International Journal of
Geo-Information

MDPI

Article

Assessing Spatial Information Themes in the Spatial Information Infrastructure for Participatory Urban Planning Monitoring: Indonesian Cities

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Received: 22 May 2019; Accepted: 12 July 2019; Published: 17 July 2019

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Abstract: Most urban planning monitoring activities were designed to monitor implementation of aggregated sectors from different initiatives into practical and measurable indicators. Today, cities utilize spatial information in monitoring and evaluating urban planning implementation for not only national or local goals but also for the 2030 Agenda of Sustainable Development Goals (SDGs). Modern cities adopt Participatory Geographic Information System (PGIS) initiative for their urban planning monitoring. Cities provide spatial information and online tools for citizens to participate. However, the selection of spatial information services for participants is made from producers' perception and often disregards requirements from the regulation, functionalities, and broader user's perception. By providing appropriate spatial information, the quality of participatory urban monitoring can be improved. This study presents a method for selecting appropriate spatial information for urban planning monitoring. It considers regulation, urban planning, and spatial science theories, as well as citizens' requirements, to support participatory urban planning monitoring as a way to ensure the success of providing near real-time urban information to planners and decision-makers.

Keywords: urban planning; participatory mapping; urban planning monitoring; spatial data infrastructure; spatial information infrastructure; citizens science

1. Introduction

The UN's 2030 Agenda of Sustainable Development Goals (SDGs) features city and spatial information noticeably and explicitly [1,2]. The localization of this agenda gives cities new targets that require a new approach in planning and practice. This raises several apposite questions that deserve critical examination, particularly to data, monitoring, and measurement of goals and indicators. Cities are demanded to provide and to update this dataset regularly. According to UN-Habitat, localization of SDGs in cities demands up-to-date spatial information to accommodate changes in planning, monitoring, and evaluation of urban planning [2]. Cities in developing countries are struggling to provide up-to-date spatial information reflecting urban dynamics. Planners and decision-makers are still accustomed to primarily using demographic and statistical projection data to forecast urban changes [3]. These changes are mainly the result of land utilization by societies, particularly in using their rights, restrictions, and responsibilities issues over specific land parcels [4]. These issues have been identified and discussed by experts and authorities in the domain of land management, involving land tenure, land use planning, land valuation, and land development [5–7]. From this viewpoint, land use changes need to be monitored, well-reported, documented, and analyzed using spatial information. By placing spatial information at the core monitoring system, land use change can be produced and shared by stakeholders to assess sustainable development.

Participatory mapping facilitates citizens in contributing their knowledge to the city government in the form of spatial information. In facilitating participatory mapping, many cities established a 'top-down' GIS system to support their decision-making [8]. Many of these 'top-down' GIS applications were established based on spatial data producers' perspective and introduced only a limited type of dataset for participants. These systems were mainly developed based on the expert's view and, in many cases, marginalized Local Spatial Knowledge (LSK) [9]. Sieber [10] also reported that the '*top-down*' approach grows skepticism among participants. The potential role of citizens is, for example, underestimated. By giving access to spatial information services, citizens will be able to enhance their knowledge in locating a phenomenon [11] by filling in the information gaps with better quality for urban planning processes [12]. The rapid advancement of Geographic Information and Communication Technology (Geo-ICT) and open spatial information services enables citizens and non-government institutions to fill these gaps left open by government data [13].

It is important to allow stakeholders to participate in defining the data specifications for participatory activities. Stakeholders in participatory urban planning monitoring should be given more responsibilities to not only access but also to determine the type and specification of spatial information and technologies for improving their LSK, as well as to comply with regulations (if any). This article assumes that regulatory demands and users' perspectives shall be integrated with functional requirements to support participatory urban planning monitoring. Participatory monitoring activities in urban planning require compliancy with data specifications defined in regulations. user-centered aspect in spatial themes selection shall also be accommodated to support situational awareness for the participant in performing urban planning monitoring. This article presents a method to determine which spatial information to be shared among stakeholders and what the specifications of the spatial data shall be to support Participatory Urban Planning Monitoring (PUPM) in Indonesian cities. Jakarta and Bandung were selected to represent the megapolitan cities. This study constructed a new method for selecting appropriate spatial information by considering regulation, functionality, and user-centric perspectives. These perspectives were quantified for construction priority list for urban planning monitoring. We extended the Demand-Driven approach proposed by Malinowski and Zimanyi [14] by creating three chains to accommodate regulations, as well as functional and user-centric requirements. The first sections of this paper present a theoretical background on urban planning and participatory monitoring in urban planning. Section 3 contains a literature study on the role of spatial information in participatory urban planning monitoring. Methodology and results are explained in Sections 4 and 5. The last section of this article presents our conclusion and future works.

