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Key words: spatial planning, participation, Indonesia

SUMMARY

Public participation is an important prerequisite for the success of spatial planning. Technology can help improve the quality and amount of public participation in spatial planning. This paper describes the development of the User Experience (UX) design guideline named '4PHASE toolkit'. The toolkit was used to create a web-based GIS prototype, applied on the spatial planning practice in Indonesia. In Indonesia the spirit of community involvement is incorporated into the spatial planning process using a bottom-up approach.

The so-called Musyawarah perencanaan pembangunan (Musrenbang) is the traditional tool in participatory planning during the plan-making process. Meanwhile, as technology development is used as communication strategy for the government, 4D Open Spatial Information Infrastructure (4D PUPM) has emerged as a modern tool to monitor the implementation of land use plans. The exploration of both traditional and modern tools is done to get valuable information about what needs to be added for building the prototype. Our research resulted in a 4D web-based GIS prototype named 4D Musrenbang, while building on 4D PUPM to facilitate citizens participating in the spatial planning process in Indonesia.

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1. INTRODUCTION

In modern-day spatial planning, the role of public participation becomes more and more important in order to find a balance between two major actors: the government as the powerholder and citizens as the individual affected by planning decisions (Vitálišová et al., 2021). 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 citizen participation and spatial information by involving non-expert stakeholders in the decision-making process leading to the land use plan (Kahila-Tani et al., 2016).

Along with the smart city agenda, and based on the insight that providing open data alone is not sufficient (Gagliardi et al., 2017), there has been an increase in the appearance of detailed, multidimensional (3D & 4D) spatial data visualisations, usually described as digital twins, to support citizen participation activity. A web-based GIS application, known as geo-web, is often used to facilitate this participation, making it possible to connect multiple users to virtually share their opinions (Atzmanstorfer et al., 2014). However, achieving a well-functioning solution that satisfies the needs of citizens is less obvious than one might expect.

While on one hand researchers argue that 3D visualisations, compared to traditional 2D maps, can significantly improve the understanding of non-expert users (Indrajit, 2021), on the other hand research shows that many users cannot handle the mass functionalities provided by geo-web applications (Kramers, 2008; Resch and Zimmer, 2013).

Participatory mapping activities such as sketching can be easy to implement using 2D maps, however the story will differ when we use 3D maps. Not everyone can draw the visualisation of their houses in 3D; thus, it requires special skills that belong to specific users. Kaplan et al. (1989) argue that a simplified model 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.

However, while geo-web technologies are emerging trends, there is still a lack of user consideration during the design process, and there is a lack of research on how this can be established (Lafrance et al., 2019). The risk is that GIS technology ends up running into an unnavigable ocean of buttons and 3D visualisations, resulting in users that can easily get lost and become frustrated. In the worst case, users may find themselves unable to use the applications successfully and quit the participation in the planning process altogether. 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.

2. USER EXPERIENCE (UX) DESIGN GUIDELINE FOR GEO-WEB

User Experience (UX), the process of enhancing user satisfaction by improving the overall experience provided by the interaction between the user and the product, is crucial to engage users with spatial planning products and effectively meeting their aspirations. The User Experience / User Interface (UX/UI) describes a set of guidelines and workflows for critical thinking about the design and use of an interactive product (Garret, 2011). Although UX and UI complement each other, they are not the same due to their difference in focus between interaction and interface. The User Interface is what the product looks like at the end, referring to the website's appearance. 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).

2.1 The 4PHASE Toolkit

The research aims to create a UX design strategy scheme in building geo-web applications for participation purposes. This design structure provides a guideline so that geo-web could accommodate and facilitates active participation from multi-stakeholders in a two-way communication, making optimal use of 3D visualisations. The research led to the development of the User Experience (UX) design guideline named '4PHASE toolkit'. The 'Toolkit' refers to the style guide templates to help to maintain the consistency of participative and user-friendliness of geo-web applications. This toolkit consists of four phases:

- **PHASE 1: Define.** The first phase is based on theoretical insights on the spatial planning process and citizen participation. This research uses 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 result of phase 1 into a conceptual UX design. Geo-web as digital mapping can be complex due to the unique spatial information representations to be displayed. UX design can help create efficient and effective user-guidelines flow before, during, and after accessing the interface. The result of this phase will be a mockup consisting of design elements of the platform, however, not yet including functional elements.
- **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.
- **PHASE 4: Test.** The final phase focuses on evaluating the platform's usability. 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.

