		ATTRIBUTE	MAPS	
Guest User	Yes	No	No	No
Contributor Attribute	Yes	Yes	No	No
Contributor Geometry	Yes	Yes	Yes	No
Validator	Yes	Yes	Yes	Yes

Table 4.2: User roles matrix of 4D PUPM - adapted from (Indrajit, 2021)

As described in Table 4.2, for the contributor attribute, the user has the capability to update (add, delete, or edit) the attribute of the 3D building, together with providing photos and videos. As for contributor geometry, the user also has the same task capability as the contributor attribute with the additional new capability to add new spatial information (geometry) in CityGML format. Finally, the third role, validator, has the capability to update the database and verify whether the input data from both contributors are valid or not. This role seems specific for government staff, but there is no detailed description of it on the website.

4.1.4 Limitation of traditional and modern participation tools in Indonesia

Throughout Section 4.1.2 and Section 4.1.3, the detailed workflows and the involved actors were described. Despite all functionalities mentioned, both Musrenbang as traditional tools and 4D PUPM modern tools have several limitations to support the higher level of participation. First, it can be observed that 4D PUPM is located on the first ladder of McCall's participation ladder. This means that 4D PUPM enables information sharing between the citizen as the contributor with the government as the powerholder. In this case, the 4D PUPM is located on the second step of Arnstein's ladder, the step of tokenism, which also focuses on sharing information and consultation. However, the drawback for this kind of participation is that the attributor has no power to enforce their input to be taken into account by the validator. Therefore, 4D PUPM potentially has little to no influence on the decision-making process in the participation activities.

On the other hand, in Musrenbang, as the traditional participation activity, both citizen and powerholder sit together to identify the current problem and discuss what kind of spatial plan should be prioritized. This indicates that Musrenbang has reached the third step of McCall's ladder, involvement in decision-making. From Arnstein's perspective, Musrenbang has reached one of the highest steps of the ladder: the partnership level. However, it is essential to note that the list of cases in Musrenbang is pre-determined by the powerholder before the discussion - making the participant has no capability to control the analysis process. Moreover, the participatory mapping scale for Musrenbang is of more detail than presented in 4D PUPM, usually on the village to sub-district level. Also, there is no current geo-web application available for facilitating Musrenbang in Indonesia.

Second, the user roles of 4D PUPM are not divided based on the background knowledge (either about GIS or spatial planning), making it complicated for the user to decide what role should (s)he registers. Furthermore, the different set of web pages of 4D PUPM also needs to be reviewed to improve the user-friendliness of the geo-web application. Finally, in terms of the spatial planning process, 4D PUPM focuses on the second and third phases of Indonesia's spatial planning process – thus, the planning formulation has not yet been included. Therefore, this research will further develop 4D PUPM based on the first phase of Indonesia's spatial planning process, planning formulation. In this case, Phase 2 (see Section 5.1) will explore the user flow of the 4D PUPM initial designs, then re-design the participation interaction and using User Experience.

4.2 Defining User Roles and Participation Activities

Throughout previous extensive literature studies about the participation process in spatial planning and its actors, this phase interprets the complexity and dynamic of participation using the conceptualized ANT diagram derived in Chapter 2. The step starts by creating lists of intended actors from each group based on their capabilities. Then, each group can share the same actor. The list of actors for each group are written as Table 4.3.

This activity can be distributed-synchronous or distributed-asynchronous. If the task is distributed-synchronous, it is mean that the actor needs guidance from another actor to convert their product as a map layer. On the other hand, the product can go to the following hierarchy if it is distributed asynchronously.

Intended actors	
PLANNING ACTORS	BAPPEDA LOCAL GOVERNMENT NGO CONSULTANT PLANNING RESEARCHERS
GIS ACTOR	BAPPEDA LOCAL GOVERNMENT NMA NGOs CONSULTANT GIS EXPERTS
INTERMEDIARIES	LOCAL GOVERNMENT NMA NGO
LAYPERSONS	INDIVIDUAL HEAD OF NEIGHBORHOOD LOCAL CITIZEN

Table 4.3: The list of intended actors

The actors could be individuals or groups (a group of individuals) with their product, such as local spatial knowledge, spatial plan products (e.g., zoning map, regulation), and map layer. Each actor is then positioned in the hierarchy of participation tasks, visualizing participants' tasks through the geo-web application. The hierarchical layers of participation tasks are described as follows.

4.2.1 Data input

The first participation task layer, Data Input, consists of eight intended actors with three types of products (Figure 4.5):

- Local Spatial Knowledge – by Laypersons
- Spatial planning product by Planning actors
- Map layer – by GIS actors

First, NMA group actors (in this case: 4D PUPM) inputs the base map to visualize the current discussed location. Then, all intended actors communicate in a distributed-synchronized way. It is due to the original form of Musrenbang activity that needs an active discussion by having two-way communication between actors involved.

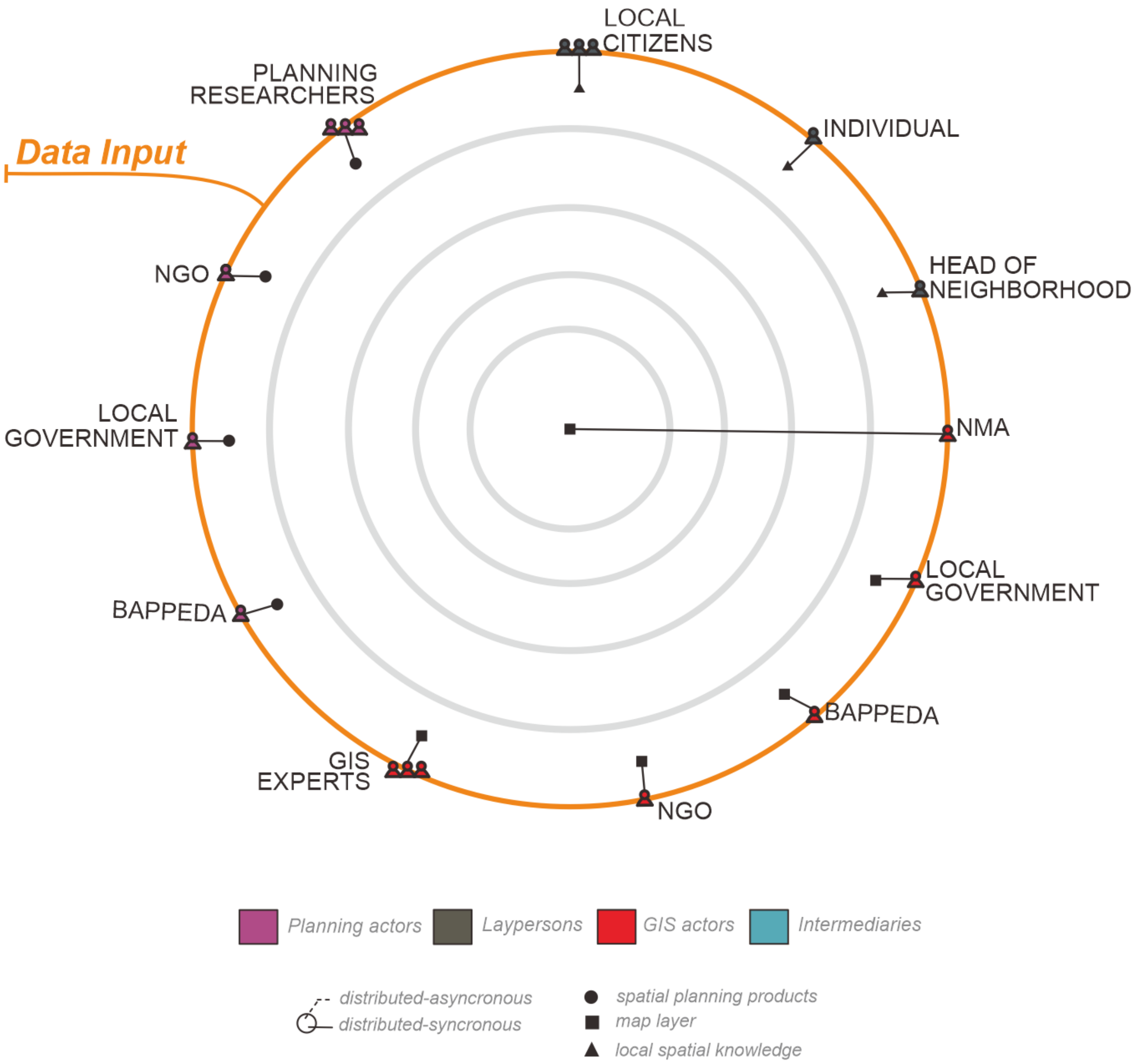


Figure 4.5: The list of intended actors

4.2.2 Visualization and consultation

The second participation task layer, Visualization and Consultation (Figure 4.6), consists of Intermediaries actors (NGO, Local government, and Bappeda). In this case, these actors fill the knowledge gap about spatial information and spatial planning and provide consultation in map visualization.

Most data input from GIS actors can directly visualize without the need for Intermediaries actors. Therefore, these data inputs are visualized directly by the platform (distributed-synchronize).

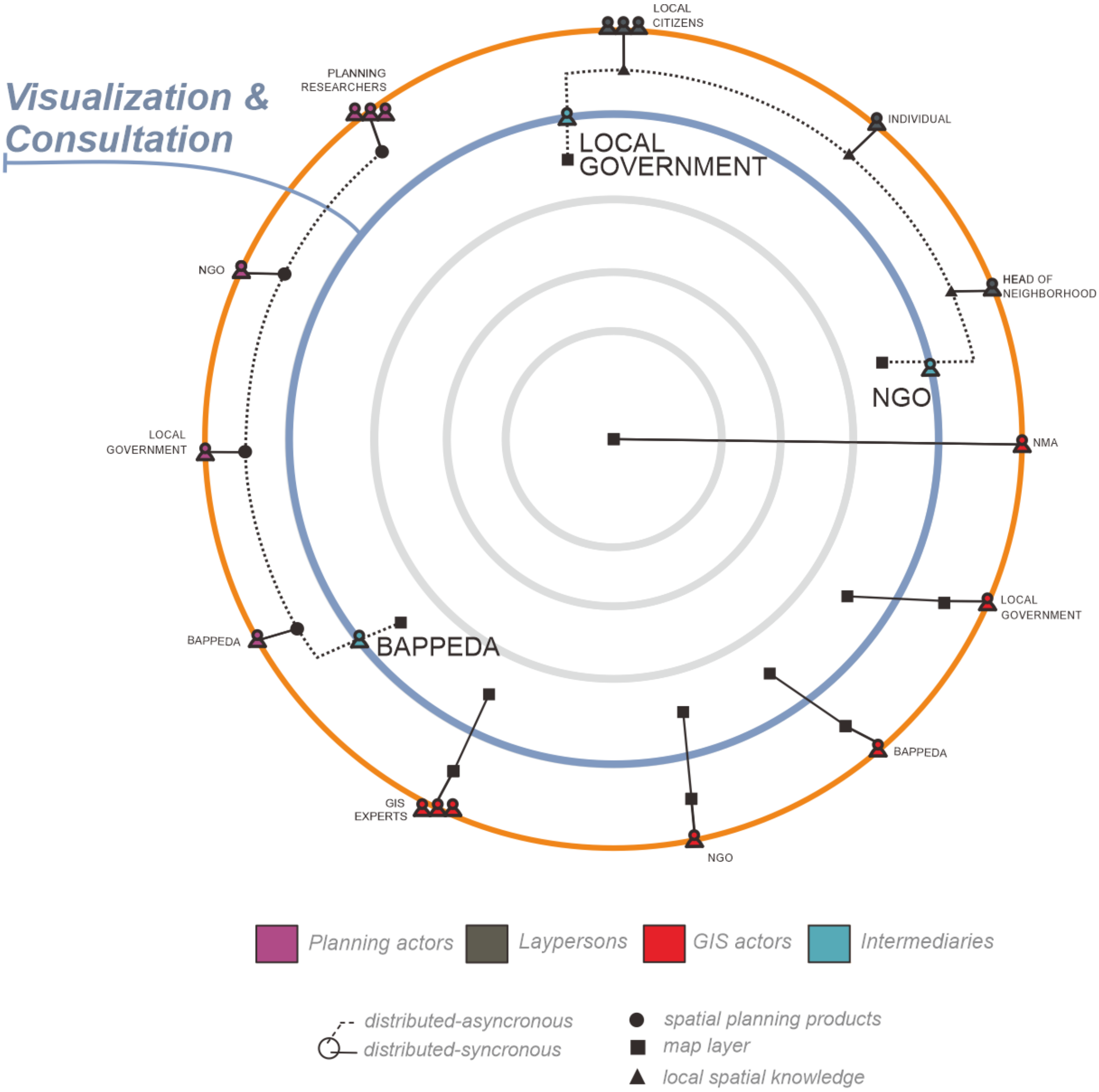


Figure 4.6: Visualization and consultation

4.2.3 Spatial analysis

Spatial analysis as the third layer gives the participants power to enforce their data inputs to the powerholder (see Figure 4.7. For this case, the activity is done by GIS actors in asynchronous ways, which means that the spatial analysis process is done outside the geo-web application, and the result will be shared as an additional input.

This third hierarchy is also useful for non-GIS actors to sense their data input from an abstraction (such as sketches or annotation) into spatial information. Moreover, it educates all participation actors about the spatial background.

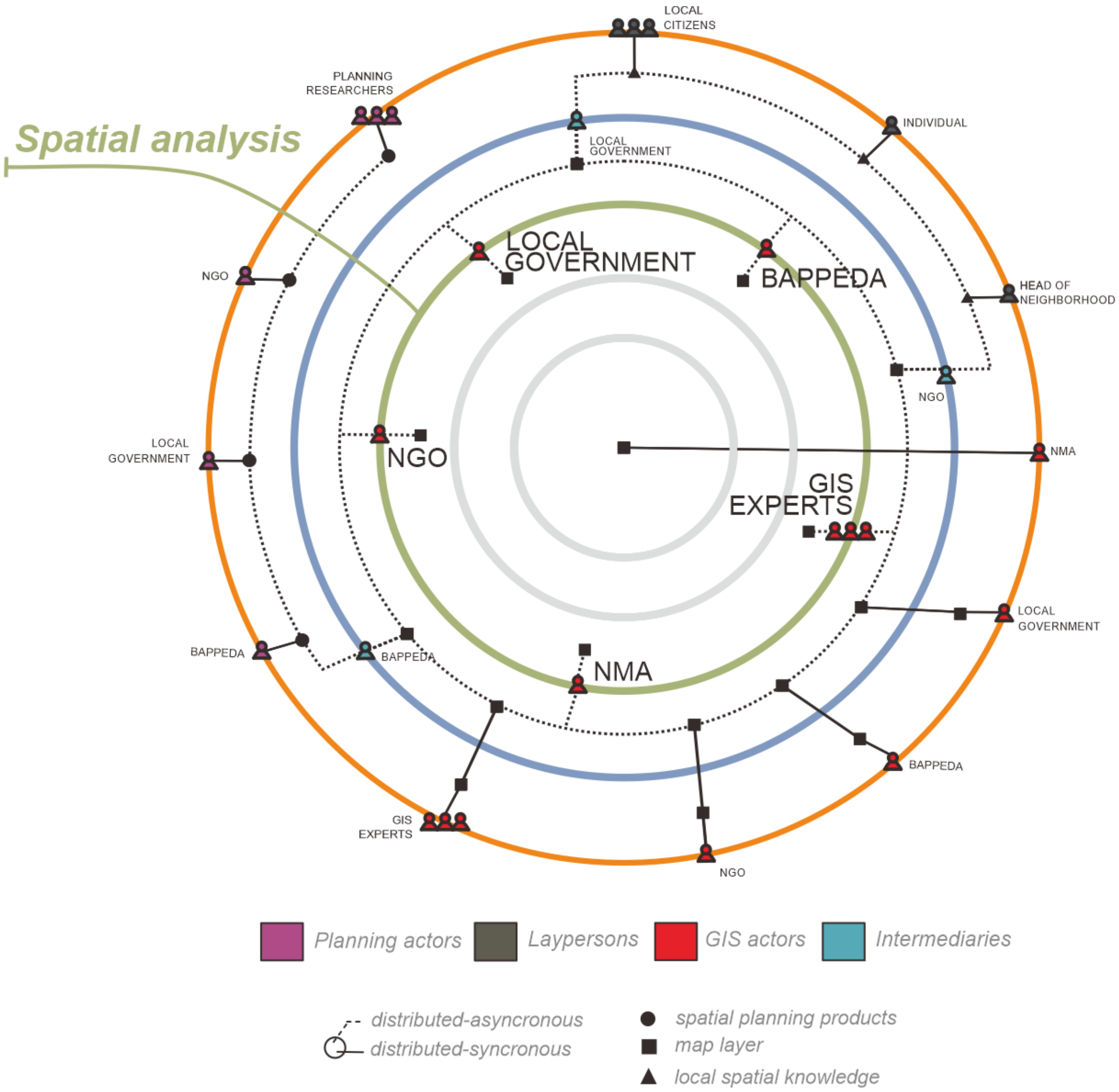


Figure 4.7: Spatial analysis

4.2.4 Database management

Database management is important to document all the participation activities (Figure 4.8). Due to the large dataset handled by the application, the actors need to store the best representatio of the result effectively and efficiently.

Therefore, GIS actors who have knowledge and background in agencies (Local Government, Bappeda, NMA) will be in charge of this participation task.

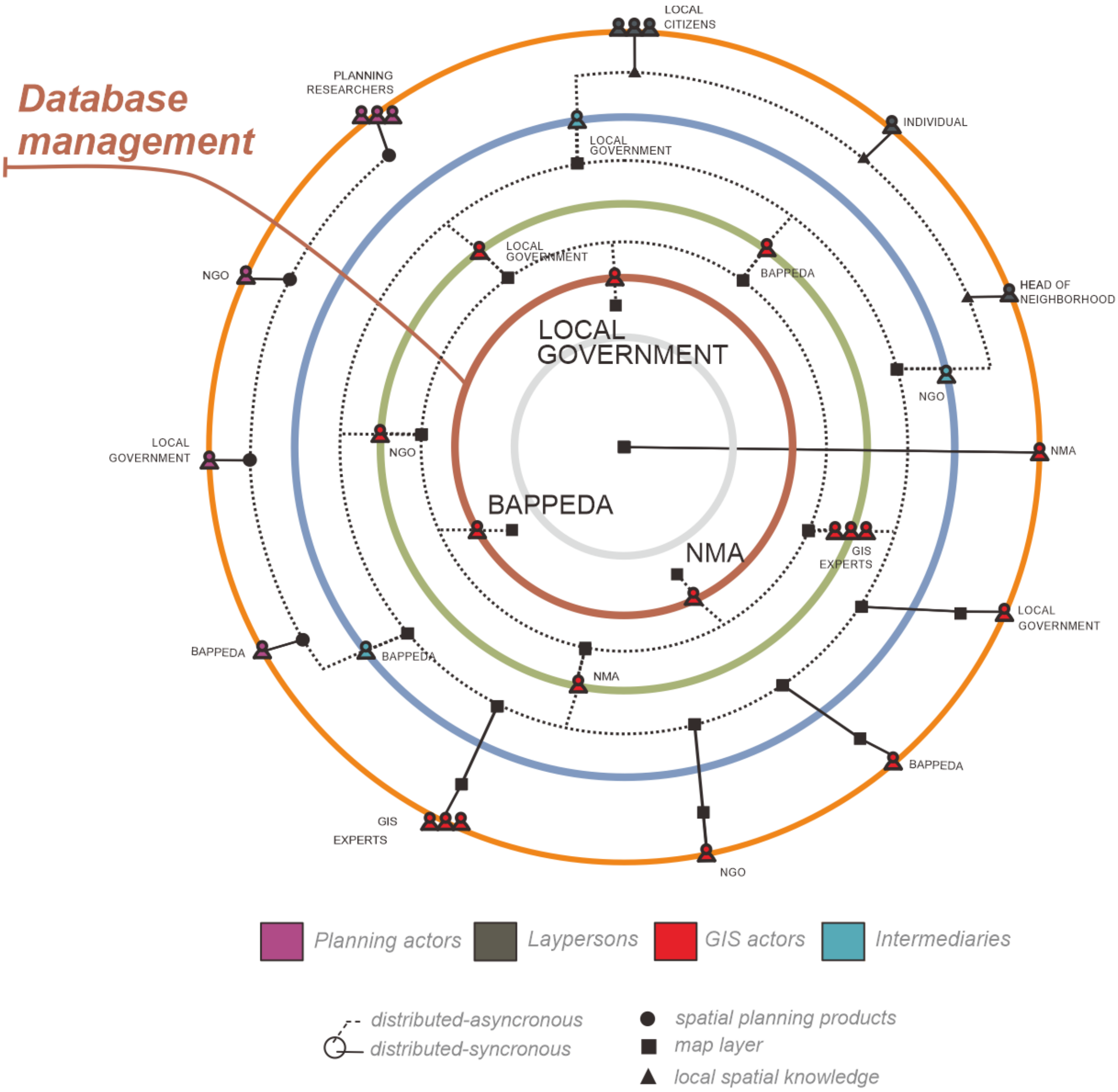


Figure 4.8: Spatial analysis

4.2.5 Validation

Lastly, Validation determines the final output of the participation. As visualized on Figure 4.9, the final product will be in one map layer, concluding all previous participation tasks from all participants involved.

Besides that, the data input, which is already saved on the database, is also validated. The actors involved are the same as the Database management layer – GIS actors with government backgrounds.

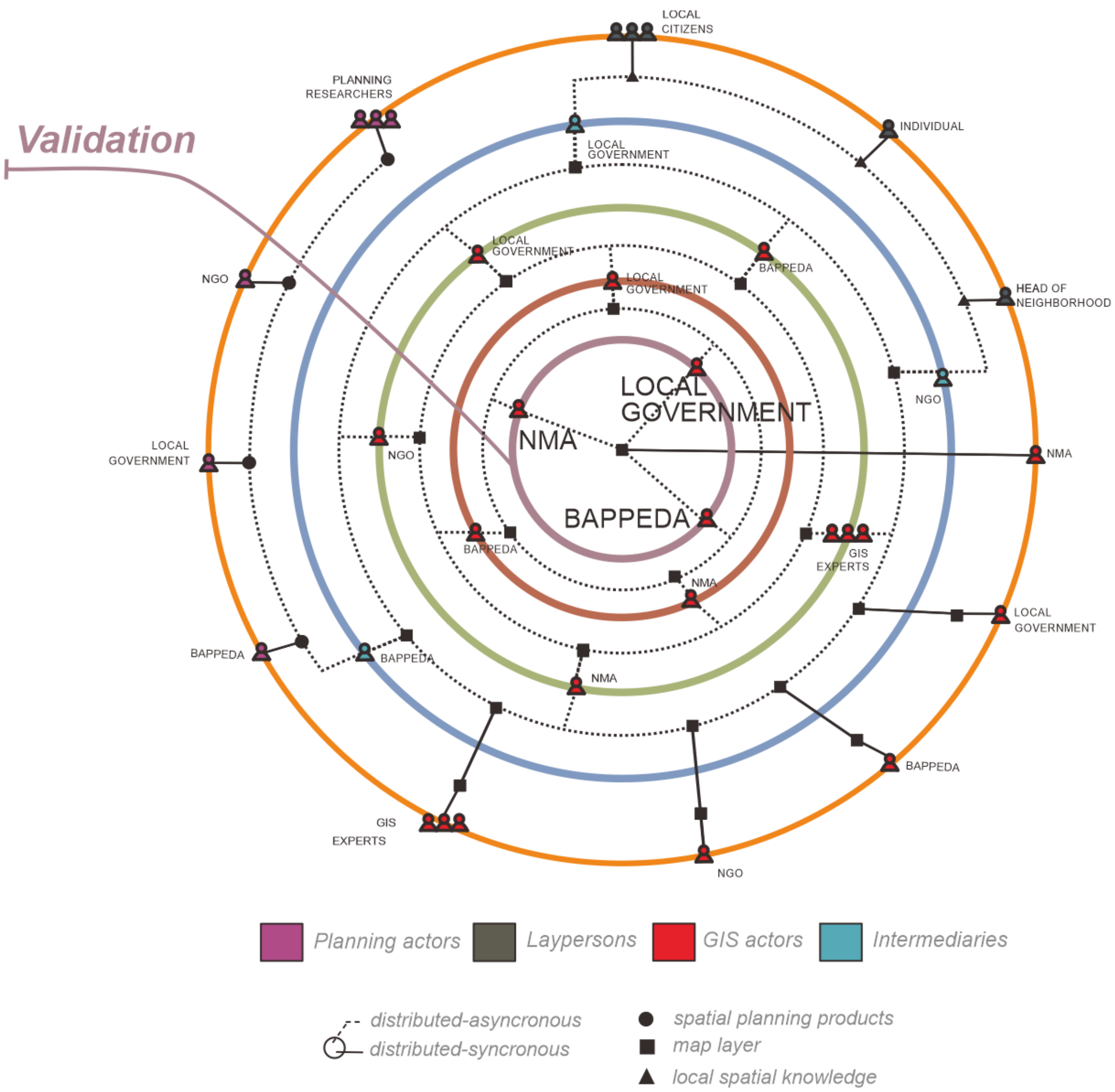


Figure 4.9: Validation

4.2.6 User roles

Based on the result shown in Figure 4.10, the roles are defined by seeing the hierarchical tasks from the ANT diagram. For the case, there are three roles: 1) contributor, 2) mediator, 3) validator. The actors of these roles are listed to get an overview of the aimed Persona and guidance for the real user when they register on the application.