2. Urban Planning and Participatory Urban Planning Monitoring

Cities change continuously due to human activities, environmental phenomena, and interaction between humans and their environment. The UN's 2030 Agenda indicates the need for new specifications in fundamental spatial datasets to support countries and cities in localization of SDGs indicators into urban planning and the city's development plan [1]. Hall and Tewdwr-Jones [15] (p. 211), defines urban planning as a subclass of planning. They consider urban planning a continuous process in improving ways of controlling the urban system with spatial components. Urban planning aims to provide spatial structures and a land use plan to improve the spatial pattern (land allocation). The existing conditions and remedial actions are needed to be documented in the zoning map, mainly for implementation, monitoring, and evaluation. It is imperative to provide up-to-date spatial information in performing a continuous assessment at every stage of the urban planning process. McLoughlin [16] (pp. 291–292), highlights the role of spatial information in urban planning for representing the interaction of observations in the real world through comparative analyses (see Figure 1). The Organization for Economic Co-operation and Development (OECD) [17] considers monitoring "a continuing function that uses systematic collection of data on specified indicators to provide management and the main stakeholders of an ongoing development intervention with indications of the extent of progress and achievement of objectives and progress in the use of allocated funds." Later, Seasons [18] enriched the definition of monitoring into a continuous assessment of activities in policies, programs, processes, or plans, which involves data regularly. The monitoring function is often paired with an evaluation to provide timely and useful information to stakeholders, as well as to integrate reality into decision-making processes. The meaning of "evaluation" in urban planning mostly correlates with the operation and outcomes of policy within a set of standards [19]. Guijt and Woodhill [20] argue that the combination of participation with monitoring and evaluation in creating knowledge can ensure the effectiveness of the program of implementation and documentation. For practical reasons, this article considers monitoring of urban planning implementation as the continuous and systematic collection of data on particular indicators to provide urban planners, decision-makers, and other stakeholder's insights into the ongoing urban development in the context of the enforcement, implementation, and development of urban plans. See Supplementary Materials.

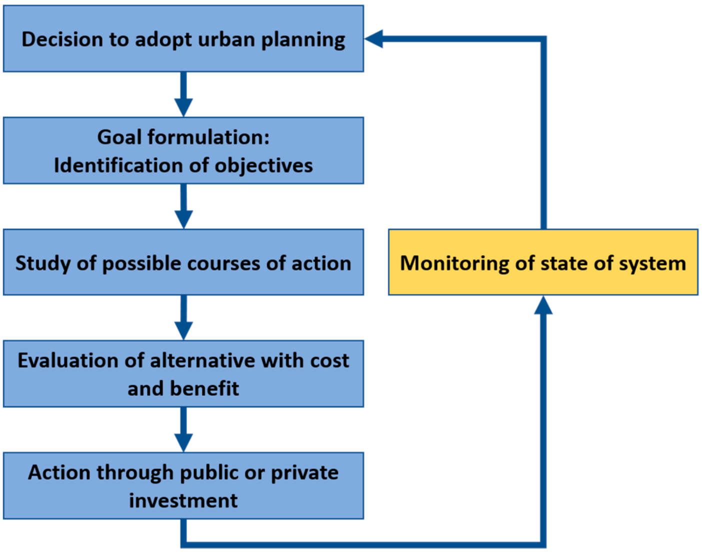

Figure 1. The McLoughlin implementation process. The planning process model interacts with the real world through comparative analyses and control processes [16].

Alexander and Faludi [21] advocated the "conformance" approach to examine a plan and its outcomes, which can be used in urban planning monitoring. In this approach, monitoring is performed in four ways: conformity, rational process, optimality ex-ante, and optimality ex-post. A conformance-based evaluation can be considered as the object-oriented material side of planning [21,22]. Conformity is defined as the valuation of the degree of compliance with the urban plan of urban development, urban operational services, decision-making, actual conditions, outcomes, and impacts. A rational process represents an analytical approach to the urban planning and urban decision-making process which conforms to the normative requirements of the process, while 'Optimality ex-ante' is to estimate the effectiveness of the strategy of action prescribed in urban planning. The last, 'Optimality ex-post' is an approach to examine whether the urban plan was used as a reference for urban developments. This approach will analyze how the strategy and course of actions are implemented. The parameters of success in conformance are more distinguishable than plan performance [23]. The conformance approach is regarded as a more practical way to measure parameters in urban planning. A participant may use binaries, the *Likert* scales, or numbers to value urban development conformity to the urban plan [24]. However, this approach is exposed by the issue of flexibility and uncertainties [22]. Conformity can be performed regularly or if specific conditions provide a reason for an evaluation.

Inclusiveness in urban planning monitoring is considered an advantage in monitoring and evaluation activities: The broader and more diverse the participants, the faster the information can be collected, and the more trusted are the evaluation process and findings [25]. The participatory approach offers unlimited resources for urban planning monitoring with the involvement of broader stakeholders [11,13]. The emphasis in the evaluation of urban planning depends on the degree of importance perceived by policy-makers, while the success is based on conformity to the urban plan [22]. In short, the conformance approach is object-oriented and more tangible in measuring the success of urban planning. However, in reality, a participatory approach requires spatial information for citizens in reporting urban change and posting their opinions of urban phenomena [26]. The degree of control of the subject, consensus, and the capability to assess future conditions will influence conformity analysis [27]. McCall and Dunn [26] consider the local citizen's knowledge over the specific area to be better in providing relevant information than general scientific knowledge because it contains local, practical and expert knowledge, which operates interactively within holistic thinking. LSK provides the spatial component of local people's knowledge. The ability of LSK to accommodate technical and cultural knowledge with specific spatial associations makes it suitable for urban planning monitoring. LSK can relate urban development with individual land ownership and urban zoning maps to any phenomena or changes on a given location, such as dysfunction of public facilities, urban planning violations, threats to urban safety and the ecosystem, or environmental hazards. Barrera-Bassols et al. [28] highlight LSK in providing cultural and personal information into a database, which is often significant to decision-making. PUPM may cover any type of observation of urban planning processes, including physical, environmental, political, social, and economic factors. However, for conformity approach, this article only focuses on participatory observation of physical and functional use of land or space to support a conformance approach for urban planning monitoring.