3. IMPLEMENTATION TO INDONESIA'S CASE

The toolkit was used to create a web-based GIS prototype, applied to Indonesia's spatial planning practice, especially on the so-called *Musyawarah perencanaan pembangunan* (Musrenbang), being the traditional tool in participatory planning during plan-making process.

Both the formal-institutional forces and the informal-cultural forces are the drivers of Indonesia's spatial planning system. While the top-down governmental structures and legal frameworks formalise 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 encourages citizens to participate in the spatial planning process.

Participation in the planning process itself is stated in Government Regulation 68/2010. According to art.2 'citizens contribute to the process of the plan-making process (*perencanaan tata ruang*), the utilisation of space (*pemanfaatan ruang*), and controlling the space development (*pengenalian pemanfaatan ruang*) based on their legal rights and obligations'. Art. 9 provides the citizen the 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; (c) to report to the government agencies violations of the actual space utilisation in comparison to the spatial plan; (d) to report the irregularities from official statements regarding the development process that is considered to violate the spatial plan. 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)' (art. 13). Also, the participation can be carried out by individuals, organisations, and professionals (Government Regulation 68/2010, 2010).

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 harmonise differences between government and non-government stakeholders to reach the 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 the Local development planning agency (Bappeda) to assign resources to each neighbourhood depending on the available funds based on their needs (Mohamed and Solo Kota Kita, 2012). 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 include sharing information resources and local spatial knowledge by creating a neighborhood-level map and socio-spatial discussion (Mohamed and Solo Kota Kita, 2012; Akbar et al., 2020). In 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).

3.1 The initial tool: 4D PUPM

In Indonesia, several modern tools have emerged to support digital participation. Among them, 4D Open Spatial Information Infrastructure (4D PUPM) provides modern-day participation tools to put a 3D city model into action to monitor the implementation of land use plans through a participatory process (Indrajit, 2021). The exploration of both traditional and modern tools is done to get valuable information about what needs to be added for building the prototype.