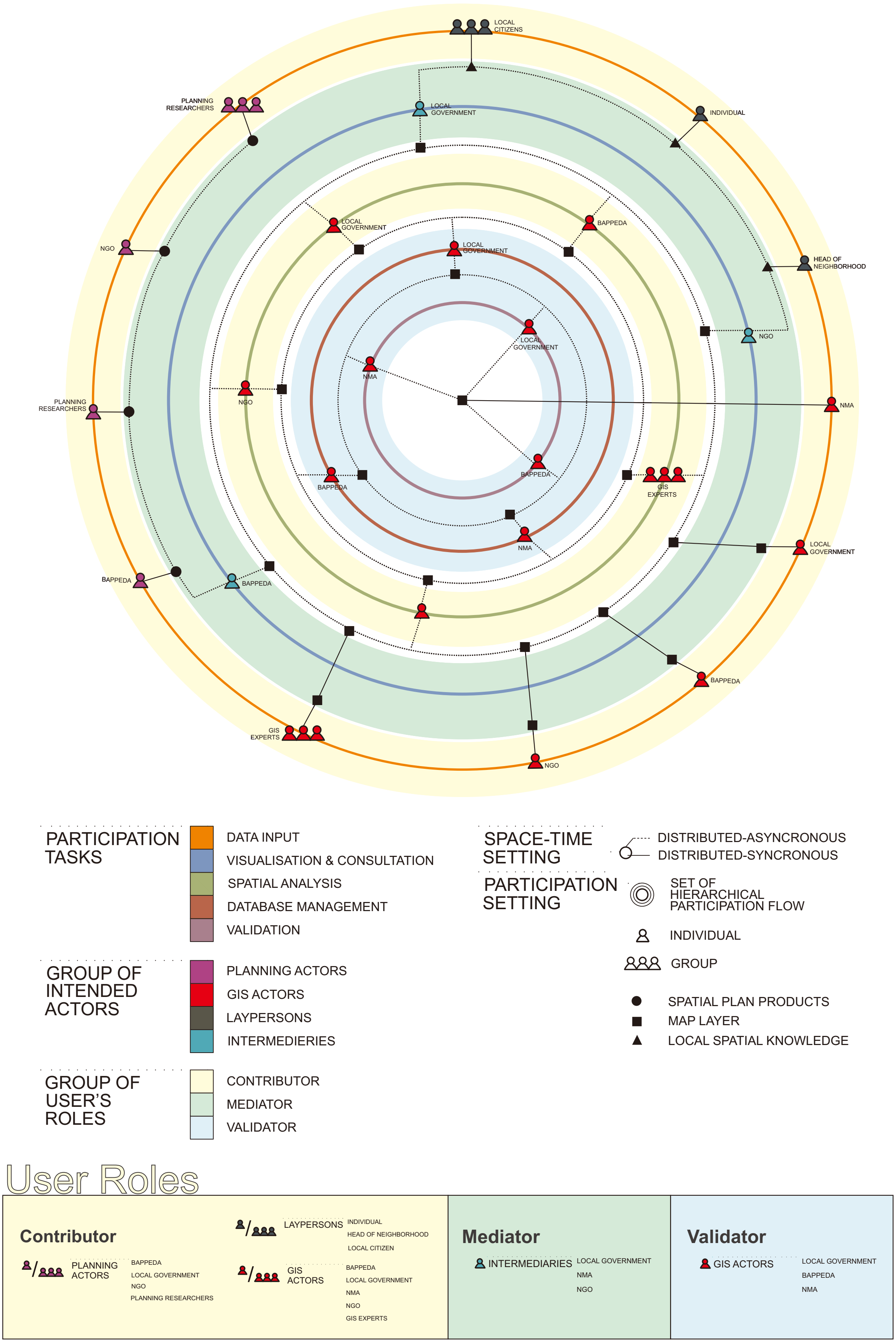


Figure 4.10: Final result of Phase 1 to define the user roles and participation tasks

4.3 The result of Phase 1

In practice, 4D PUPM helps to facilitate participation in the spatial planning process using 3D spatial representations. However, the two main drawbacks of the existing platform are: 1) the intended actors for each user role are not yet defined, and 2) the platform still focuses only on the second planning process: the monitoring. Therefore, this phase adds the existing traditional participation activities, Musrenbang, to add the first process, the planning formulation.

As the final result of Phase 1 (Figure 4.10), the ANT diagram is created to model the networking system between intended actors as the human actors with GIS as the non-human actors. In theory, participation in the spatial planning process depends on who gets involved in the process and their parts to influence the decision-making process.

Therefore, throughout Phase 1, user roles conception is made based on the intended actor's capabilities. These roles are based on whether they know about spatial planning, GIS, both, or none. This model visualizes the hierarchical layer of the task capabilities in the GIS application's participation network, together with a list of the intended actors and the space-time setting. In the end, the user roles are divided into three types: 1) Contributor, 2) Mediator, 3) Validator.

Chapter 5

Designing 4D Musrenbang

This chapter is the simulation-based process of Phase 2, creating a UX design for the geo-web application, in this case: 4D PUPM. Additionally, it explores the initial design of 4D PUPM to see what needs to be added for the re-design purposes. The conclusion of this chapter creates a mockup design, namely 4D Musrenbang, that will be developed as a prototype on the next phase.

5.1 Exploring the initial design of 4D PUPM

The exploration of the initial design is important to get valuable information about what needs to be added for re-design purpose. Therefore, this section evaluates the existing 4D PUPM based on its initial users, interfaces, and functionalities.

5.1.1 Initial interface design

The interface design of 4D PUPM consists of two interface models: dynamic map interface and static web interface. The dynamic map interface acts as the home page of the website. It calls as a 'dynamic' interface due to its nature that provides human-map interaction through several map functionalities. On the other hand, a static web interface provides 'static' information about each user's participation status; therefore, there is no functionality through this interface.

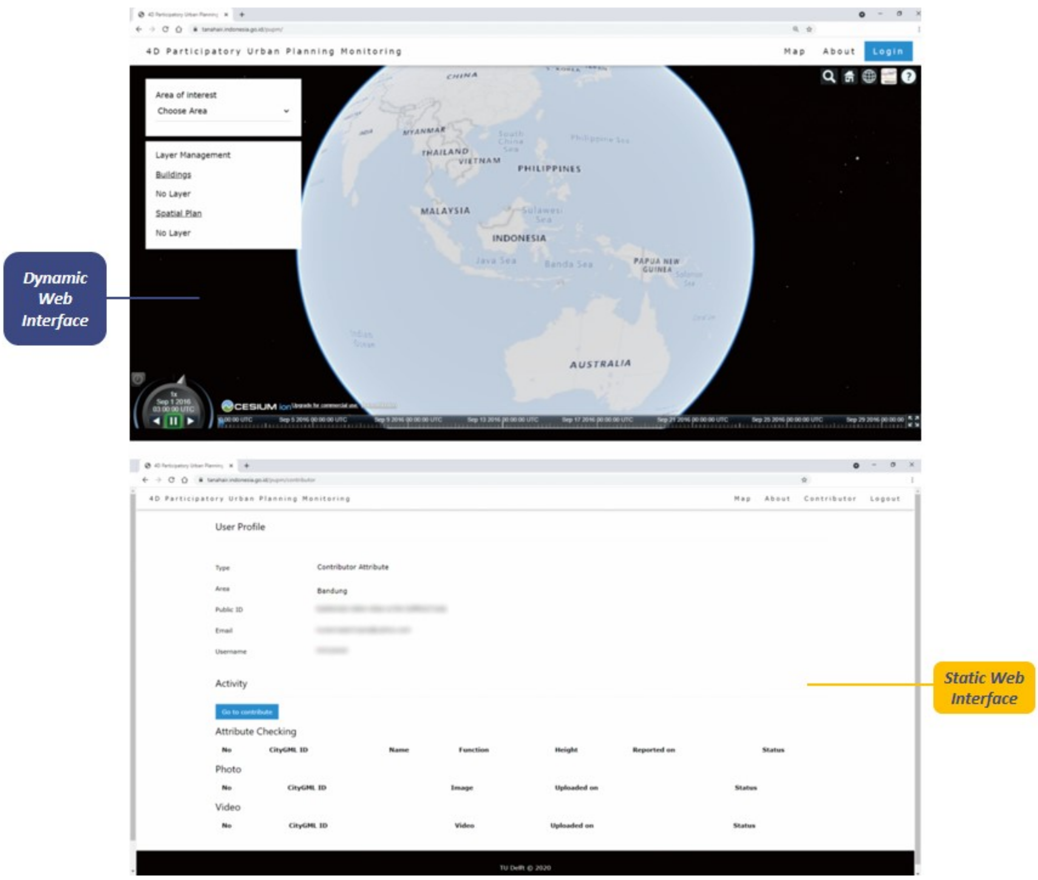


Figure 5.1: Dynamic map interface (top) and static map interface (bottom) of 4D PUPM

5.1.2 Initial user roles and flow

The initial user roles of 4D PUPM are divided into three groups: 1) Contributor Attribute, 2) Contributor Geometry, 3) Validator. At first, the user has a role as a guest user since (s)he has not registered or logged in to the system. After registration, the user can choose the user role based on preference to access different interfaces and functionalities (see Figure 5.2). However, there is no guideline about what qualification/skill the user should have to register for the specified user role.

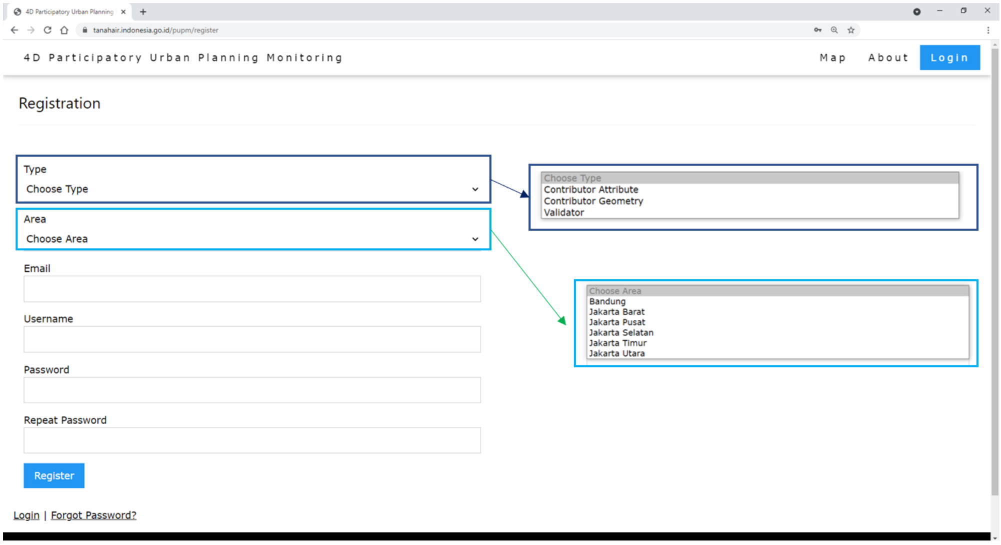


Figure 5.2: The process of choosing user roles during registration

As visualized in Figure 5.3, 4D PUPM provides several functionalities related to 3D map access and assessment related to spatial planning products. In this case, different functionalities can be accessed by the user according to their user roles.

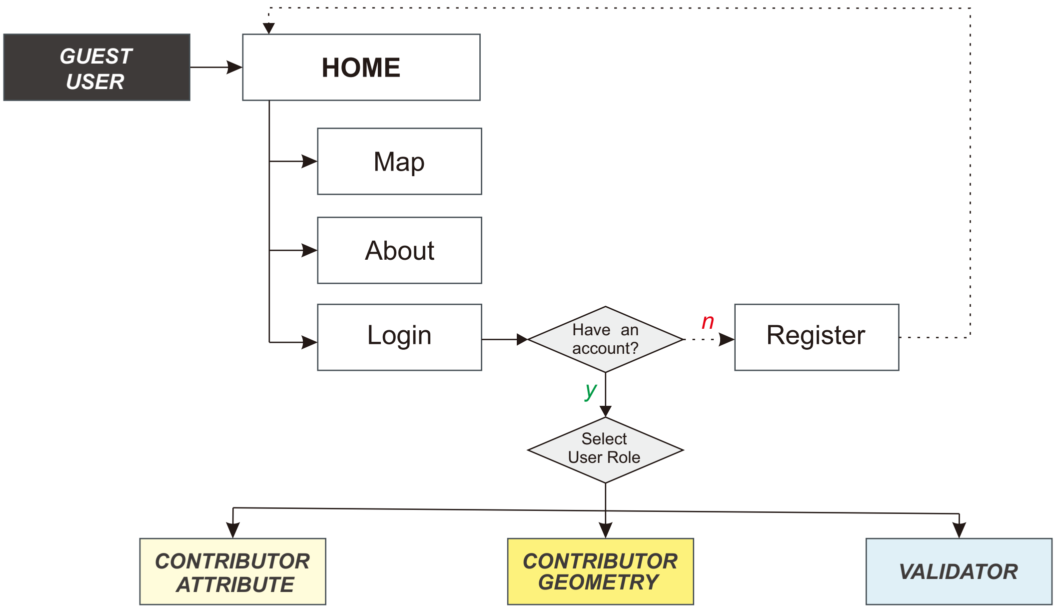


Figure 5.3: Web flow of initial 4D PUPM

A guest user.
A guest user only has access to the dynamic map interface with limited functionalities, such as layer, search, and attribute information (Figure 5.4). The attribute information function is only available for 3D building layer, so no information about 3D spatial plan layer existed. The provided functions are only limited to map view activities - thus, the participation activity is neglected. In this case, the guest user cannot input any spatial or non-spatial information into the platform.

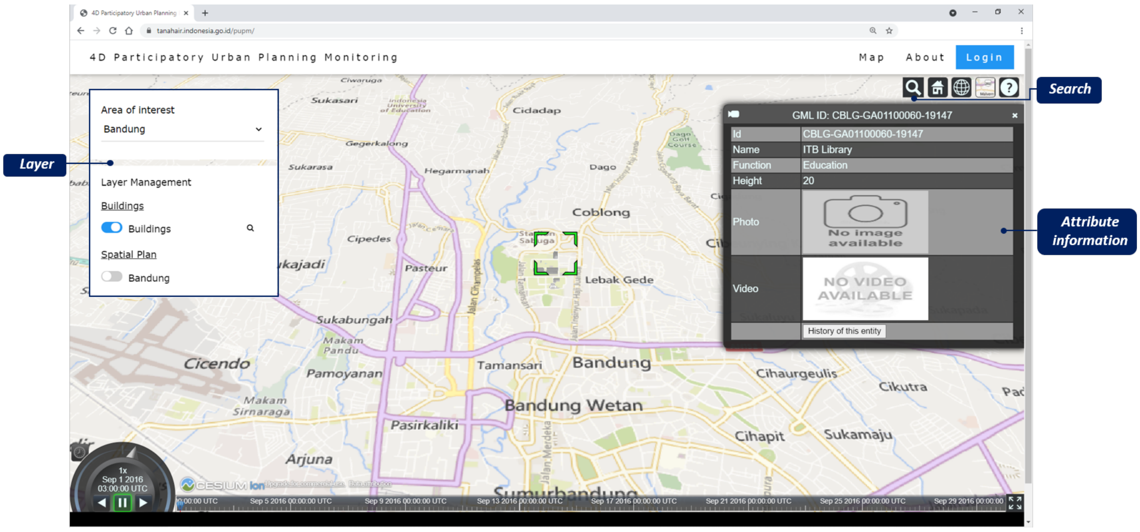


Figure 5.4: Dynamic map interface for guest user

The contributor attribute.
The contributor attribute has access to both dynamic map interface and static map interface (Figure 5.5). The provided functions are similar to the guest user, with only one update on the 'Attribute information' to the 'Attribute checking'.

For this case, the contributor attribute is only limited for inserting non-spatial information into the dynamic map interface. Therefore, participation activities in the spatial planning process are only limited to providing non-spatial information. Furthermore, this non-spatial input needs to get verification from the validators before publishing it to the platform. Thus, seamless multi-users participation is not possible using the initial design.

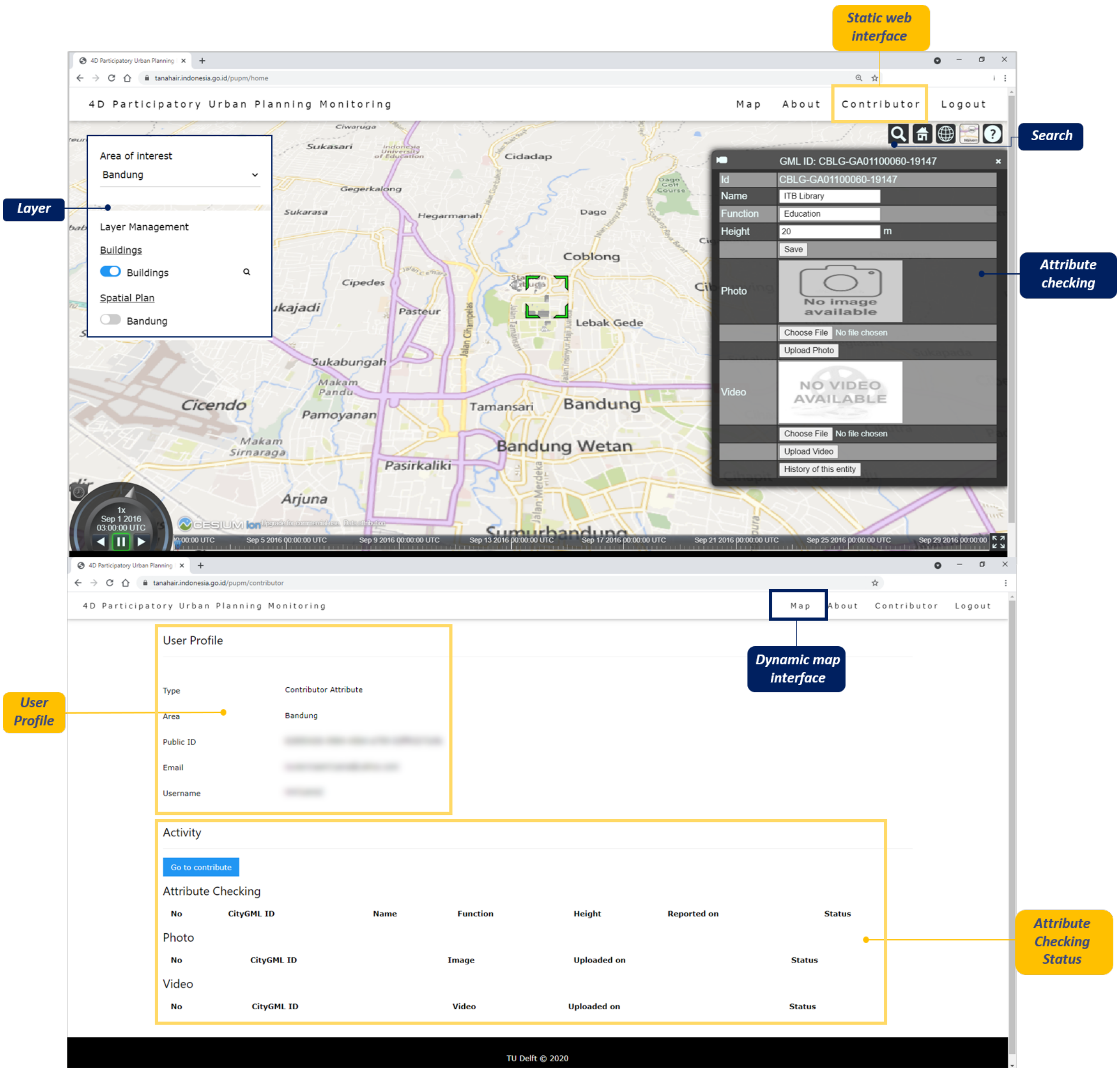


Figure 5.5: Dynamic map interface (top) and static map interface (bottom) for contributor attribute

The contributor geometry

The contributor geometry has similar access and functionalities with contributor attribute, with one additional function: Data Input (see Figure 5.6). Therefore, contributor geometry can participate using both non-spatial and spatial information. Both non-spatial and spatial information need to get verification from the validator.

Therefore, it is impossible to visualize the data input directly to the dynamic map layer. Moreover, no functionality facilitates map sketches and drawings throughout the dynamic map interface. Thus, seamless multi-actors participation is still not possible.