3. Spatial Information in Participatory Urban Planning Monitoring

Spatial information is vital in urban monitoring [29,30]. According to Faludi [31], an urban plan map should be regarded as an explicit reference for decision-making by city government. This map will also be used as the baseline for calculating costs and impacts of any violations or accidents. Yeh [32] advocates spatial information shall be used in determining the objectives, identification, and resources inventory in urban planning. He also added that a map is the most appropriate format for analyzing current situations, forecasting, presenting options in the urban planning process, and representing planning strategy for implementation, monitoring, evaluation, and monitoring. Nyerges and Jankowski [33] stated that land information, such as land rights, land value, and tax parcels are required for decision-making to represent residential, public, parks and recreation, agricultural, industrial, and commercial uses. The available large-scale maps can make the boundaries of parcel clearer, to minimize the possibility of land conflict. However, the current sensing technology-based approaches (i.e., remote sensing techniques and sensor networks, and so forth) can present only synoptic views over space and time-based on earth and terrestrial observations [34] and have difficulty in detecting non-physical changes [35]. Without the participatory approach, the local government has to face very challenging task to survey directly on the ground. Improvement in providing required spatial information can be implemented into an open government initiative to introduce accountability into urban planning activities [36,37].

3.1. Policy and Regulation

Regulation on spatial information sharing and policy on open data are essential in participatory urban planning. However, the organizational culture influences the success of participatory monitoring initiatives. Citizens should be allowed to access, use, and to contribute spatial information in the form of public participation in urban planning. The law and policy will determine the scope of the role of citizens and non-government institutions in the monitoring of urban planning processes. Critical factor in participatory urban planning monitoring is the legitimacy of spatial information produced by citizens or by the power-holder and policy on communicating public information [12]. Whereas there is no legislation allowing citizens' involvement in urban planning monitoring, Non-Government Organizations (NGO) and community groups may implement the "sidestep strategy" to avoid legal, policy and cultural obstacles in accessing and contributing spatial information for Public Participatory in Geographic Information (PPGIS) [38].

Urban monitoring and evaluation activities need reference maps for all interested parties, between the regulator (the government) and the supervised party (the beneficiaries or the space developer). These maps are essential to reduce dispute over map-making. Van Loenen [39] stated that the fundamental dataset should be trusted, certified, and used as a reference in the creation of spatial information. Further, he argues that these datasets should be freely accessible to all stakeholders for various purposes, including participatory urban planning monitoring. A framework dataset contains reference layers, such as topography and bathymetry, which provide a foundation for other spatial datasets. Urban zoning maps are eligible to be included in framework dataset as they contain essential information, such as land use permit, building location permit, infrastructure location permit, capacity and intensity of building and infrastructure, and zoning permit. Urban development plan maps contain various physical urban developments. This paper presupposes that all stakeholders in participatory urban planning monitoring should be given free access to the spatial information in order to produce better spatial information in urban planning monitoring. Many countries are enforcing zoning maps with regulation to be used as a reference for all in allocating public and private investment, land or space utilization, and urban development [26]. In these countries, regulation may also contain an open data policy for the zoning map and the responsibility of city government to inform land use policy for socio-economic-environmental conservation activities, the issuance of the spatial use permit, the preparation of the building and environment plan, and the development of the infrastructure network plan.

3.2. Voluntary Geographic Information (VGI) in Urban Planning Monitoring and Its Quality

There is growing attention among city councils in developing countries to incorporate location and spatial knowledge in their procedures for decision-making [40,41]. These cities have primarily utilized Information and Communication Technology (ICT) and social media [41,42] to make cities smarter [43]. According to McCall and Dunn [26], Geo-ICT enables citizens in translating spatial concepts of reality and their knowledge of phenomena into maps. Elwood [44] reported that existing spatial information could not fulfill the needs of the citizen to perform their tasks in urban planning monitoring. Nevertheless, there are success stories in organizing a facilitated VGI (f-VGI) by utilizing web mapping interfaces to allow citizens individually or collaboratively to contribute information on a map with a predefined set of criteria and specific geographical extent [45]. Participatory urban planning monitoring and evaluation aim to accommodate the local people or non-government organizations that are affected by urban planning processes [18]. Goodchild proposed the concept of "*citizen sensor*" [13] and the term "Volunteered Geographic Information" (VGI) for participatory mapping to collect real-world phenomena in the form of maps (spatial information) as a mental understanding of a specific area. The collaboration will stimulate accountability and will increase acceptances from the people by recognizing and translating their knowledge of object phenomena in the real world to produce urban information. By involving local people, the city government can improve the quantity of urban information and at the same time, comply with the principles of SDGs [1]. Citizens or non-government institutions can step in as the external stakeholders to complement local government staff in participatory urban planning monitoring.

The quality of spatial information often hinders the citizens in contributing spatial information containing LSK [46]. There are imperfections to be considered for spatial information produced by external stakeholders (e.g., VGI, participatory mapping), including fuzziness in classification and semantics, inconsistent scale, imprecision in boundaries and distances, spatial overlaps and gaps, and human senses preferences [47–49]. Similar to the external stakeholders, Patton [25] reported the quality of monitoring performed by the internal stakeholders (government staff) might also be exposed to a personal bias, organization culture, and organizational politics. The external stakeholders are considered to have more motivation with a higher degree of neutrality, and therefore may neutralize this exposure. Lynam et al. [50] reported that the absence of the georeferenced maps would influence the quality of VGI products, mainly to relate features to a location on the earth, to geometric accuracy, and completeness in attributes. The standard ISO 19157:2013—Geographic information—Data quality specifies elements for data quality measures [51]. These are: Positional Accuracy, Completeness, Thematic Accuracy, Temporal Accuracy, Logical Consistency, and Usability Element. This article considers only spatial information meet these elements to be shared in participatory urban planning monitoring.