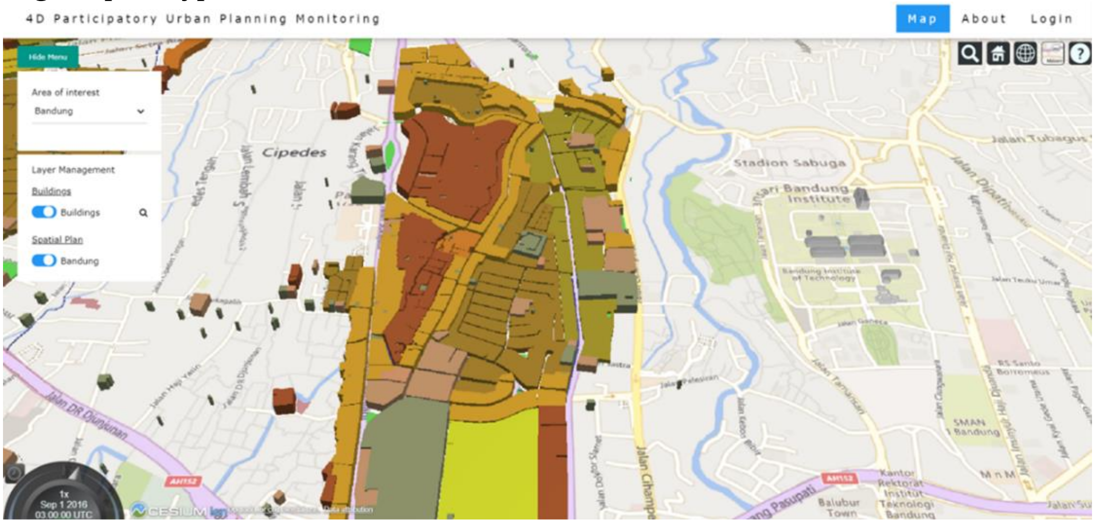

Figure 1. Interface of 4D PUPM

Developed by Indrajit (2021), the 4D Open Spatial Information Infrastructure (4D PUPM) is a geo-web application to monitor through a participatory process the implementation of spatial planning. The platform works under the national mapping agency named Geospatial Mapping Agency and can be accessed on: https://tanahair.indonesia.go.id/pupm. This application shows the 3D spatial zoning from provincial to city level. 4D PUPM aims to provide the citizen a better understanding of the spatial properties of the urban objects. At the moment, the 4D (3D + time) spatial information available on 4D PUPM are the 3D buildings and 3D spatial plans of two cities in Indonesia: Bandung and Jakarta.

The user's roles of 4D PUPM are divided into three types: 1) Contributor Attribute, 2) Contributor Geometry, and 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. The guest user cannot input any spatial or non-spatial information into the platform. After registration, the user can choose the user role based on preference to access different interfaces and functionalities. Being a contributor attribute, the user has the capability to update (add, delete, or edit) the attribute of a 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 latter role seems specific for government staff. 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, in this phase of the toolkit the research added the existing traditional participation activities, Musrenbang, to the first process, the formulation of planning.

3.2. The proposed tool: 4D MUSRENBANG

With the recent development of Web 2.0, further development of GIS 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.

The research resulted in a 4D web-based GIS prototype named 4D Musrenbang, building on the 4D PUPM to facilitate citizens participation in the spatial planning process and resulting in a UX design that combines existing 4D PUPM functionalities with the Musrenbang workflow to maximise the participation process of the platform.

3.2.1. PHASE 1: Defining the Human-to-GIS connection

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. Thus, it has brought a paradigm shift of how citizens could engage with spatial planning issues and policy-making processes using GIS technologies. With this in mind, we might ask what an ideal GIS would be like to support participation in the spatial planning process? By exploring the theory of PPGIS, the conceptualisation 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. The research conceptualised 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, which emphasises the connection between human and non-human, that is, the GIS, actors to examine how spatial planning participation is manifested.

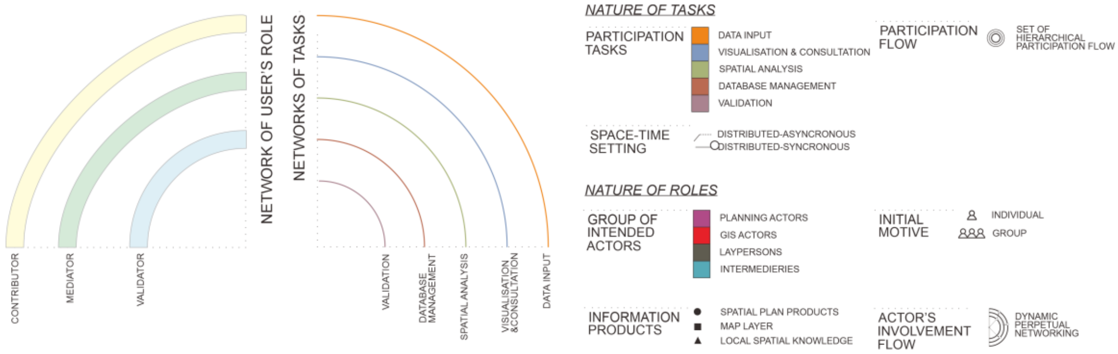

Figure 2. Conceptualisation of human-map interaction in participatory GIS using the ANT diagram

This research develops the ANT diagram (see Figure 2) based on the intended actors as the human actors with GIS application as the non-human actors into two natures:

- 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).
- Nature of roles: The nature of roles is displayed to maximise 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.