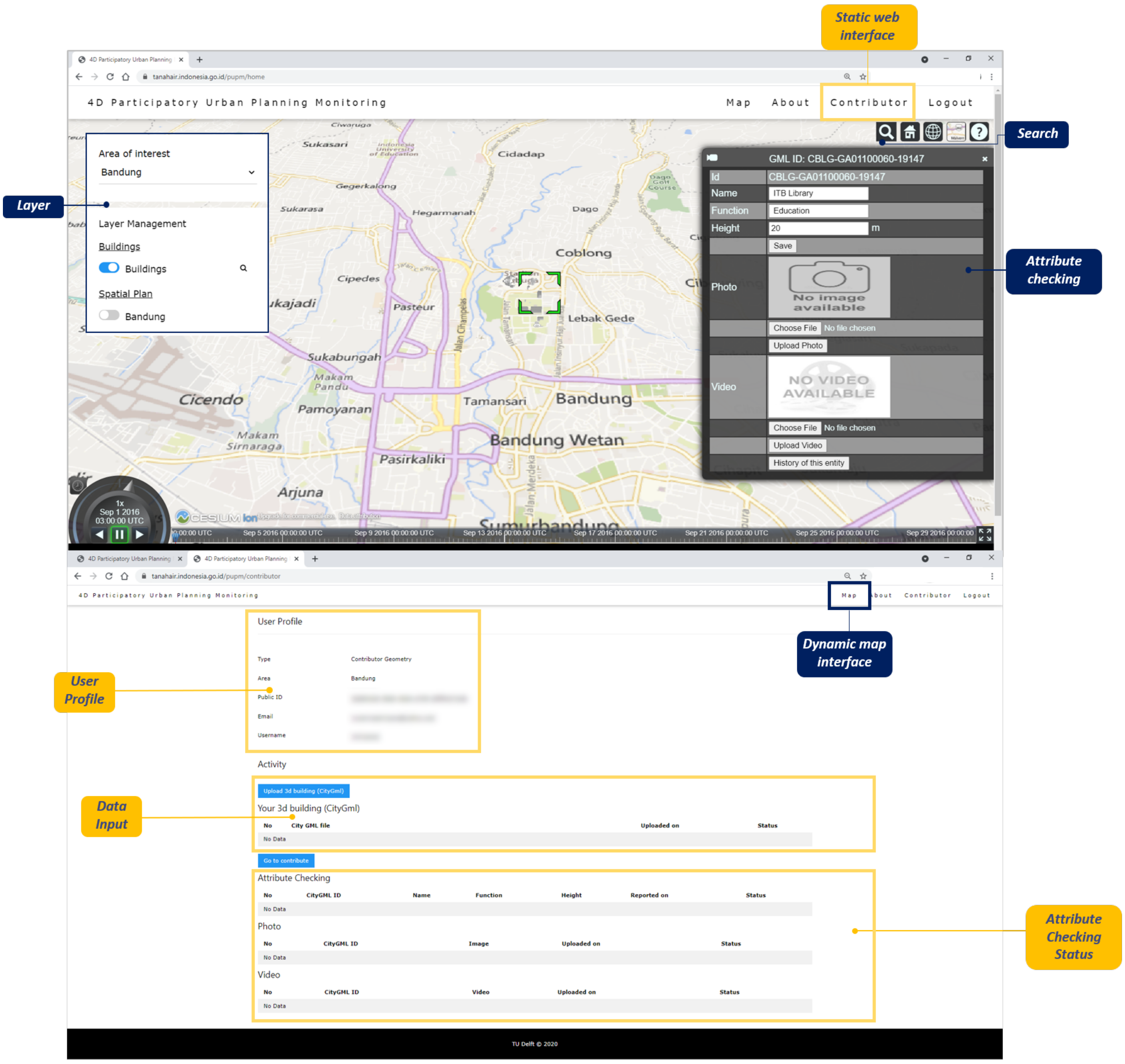


Figure 5.6: Dynamic map interface (top) and static map interface (bottom) for contributor geometry

The validator.
The validator has access to both dynamic map interface and static map interface (Figure 5.7). The provided functions are similar to the guest user in terms of functionality throughout the dynamic map interface.

The validator has a responsibility to approve or reject any participation input from contributor attribute and contributor geometry. In this case, participation activities are fully controlled by this role. However, the validator has no ability to input any non-spatial or spatial information. Thus, the validator can only control data flow but not possible to participate through the platform.

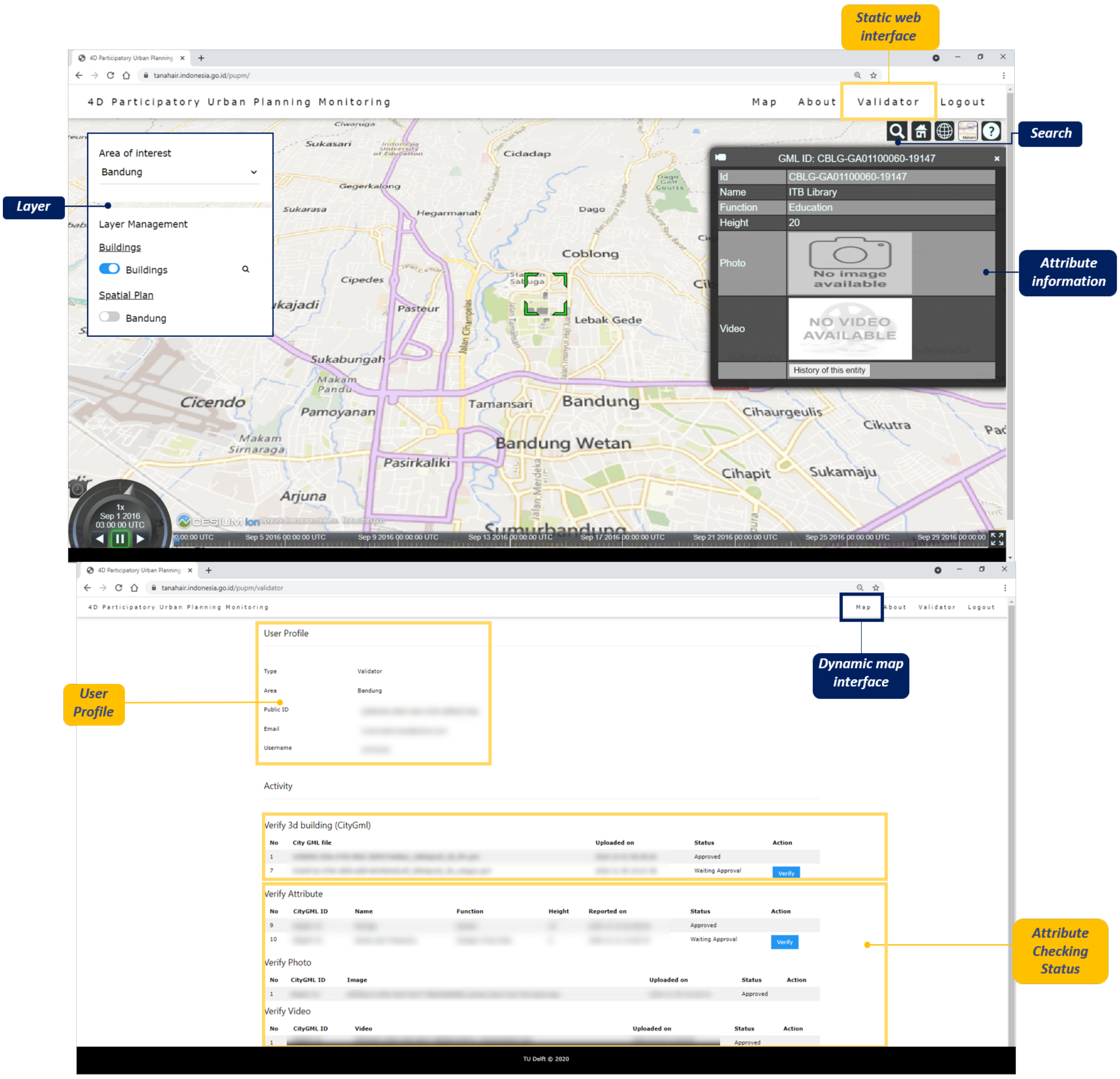


Figure 5.7: Dynamic map interface (top) and static map interface (bottom) for validator

5.2 Building the UX Design for 4D Musrenbang

After exploring the initial design of 4D PUPM, this research builds a UX design that combines 4D PUPM functionalities with Musrenbang workflow to maximize the participation process of the platform. This section is mainly based on the result of the initial analysis in Chapter 2 and Chapter 3. The result creates a design mockup named '4D Musrenbang' in HTML, Javascript, and CSS format. The design steps are based on Section 3.3, which is explained in detail below.

5.2.1 Persona

Persona is a fictional user to guide the design by setting a potential user's target instead of pleasing all kinds of real users at once (Pruitt and Grudin, 2003). These fictional users are used to decide for whom the design will be targeted.

Throughout Phase 1, the research represents the different intended actors that might use the website - creating a network of actual user roles and tasks in a participatory GIS application using the ANT diagram. However, the existing 4D PUPM only determines the web flow according to the user roles inside the application (for example: as contributors or validators). Therefore, the actual user's personality/background is neglected. In this case, a persona needs to be created based on a real-life person who shares similar traits. These descriptions are visualized by creating graphical persona sheets, which are important for designers to visualize each user's empathy side. The designer will also rely on personas in every UX subsequent steps, such as creating user flows, functions, and interactions (Pruitt and Grudin, 2003). The hypothesis about each actor's goals, frustrations, and skills can be gained based on literature studies in Section 4.1.2.2. Therefore, the research specifies persona through the four intended actors in Section 2.3, such as: 1) Planning actors, 2) GIS actors, 3) Layperson and 4) Intermediaries. The detailed persona sheets for four intended actors are shown in Figure 5.8.

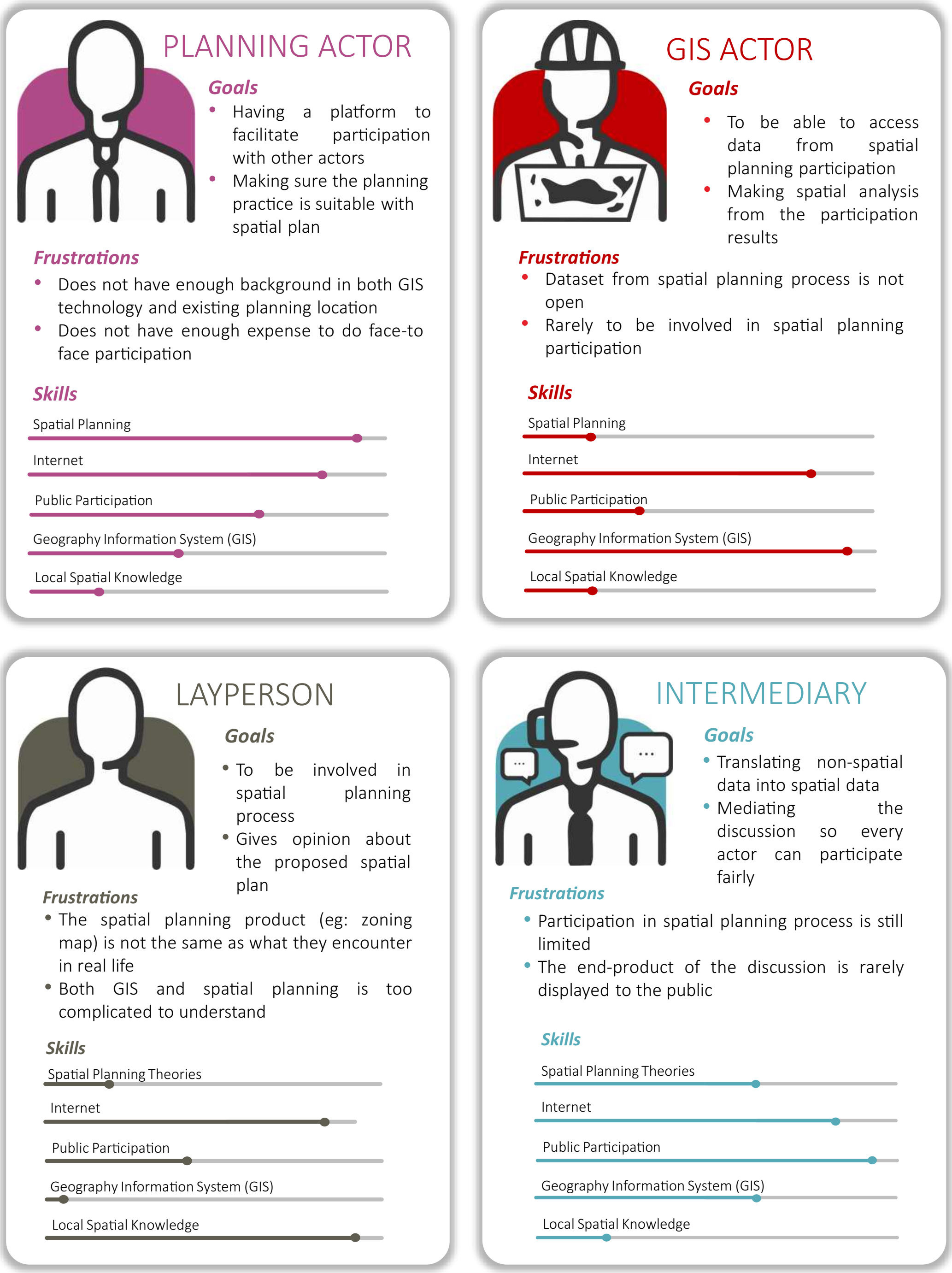


Figure 5.8: Persona sheets of four intended actors

5.2.2 User flow and the 5E model

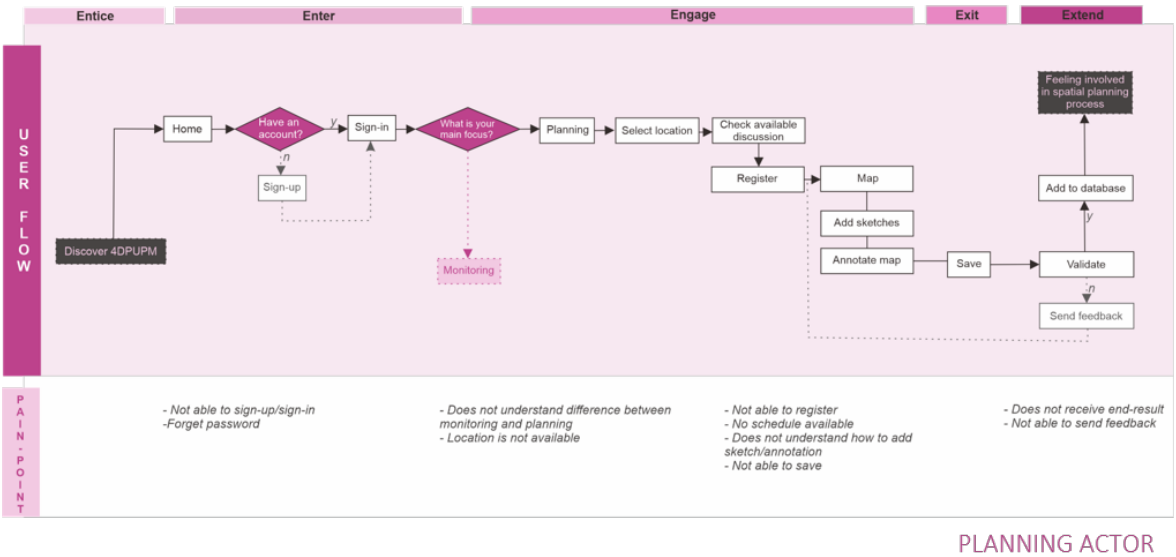
To break down the platform's whole experience from each persona's type, the research step of UX will use the 5E model to translate participation activities into the experience design concept (Richardson, 2010; Rosenbaum et al., 2017). This model can help the UX designer understand how users can enter the platform and what they carry with them after they close the platform.

The 5E model consists of 5 elements, such as:

1. **Entice**: How the user becomes aware of the experience and is attracted to it?
2. **Enter**: How does the user begin?
3. **Engage**: What activities immerse the participant in the experience?
4. **Exit**: How does a user complete the experience?
5. **Extend**: What will the user get after the experience has ended?

The designer illustrates each step that the users will go through while engaging with the platform by creating user flow through these five elements. Overall, this step aims to get the outline of experience for the design to communicate seamlessly within each user. The pain-point is also listed to predict each step's difficulties based on each user's skills and frustrations.

The detail 5E model, together with user flow and pain-point of all intended actors, are visualized in Figure 5.9.



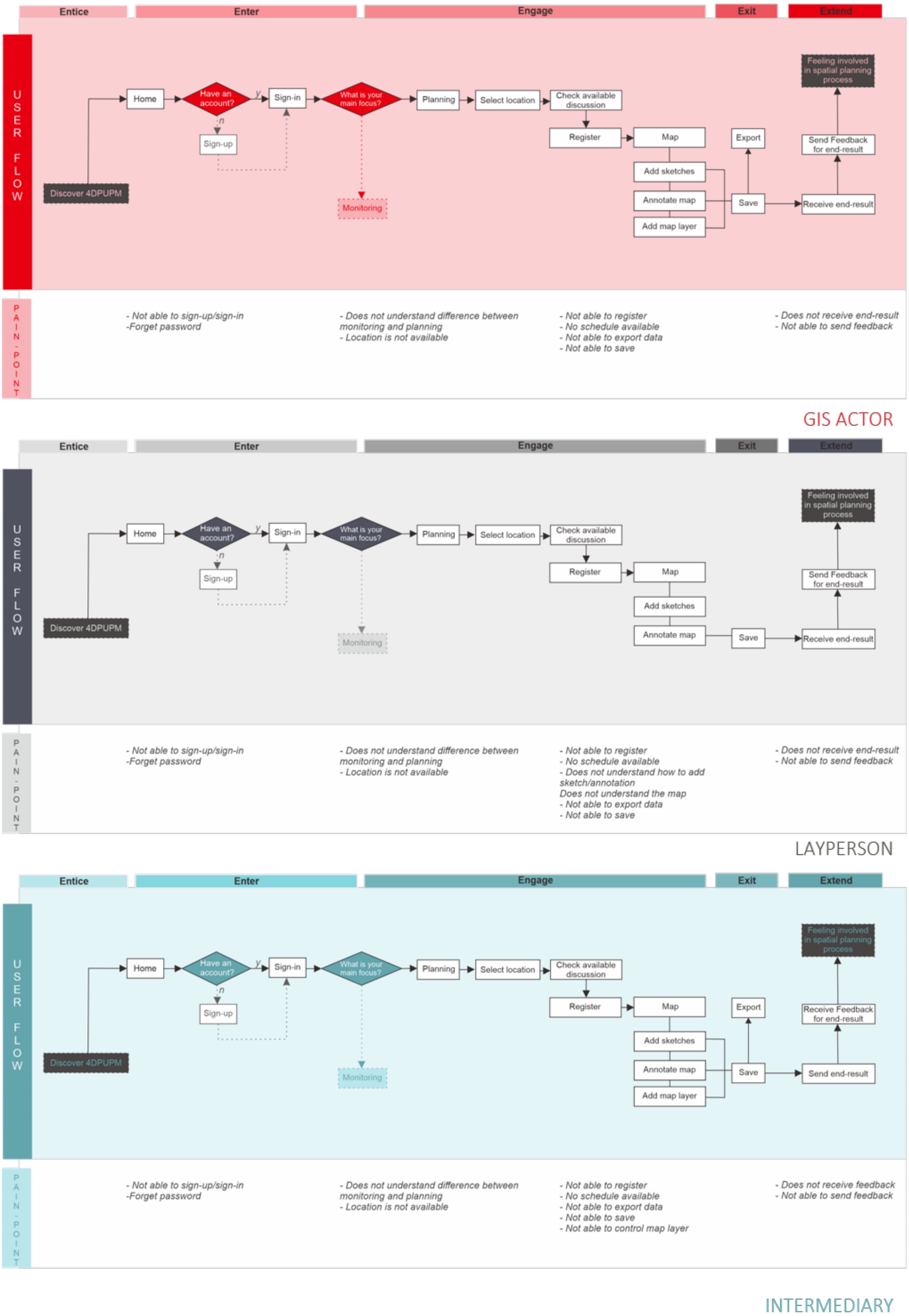


Figure 5.9: The 5E model of four intended actors

After creating the 5E Model, the four intended actors are mapped based on the user roles, such as Contributor, Mediator, and Validator (see Figure 5.10. These three roles have different functionalities based on the ANT diagram result in Phase 1.

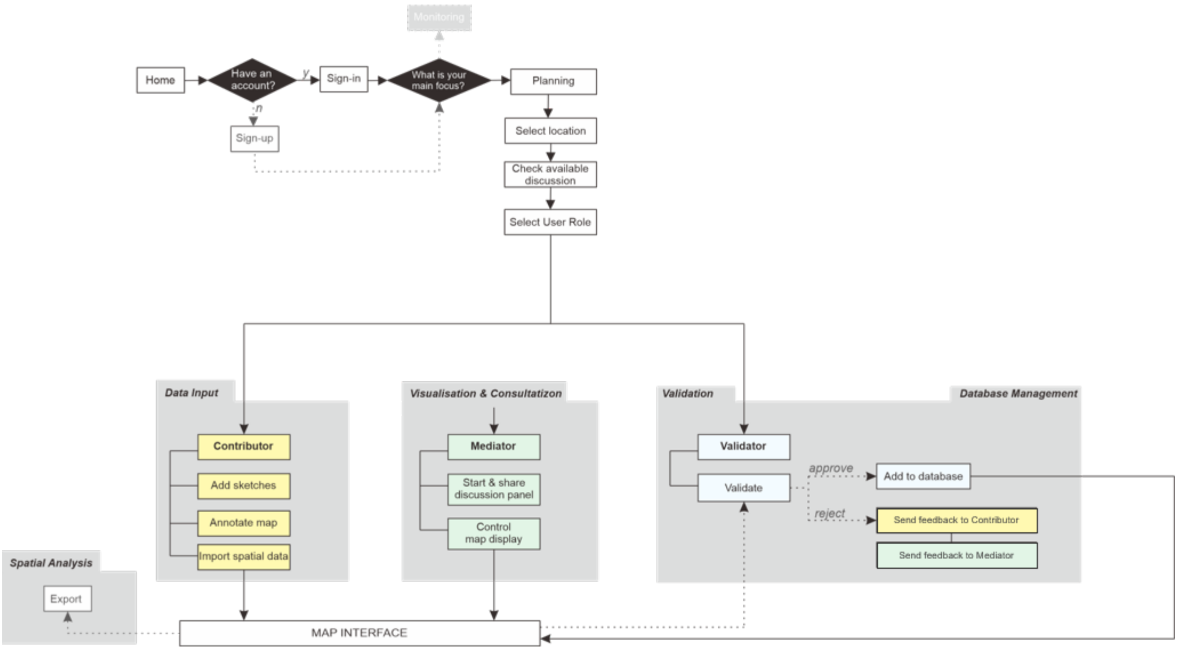


Figure 5.10: User flow of 4D Musrebang

Contributors, consist of all participants, are the main key during the beginning of the participation process. In this case, they can foster both spatial information and local spatial knowledge through sketches, annotations, and existing spatial datasets – which then will be visualized on the "Map Interface" panel during the discussion process. For 4D Musrenbang, the participation scale will be focusing on the village (Musrenbangdes) to the district area (Musrenbangcam).

Mediators, which consist of Intermediary actors, are in charge of providing discussion panels and translating the visualisation and controlling map layer visualisation during the discussion process. In this case, they are active during the Visualisation and Consultation step. The export option is also provided to provide an intermediate result of the discussion so GIS actors can use the data to perform the Spatial Analysis step. Mediators mainly focus on visualising the final proposal of Musrenbangdes/Musrenbangcam that will be submitted to higher government agency levels.

Validators, which consist of GIS actors working on the governmental agencies, cover both Validation and Database Management steps. Validators are in charge of checking the proposal's spatial information and giving feedback on whether the design proposal is approved or rejected. The final result will be shared with all participants after the process ends. This can solve the traditional Musrenbang process's main problem: a lack of openness and feedback from all stakeholders.

5.2.3 Wireframes

Wireframes can be defined as a schematic way to create the skeleton of a website, which shows how web elements can fit the elements together to communicate with users. Wireframes collect all ideas in a single document and in the process of working on a web project, and it is an important reference for the implementation of visual design (Garret, 2011).

There are four functions and four static pages in the initial 4D PUPM interface. The initial interface of 4D PUPM consists of two interfaces: the dynamic map interface and the static web interface. The previous analysis finds that these differences create a limitation for a seamless multi-actors participation process. Therefore, the redesign focuses on extending the dynamic map interface to support more participation interaction between users. Some static web interfaces are converted into functions for dynamic map interface depending on the need of each persona groups.