3.3. Common Operational Map for Participatory Urban Planning Monitoring

Participants in VGI initiatives have more knowledge of the local area, which can lead to producing better spatial information [52]. However, the VGI approach relies on access to the fundamental datasets (including ortho-imageries) provided by governments or global data providers. According to Talen [53], sophisticated maps published by authorities or data providers may not be suitable for the non-skilled citizens. The representation of these spatial maps contains technical information which is too complicated to understand by local people in contributing to participatory mapping activities [44,54]. On the other hand, Google Earth and Google Map provide the success story for involving local people in interacting with online map visualization and utilizing topographic maps, aerial and satellite imageries, as well as enabling people to interact with spatial information and 3D city models. To improve the quality of urban planning monitoring, local government should also open their data and stimulate citizen participation to monitor urban changes—both physical and non-physical changes. The shared information is useful to minimize inefficiencies, to create innovation and opportunities, to avoid environmental degradations, to enforce laws, and to reduce social conflicts [44]. A '*Common Operational Map*' (COM) has the potential to ensure consistencies between urban plan and the reality and to ensure the common perception of urban space between government and its citizens. LSK has the advantage to detect urban dynamics and plays a crucial role in constructing COM. An accurate 'live map', such as COM, can be utilized as an effective communication medium for urban planning monitoring between governments, the holders of the permit, and affected parties.

4. Selection of Spatial Information Themes for Participatory Urban Planning Monitoring

The methodology applied in this study is adapted from Malinowski and Zimányi's [14] approach on data selection in data warehouse design. This approach can accommodate both subjective and objective selection of required spatial information by considering three aspects: regulation, functional, and user-centric requirements to perform participatory urban planning monitoring. This article considers these aspects as three chains of requirements. The first chain corresponds to the regulation-driven approach and creates a specification as it emerges from urban planning regulation requirements. The second chain contains the scientific-driven approach and delivers a requirement that can be served from the existing information infrastructure. The last chain represents a user-centric flow derived from the requirement from participants in participatory urban planning monitoring. Citizens are expected to utilize shared spatial information in participatory urban planning monitoring to capture real urban change based on their assessment. Therefore, the requirements of citizens as the users in the PUPM system should be taken into account. Figure 2 shows the three chains methodology schematically.

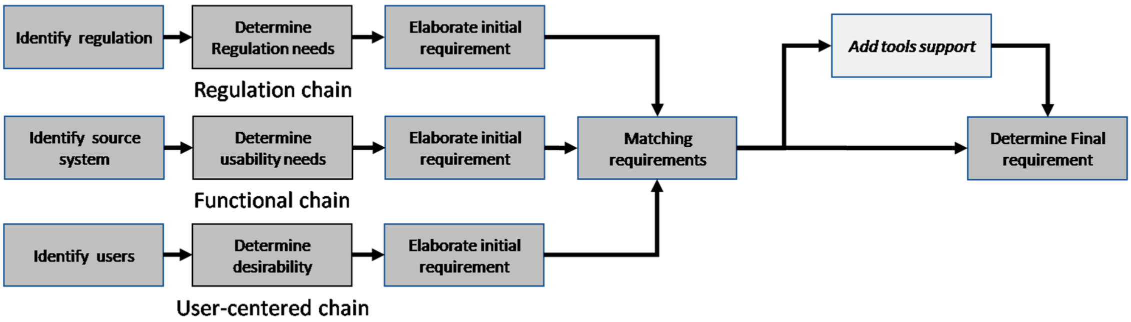

Figure 2. Methodology for determination of requirements for spatial information services for Participatory Urban Planning Monitoring adapted from Malinowski and Zimányi [14].

4.1. Regulation Chain

Technical data specification may appear in the form of regulation or standards. Typically, a regulation is mandatory whereas standards are voluntary [55]. A government may use an enforcing law or regulation for a successful implementation of policies [56]. When referenced in a regulation, the use of standards can be mandatory [57]. There are many countries establishing Spatial Planning Act to ensure conformity to specific norms or behaviors. Needham [58] reported that regulation may increase level of conformity stated in central government at the expense of flexibilities at the lower jurisdictions.

4.2. Functional Chain: Utility of Spatial Information to Perform Monitoring and Evaluation

The rapidly growing sensing technologies enable the production of urban monitoring data with higher quality on the positioning accuracy and thematic accuracy. However, sensing technology alone has limitations in determining the actual use of urban space. The challenge for local governments to harmonize urban improvement programs with urban planning is producing and synchronizing high-resolution databases in the planning activities and the city's project management. Meinel et al. [59] stated that topographical maps to a scale of 1:5000 are sufficient for urban planning. Nyerges and Jankowski [33] presented a theoretical framework to examine functional requirements of spatial information for situational awareness. This framework contains five dimensions: functional activities, community conditions, decision process, spatial and temporal dimensions. Participatory urban planning monitoring is regarded as an effort to represent a complex problem in the city by utilizing these dimensions. It is vital to evaluate the nature of spatial information sharing for a city to develop a strategy for collaborative actions in collecting, processing, managing, visualizing, disseminating, and utilizing them. The decision is made from updates represented from these maps will stimulate changes in the requirement of mobility, water resources, and disaster management. Land use map and urban development map are required to guide growth, to correlate urban management with planning-, programming-, and implementation-level assessment, and to promote a sustainable development perspective.

Nyerges and Jankowski [33] proposed a "*phase–construct–aspect*" theory to measure spatial information utilization in assessing situational awareness to make a decision. The "phase" of a decision situation contains three steps: Design, Process, and Outcomes. "Construct" considers motivation from social-institutional mandates (or regulation), stakeholder's knowledge, and technology [33]. "Aspect" represents detailed characteristics of an object to be assessed. Based on this theory, this paper associates the functional requirement of spatial information for participatory urban planning monitoring with utilizing at these three levels of detail:

(1) General urban planning assessment—Has spatial information been useful in describing the spatial situation related to urban planning monitoring requirements?
(2) Decision situation assessment by phase—Has spatial information been useful in a phase-to-phase description associated with urban planning monitoring requirements?