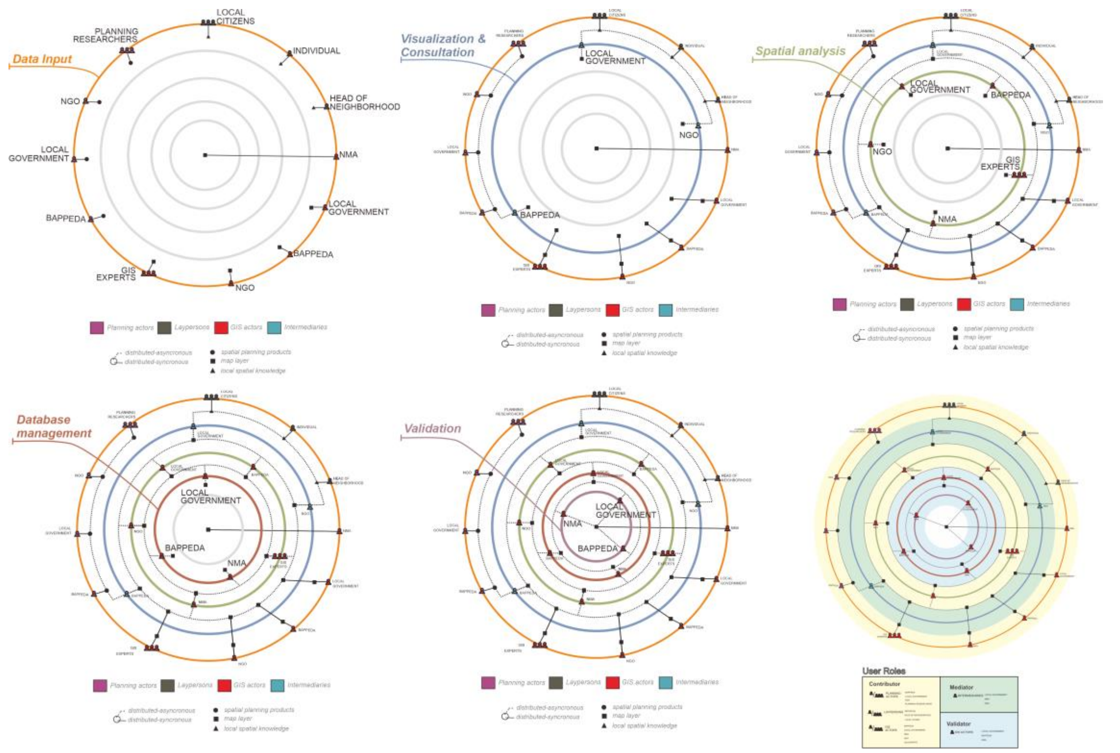

Figure 3. Final result of Phase 1 to define the user roles and participation tasks

As the final result of Phase 1, the user roles conception is made, based on the intended actor's capabilities (see Figure 3). These roles are based on whether they know about spatial planning, GIS, both, or none. This Model visualises 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, and 3) Validator.

3.2.2. PHASE 2: Designing the interface

The research resulted in a 4D web-based GIS prototype named 4D Musrenbang, building on the 4D PUPM to facilitate citizens participation in the spatial planning process, and resulting in a UX design that combines existing 4D PUPM functionalities with the Musrenbang workflow to maximise the participation process of the platform. The result creates a design mockup named '4DMusrenbang' in HTML, Javascript, and CSS format.

Once the targeted user roles and tasks were discovered, the user goals, skills, and frustration, were visualised as the hypothesis personality, or referred to as 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. The four Persona that could be distinguished, i.e. Planning Actor, GIS Actor, Layperson and Intermediary, were then grouped based on a group of people that share similar traits.

To break down the platform's whole experience from each persona's type, the 5E Model to translate participation activities into the experience design concept (Richardson, 2010;

Rosenbaum et al., 2017), helps the UX designer understand how users can enter the platform and what they carry with them after they close the platform.

The designer illustrates each step that the users will go through while engaging with the platform by creating a user flow through five elements called the 5E Model. This consists of:

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

After creating the 5E Model, the four intended actors are mapped based on the user roles: Contributor, Mediator, and Validator. The contributors can foster both spatial information and local spatial knowledge through sketches, annotations, and existing spatial datasets. This will be visualised on the 'Map Interface' panel during the discussion process. Mediators, which consist of Intermediary actors, provide discussion panels and translate the visualization-and-control-map-layer visualisation during the discussion process. Finally, 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.