Constructing a wireframe could help to brainstorm many ways to decide the design's placement (maps, buttons, texts) and web pages in the best way to fit the user's need. To avoid many interaction with the static web interface and maximize the interaction with the dynamic map interface, I decided to put the map functions on the left sidebar and header of the page (see Figure 5.11). These functions are exist in a collapsible form, which means that the bigger sidebar will be shown so that I can put more buttons and functions without the user leaving the map interface first. So far, the functionalities are: Search, Map attribute, Layer control, Filter, Draw, Validate.

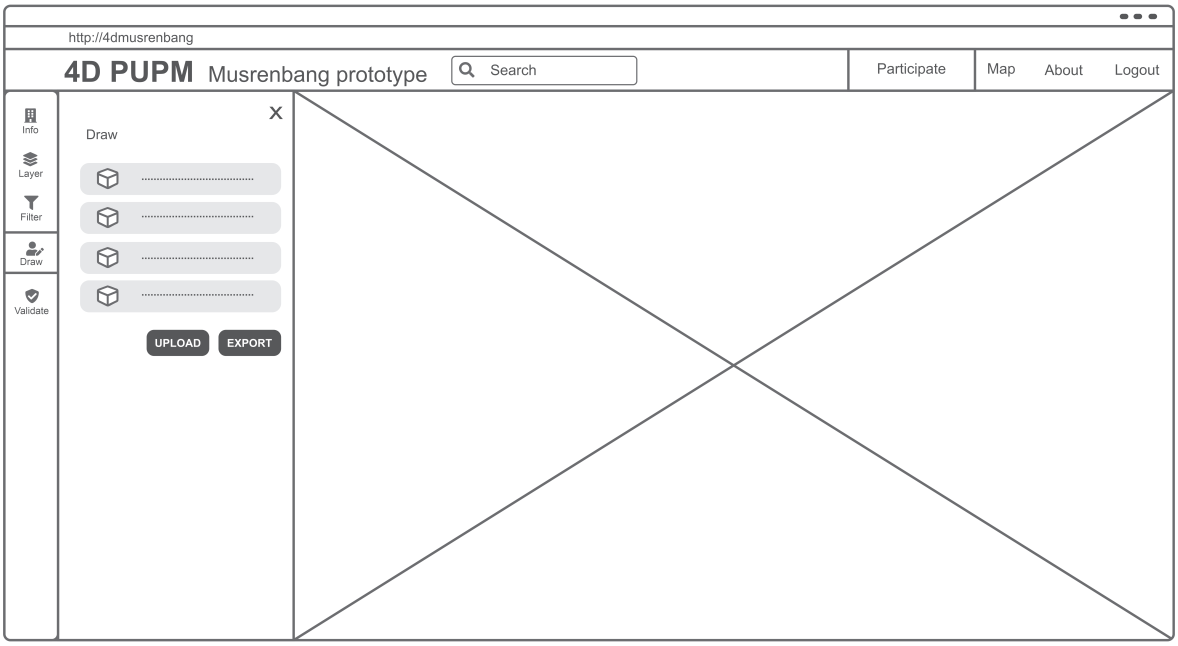


Figure 5.11: One of the wireframe for 4D Musrenbang with the suggested functionalities on sidebar

5.2.4 Interface mockup

After creating wireframes, the interfaces are implemented to set the appearance of the platform. To achieve a pleasing appearance, several theories were taken into consideration to get a user-friendly interface. Several elements from previous research by Jansen (2020) can also be included as guidance to generate requirements such as content presentation, system interaction, communication mechanism. Additionally, cartography and geo-visualization concepts are added as the requirement for the digital mapping presentation and will be implemented in the data preparation process.

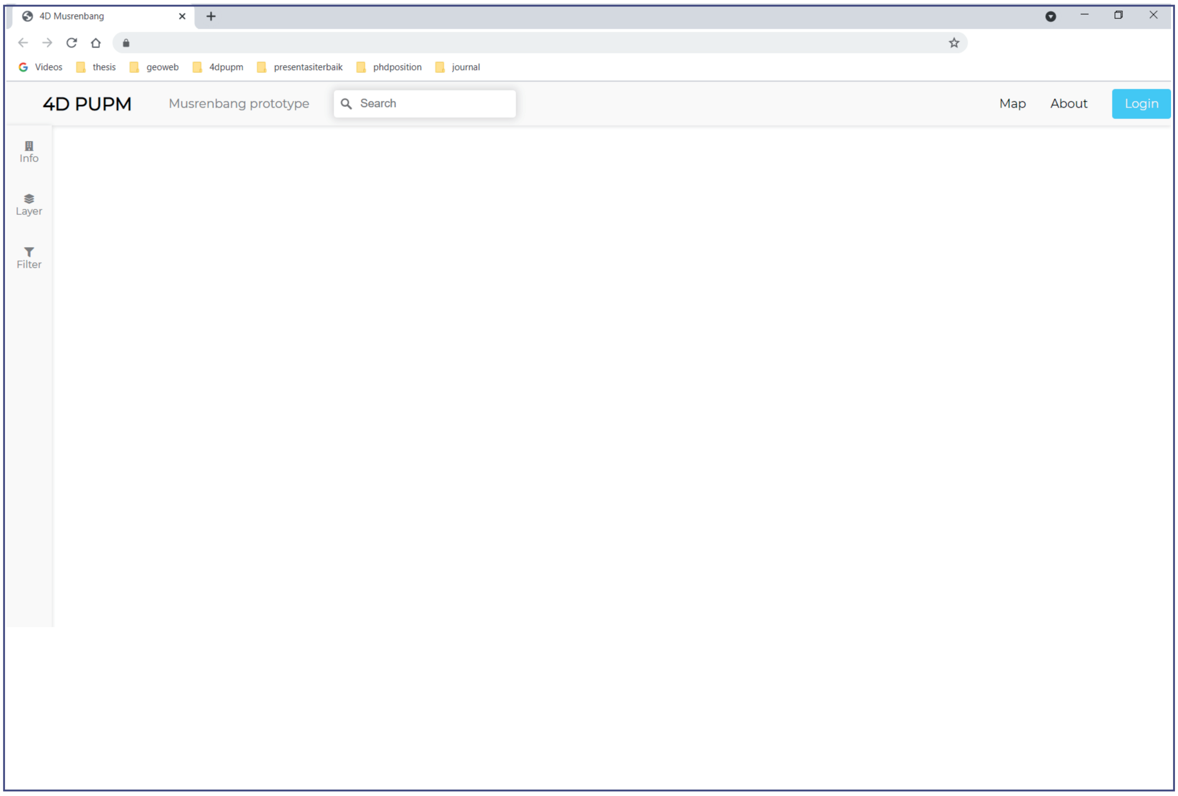


Figure 5.12: 4D Musrenbang Interface

Due to its environment in HTML and CSS format, the map interface is shows as white space. Then later, this white space can be feeded with map interface using Javascript on Phase 3.

I referred this as interface as mockup due to no functionality exist yet (see Figure 5.12). The mockup can be accessed in the Github repository: '4D Musrenbang' - https://github.com/nurannisam/4Dmusrenbang.

5.3 The result of PHASE 2

The main problem of implementing GIS technologies to facilitate participatory planning lies in the lack of user understanding. Therefore, UX helps to recognize the need of each involved users, guide users to do a specific task, organize the platform to allow users to achieve their goals, and visualize the process for better user understanding.

In practice, 4D PUPM needs to facilitate five different participation activities from four intended groups of actors based on the Phase 1 result. Moreover, the current workflow of traditional Musrenbang also provided an initial flow of the planning formulation step in the 4D PUPM system. Due to this complexity, 4D PUPM needs to consider four phases of building user experience such as 1. Creating Persona based on user roles, 2. Translating all participation tasks into 5E elements, 3. Building wireframes of the web organization, 4. Designing the final interface based on user-friendliness.

The map product of this Phase is a map interface, which is built using `HTML` and `CSS`. At last, the result of this Phase will further be developed as a highly functional geo-web prototype.

Chapter 6

Building the Prototype of 4D Musrenbang

This chapter explains the process of PHASE 3 - related to the conversion of a mockup into a prototype. A prototype is a high-fidelity representation of the final product, which means that this prototype demonstrates the realistic front-end web experience with real datasets in 2D and 3D. The prototype is developed based on the current web environment (HTML, CSS, and Javascript) combining with tile set visualization.

6.1 Deployment of the dynamic map interface

One of the main goals from the mockup resulting from PHASE 2 is to re-design the initial4D PUPM into a fully dynamic map interface to maximise the participation activities. Consequently, the prototype should have the most appropriate 3D geo-web platform available and easy to access by everyone. Therefore, choosing the right geo-web platform is very crucial.

For the context of this research, two geo-web libraries are analysed: Cesium JS and Mapbox GL JS. These two libraries are selected due to their wide variety of functions, and free to use and access. Since the focus of this research is mainly about usability, these two platforms are compared based on the most effective way to simulate user experience similar to offline participation situation. User interaction and environment simulations are the key points for the comparison; hence, technical aspects such as spatial validity and database system are not the main priority.

Cesium JS

Cesium JS is an open-source Javascript library to create a 3D geo-web application (Figure 7.1), free to use for commercial and non-commercial use (Cesium, 2021). It helps to transform massive 3D spatial data into streamable 3D content for the web environment. Originally, the initial 4D PUPM runs using Cesium JS in combination with 3DCityDB as the geo-database.

Figure 6.1: Example Cesium JS geo-web application (Cesium, 2021)

To analyse Cesium JS, the benefits and limitations of the library are explored in detail below.

Benefits:

1. Globe view experience
   Cesium JS provides the ability to freely move around through the virtual environment by changing the viewing angle and allowing for rotation. It also has an ability to switch from 2D to 3D map. Moreover, realistic environment settings such as atmosphere, sunlight, and water surface area available to use for more realistic visualization.

2. 3D data tiling
   Cesium JS provides 3D data tiling to handle large 3D datasets into streamable and ready to use 3D content. The user can also arrange multiple data types from multiple sources to visualize it in one platform.

3. Large community supports
   The Cesium forum and a large community supporting developers are helping to support the working process. Developers can ask questions to others using the forum. Moreover, Cesium also provides a live code editor (Sandcastle) to run their code directly via a web browser.

Limitation:

1. Slow response time
   Cesium has a slower response time in comparison with Mapbox. The globe view loading time at around 3 seconds on a stable 7.2 Mbps internet connection. This limitation affects the loading time of the inital 4D PUPM, due to its large 3D datasets.
   It is important to note that this limitation can disturb the user-friendliness of the application. Thus, it might also become one of the pain-point of the user while using the application.

2. Interface design
   In comparison with Mapbox, there is only limited map styling provided in Cesium JS. In terms of interface design, it is arguable that the design can be more sophisticated.

Mapbox GL JS
Mapbox GL JS is a Javascript library to render interactive maps using WebGL (Mapbox, 2021). It is part of the cross-platform Mapbox ecosystem, which compatible with multiple devices such as Android, iOS, macOS, Qt, and React Native. The user needs a Mapbox account to gain token access to their platforms to start using the library.

Figure 6.2: Example Mapbox GL JS geo-web application (Mapbox, 2021)

The benefits and limitations of Mapbox GL JS library are explored below.

Benefits:

1. Fast loading and update time
   Mapbox is famous for its faster loading map time than other mapping libraries in terms of loading time. It enables to load of 3D datasets in less than a second while under a stable (7.2 Mbps) internet connection.
   This benefit can create a seamless user engagement between the user and the geo-web application.

2. Various map styles
   Mapbox provides many map styling that can be either directly used using provided codes or completely customised style using Mapbox studio.

3. Large repositories support Similar with Cesium, Mapbox also provides many repositories containing codes, issues, and tutorials to help the developers solving specific issues.

Limitation:

1. 2.5 visualization instead of 3D
   To visualize buildings in 3D, Mapbox is not using pure 3D but 2.5D, which means that the building is a 2D shapefile which then extrude based on its height. This limitation makes Mapbox not suitable for 'stacking' visualization (for example: visualizing 3D building with each floor having different ownership). However, it is still possible to solve this limitation by using a third party application like Three.js.

2. Limited free trial
   Mapbox only offers up to 50.000 free map loads/month for web and 25.000 monthly active users for mobile SDK, which is not suitable for long term purposes. However, it is still a considerably large free tier for the purpose of creating a prototype.

Based on the comparison above, Mapbox GL JS provides more benefits for supporting user-friendly geo-web application due to several reasons. First, it provides fast loading map time, which is useful for a seamless participation process between multiple users throughout the platform. Second, it is more feasible to apply design and visualization requirements from Phase 2 using Mapbox due to its ability customise the map styling features. Therefore, I decided to change the original geo-web library of the initial 4D PUPM from Cesium JS to Mapbox GL JS.

6.2 Development of the prototype

Throughout Phase 2, the mockup interface of 4D Musrenbang is made, consisting of several web pages using HTML and CSS. This phase further developed a mockup into a prototype by adding several map functionalities and interactions and adding real 3D datasets in order to develop it into a realistic front-end geo-web. The implementation related to the prototype development is based on a hierarchy to make sure that all elements work together in synergy. This section explains the whole process of creating a 4D Musrenbang prototype, starting from data preparation to the functionalities.

6.2.1 Data preparation

Due to the uneditable dataset type provided in the initial 4D PUPM, a sample data is created as a substitute to make the prototype more realistic. The dataset utilised in the prototype combines 3D spatial plans with building models of Jakarta, Indonesia. These datasets were accessed from the geoportal of DKI Jakarta together with cadastral data from National Land Agency (BPN). Overall, the input 3D datasets of the prototype are:

- 2D spatial zoning plans from DKI Jakarta's geoportal - recorded as a polygon in 2D shapefile format.
  The attribute information of each 2D zones provides spatial development guideline such as the function of land or area, urban infrastructure, and the intensity of each zone such as coefficient of the building (KDB), coefficient of the floor (KLB), the height of the building (KB), and coefficient of a green area (KDH).

- 2D building parcels in combination from official Jakarta city's geoportal and BPN - recorded as a polygon in 2D shapefile format with information related to individual's RRRs are removed due to privacy issue.

The area of interest is located in Tebet district in Jakarta city, Indonesia. This part of the city is chosen because of its detailed attribute information compared to other districts' datasets. The scale of the dataset is on the district level - making it suitable with the scale requirements written in Figure 4.3.

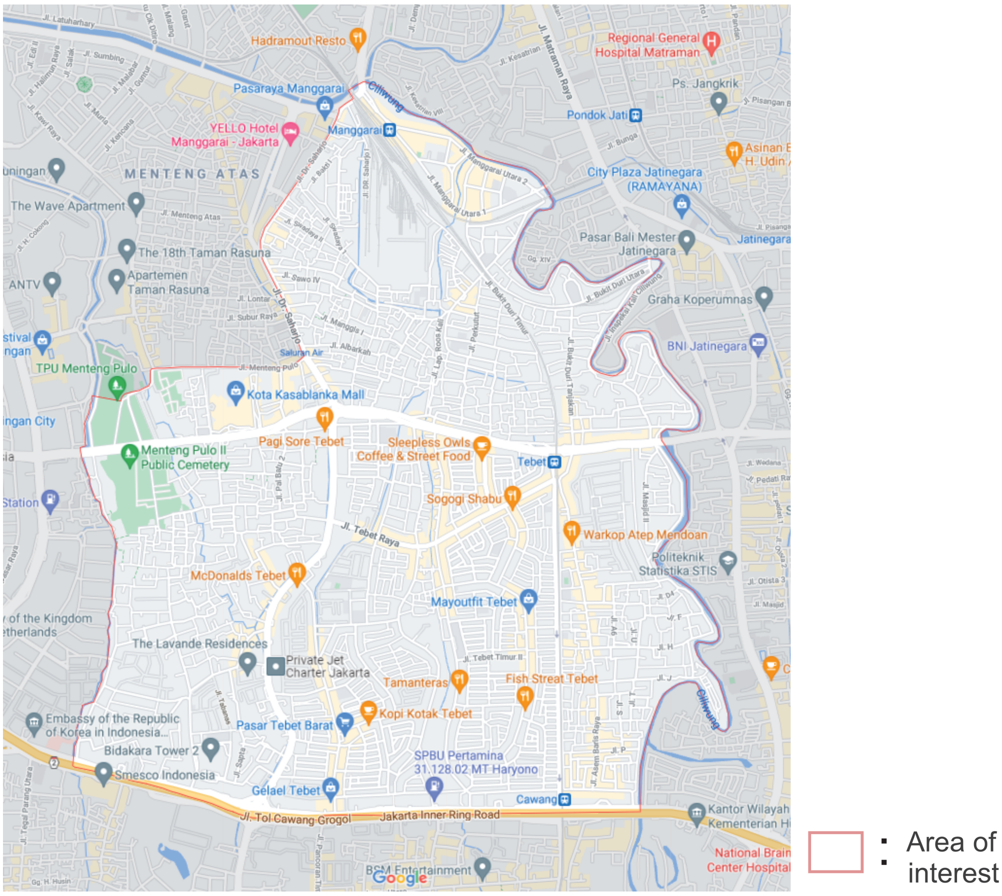


Figure 6.3: Area of interest of the dataset

The original dataset is in 2D shapefile format, provided with the building height attribute. Therefore, the data conversion process is conducted to convert the 3D map (in shapefile) into 3D map (in GeoJSON), which then later would be inserted to the dynamic map interface. Mapbox itself has two data input types with different characteristics: a) dataset (GeoJSON, CSV); and b) tileset (KML, Shapefile, GeoTIFF, MBTiles). The main difference is that the 'dataset' is editable through Mapbox

API while the 'tileset' is not editable. Therefore, two shapefiles are converted into GeoJSON formal using FME.

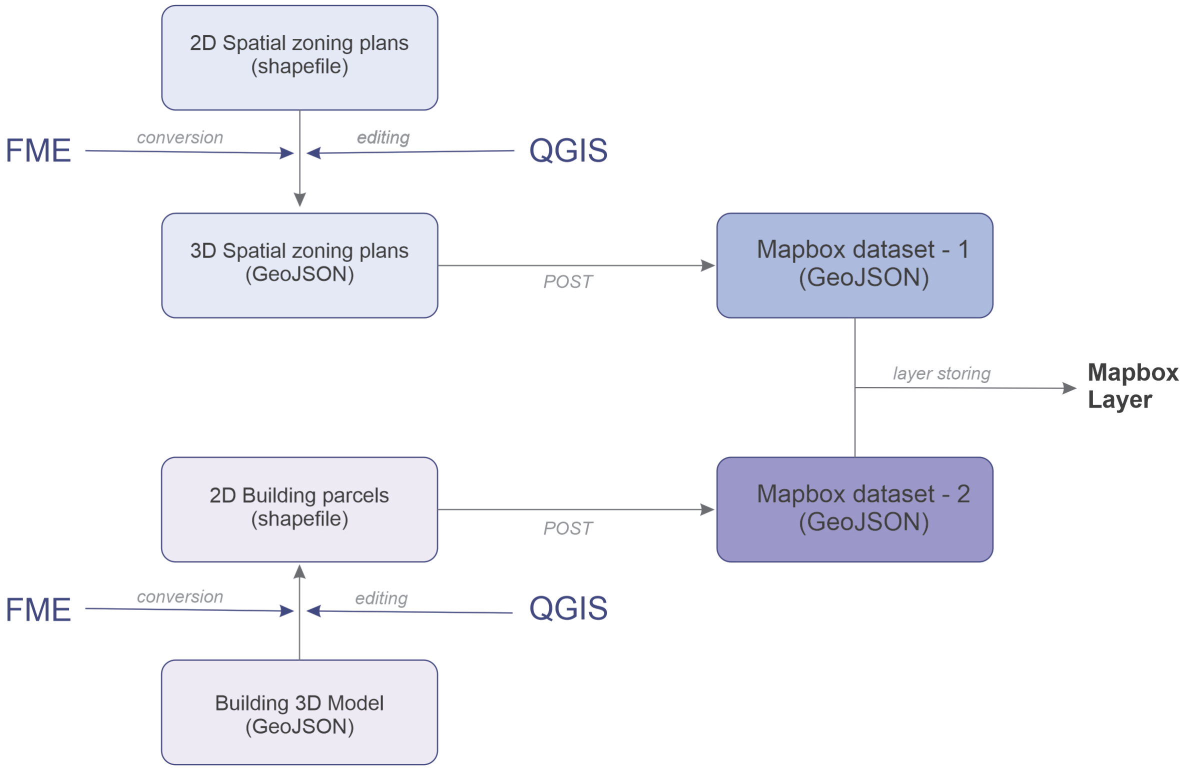


Figure 6.4: Data preparation workflow for Mapbox

6.2.2 Data visualisation and attribution

With all datasets are ready, I overlay both 3D datasets and insert it into Mapbox. Additionally, a base map layer is added using custom Mapbox styling. The, each layer in Mapbox datasets is then configured with the attributes according to Table 6.1.

3D SPATIAL PLAN		3D BUILDING
Function	Building Coverage Ratio (KDB)	City
City	Floor Average Ratio (KLB)	District
District	Building Height (KB)	Sub-district
Sub-district	Green Base Coefficient (KDH)	Floor(s)

Table 6.1: Data attributes specification

To specify the zoning color, the zoning attributes act as a guideline to match the required color based on Government Regulation 8/2013. Meanwhile, all 3D buildings have a dark colour with 80% opacity to be able to easily being recognized by the user.

Spatial plan map visualisation guideline based on Government Regulation 8/2013:

- zona lindung (conservation area)
- zona hutan kota (urban forest area)
- zona taman kota (urban park area)
- zona pemakaman(cemetery area)
- zona jalur hijau(greenspace area)
- zona hijau rekreasi(green recreation area)
- zona terbuka hijau budidaya (urban agriculture area)

- zona pemerintahan nasional (national government offices area)
- zona perwakilan negara asing (embassy offices area)
- zona pemerintahan daerah (region government offices area)

- zona perumahan kampung (sprawl residential area)
- zona perumahan KDB tinggi (high density residential area)
- zona perumahan vertikal (vertical residential area)
- zona perumahan KDB rendah (lowdensity residential area)
- zona perumahan vertikal KDB rendah (low density vertical residential area)
- zona perumahan di wilayah perairan (waterfront residential area)

- zona perkantoran, perdagangan, dan jasa (offices, commercials, and services area)
- zona perkantoran, perdagangan, dan jasa KDB rendah (low density offices, commercials, and services area)
- zona perkantoran, perdagangan, dan jasa KDB tinggi (high density offices, commercials, and services area)
- zona campuran (mixed-use area)
- zona pelayanan umum dan sosial (public and social facilities area)
- zona industri (industrial area)

- zona terbuka perairan (water area)
- zona konservasi perairan (conservational water area)
- zona pemanfaatan umum perairan (water agriculture area)

Table 6.2: Spatial plan map visualisation guideline based on Government Regulation 8/2013

These 2D datasets were extruded based on their height value from the terrain elevation (set=0; assuming that the base map is in 2D) to gain three-dimensional visualizations. Together with the color specification, these visualizations were applied for each data layer using custom Javascript (i.e., 'match'). This could also set up custom scripts for specifying certain visualisation conditions in the layer, such as only showing all buildings which have house as their spatial zone.

To simulate the 3D environment in a more realistic way, a sky atmosphere was also added using Javascript (see Figure 6.5). This feature enabled a sky filling to the blank space above the mapping horizon. The sky layer was set with a custom colour gradient to simulate real-world sky situations with light scattering.