(3) Decision situation assessment by phase and construct—Has spatial information been useful in describing all constructs within phase associated with urban planning monitoring requirements?

The right selection of spatial information shall improve the visual and cognitive ability of contributors to perform tasks in the participatory urban planning monitoring. The presence of specific layers is essential for map-making as they enable users to perform orientation purposes or comparison of objects and understandability [60]. Rinner [61] presented the importance of street layers for orientation. Today, urban spaces are often located in tall buildings, skyscrapers, and underground constructions. In consequence, the use of the 3D city model and 3D cadastre for navigation and to develop the spatial relation of objects has increased. This paper adopts "phase–construct–aspect" theory as functional chain for selecting layer selection to be used by common citizens in contributing to participatory urban planning monitoring based on Nyerges and Jankowski [33].

4.3. User-Centered Chain: Requirements of Stakeholders (Jakarta and Bandung City)

The third chain is the user-centered chain. This chain shall support the identification of spatial information requirements for participatory urban planning monitoring from a user's perspective. Users in participatory urban planning can be categorized into two clusters: internal and external users. The internal users include city councils, city managers, and staff from local governments. Other users from public institutions included in this cluster are the officials from central government (ministries and agencies) and provincial or state government. The external users are users from non-government institutions, private sectors, and citizens.

5. Spatial Information Requirements for Participatory Urban Planning Monitoring in Indonesian Cities

Indonesia adopts the '*top-down*' approach for its urban (spatial) planning through Spatial Planning Act [62]. The top-down spatial planning approach recognizes the existence of centralization of planning, whether in the form of a centralized plan or in the form of a referencing, whereas the plan of the lower jurisdictions must follow the upper plan. This Act aims to achieve harmonious condition between the natural and artificial environments. Central government utilizes Spatial Planning Act in ensuring harmonious plans between jurisdictions [63] (see Figures 3 and 4). The Spatial Planning Act provides a strong legal foundation for the Indonesian citizen to contribute spatial information in urban planning monitoring and evaluation, as well as enabling citizens to negotiate their interest with the power-holders (the government). Moreover, this Act also mandates that every land use must be following the spatial plan, and the authorities must approve any land use changes. Spatial Planning Act [62] considers urban planning monitoring and evaluation as an activity of direct or indirect on observation by stakeholders for objective assessment of urban planning through public reporting and formal documentation. According to this Act, the scope of monitoring and evaluation of urban planning covers administrative, the substance, and the urban planning process. Hence, the government must organize continuous monitoring and evaluation of land or space utilization.

Government Regulation No. 15 Year 2010 [64], the lower regulation on spatial planning implementation, instructs cities to develop a zoning map and the Urban Planning Information (UPI) system to support compilation, monitoring and evaluation of urban planning (see Figures 3 and 4). Detailed specification of spatial information is shown in Table A1 in Appendix A and Table A3 in Appendix B). Spatial data quality is specified in Government Regulation No. 8 Year 2013 on Accuracy of Spatial Plan Map [65]. These regulations define criteria for the visualization of maps used in urban planning. Zoning map aims to ensure optimal function of an area by providing criteria for the implementation (e.g., basic coefficient of the building, the basic coefficient of the floor, the height of the building, and basic coefficient of the green area). According to this regulation, a zoning map must at least contain a set of the function of land or area, existing and planned urban infrastructure, and intensity of each zone. The UPI system shall include relevant spatial information representing (existing) land use and planned land use (zoning plan) that can be accessed by all stakeholders, particularly by the authority in issuing the permit (license) and performing corrective actions or imposing a sanction. In practice, additional information is required to monitor specific functions, such as cultural heritage areas, disaster vulnerability areas, and safety areas of aerial transportation operation. Although the spatial planning implementation regulation specifies in detail the activities in urban planning monitoring, specification of spatial information is not mentioned. In reality, the city is free to include a variety of maps based on producers' viewpoint to support urban planning monitoring and evaluation, as well as for issuing permits, and other purposes [66]. Government Regulation on Spatial Planning Implementation defines the step in performing technical and specific oversight of urban planning monitoring (Figure 5). Technical oversight is a regular activity for supervising the overall process of spatial planning, while specific oversight is the supervision on particular problems or violations in the implementation of the urban plan. A specific oversight comprises activities for validation and verification of information; technical analysis for these problems; and violation of spatial planning. This regulation also specifies the result of the process in two possibilities of conclusions: compliance or inconsistency with the urban plan. If the report concludes there is an inconsistency with the urban plan, then it shall contain a recommendation for making the physical characteristics/ function conform to the urban plan.

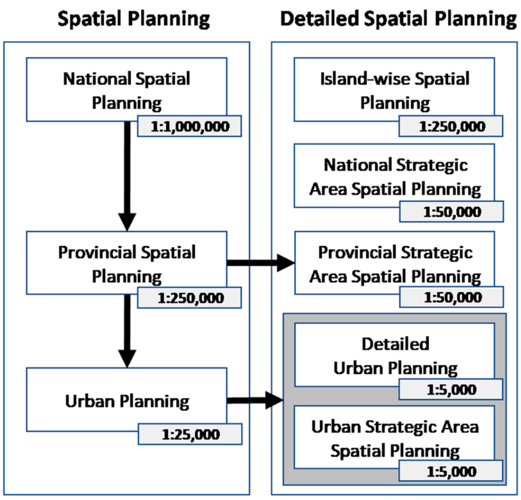

Figure 3. Detailed Urban Planning in Indonesian Spatial Planning System according to the Minister of Public Work Decree 20 Year 2011 [67].