The main challenge of implementing GIS technologies to facilitate participatory planning lies in that users do not understand the GIS. Therefore, UX helps to recognise the need of each involved user, guide users to do a specific task, organise the platform to allow users to achieve their goals, and visualise 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 organisation; 4) Designing the final interface based on user-friendliness.

3.2.3. PHASE 3: Building participatory geo-web

One of the main goals from the mockup resulting from PHASE 2 is to re-design the initial 4D 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 were analysed:

- Cesium JS: an open-source Javascript library to create a 3D geo-web application.
- Mapbox: a Javascript library to render interactive maps using WebGL.

These two libraries are selected because of their wide variety of functions and are free to use and access. Since this research focuses mainly on 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.

Based on a comparison Mapbox GL JS provides more benefits for supporting user-friendly geo-web applications 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 visualisation requirements from Phase 2 due to its ability to customise the map styling features. However, Mapbox has an important technical limitation: to visualise 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' visualisation (for example: visualising 3D building with each floor having different ownership like an apartment building). However, it is still possible to solve this limitation by using a third-party application like Three.js.

In Phase 3, the mockup was developed into a prototype by adding several map functionalities and interactions and adding real 3D datasets. The area of interest is located in Tebet district, Jakarta city, Indonesia. This part of the city is chosen because of its detailed attribute information compared to other districts' datasets. The dataset utilised in the prototype combines 3D spatial plans with building models of Jakarta, Indonesia. The input datasets of the prototype are:

- 2D spatial zoning plans from the province 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 accessed from the official Jakarta city's geoportal and the National Land Agency (BPN), recorded as a polygon in 2D shapefile format. The original dataset is in 2D shapefile format, provided with the building height attribute. Therefore, a data conversion process has been conducted to convert the 3D map in shapefile into a 3D map in GeoJSON, which then later would be inserted to the dynamic map interface.

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 a 3D visualisation. To simulate the 3D environment in a more realistic way, a sky atmosphere to the space above the mapping horizon was also added using Javascript.

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

- **View.** 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: by mouse and button. Through mouse interaction, the user can 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 a 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 feature was added by calling Mapbox API, which defines mapboxgl.NavigationControl plugin in Javascript.

- **Search.** The search box is a map function to allow the user to find a specific location quickly and easily. The search can be based on addresses, coordinates, name of places/landmarks. This function was added by callingMapbox 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 be recognised 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.
- **Object selection.** Object selection refers 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 is 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 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 a custom script with map.getCanvas plugin from Mapbox API in Javascript.
- **Attribute information.** Attribute information shows the selected layer attribute that is already specified in. 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.
- **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.
- **Draw.** The 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 in 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.