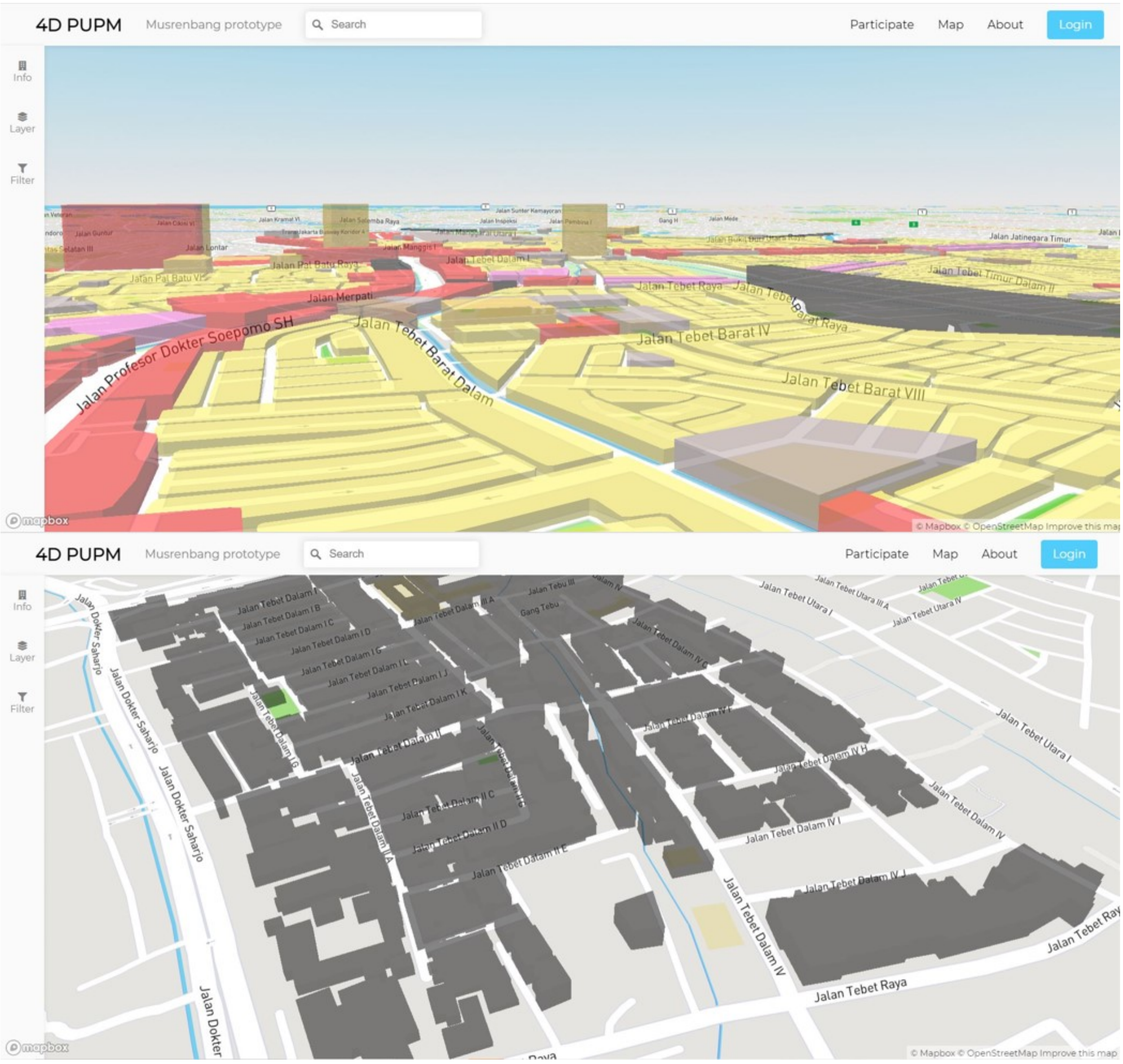


Figure 6.5: Data visualisation for 3D spatial plan (top) and 3D building (bottom) with sky atmosphere

6.2.3 Map functionalities and interaction

With all these datasets already in place, several map functionalities and interactions were developed using a custom script (Javascript) to facilitate user's involvement during the participation process.

View control
The view control refers to a set of map functionalities on adjusting the map camera for a better

3D navigation experience. This feature could be performed based on two interactions: mouse interaction and button interaction (Figure 6.6).

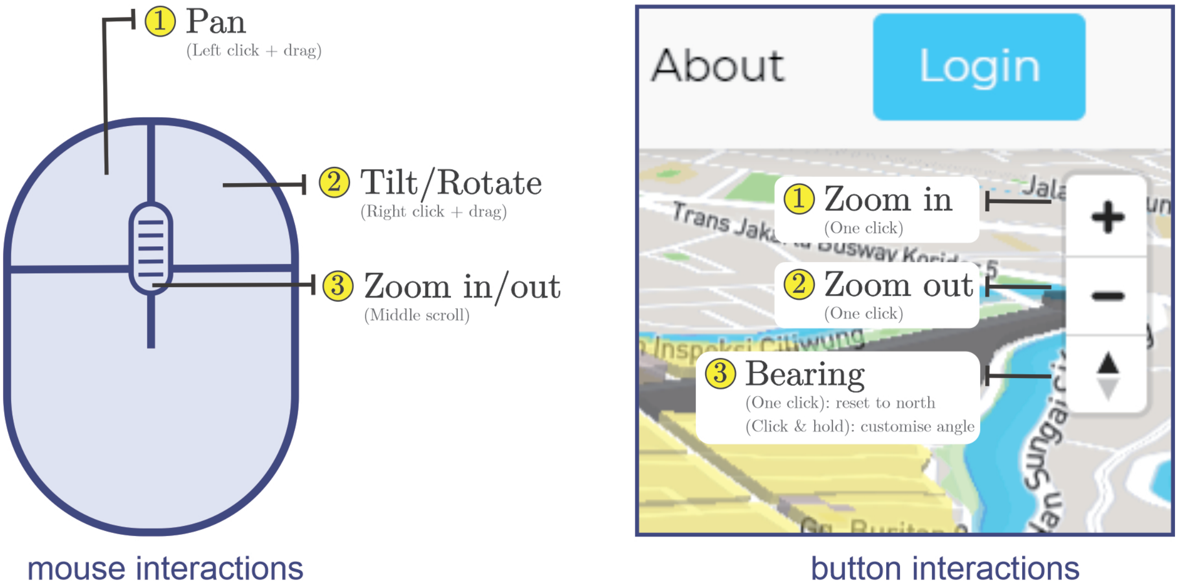


Figure 6.6: Mouse interactions (left) and button interactions (right) functionalities

Through mouse interaction, the user could manipulate the angle and position of the map using their mouse button. Different functions were assigned to each button on a mouse for facilitating user experience. Mapbox provides these functionalities from default. The functionalities provided are: pan, zoom in and out, and rotate.

Button interaction was also provided on the top right of the interface, consisting of zoom in and out button and a compass. The compass button could manipulate the camera bearing with two modes: 1) single click to reset bearing to the north; and 2) click and hold to customise bearing angle. This featured was added by calling Mapbox API, which defines with `mapboxgl.NavigationControl` plugin in Javascript.

Search

Search box is a map function to allow the user to find a specific location quickly and easily. The searching method can be based on addresses, coordinates, name of places/landmarks. This function was added by calling Mapbox Geocoding API through `mapbox-gl-geocoder` plugin inside Javascript, then adding `map.addControl` to display the search button on the interface.

Based on the mockup design, the search function was positioned at the top of the map in order to recognise easily by the user. The user could type an address, a coordinate, or place name; then the closest suggestion will show up. Once the user clicks on the desired suggestion, the map interface would zoom in and pinpoint to the targeted place. The pinpoint would automatically remove once the user clicked on the close ('X') button.

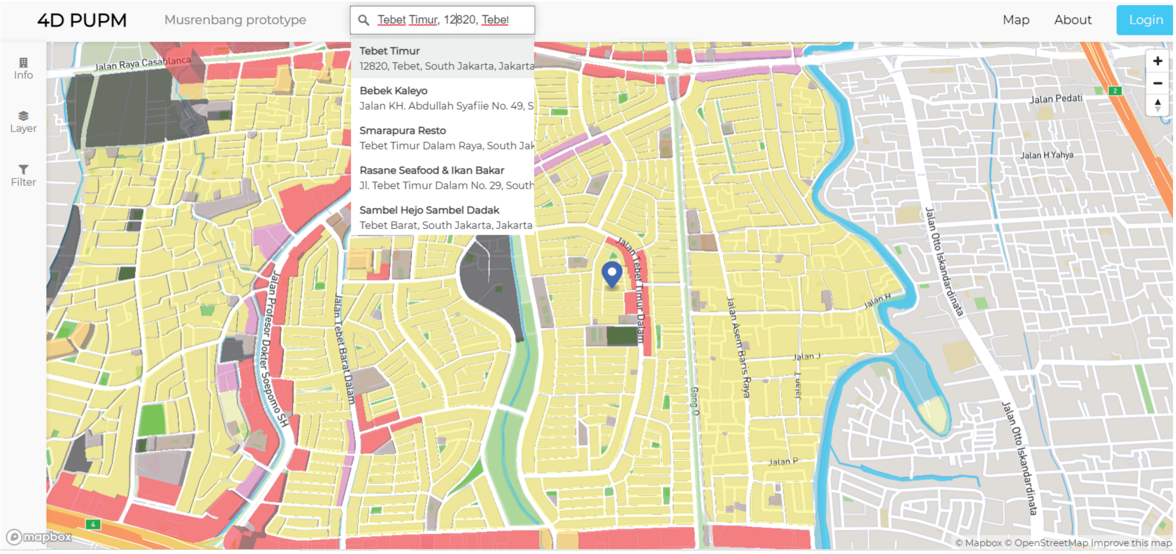
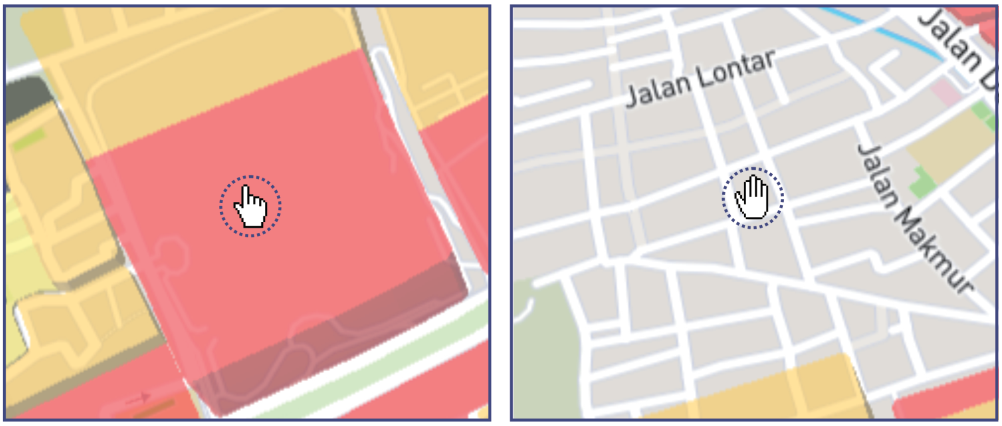


Figure 6.7: Search function in 4D PUPM interface

Object selection

Object selection is referred to the user activity when clicking or touching a certain object on the map interface. In this case, the object selection is used to show attribute information of the selected area. The user only able to click on the dataset layer: the spatial zone. To inform the user, the cursor style would automatically change to a pointer once it touches the datasets, then change it back to hand when it leaves. This feature is crucial to avoid the user sending the wrong action to the map. This function was added using custom script with `map.getCanvas` plugin from Mapbox API in Javascript.



pointer cursor for object selection   drag cursor for panning the view

Figure 6.8: Cursor style in object selection

Attribute information

Attribute information shows the selected layer attribute that is already specified in (Figure 6.9). It is linked to the object selection function, making the selection action to become more convenient. By using this function, the user could get the administrative information to the area. This function gives an overview to non-expert users about what building type they can/cannot build in the specific area during the participation process.

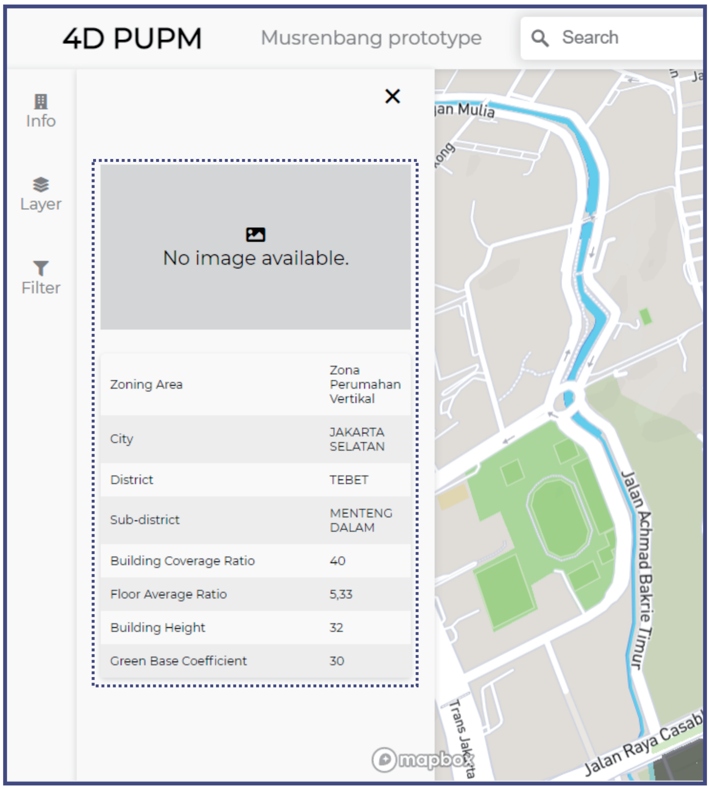


Figure 6.9: Attribute information

This function is usually shown as a popup (or Tooltip) above the selected location. However, based on the mockup design, it is now linked to a hidden sidebar that only activate once the user performs an object selection. When the user clicks on the specific area, each attribute name is added to the desired column by matching the feature property based on the GeoJSON ID. Additionally, an image overview is also added as one attribute in the mockup - but it is not covered in the prototype due to technical issues.

Layer

Layer is a function that helps the user switch on and off the visualisation of the dataset layers on the map interface. This functionality uses `setLayoutProperty` to toggle the visibility value of each layer between 'visible' and 'none. This function is also added to the hidden sidebar activated when the user clicks on the 'Layer' icon. Then, the user could show or hide the layer when the checkbox is checked.

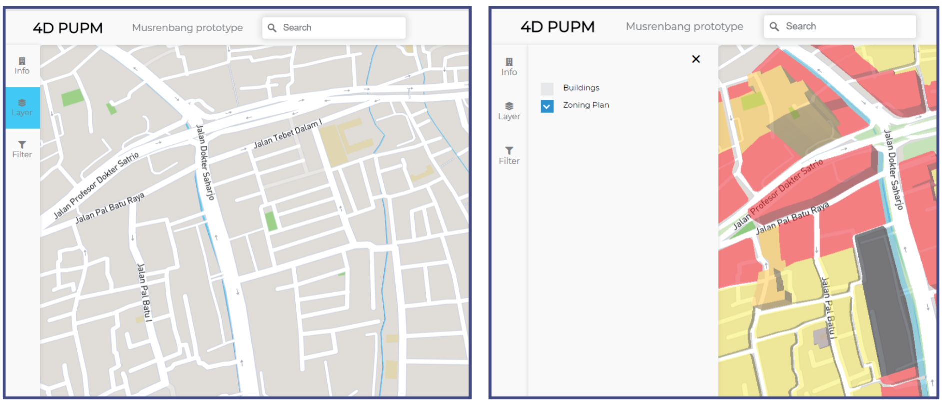


Figure 6.10: Activating the layer function with sidebar icon, then show or hide layer using the checkbox option

Draw

Draw function is developed to simulate the traditional participation activity in Musrenbang. Instead of drawing or sketch on the map, the user can add a 3D building by simply clicking on one of the building options, similar to putting Lego on top of a map. This method is chosen to avoid any errors that might cause by using the sketching method: invalid geometry; polygon does not close, and others.

In this case, the user can give a design idea in a straightforward visualisation (LoD1). However, it is important to note that this prototype aims to increase participation by expanding the non-expert user's involvement during the design process.

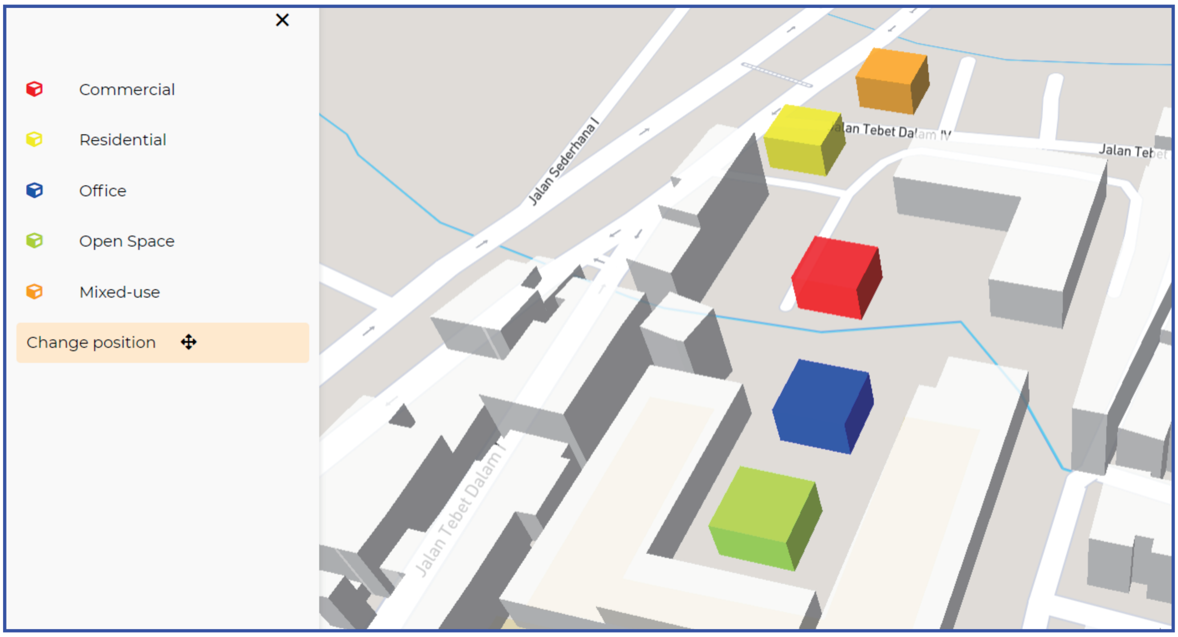


Figure 6.11: Input buildings from Draw function

To build this function, five GeoJSON datasets were added as the 'drawing' tools. This GeoJSON have different colour based on Table 6.2. A snipped from the custom Javascript code is provided below.

The participation mechanism using these simplified 3D models is also very straightforward. The participant could click on the selected building function then position it on the map. The participation process itself is based on distributed-synchronous, meaning that each participant can simultaneously place the model at the same time. However, due to the lack of a database system, the input is only available in up to 15 buildings.

6.3 The result of Phase 3

This phase begins with turning the mockup design into a prototype by adding real 3D datasets of Tebet district, Jakarta, Indonesia and several functionalities so that the user could interact easily with the map. The list of functionalites were added based on analysis of the initial 4D PUPM in Section 5.1.

Overall, this phase has successfully managed to build a prototype, which is called 4D Musrenbang, together with 7 functionalities. Some suggested functions like Filter, Input/Output, and Validation were decided not to be added due to bug issues and time constraints. This prototype is hosted in the Github repository, together with the mockup. It is also available to access via web on: https://nurannisam.github.io/4Dmusrenbang/.

Chapter 7

Testing the Usability of 4D Musrenbang

This chapter is the last part of the simulation-based research, which is PHASE 4. Before explaining each step of the user test, it is important to understand what does the usability mean for this research context. Usability focuses on users' effectiveness to complete tasks and achieve specific goals, as well as the efficiency of time and effort while doing the tasks ISO 9241-11 (2018). In the end, these combinations are well connected to the user opinion and satisfaction with the design of the platform.

7.1 User test setup

The user test aims to validate the level of participation and the prototype's usability for this research. The user test was taking place online using a video conference application (Zoom) and online questionnaire. Even though user test is a crucial step to measure the usability of the 4D PUPM prototype, some limitations need to be taken into account:

- The testing session was conducted in an artificial situation with time and place constraints due to the COVID-19 situation.
  This means that some unsolved technical issues and measurements could affect the result despite the test was simulated as close to the real-world environment.
- The main goal of the user test is not focusing on technological matters.
  Therefore, this does not guarantee that the prototype is 100% reliable and prone-to-errors after the test sessions end.
- Different type of tests and participants might affect the result.
  Different researchers have their own different methods - therefore, it depends on each individual's ability to identify which user test is the best to conduct.

In total, there were two sessions of the user test: 1) pre-test (limited amount of users and tests); and 2) final test. The user session consists of two main tests, which are explained in Table 7.1.

User test session
Persona validation and semi-structured interview
Task-based completion

Table 7.1: Types of user test

The user session leads to two results: the prototype's usability metric and several comments about the participation experiences through the prototype (Jansen, 2020). It means that both qualitative and quantitative elements were assessed during this phase.

The task-based completion test was conducted with quantitative research using a time-based mission that indicates how long the user could complete specific tasks. The participants were also asked to rate their experiences while using the prototype quantitatively. As for Persona validation, mixed-method (qualitative and quantitative) researches were conducted using a semi-structured interview and fill-out online form to elaborate on several issues that the participants thought to need some improvements.

7.1.1 User selection

In general, there is no "one size fits all" solution to determine how many participants should be involved in the user test. Nielsen (2000) stated that a user test with a focus on discovering a problem in an early conceptual prototype ("show-stopping") using five participants could discover over 80% of the problem of the interface. However, this method might not be the best for statistical test purposes since most tasks and questions often rely on opinions and assumptions.

To get the result that fits the best to reality, the user test was performed with participants who match with the initial Persona. Three participants were invited to the pre-test session, then became five participants for the final test. The users then were split into four study groups based on their Persona background.

The participants come from different backgrounds. It is important to mention that all participants were agreed to share their background, experiences, and quotes during their testing process in an anonymous way. Therefore, in this thesis, the participants name were mentioned using nicknames as written in Table 7.2:

Participant A - LAYPERSON
Citizen with an experience joining offline Musrenbang discussion
Participant B - PLANNING ACTOR
Researcher in the field of urban planning
Participant C - GIS ACTOR
Gorvernment staff with experience in cadaster
Participant D - LAYPERSON
Citizen with no experience
Participant E - INTERMEDIARY
Professional in local NGO group

Table 7.2: The invited participants for user test

During the pre-test session, only Participant A, B, and C joined for the user test. Due to this condition, I participated as one of the actor (Intermediary actor) to fill the role gap. However, we discovered some problems during the process:

- One of the participants mentioned that my involvement as an additional participant could create a bias to the result.
- Participants felt exhausted in the middle of the process since they were asked to do the same test multiple times due of Persona differences and technical difficulties.
- Participants agreed to do second test with enabling interaction between participants during the next discussion.

For this reason, a follow-up session was held, and considered as the final result of the prototype with all participants involved. Note that Participant D is considered an 'extreme user', which referred to someone who does not know anything related to this research. The participant's existence might cause a gap from other participants' measurement results (Pruitt and Grudin, 2003). However, I still decided to include Participant D in both test and measurement.