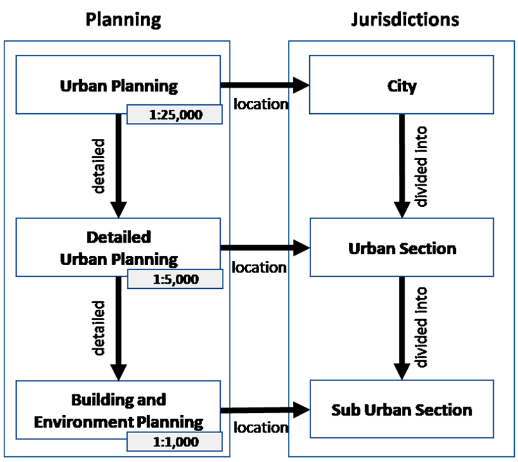

Figure 4. Relationship between Urban Planning, Detailed Urban Planning, and Building and Environment Planning according to the Minister of Public Work Decree 20 Year 2011 [67].

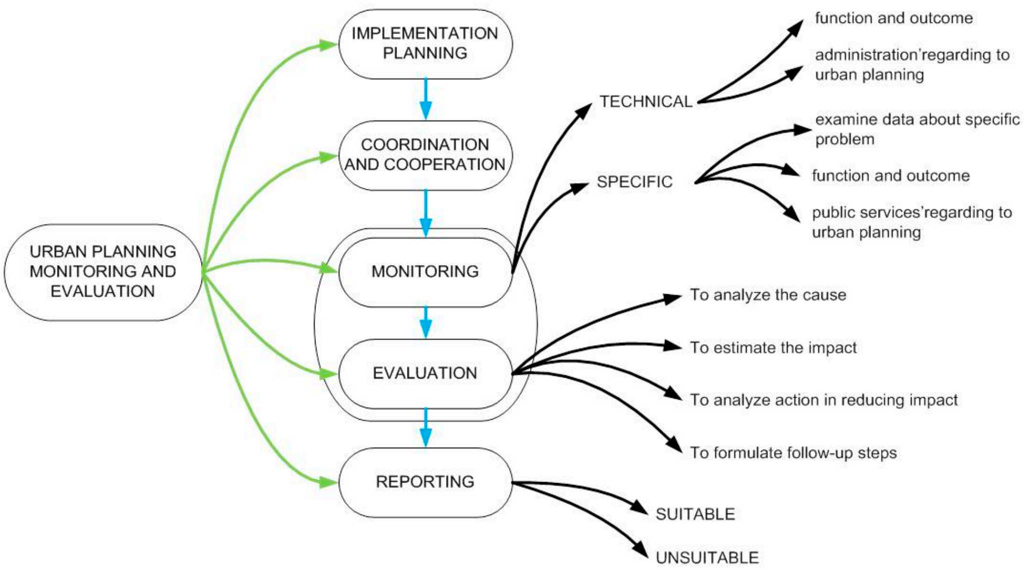

Figure 5. The workflow of Urban Planning Monitoring Process in Indonesia according to Indonesian Government Regulation No. 15 Year 2010 [64].

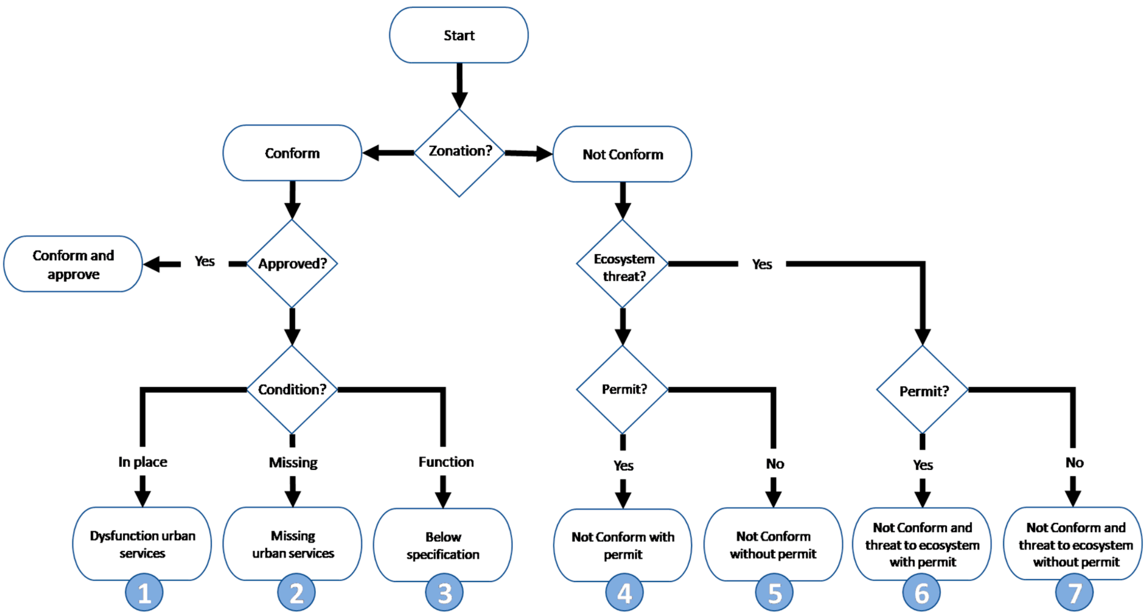

Figure 6. The workflow of conformance checking for urban planning monitoring derived from the Indonesian Government Regulation No. 15 Year 2010 [64].