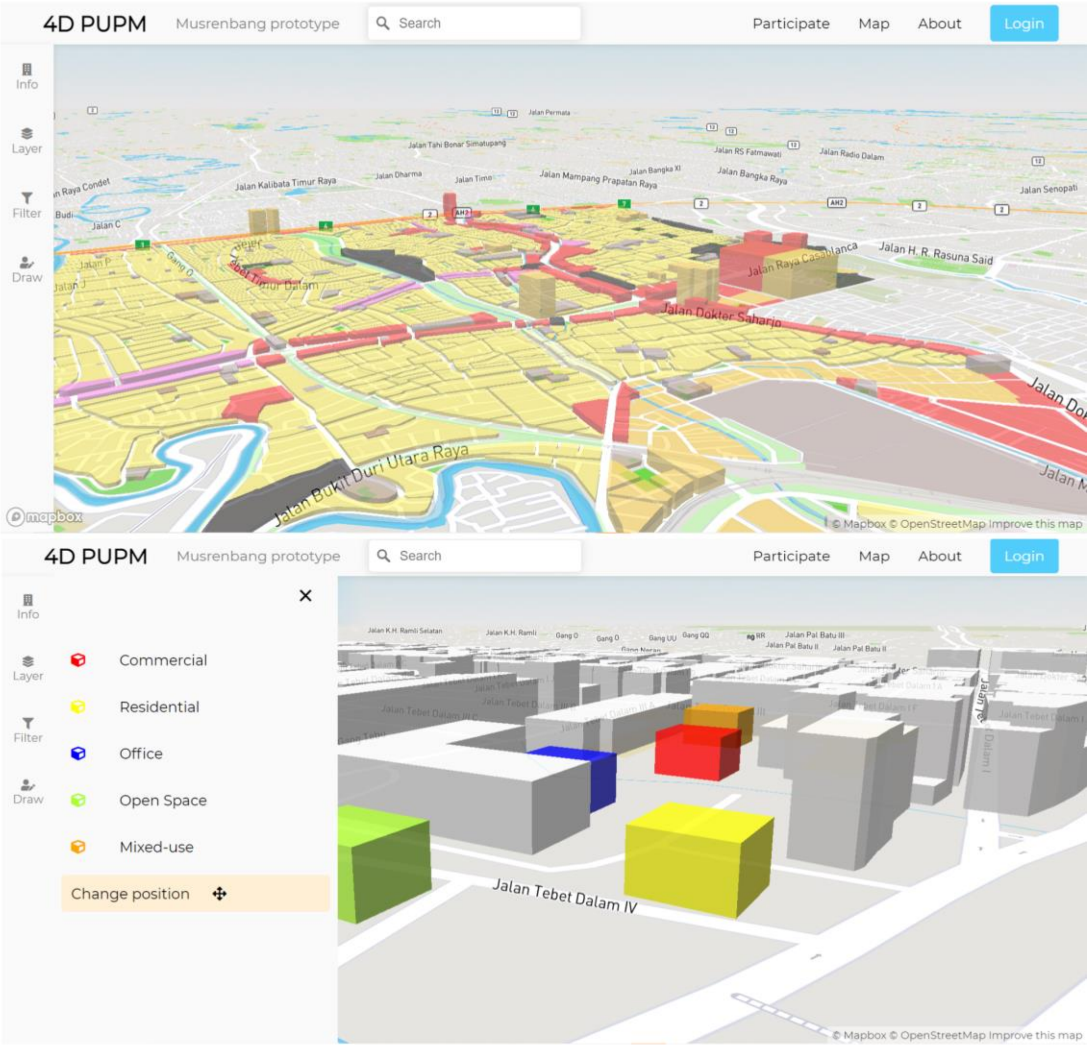

Figure 4. Data visualisation for 3D spatial plan (top) and 4D (3D + time) participatory activity (bottom)

The participation mechanism using these simplified 3D models is also very straightforward (Figure 4). 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.

Therefore Phase 3 resulted in 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/.

<u>3.2.4. PHASE 4: Testing the prototype</u>

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 an online questionnaire. Even though the 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.
- The main goal of the user test is not focused on technological aspects.
- 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: a) pre-test (limited number of users and tests); and the final test. To get the result that fits the best to reality, the user test was performed with participants who matched the initial Persona: Planning Actor, GIS Actor, Layperson and Intermediary. 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. All participants agreed to share their background, experiences, and quotes during their testing process anonymous.

The users were given the following tasks
- Login according to your user role
- Access the 'Participate' map interface
- Search for an address
- Display information from 3D spatial plan layer
- Switch 3D dataset layer
- 'Draw' 3D building
- Move the added building

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 semiconstructed interview was also done while the participants completed 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 felt after finishing the task.

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. Although the test was limited, the conclusion, 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.

4. CONCLUSIONS

Even though many researchers focus on establishing a higher accuracy for 3D spatial information, only a few researchers study how 3D geo-visualization can be developed towards a communication platform for citizens to provide content to planning and express their opinion about the spatial planning process. Meanwhile, designing user experience is a very long and iterative process. We constructed 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 activity, meaning that all individuals with their skills and knowledge join forces in the decision-making activities. In order to make sense of the user roles and participation tasks in a hierarchical GIS process, creating a network of human-to-GIS using the ANT diagram is needed.
- PHASE 2: Design. Once the targeted user roles and tasks were discovered, this research explored user goals, skills, and frustration, then visualised 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 constructed 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 fed 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 users could use the prototype, 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, this research has successfully produced two main products: 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. 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 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 or other GIS-related applications with multiple users involved.

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BIOGRAPHICAL NOTES

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