7.1.2 Task selection

To ensure the prototype implementation was able to perform as expected, tasks related to interaction during the participation process were constructed. The main goal of this test is to ensure the usability aspect are covered - such as a) facilitating users to perform participatory planning activities effectively and efficiently; and b) making users feel satisfied.

The tasks are formulated with a short scenario to give some context about what the user should perform. The tasks are listed as follow:

1. Login according to your user role
    a) Request for creating 4D PUPM discussion
2. Access the 'Participate' map interface
3. Search for an address
4. Display information from 3D spatial plan layer
5. Switch 3D dataset layer
6. 'Draw' 3D building
7. Move the added building
    a) Validate the participation input data

7.1.3 Interview and Questionnaire session

The interview is conducted in *Bahasa Indonesia* (Indonesian Language), despite the website's interface is using English. It is based on the agreement from all participants during the pre-test session to avoid confusion and to easily give an opinion with their mother language. However, the interview questions are available in English and *Bahasa Indonesia*. This interview session was semi-structured while the user answering to the question via an online questionnaire.

The interview consists of two parts:

1. In the beginning, the participants were interviewed about their experiences and basic knowledge about Spatial Planning, GIS, and Musrenbang. They were also answering the first test, persona validation, using an online questionnaire. The questionnaire was available via Google Forms for the participants to answer and rate several questions.
2. After the task-based completion test finished, a semi-interview was held using the second part of the questionnaire. This step was to check if the prototype met the participant's expectation.
3. At last, there was a free discussion regarding their personal opinion of the platform. For this part, the participants could ask one another to share their experiences and feelings during the participation process.

7.1.4 Measurement methodology

Several methods are used to analyse the participants' experiences based on the test session during the user test.

Five-point scale of Likert
The first test (Persona validation) and the third test (Semi-interview) requires the participants to rate several statements using a 5-point scale by Likert (1932). For the Persona validation test, the result is compared with the hypothesis Persona on Section 5.1.1. Meanwhile, for semi-interview, the result is combined with Satisfaction measurement from the second test.

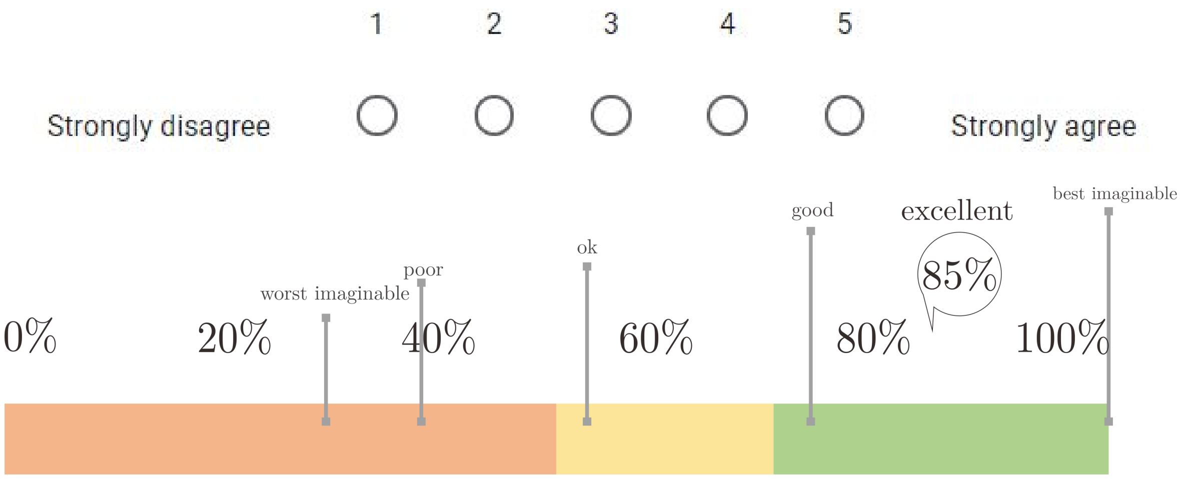


Figure 7.1: Five-point scale of Likert

Performance metrics
The second test measured the usability by creating performance metrics according to the criteria of ISO 9241-11 (2018).

Effectiveness - is measured based on whether the participant has completed a task. The measurement is in binary number with 1 = Success and 0 = Fail.

Efficiency - is measured based on the time duration of the user to complete a task.

Satisfaction - is measured to check whether the participant satisfied with the prototype features and functionalities. This can be measured using Likert and the answer during the interview.

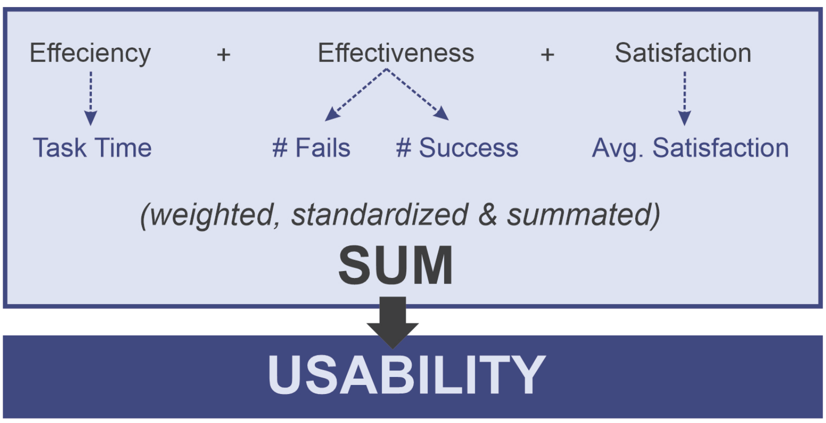


Figure 7.2: Performance metrics using SUM to measure the usability (Sauro and Kindlund, 2005; ISO 9241-11, 2018)

These three criteria are calculated using the Single Usability Metric (SUM) to calculate both subjective (Satisfaction score) and objective (Task time, errors, and success rates) variables (Sauro and Kindlund, 2005). The result indicates the prototype meets the target expectation when the score is 50% to above.

7.2 Persona validation result

During the early development stages of 4D PUPM, most of the user's aspect derived from literature studies and the hypothetical concept of real users. Therefore, before the testing part of the prototype, it is important to validate this personality concept with the target audience.

For the purpose of the personality menasurement, the rating scale of the 'Skill' from Persona groups is being measured.

This research uses Likert (1932) five-point rating to match their reaction from several statements regarding their background and knowledge in Spatial Planning, GIS, Musrenbang. In this case, the hypothetical Persona Section 3.2 is not informed before the discussion to avoid any biased answers.

There are a total of six statements, categorised by Persona skill:

Spatial Planning
Statement 1: I am familiar with the theoretical background of spatial planning in general Statement 2: I am familiar with the spatial planning process in Indonesia Statement 3: I have experienced with participation in the spatial planning process in Indonesia
GIS
Statement 4: I am familiar with the use of GIS tools and software
Public participation
Statement 5: I am familiar with Musrenbang Statement 6: I have experienced participating in Musrenbang in Indonesia

Table 7.3: Statements for matching Persona rating scale

7.2.1 Spatial planning rating scale validation

For this part, the participants were required to rate their opinion for Statement 1, 2, 3 using Likert rate scale. The result is shown in Figure 7.3.

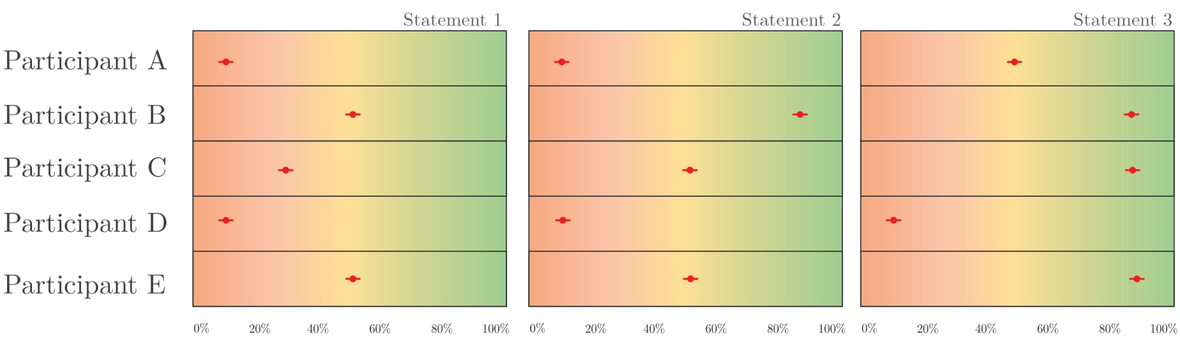


Figure 7.3: Rating scale for spatial planning per participant

Most participants responded to the first statement (spatial planning in a general context) with 50% below average, meaning that the participants disagree with the statement. For Statement 2, regarding the spatial planning process in Indonesia, all users besides Participant A and B were confident having the skill due to their working experience with spatial planning in Indonesia. Surprisingly, Participant C responded to the second statement in neutral even though (s)he currently working under a government agency. As for Statement 3 regarding experience in Indonesia's spatial planning process, all participants except Participant D were confident since they had a history of joining participatory discussion such as Musrenbangdes.

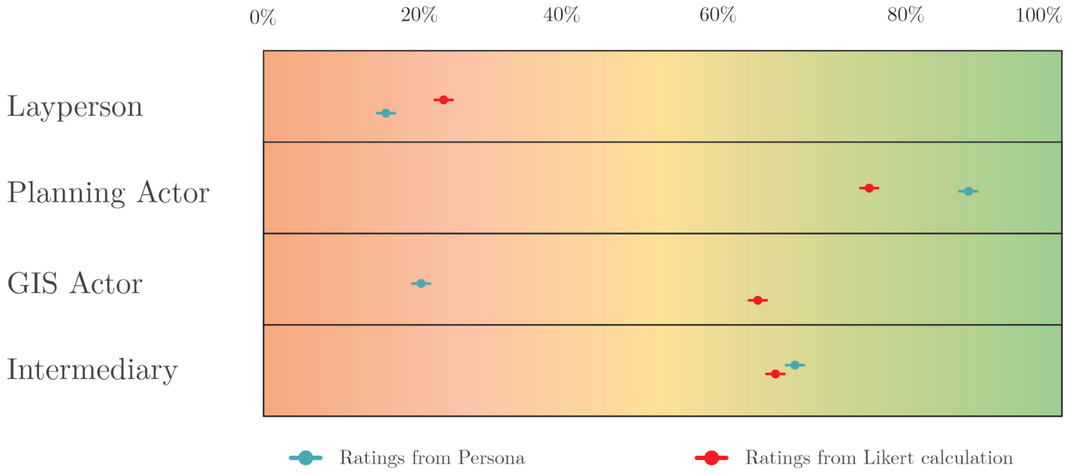


Figure 7.4: Rating scale for GIS per participant

The results from Figure 7.3 are grouped based on the Persona and compared to the initial ratings during Phase 2. The aggregated result in 7.4 shown that as for the GIS actors, the initial assumption for this persona group is too low. However, it could also be due to the invited participants work closely with spatial planning products. Therefore, revising the rating scale of GIS actors through real GIS representation of individual/group will benefit the further design process.

7.2.2 GIS rating scale validation

For this part, the participants were required to rate their opinion for Statement 4 using Likert rate scale. The result is shown in Figure 5.5.

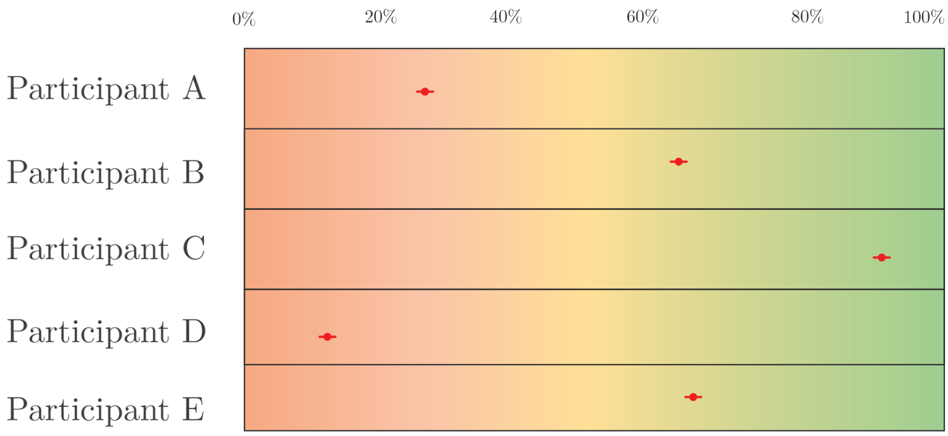


Figure 7.5: Rating scale for GIS per participant

The rating scale for GIS was dispersed from the lowest to the highest rank. Participant C and E responded to the statement with high ranks, while Participant D gave low ranks due to lack of background in GIS technology.

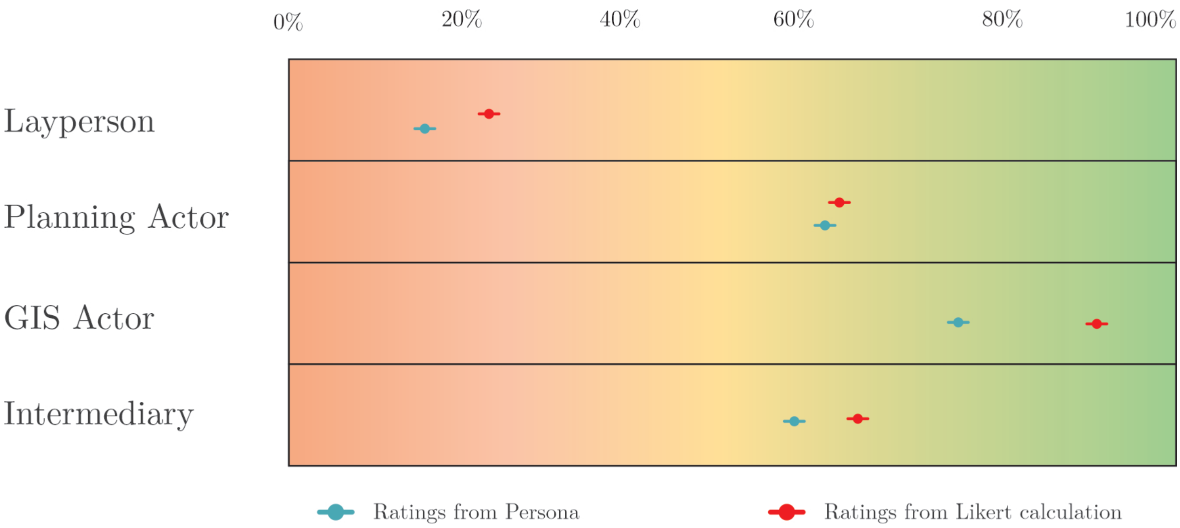


Figure 7.6: Comparison between ratings from initial Persona (blue) and Likert calculation (red) for GIS

The result from Figure 7.6 shows that the initial Persona rating scale is similar to the result from the Likert calculation. This means that the Persona for this group had represented close to the real life actor's condition.

7.2.3 Public participation rating scale validation

Public participation is an extensive-term. Therefore, the statements were specified to spatial planning and/or Musrenbang in Indonesia to get a better rating scale from the participant.

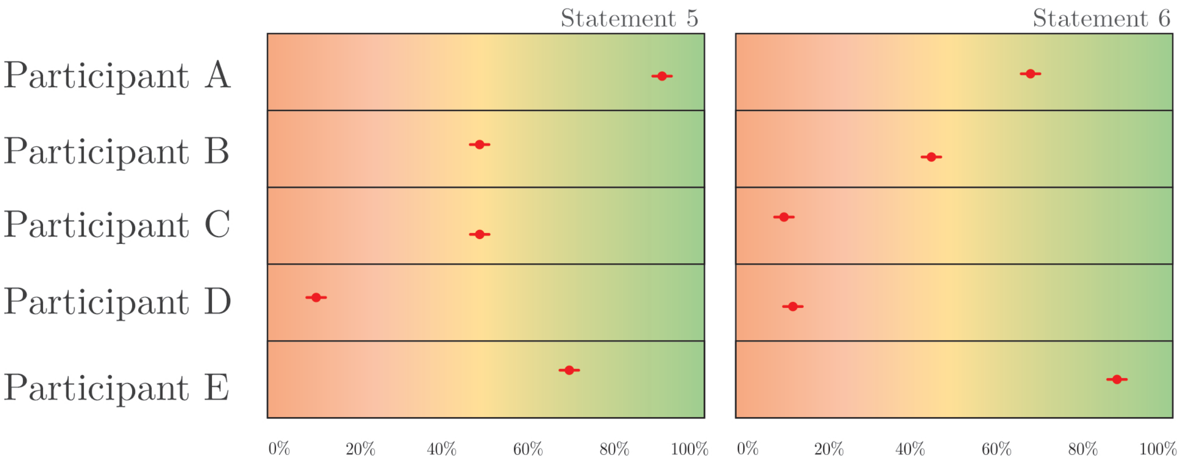


Figure 7.7: Comparison between ratings from initial Persona (blue) and Likert calculation (red) for Public participation

Although Participant A and D are considered non-expert users, Participant A has more experience with traditional Musrenbang. Therefore, (s)he decided to give high rank to themselves compared to other participants.

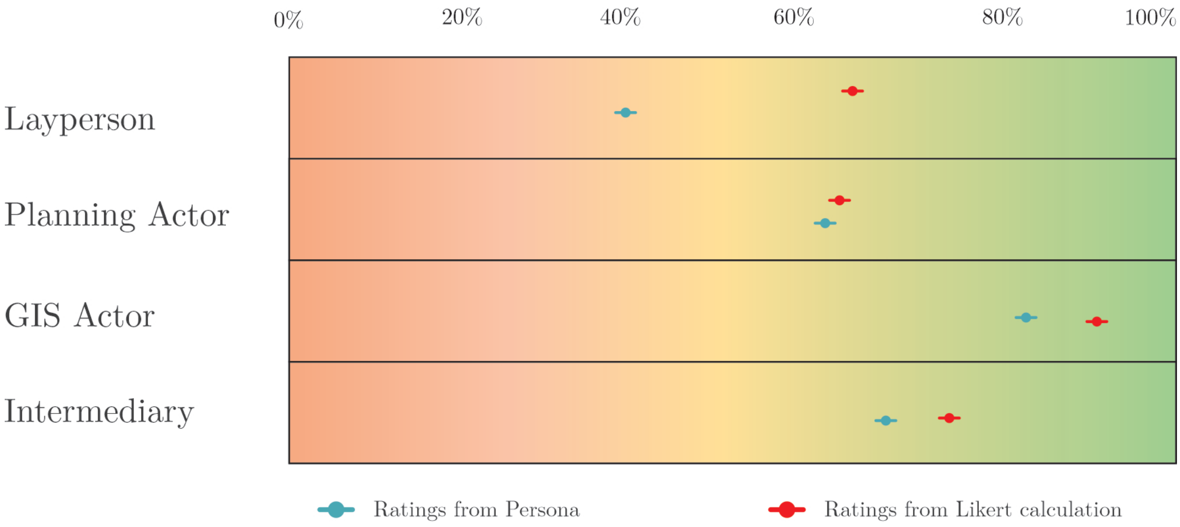


Figure 7.8: Comparison between ratings from initial Persona (blue) and Likert calculation (red) for Public participation

Due to the high bias between Participant A and D, the SUM calculation automatically considered the average of both scores to determine the Layperson rating scale. This created a false statement that increased the initial Persona from only 40% into more than 60%. I had mentioned this problem when introducing the participants on Table 7.2

7.3 Task-based completion result

This section was held to measure how the participants execute and complete tasks using the prototype. During the session, I noted how long did it take for the participant to perform each task successfully.

The measurement was done as follow:

- All participants were required to share their screen during the process.
  However, due to limitation in Zoom, I was only able to see two participant's screens simultaneously. Therefore, there might be some user activity that I was not able to pay attention to.
- The task was informed step by step to the participants, so the participant must perform the task with the right order.
  The timing for each step was started once I finished explaining.
- Once the participant finished a task, they should inform me by click on the 'clap' button.
- To store the time with as high accuracy as possible, the interruption during the task were minimized. If the participant encounter problem during the task, they could 'raise hand' to inform me and send a private chat regarding their problem.
- The participants could only get hints from me a maximum of 5 times, or they would consider to Fail the task. Other than that, I tried to give time constraints for each task within a maximum of 2 minutes. However, this time constraint was decided to be removed for a due to technical issues.

7.3.1 Task 1: Login according to user roles

For this task, the participants were required to perform login action based o their user roles. The information regarding the user role was explained in brief before the task was performed.

Task 1: Login according to user's role

Participant	User Role	Task Time (m:s)	Success	Error	Satisfaction (1 ~ 5)
Participant A	Contributor	00:45	1	0	5
Participant B	Contributor	00:41	1	0	5
Participant C	Validator	00:40	1	0	3
Participant D	Contributor	00:30	1	1	4
Participant E	Mediator	00:50	1	0	3
SUM 84.5%		TIME 97.3%	COMPLETION 100%	ERRORS 8.4%	SATISFACTION 83%

Table 7.4: Usability metric related to Task 1

Before the task started, I explained user roles and who the participant is in this position. All participants can perform this task very quickly without asking for help. However, Participant D accidentally clicked on `Esc` button, and the web page was directed to Github Repository. Although (s)he could finish the task, however, I still considered the error time in the calculation.

In terms of the task, Participant C and E mentioned that Task 1 was not necessary to be added because they focused more on the functionalities. In response to this, I explained my conclusion to PHASE 1 to share knowledge about why I think it was matter to start the task by understanding the concept of user roles to the users.

7.3.2 Task 2: Access the 'Participate' map interface

Participate is HTML hidden page from the guest user. This page contains all the main functionalities regarding the participation process in spatial planning.

Task 2: Access the 'Participate' map interface

Participant	User Role	Task Time (m:s)	Success	Error	Satisfaction (1 ~ 5)
Participant A	Contributor	00:25	1	0	5
Participant B	Contributor	00:33	1	0	5
Participant C	Validator	00:23	1	0	4
Participant D	Contributor	00:46	1	0	4
Participant E	Mediator	00:34	1	0	4
SUM 91.8%		TIME 98.9%	COMPLETION 100%	ERRORS 0%	SATISFACTION 91.9%

Table 7.5: Usability metric related to Task 2

The idea of this task is for the participants to understand the benefit of connecting different tasks with different roles based on the Persona of the user. The task was also straightforward so that the participants could perform without any error.

During this task, all participants expressed satisfaction toward the interface design and map loading speed. Participant A mentioned that the common struggle that (s)he encounters when browsing government site is the web takes too long to load.

"It feels like I can open their website, leave it for a long shower, but yet surprisingly it is still loading when I come back" (Participant A).

This discussion gives an insight into how loading time might affect user's perception of a platform. Since the beginning of Phase 3, I mentioned that my real concern was that the prototype should be easily loaded by the users. However, it is important to note that many things were compromised while building this prototype, such as smaller scale of the datasets, no database system for facilitating GET and POST functionalities, and several custom Javascript library for better map interaction.

Therefore, a better way to facilitate the participation process is always an important concern for further developing a similar prototype.

7.3.3 Task 3: Search an address

For this task, the participants were asked to search for an address using the search function.

Task 3: Search an address

Participant	User Role	Task Time (m:s)	Success	Error	Satisfaction (1 ~ 5)
Participant A	Contributor	01:22	1	0	4
Participant B	Contributor	01:14	1	0	5
Participant C	Validator	01:09	1	0	4
Participant D	Contributor	01:54	1	2	4
Participant E	Mediator	01:21	1	0	3
SUM 82.1%		TIME 94.3%	COMPLETION 100%	ERRORS 14.9%	SATISFACTION 83%

Table 7.6: Usability metric related to Task 3

Participant D was navigated to another place instead of the required address. This is because the API was not locked to only to Indonesia. Therefore, searching for another address in another country is possible. Furthermore, I did not notice that the enter button was connected to the search function. Accidentally pushing the button causing the function to immediately perform before the correct address appeared on the suggested box.