The urban planning monitoring database should at least contain information representing urban change, including the location, type of urban change, and impact. The Geospatial Information Act [68] and Government Regulation No. 9 Year 2014 on Geospatial Information Management Implementation [69] provide a legal basis for citizens in contributing spatial information. Government Regulation No. 9 specifies some layers in fundamental datasets to be incorporated into urban plan map to be available via Spatial Information Infrastructure (SII) and other channels for urban planning monitoring. This regulation also instructs the government to facilitate non-government institutions, business, and citizens in participating and contributing their spatial data through SII. Contributors and the citizens in PUPM have a minimum requirement of spatial information to perform a conformance approach in urban planning monitoring and analysis for generating a zoning violation report (see Figure 6). Government Regulation on spatial planning implementation commands government institutions to perform urban planning monitoring continuously and facilitate citizen participation. Assessment on what is the best specification of spatial information for stakeholders to perform participatory urban planning monitoring will be presented in later sections.

Stakeholders in urban planning monitoring may perform continuous, direct, and indirect observation, or participate in urban planning monitoring. Participants may apply conformity assessment on actual space utilization using openly published zoning maps. If participants experience conformity to the zoning map and urban development plan, then they can validate the availability of necessary infrastructure and its public services on that area. If stakeholders find inconsistencies (or 'nonconformity') with the zoning map and urban development plan, then they shall examine the presence of threat to human, ecosystem, or indication in permit (Figure 6). This scenario may allow for early detection of corruption if the observer finds a permit for a building which is inconsistent with the zoning plan map (result number 4 and 6 in Figure 6).

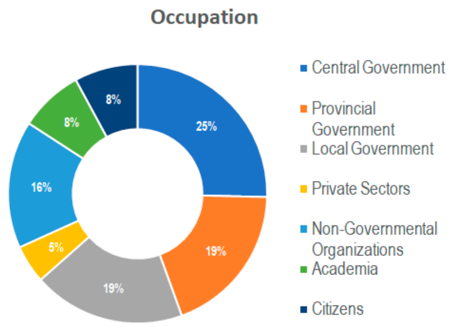

Figure 7. Respondents based on affiliation (sectors).

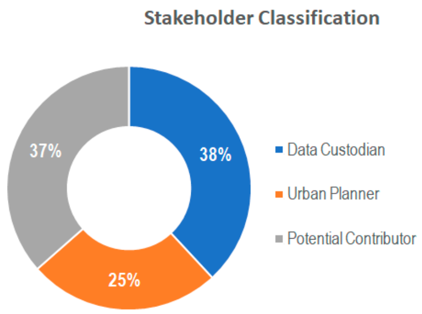

Figure 8. Respondents based on actor role derived from their affiliation.

A pre-tested survey was conducted by interviewing urban planners, SII facilitators, and GIS professionals from *Badan Informasi Geospasial* (Geospatial Information Agency/GIA), the national mapping agency (www.big.go.id), and academics from the Institute Technology of Bandung (www.itb.ac.id). A self-administered survey was performed to identify the user's perception of open data principles in participatory urban planning monitoring. The survey was targeted to people with adequate knowledge, skills, and experience from local governments (city and provincial), central government, citizens, and non-government organizations. This paper anticipated that the respondent had more experience in using 2D than 3D maps. The survey provided 80 printed questionnaires with an explanation to officials from participating members of Indonesian SII in the annual meeting in March 2017. An online form was provided from March to June 2017. The survey yielded 90 successful samples, 62 samples from printed questionnaires, and 27 from online responses. After data collection, three interviews were conducted from three types of stakeholders for validation purposes. From the survey, this study classified the respondents as seven groups based on occupation (central government, the provincial government, local government, private sector, non-government organizations, academia, and citizens) (see Figure 7) and three groups based on their roles (data custodian, urban planner, and potential contributor). Regarding the organization types represented in the survey, more government institutions responded than other groups (Figure 8). This study assumed potential contributors as citizens or persons affiliated with non-government institutions, but motivated to perform participatory urban planning monitoring activities. By definition, a user's perspective on spatial information may contain personal bias which depends on knowledge, skills, and experience in utilizing spatial information.

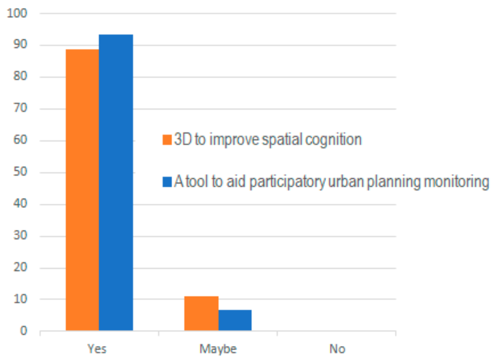

Figure 9. Type of spatial information needed by urban planners, citizens, and non-government institutions to contribute to participatory urban planning monitoring.

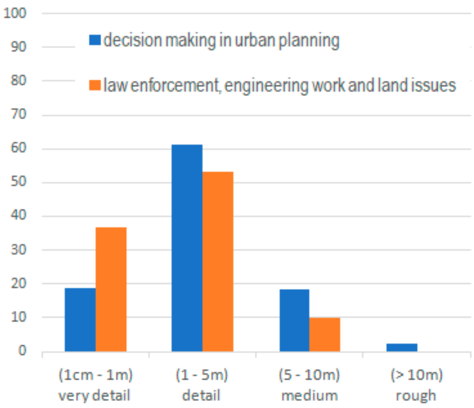

Figure 10. The quality of spatial information expected by urban planners, citizens, and non-government institutions in participatory urban planning monitoring.