Participant C and E mentioned the suggestion to add functionality to perform searching based on data attribution. However, due to time constraint, this feature was not added to the interface.

7.3.4 Task 4: Display information from a 3D spatial plan

For this part, I informed the task was not as straightforward as the previous tasks to give more challenge to the participants. Eventually, it was affecting the measurement result:

Task 4: Display information from 3D spatial plan					
Participant	User Role	Task Time (m:s)	Success	Error	Satisfaction (1 ~ 5)
Participant A	Contributor	01:44	1	1	2
Participant B	Contributor	01:04	1	0	4
Participant C	Validator	00:46	1	0	4
Participant D	Contributor	01:24	1	1	3
Participant E	Mediator	01:01	1	0	4
SUM 74.1%		TIME 77.8%	COMPLETION 100%	ERRORS 14.9%	SATISFACTION 54.6%

Table 7.7: Usability metric related to Task 4

Instead of using a straightforward sentence, I asked the participants to search for high-rise building development areas. Participant C could understand the task directly due to knowledge of 3D mapping. Participant B and E also did not need a long time to understand the task due to their background in spatial planning.

However, participant A and D were not able to fully understand the meaning of the task. Moreover, some rules regarding maximum hints and time constraints were making them feeling frustrated. Therefore, I figured out that translating spatial terms for non-expert user is also an important usability factor.

7.3.5 Task 5: Switch 3D dataset layer

For this part, the participants were asked to change the map display from a 3D spatial plan to a 3D building.

Task 5: Switch 3D dataset layer					
Participant	User Role	Task Time (m:s)	Success	Error	Satisfaction (1 ~ 5)
Participant A	Contributor	00:44	1	1	5
Participant B	Contributor	01:04	1	0	4
Participant C	Validator	00:46	1	0	4
Participant D	Contributor	00:45	1	1	3
Participant E	Mediator	00:31	1	3	2
SUM 70.1%		TIME 92.4%	COMPLETION 100%	ERRORS 37.9%	SATISFACTION 69.4%

Table 7.8: Usability metric related to Task 5

Task 5 was very simple, and most users can perform it within a short time. Participant E, as the fastest user, criticized the sidebar interface. The placing of two lines of text in a big box was not pleasing from the design perspective.

Participants A, D, and E also tried to click on the text instead of the checkbox multiple times, causing error for themselves.

7.3.6 Task 6: Draw 3D Building

This task was one of the most challenging parts when it came to the user test session. Therefore, the result of the task was as follow:

Task 6: Draw 3D Building

Participant	User Role	Task Time (m:s)	Success	Error	Satisfaction (1 ~ 5)
Participant A	Contributor	02:34	1	1	5
Participant B	Contributor	02:34	1	2	5
Participant C	Validator	02:46	1	1	3
Participant D	Contributor	02:45	0	1	1
Participant E	Mediator	01:31	1	0	5
SUM 65.7%		TIME 61.4%	COMPLETION 96.4%	ERRORS 50.9%	SATISFACTION 80.4%

Table 7.9: Usability metric related to Task 6

Due to technical issue, the task took more than two minutes for all participants, except Participant E (Mediator). The main problem was that the added building overlapped within each other, sometimes even stucked between other buildings. Participant D decided to give up on this task after almost reaching three minutes.

Besides that, Participant A, B, and E were very enthusiastic about this function. Participant B describes the experience *"...like playing with simple building model (Maket) but through laptop"*.

For the calculation, Participant A and B forgot to inform me when they finished the task, so the timing might not be accurate.

7.3.7 Task 7: Move 3D Building

This task was simple yet challenging for all participants. However, the problem was not caused by the participant but due to the technical problem of the function script.

Task 7: Move 3D Building

Participant	User Role	Task Time (m:s)	Success	Error	Satisfaction (1 ~ 5)
Participant A	Contributor	02:54	0	1	1
Participant B	Contributor	02:24	1	2	3
Participant C	Validator	02:30	0	2	1
Participant D	Contributor	02:32	0	2	1
Participant E	Mediator	02:31	1	3	2
SUM 34.7%		**TIME 61.4%**	**COMPLETION 43.5%**	**ERRORS 51.9%**	**SATISFACTION 20.4%**

Table 7.10: Usability metric related to Task 7

Based on the discussion, all participants clearly understood what they did. However, the function caused glitch in the interface, causing a longer time to finish the task. Therefore, many users decided to give up on this task. Participant C suggested that it was better to move the building by setting the coordinates of the selected area.

7.3.8 Reflection

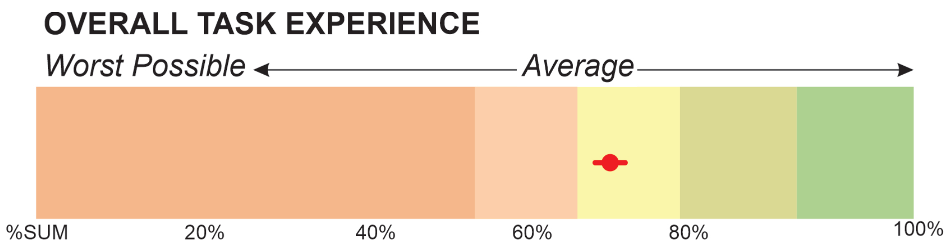


Figure 7.9: Overall Task Experience

Based on the test session, the value for each task were assigned to get a statement of whether the prototype is usable or not. Overall, the usability level of 4D Musrenbang is 71%, meaning that the prototype has successfully achieved this research aim.

7.4 The result of Phase 4

To sum up the whole Phase 4 process, the user test has been carried out by inviting some participants related to the persona group. Then test session was started by doing a Persona validation test to see whether the hypothesis skills of the initial actor groups match with the participants. Then, the session continued with a task-based test, letting the participants interacted with the prototype and measured the usability metric based on the effectiveness, efficiency, and satisfaction. A semi-constructed interview was also done while the participants completing their tasks to get their opinion of what they felt when using the prototype. At last, post-interview and rating scale statements were asked to the participant to get how they feel after finishing the task.

At last, I can conclude, based on the calculation and general thoughts from the interview, designing GIS technology, especially geo-web, using UX could increase the usability and broaden the task experiences during the participation discussion.

Chapter 8

Conclusion

This chapter is the conclusion of all the research processes and a summary of achieved results. Overall, the end goal of this thesis has been achieved by exploring insights of literature and planning regulation documents for general and case studies, conceptualizing the 4PHASE toolkit as the UX design flow, implementing it into a mockup and prototype named 4D Musrenbang, and testing with real actors.From the user test results, it is showed that by using 4D Musrenbang, it is possible to conduct participation activities using 4D representation while having two-way interaction with multiple user types, from the novice to the expert one. However, due to the fact that several technical issues were not included such as a proper database system and a communication tools to support participation, 4D Musrenbang still needs more improvement to be implemented as a geo-participation tool for Indonesia's spatial planning system. Additionally, after experiencing the whole research process, I believe the 4PHASE toolkit can be used in a more broadly designed participation process, other than the spatial planning process.

This research aims to enable interactive geo-web application as a two-way communication platform in the spatial planning decision-making process using a User Experience (UX) approach. Based on this objective, the main research question was determined as follow:

How to design the user experience (UX) for the geo-web applications to support public participation in the spatial planning process?

Even though enormous researchers focus more on the higher accuracy for 3D spatial information, only a few talk about how 3D geo-visualization can be a communication platform for citizens to express their opinion about the spatial planning process. Meanwhile, designing user experience is a very long and iterative process. Through this thesis project, I construct the 4PHASE toolkit to guide the design process of geo-web applications. Toolkit itself means guidance to help to maintain the consistency of participation and user-friendliness of the platform. The 4PHASE toolkit is consisting of four phases of the design methods.

PHASE 1: Define. Participation is a multi-actors activities, meaning that all individual together with their skills and knowledge join forces in the decision-making activities. In order to make sense the user roles and participation tasks in a hierarchical GIS process, creating network of human-to-GIS using the ANT diagram is needed.

PHASE 2: Design. Once the targeted user roles and tasks were discovered, I explored user goals, skills, and frustration, then visualize these as the hypothesis personality (or referred to as Persona). The Persona were then grouped based on a group of people that share similar traits. After creating a persona, it continued to constructing user roles, wireframes (sketches of web flow), and the interface. The result of this phase would be referred to as a mockup.

PHASE 3: Build. In order to convert a mockup into high-fidelity geo-web, 3D spatial datasets and functionalities were feeded into the proposed mockup using HTML, CSS, and Javascript. This was done by converting a mockup into a prototype so that users could use and interact with the platform.

PHASE 4: Test. At last, to check whether the prototype could be used by the users, the phase was ended with the user test. During this phase, several users were invited to check and see whether the prototype's effectiveness, efficiency, and satisfaction.

Throughout these four phases of UX design, I successfully produced two main products for my thesis: mockup design and geo-web prototype, which is called 4D Musrenbang - the main result of that the five user groups tested and evaluated the overall performance of the prototype as good.

To conclude the whole research process, six sub-questions were also answered as follow:

SRQ-1 What is the role of public participation in the spatial planning process in theory?
In general, public participation has a vital role in seeking a balance between two major actors in the spatial planning process: the government as the powerholder and citizens as the individual affected by planning decisions. To find harmony between these actors, modern-day spatial planning requires GIS applications to enhance the placemaking process by allowing citizens to express their needs and preferences. However, current geospatial applications are unable to facilitate instant multiple user input and do not allow to add citizen preferences in the system, making the participation activities with multiple users still unbalance.

Throughout Phase 1, the conceptualization of the human-map participatory planning process was created using the Actor-Network Theory (ANT) diagram. This diagram helped to examine how the "ideal" participatory planning using GIS application could be manifested. As a result, a hierarchical participation flow was made with a list of all intended actors and their task capabilities. In the end, I concluded the process by defining GIS user roles for participatory planning purposes into three groups: 1) Contributor, 2) Mediator, and 3) Validator. Contributor is an individual/group who gives spatial information and shares local spatial knowledge to geo-web as the geo-participation tools – in this case, all participants involved are considered Contributors. Meanwhile, a Validator is an individual/group who checks the validity of the input spatial information. At last, I introduced the concept of Mediator, who facilitates the collaborative flow and communication between users and helping to transfer knowledge from the novice users to the expert users, or the other way.

SRQ-2 What is the role of public participation, as applied to the spatial planning process in Indonesia, and how can this be improved by the use of 4D PUPM?
According to Government Regulation 68/2010, public participation has a crucial role in the spatial planning process in Indonesia. The traditional form of bottom-up participatory planning is actively seen through Musrenbang. However, it is still conducted in a traditional way, which happens offline in face-to-face discussion. Due to this, the submitted ideas or opinions are not shared with the participants of Musrenbang – creating some concerns that there is no guarantee that the decision-makers in spatial planning have considered the voice of the participants.

4D PUPM is an online platform designed for an urban planning monitoring system using 3D spatial representation. Shifting Musrenbang from offline to online using 4D PUPM could make the participation process more democratic than the traditional Musrenbang due to its freedom from the limit of time and place and its potential to reach large numbers of participants. Overall, geo-web applications offer varied opportunities for the citizens to understand their city's transformation better through spatiotemporal visualization. These visualization components are relevant to visualize and analyze the impacts of their land-use choices during the discussion process.

SRQ-3 To what extent can the user experience design bring added value for public participation in the spatial planning process?
Involving GIS technology within the participatory planning decision process has increased the complexity of spatial planning products, such as zoning maps and 3D building models. On the other hand, implementing GIS technologies to facilitate participatory planning could increase its level of participation. If the user aspect is left unchecked, GIS could run into an unnavigable ocean of buttons and maps, resulting in the user becoming frustrated – leading to the users feeling not engaged with the participation activities.

User Experience (UX) helps to visualize these spatial planning products to become more "humane" by guiding users to do a specific task, organizing the participation activities to allow users to achieve their goals, and easy visualization for better user understanding.

SRQ-4 What are the requirements for UX for implementation in 4D PUPM? The initial 4D PUPM has the main drawback with the intended actors because each user role is not yet defined. Therefore, throughout Phase 1, this research mapped all possible actors into the ANT diagram based on Indonesia's spatial planning process. After finding all intended actors and group them based on the most suited user roles, 4D PUPM could start the redesigning process by following four steps: 1) Create Persona, which is a fictional user to guide the design by setting a potential user's target; 2) analyze user flows and participation tasks using the 5E (Entice, Enter, Engage, Exit, Extend) elements; 3) Design wireframes to visualize the schematic of the web flow; 4) Build the interface by considering on the user-friendliness.

SRQ-5 How can these UX requirements be implemented to increase public participation in the spatial planning process in Indonesia?
The proposed 4PHASE toolkit was implemented by creating a prototype to demonstrate the realistic front-end web experiences with a subset dataset of one district in Jakarta (Indonesia) in a GeoJSON format. The development of the prototype uses HTML, CSS, and Javascript for creating high-fidelity representation with the support of GIS and FME for data preparation. The deployment of map interface runs using Mapbox GL JS as the web viewer and several custom functionalities using Javascript to simulate the close experience with offline Musrenbang situation.

SRQ-6 How do users assess the added value in the specific case of spatial planning in Indonesia?
Based on the user assessment, the users appreciate 4D Musrenbang as the modern tool for supporting the participatory planning process in Indonesia. Several participants were happy to be able to put their design opinions by using simplified 3D objects and to be able to actively contributed to the spatial planning system in Indonesia. This could be proven based on the user test result that the usability measurement of 4D Musrenbang is 71%, meaning that the users considered the prototype as good.

8.1 Contribution to the Geomatics Field

This MSc thesis research explores the possibility of designing a 4D geo-web application using the User Experience (UX) approach. Through this research, I combined my technical and non-technical knowledge from what I have learned in Geomatics to built a prototype for facilitating a multi-stakeholder participatory planning process. The scope of the prototype is limited to Jakarta, Indonesia - which might contribute as a starting point of developing a 3D participatory map interface of the chosen location.

The research contributes to bridging spatial planning, GIS, and User Experience ux aspects to both Geomatics and its broader functionalities to the Built Environment, specifically to the urban planning formulation. Also, the position of citizens as active contributors toward spatial information was also rarely explored before. The research about user experience (UX) for geo-web applications to enable active participation is still in the early stages. At last, the proposed 4PHASE toolkit and 4D Musrenbang as the prototype also could contribute in giving guidance to the design aspect of geo-web and/or other GIS-related aplications with multiple users involved.

8.2 Limitations of the Research

Despite a very satisfactory result, still, there are many limitations during the process that I compromised. Firstly, I did not solve several technical issues, mainly to provide the possibility to adapt the size and height of the building and a proper database system into the platform. Furthermore, the terrain visualization is also still in 2D. Therefore, the implementation of 4D Musrenbang is still far from perfect.

Secondly, even though the conception of the user roles and task capabilities comes from a broad perspective, the implementation itself focuses on the current participation mechanism of traditional Musrenbang, specifically in Indonesia. Moreover, the involved actors of traditional Musrenbang during the decision-making can be varied based on the local laws and regulations of each city/region. Therefore, implementing a similar approach would heavily depend on the participation condition and legal aspects of the specific cities/region.

Thirdly, there is a possibility of bias to the user test results due to generalizing the result of small size and no filter to any outlier results. The bias could also happen due to my unclear instructions during the user test session. Personally, I think it is way easier to conduct task-based completion tests face-to-face to measure everything without any delay. However, due to the COVID situation, it was too risky for me to go back to Indonesia, so it was held it via Zoom. For this reason, I recommend additional user tests involving more comprehensive types of participants in future research.

8.3 Future Works

This thesis research presents theoretical and empirical-based research to develop a framework for designing User Experience for geo-web applications. Furthermore, this study highlights that laypersons, as the less-tech savvy users, could contribute as equal as the expert user by creating two-way communication tools using geo-web in a collaborative way and easy-to-use. Finally, through the research, I identify three directions of future work building upon the contribution of this thesis:

1. As the reflection to the prototype, there are still no communication tools provided in 4D Musrenbang. Therefore, this could be a continuation topic to be explored to find the best way to design geo-web as a two-way communication tool in participation. Moreover, other visualization methods such as Virtual Reality (VR) for facilitating participation in the spatial planning process could be an interesting topic.

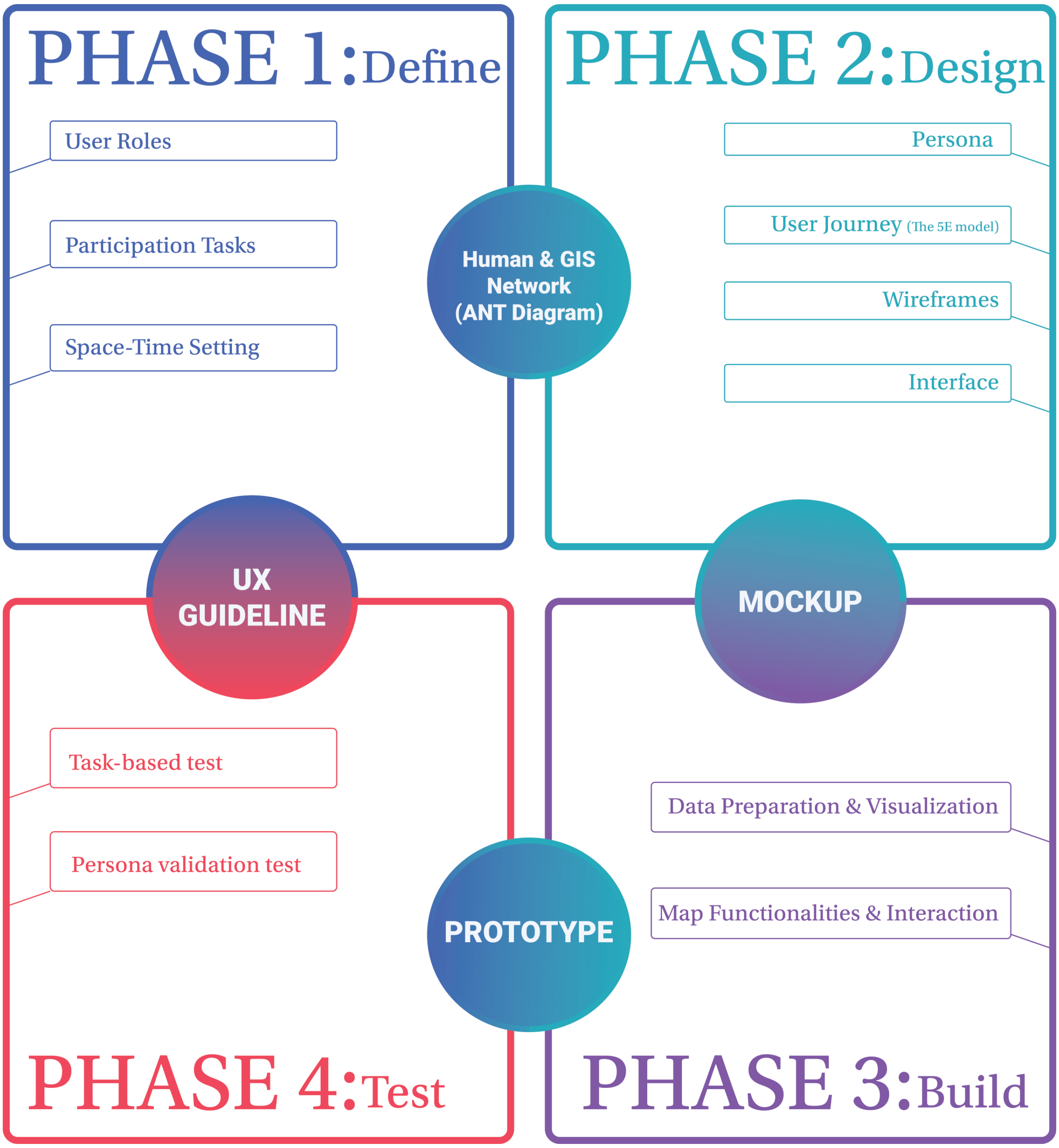
2. Throughout the research process, I constructed the 4PHASE toolkit as the guideline framework to conduct the user experience (UX) methodology and built the 4D Musrenbang prototype. Despite conducting a user test for 4D Musrenbang, I did not conduct any test regarding the design characteristics and phases listed in the 4PHASE. Therefore, a benchmarking study of this toolkit to the other geo-participation tools or other case study locations could be an interesting topic.

3. Nowadays, many governments develop digital twins to represent the physical objects in 3D city models. However, several studies in Chapter 3 mentioned that the duality of simple versus complex 3D spatial visualization strongly impacts the citizen as the layperson to understand the spatial information. Furthermore, some researchers have been reported that when laypersons are exposed to a complex architect's drawing, the visual representation becoming has little meaning as they could not understand what was represented. Therefore, exploring the best way to visualize 3D-based spatial information to the local citizens with no background in GIS could bring more insights, especially to the third phase of the 4PHASE UX framework: data visualization and attribution.

4. Most recent Geomatic research focuses on autonomous geospatial technology with more focus on AI domains, erasing the mediator as one of the user roles on GIS system. However, through this research, the intermediary actors who are positioned as the mediator are considered crucial to help the government-citizen interaction within geo-participation tools. Therefore, in-depth research about how the position of the intermediary actors as the mediator in the autonomous geoinformation environment is still needed may also lead to interesting insights.

Appendix A

The PHASE toolkit



Appendix B

Questionnaire for 4D Musrenbang User Test

4D Musrenbang Questionaire

Background

Thanks for agreeing to join for the user test of 4D Musrenbang today.
For the purpose of this research, I will record this meeting. However, I promise not to share the recording with anyone else, and I will delete all recordings at the end of my thesis research project.

Name

Initial

Job

Select which category might be suitable for you

- ○ **Planning actors**
- ○ **GIS actors**
- ○ **Layperson / Individual**
- ○ **Government**

Persona measurement

Please circle the most appropriate nunmber of each statement which correspond most closely to your desired response

I am familiar with theoritical background of spatial planning in general

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	**Strongly agree**

I am familiar spatial planning process in Indonesia

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	**Strongly agree**

I have experienced participating in spatial planning process in Indonesia

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	**Strongly agree**

I am familiar with Musrenbang

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	**Strongly agree**

I have experienced participating in Musrenbang in Indonesia

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	**Strongly agree**

I am familiar with the use GIS tools and software

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	**Strongly agree**

Usefulness of online musrenbang - 4DPUPM

Please circle the most appropriate nunmber of each statement which correspond most closely to your desired response

Efficient approach for gathering knowledge about spatial plan

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	**Strongly agree**

Enabling involvement for all citizens in spatial planning process

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	**Strongly agree**

Offers opportunity to express user's point of view in spatial planning process

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	**Strongly agree**

Users with no background about GIS or spatial planning can easily participate

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	**Strongly agree**

If yes, what kind functionality do you wish to be included on the platform?

Your answer

Do you have opinion regarding the platform?

Your answer

Appendix C

Wireframes of 4D Musrenbang

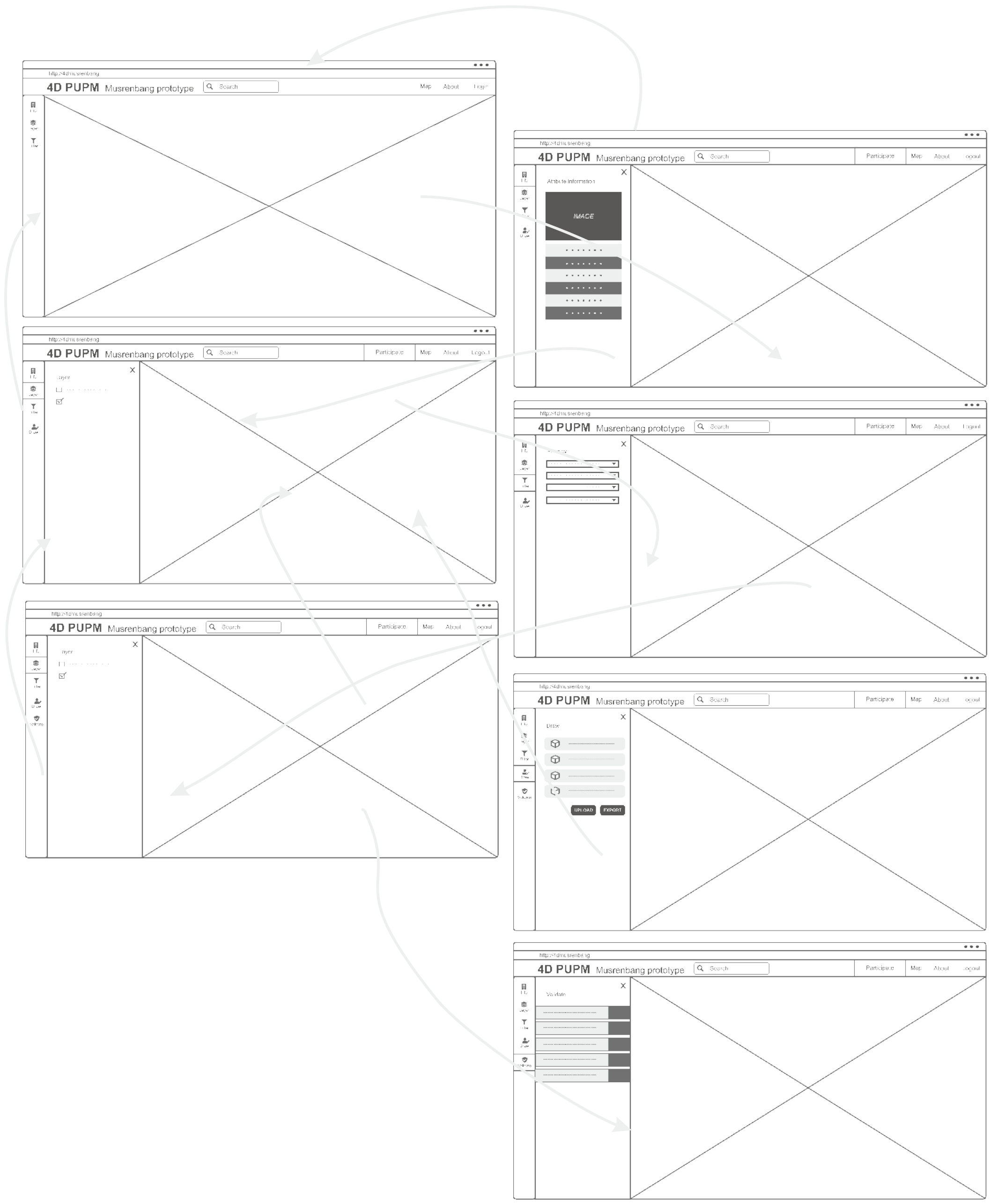


Figure C.1: Interconnection of wireframes - 4D Musrenbang

Appendix D

Javascript code

This appendix contains the customise code which has been included on 4D Musrenbang prototype. The explanation and visualisation of each code were available on Chapter 3. Some codes runs perfectly fine, some sometimes does not run well.

```
//Set variable per attribute
var zonaDisplay = document.getElementById('zona');
var cityDisplay = document.getElementById('city');
var distrDisplay = document.getElementById('district');
var subdistrDisplay = document.getElementById('subdistrict');
var kdbDisplay = document.getElementById('kdb');
var klbDisplay = document.getElementById('klb');
var kbDisplay = document.getElementById('kb');
var kdhDisplay = document.getElementById('kdh');

var zonaID = null;
map.on('click', 'spatplan', (e) => {
    map.getCanvas().style.cursor = 'pointer';
  // Set variables equal to the current feature's attribute
  var quakeZona = e.features[0].properties.ZONA;
  var quakeCity = e.features[0].properties.NAMA_KOTA;
  var quakeDistr = e.features[0].properties.KECAMATAN;
  var quakeSubdistr = e.features[0].properties.KELURAHAN;
  var quakeKdb = e.features[0].properties.KDB;
  var quakeKlb = e.features[0].properties.KLB;
  var quakeKb = e.features[0].properties.KB;
  var quakeKdh = e.features[0].properties.KDH;

    // Check whether features exist
    if (e.features.length > 0) {
    // Display the attribute information
      zonaDisplay.textContent = quakeZona;
      cityDisplay.textContent = quakeCity;
      distrDisplay.textContent = quakeDistr;
      subdistrDisplay.textContent = quakeSubdistr;
      kdbDisplay.textContent = quakeKdb;
      klbDisplay.textContent = quakeKlb;
      kbDisplay.textContent = quakeKb;
      kdhDisplay.textContent = quakeKdh;

        // If ID for the hovered feature is not null,
        // use removeFeatureState to reset to the default behavior
        if (zonaID) {
        map.removeFeatureState({
          source: "spatplan",
          id: zonaID
        });
        }
        zonaID = e.features[0].id;

      map.setFeatureState({
          source: 'spatplan',
        id: zonaID
        });
  }
});
```

```
//Add GeoJSON
    document.getElementById("draw-rectangle4")
    .addEventListener("click", () => {
      // draw.add(user_data);
      map.addSource('fields4', {
        "type": "geojson",
        "data": 'dataset/marker-4.json'
      });
      map.addLayer({
        'id': 'fields4-layer',
        'type': 'fill-extrusion',
        'source': 'fields4',
        'layout': {'visibility': 'visible'},
        'paint': {'fill-extrusion-color': 'orange',
        'fill-extrusion-height': 10,
        'fill-extrusion-base': 0,
        'fill-extrusion-opacity': 0.8}
      });
  });

    \\Zoom to the drawing
  document.getElementById('draw-rectangle').addEventListener('click', function () {
       Fly to a random location by offsetting the point -74.50, 40
        by up to 5 degrees.
        map.flyTo({
        center: [
                    106.85083664953709,
                  -6.2246789378551775
                ], zoom: 18
        });
});
\caption{Javascript code to perform Draw}
```

s

```
map.on('style.load', function() {
    //  Set 3D buildings extrusion and visualisation
  map.addSource('buildings', {
      'type': 'geojson',
      'data': 'dataset/building.json'});
  map.addLayer({
    'id': 'buildings',
    'type': 'fill-extrusion',
    'source': 'buildings',
    'layout': {'visibility': 'none'},
    'paint': {
        'fill-extrusion-color': 'black',
      'fill-extrusion-height': ["match", ["get", "height"]],
      'fill-extrusion-base': 0,
      'fill-extrusion-opacity': 0.5}});

    //Set the 3D buildings extrusion and visualisation
  map.addSource('spatialplan', {
      'type': 'geojson',
      'data': 'dataset/spatialplan.json'});
  map.addLayer({
    'id': 'spatialplan',
    'type': 'fill-extrusion',
    'source': 'spatialplan',
    'layout': {'visibility': 'visible'},
    'paint': {
      'fill-extrusion-color': ["match",["get", "ZONA"],
          ["Zona Campuran"], "hsl(312, 94%, 72%)",
          ["Zona Pelayanan Umum dan Sosial"],"hsl(0, 11%, 64%)",
          ["Zona Perumahan Vertikal"],"hsl(45, 95%, 60%)",
          ["Zona Perumahan KDB Sedang-Tinggi"],"hsl(55, 94%, 64%)",
          ["Zona Perumahan KDB Rendah"],"hsl(58, 98%, 83%)",
          ["Zona Jalur Hijau"],"hsl(107, 91%, 79%)",
```

```
            ["Zona Terbuka Biru"],"hsl(196, 61%, 61%)",
            ["Zona Taman Kota/Lingkungan"],"hsl(105, 90%, 42%)",
            ["Zona Pemerintahan Daerah"],"hsl(29, 46%, 46%)",
            ["Zona Perkantoran, Perdagangan, dan Jasa"],"hsl(0, 88%, 51%)"],
          'fill-extrusion-height': ["match",["get", "z_height"]],
          'fill-extrusion-base': [0],
          'fill-extrusion-opacity': 0.5}});

  //Adding sky atmosphere
  map.addLayer({
    'id': 'sky',
    'type': 'sky',
    'paint': {
    'sky-type': 'gradient',
    'sky-gradient': ['interpolate', ['linear'], ['sky-radial-progress'], 0.8,
            'rgba(135, 206, 235, 1.0)', 1, 'rgba(0,0,0,0.1)'],
    'sky-gradient-center': [0, 0],
    'sky-gradient-radius': 90,
    'sky-opacity': ['interpolate', ['exponential', 0.1], ['zoom'], 5, 0, 22, 1]}});
```
Listing D.1: Javascript code used to set up data visualisation

Bibliography

Adikari, S., McDonald, C., and Campbell, J. (2011). A Design Science Framework for Designing and Assessing User Experience. In Jacko, J. A., editor, *Human-Computer Interaction. Design and Development Approaches*, pages 25–34, Berlin, Heidelberg. Springer Berlin Heidelberg.

Aguilar, R., Calisto, L., Flacke, J., Akbar, A., and Pfeffer, K. (2021). OGITO, an Open Geospatial Interactive Tool to support collaborative spatial planning with a maptable. *Computers, Environment and Urban Systems*, 86:101591.

Aguilar, R., Flacke, J., and Pfeffer, K. (2020). Towards Supporting Collaborative Spatial Planning: Conceptualization of a Maptable Tool through User Stories. *ISPRS International Journal of Geo-Information*, 9(1).

Akbar, A., Flacke, J., Martinez, J., Aguilar, R., and van Maarseveen, M. F. A. M. (2020). Knowing my village from the sky: A collaborative spatial learning framework to integrate spatial knowledge of stakeholders in achieving sustainable development goals. *ISPRS International Journal of Geo-Information*, 9(9):515.

Arnstein, S. R. (1969). A Ladder Of Citizen Participation. *Journal Of The American Institute Of Planners*, 35(November 2012):37–41.

Ballatore, A., McClintock, W., Goldberg, G., and Kuhn, W. (2020). Towards a Usability Scale for Participatory GIS. In Kyriakidis, P., Hadjimitsis, D., Skarlatos, D., and Mansourian, A., editors, *Geospatial Technologies for Local and Regional Development*, pages 327–348, Cham. Springer International Publishing.

Banfield, E. (1959). Ends and Means Planning. *International Social Science Journal*, 11(3):361–368.

Bowen, J. R. (1986). On the Political Construction of Tradition: Gotong Royong in Indonesia. *The Journal of Asian Studies*, 45(3):545–561.

Brown, C. L., Robitaille, A., Zelinski, E. M., Dixon, R. A., Hofer, S. M., and Piccinin, A. M. (2016). Cognitive activity mediates the association between social activity and cognitive performance: A longitudinal study. *Psychology and aging*, 31(8):831.

Buckwalter, N. D. (2014). The potential for public empowerment through government-organized participation. *Public Administration Review*, 74(5):573–584.

Carver, C. (2003). Pleasure as a sign you can attend to something else: Placing positive feelings within a general model of affect. *Cognition and Emotion*, 17(2):241–261.

Carver, S., Evans, A., Kingston, R., and Turton, I. (2001). Public participation, GIS, and cyberdemocracy: Evaluating on-line spatial decision support systems. *Environment and Planning B: Planning and Design*, 28(6):907–921.

Cesium (2021). CesiumJS – Cesium.

Christodoulou, S., Griffis, F. H., Barrett, L., and Okungbowa, M. (2004). Qualifications-based selection of professional A/E services. *Journal of Management in Engineering*, 20(2):34–41.

Corbett, J. M. and Keller, C. P. (2005). An analytical framework to examine empowerment associated with participatory geographic information systems (PGIS). *Cartographica: The International Journal for Geographic Information and Geovisualization*, 40(4):91–102.

Cvetinovic, M., Nedovic-Budic, Z., and Bolay, J.-C. (2017). Decoding urban development dynamics through actor-network methodological approach. *Geoforum*, 82:141–157.

Dias, E., Linde, M., Rafiee, A., Koomen, E., and Scholten, H. (2013). Beauty and brains: Integrating easy spatial design and advanced urban sustainability models. In *Planning support systems for sustainable urban development*, pages 469–484. Springer.

Dovey, K. (2009). *Becoming Places: Urbanism / Architecture / Identity / Power.*

Eikelboom, T. and Janssen, R. (2017). Collaborative use of geodesign tools to support decision-making on adaptation to climate change. *Mitigation and Adaptation Strategies for Global Change*, 22(2):247–266.

Elwood, S. (2010). Geographic information science: Emerging research on the societal implications of the geospatial web. *Progress in human geography*, 34(3):349–357.

Faehnle, M. (2014). *Collaborative planning of urban green infrastructure – need, quality, evaluation, and design.* PhD thesis.

Flacke, J. and De Boer, C. (2017). An interactive planning support tool for addressing social acceptance of renewable energy projects in the Netherlands. *ISPRS international journal of geo-information*, 6(10):313.

FPPM (2008). *Panduan penyelenggaraan musyawarah perencanaan pembangunan desa.*

Gad, C. and Bruun Jensen, C. (2010). On the consequences of post-ANT. *Science, Technology, & Human Values*, 35(1):55–80.

Garret, J. J. (2011). The elements of user experience. *Berkeley, CA: New Riders.*

Getto, G. and Moore, C. (2017). Mapping personas: Designing UX relationships for an online coastal atlas. *Computers and Composition*, 43:15–34.

Ghose, R. (2007). Politics of Scale and Networks of Association in Public Participation GIS. *Environment and Planning A: Economy and Space*, 39(8):1961–1980.

Goodchild, M. F. (2013). The quality of big (geo) data. *Dialogues in Human Geography*, 3(3):280–284.

Government Regulation 15/2010 (2010). Spatial planning implementation.

Government Regulation 68/2010 (2010). Public role in spatial planning.

Government Regulation 8/2013 (2013). Accuracy of Spatial Plan Map.

Haklay, M. (2010). How good is volunteered geographical information? A comparative study of OpenStreetMap and Ordnance Survey datasets. *Environment and planning B: Planning and design*, 37(4):682–703.

Harrlichack, M. A. (1993). The effect of rendering technologies on the evaluation of computer generated design simulation. *Unpublished Master's thesis, State University of New York, Syracuse.*

Healey, P. (2003). Collaborative planning in perspective. *How Concepts Solve Management Problems*, 2(2):101–123.

Hersperger, A. M., Oliveira, E., Pagliarin, S., Palka, G., Verburg, P., Bolliger, J., and Grădinaru, S. (2018). Urban land-use change: The role of strategic spatial planning. *Global Environmental Change*, 51:32–42.

Hudalah, D. (2010). Peri-urban planning in Indonesia. *Contexts, Approaches and Institutional Capacity (Grafimedia, Groningen).*

Indrajit, A. (2019). *4D Open Spatial Information Infrastructure Supporting Participatory Urban Planning.* Number 76.

Indrajit, A. (2021). *4D Open Spatial Information Infrastructure: Participatory urban plan monitoring in indonesian cities*. PhD thesis, Delft University of Technology.

Innes, J. E. and Simpson, D. M. (1993). Implementing GIS for planning lessons from the history of technological innovation. *Journal of the American Planning Association*, 59(2):230–236.

Involve, U. K. (2005). People and Participation: How to Put Citizens at the Heart of Decision Making.

Isenberg, P., Elmqvist, N., Scholtz, J., Cernea, D., Ma, K.-L., and Hagen, H. (2011). Collaborative visualization: Definition, challenges, and research agenda. *Information Visualization*, 10(4):310–326.

ISO 9241-11 (2018). Ergonomics of human-system interaction - Part 11: Usability: Definitions and concepts.

Jansen, C. (2020). *A CHANGE OF VIEW : Usable Interface design propositions for geoportals*. PhD thesis, Delft University of Technology.

Kaplan, R., Kaplan, S., and Brown, T. (1989). Environmental preference: A comparison of four domains of predictors. *Environment and behavior*, 21(5):509–530.

Kato, S. and Ahern, J. (2008). 'Learning by doing': Adaptive planning as a strategy to address uncertainty in planning. *Journal of Environmental Planning and Management*, 51(4):543–559.

Keeble, L. B. (1969). *Principles and practice of town and country planning*. Estates Gazette.

Kingston, R. (2011). Online public participation GIS for spatial planning. *The SAGE handbook of GIS and society*, pages 361–380.

Kinzer, K. (2016). Missed Connections: A Critical Analysis of Interconnections between Public Participation and Plan Implementation Literature. *Journal of Planning Literature*, 31.

Kramers, R. E. (2008). Interaction with maps on the internet - A user centred design approach for the atlas of Canada. *Cartographic Journal*, 45(2):98–107.

Lafrance, F., Daniel, S., and Dragićević, S. (2019). Multidimensional Web GIS Approach for Citizen Participation on Urban Evolution. *ISPRS International Journal of Geo-Information*, 8(6).

Laksono, D. and Aditya, T. (2019). Utilizing A Game Engine for Interactive 3D Topographic Data Visualization. *ISPRS International Journal of Geo-Information*, 8(8).

Latour, B. (1996). On actor-network theory: A few clarifications. *Soziale welt*, pages 369–381.

Latour, B. and others (2005). *Reassembling the social: An introduction to actor-network-theory*. Oxford university press.

Law No. 25/2004 (2004). National Development Planning System.

Law No. 26/2007 (2007). Spatial plan.

Likert, R. (1932). A technique for the measurement of attitudes. *Archives of psychology*.

Loonen, L. (2020). *Timing the Level of Citizen Participation in Spatial Planning Processes*. PhD thesis, Utrecht University.

MacEachren, A. and Taylor, D. (1994). *Visualization in Modern Cartography*. Pergamon, London.

Maceachren, A. M. and Brewer, I. (2004). Developing a conceptual framework for visually-enabled geocollaboration. *International Journal of Geographical Information Science*, 18(1):1–34.

Mapbox (2021). Mapbox GL JS | Mapbox.

Mapuva, J. (2015). Citizen participation, mobilisation and contested participatory spaces. *International Journal of Political Science and Development*, 3(10):405–415.

McCall, M. K. (2003). Seeking good governance in participatory-GIS: A review of processes and governance dimensions in applying GIS to participatory spatial planning. *Habitat International*, 27(4):549–573.

McCall, M. K. and Dunn, C. E. (2012). Geo-information tools for participatory spatial planning: Fulfilling the criteria for 'good' governance? *Geoforum*, 43(1):81–94.

Mohamed, A. and Solo Kota Kita (2012). Solo Kota Kita, Indonesia.

Morphet, J. (2010). *Effective practice in spatial planning*. Routledge.

Morrison, A. and Arnall, T. (2011). Visualizations of digital interaction in daily life. *Computers and Composition*, 28(3):224–234.

Nabatchi, T. (2012). *A manager's guide to evaluating citizen participation*. IBM Center for the Business of Government Washington, DC.

Nielsen, J. (2000). Why you only need to test with 5 users.

Nurmandi, A., Purnomo, E. P., Prianto, A. L., and Jaenuri, M. (2015). The current practice of citizen participation in Indonesia netizen and selected cases of local democracy in Indonesia. *CITIZEN PARTICIPATION*, page 21.

O'Donnell, A. M. and O'Kelly, J. (1994). Learning from peers: Beyond the rhetoric of positive results. *Educational Psychology Review*, 6(4):321–349.

Oviatt, S., DeAngeli, A., and Kuhn, K. (1997). Integration and synchronization of input modes during multimodal human-computer interaction. In *Proceedings of the ACM SIGCHI Conference on Human factors in computing systems*, pages 415–422.

Pánek, J. (2016). From mental maps to GeoParticipation. *The Cartographic Journal*, 53(4):300–307.

Pettersson, M., Stjernström, O., and Keskitalo, E. C. H. (2017). The role of participation in the planning process: examples from Sweden. *Local Environment*, 22(8):986–997.

Pruitt, J. and Grudin, J. (2003). Personas: practice and theory. In *Proceedings of the 2003 conference on Designing for user experiences*, pages 1–15.

Resch, B. and Zimmer, B. (2013). User experience design in professional map-based geo-portals. *ISPRS International Journal of Geo-Information*, 2(4):1015–1037.

Richardson, A. (2010). Using customer journey maps to improve customer experience. *Harvard business review*, 15(1):2–5.

Rinner, C. and Bird, M. (2009). Evaluating Community Engagement through Argumentation Maps—A Public Participation GIS Case Study. *Environment and Planning B: Planning and Design*, 36(4):588–601.

Rosenbaum, M. S., Otalora, M. L., and Ram\'\irez, G. C. (2017). How to create a realistic customer journey map. *Business Horizons*, 60(1):143–150.

Salomon, G. and Globerson, T. (1989). When teams do not function the way they ought to. *International journal of Educational research*, 13(1):89–99.

Sauro, J. and Kindlund, E. (2005). A method to standardize usability metrics into a single score. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 401–409.

Sawczuk, B. and Nicholson, M. (1992). The management of the design process. *Architectural management*, pages 84–89.

Shrestha, R., Flacke, J., Martinez, J., and Van Maarseveen, M. (2018). Interactive cumulative burden assessment: Engaging stakeholders in an adaptive, participatory and transdisciplinary approach. *International journal of environmental research and public health*, 15(2):260.

Sieber, R. (2006). Public Participation Geographic Information Systems: A Literature Review and Framework. *Annals of the Association of American Geographers*, 96(3):491–507.

Sieber, R. E., Robinson, P. J., Johnson, P. A., and Corbett, J. M. (2016). Doing public participation on the geospatial web. *Annals of the American Association of Geographers*, 106(5):1030–1046.

Sindre, G. M. (2012). Civic engagement and democracy in post-Suharto Indonesia: A review of Musrenbang, the kecamatan development programme, and labour organising. *PCD Journal*, 4(1-2):1–40.

Sopanah, A. (2012). Ceremonial budgeting: public participation in development planning at an Indonesian local government authority. *Journal of Applied Management Accounting Research*, 10(2):73.

Stellingwerff, M. and Kuhk, A. (2004). 3D/4D communication tools for facilitators in public participation.

Thwaites, K. (2001). Experiential landscape place: An exploration of space and experience in neighbourhood landscape architecture. *Landscape Research*, 26(3):245–255.

Van De Ven, F. H. M., Snep, R. P. H., Koole, S., Brolsma, R., Van Der Brugge, R., Spijker, J., and Vergroesen, T. (2016). Adaptation Planning Support Toolbox: Measurable performance information based tools for co-creation of resilient, ecosystem-based urban plans with urban designers, decision-makers and stakeholders. *Environmental Science & Policy*, 66:427–436.

Vonk, G. and Ligtenberg, A. (2010). Socio-technical PSS development to improve functionality and usability—Sketch planning using a Maptable. *Landscape and Urban Planning*, 94(3-4):166–174.

Webb, B. R. (1996). The role of users in interactive systems design: when computers are theatre, do we want the audience to write the script? *Behaviour & Information Technology*, 15(2):76–83.

Zenghong, W., Yufen, C., and Jiaquan, L. (2012). An emerging trend of GIS interaction development: Multi-touch GIS.