The citizens who responded are familiar to the spatial information and urban planning, as well as their ability to contribute LSK. There is a possibility of urban planners and data custodians participating in urban planning monitoring as volunteers. Respondents were provided a list of questions (see Annex to this article) containing the types of spatial information to be selected in performing participatory urban planning monitoring. From the questionnaire, most respondents were in favor of contributing to participatory urban planning monitoring. Eighty-nine percent of the respondents agreed to implement open data in participatory urban planning monitoring. Similar percentages of respondents accepted the citizen's involvements in this activity. Almost 65 percent of respondents were willing to share their personal information (e.g., name or address) in contributing to participatory urban planning monitoring. Further, 74 percent declared to allow re-use of spatial information from participatory urban planning monitoring. Most respondents (53 percent) required detailed spatial information (1–5 m) for urban planning monitoring, and 39 percent required very detailed (1 cm–1 m) datasets.

The survey also revealed that potential contributors expect the participatory urban planning monitoring system to provide them with detailed spatial information (1–5 m) for urban planning monitoring (61 percent), some requiring even more detailed information (1 cm–1 m) and streamed data (20 percent) for law enforcement-related actions (see Figures 9 and 10). Very detailed spatial information consists of maps at scale 1:2500 or better, while detailed maps fall between a scale of 1:2500 to 1:10,000. More than 75 percent of the respondents indicated 2D high-resolution spatial information as (highly) relevant for PUPM: digital elevation model (hill shade), toponym, ortho-imageries, aerial photo, coastline, public facilities, transportation, utility, building, land cover, land use, land tenure, urban zonation, and land value. These datasets should, according to the survey, be shared and provided in participatory urban planning monitoring tools. As much as 88 percent of the respondents demanded 3D spatial information (see Figure 9). Approximately 75 percent of the potential contributors selected 3D high-resolution spatial information as relevant for PUPM. This response includes digital elevation model (3D raster), ortho-imageries, aerial photo, buildings, public facilities, transportation, utilities, land cover, land use, and urban zonation (see Figure 11).

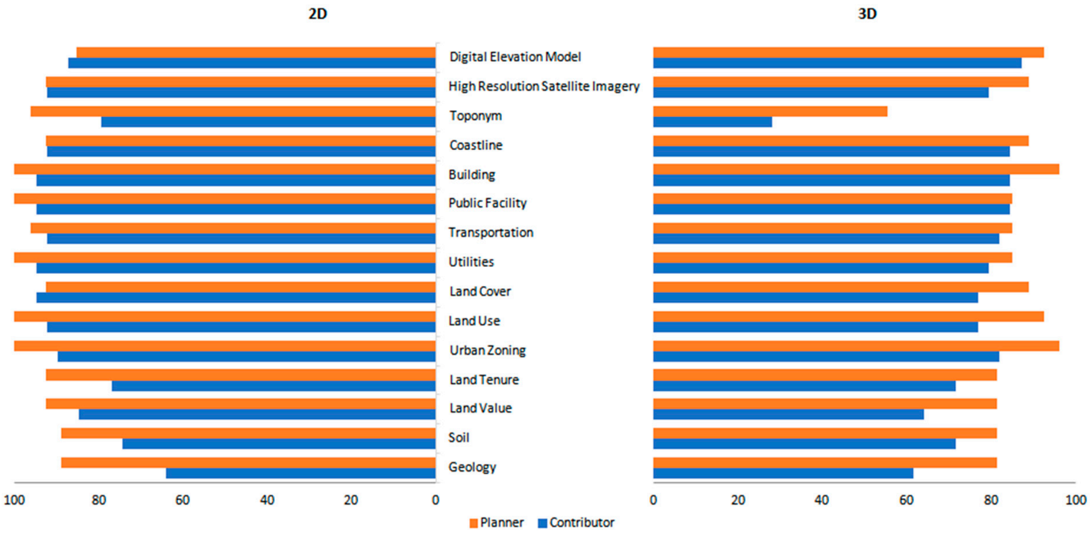

Figure 11. Preferences of spatial information to be used in participatory urban planning monitoring from the potential contributor (**red**) and urban planners (**blue**) (in percentages).

6. Discussion

The requirement of spatial information is designed to accommodate the contextual background for the findings on fitness for use to balance requirements directed from the regulation and functionality analysis. The selection method incorporates three requirements to support participatory urban planning monitoring, which is placed in three chains: regulation chain; functional use of spatial information chain; and a user-centered chain. A value of '1' was given for each category of spatial information that met the criteria of the regulation and functional chain requirements. For the user-centered chain, this study added the percentage of all users that indicated a need for these datasets (see columns 7–12 in Table 1). Then, the total score is created by aggregating the scores from each chain. Assessment of spatial information requirements based on the regulation, functional, and user-centered chains of spatial information to perform the task requirements and conformance approach for PUPM in Jakarta and Bandung is explained in Table 1. User-centered value was determined by the responses from three actors (planners, contributors, and providers). All respondents tended to select as many layers as possible in urban planning monitoring. There is a small difference in preferences between urban planners and contributors (Table 1). From the questionnaire, this study found nine layers of 2D and eight layers of 3D spatial information scored more than 3.5, or more than two-thirds of the possible score (see light grey area in Table 1) and 9 layers are selected with 90 percent of possible values (see dark grey area in Table 1). These layers are considered as critical layers to be provided in participatory urban planning monitoring.

6.1. Consistency Between Regulation and Functional Requirements

Selection of spatial information for urban planning processes is highly regulated in Indonesia, both in type and quality. For example, the National Transportation System map has to contain types of road network at a scale of 1:5.000. These regulations have not included all stakeholders in developing a specification of spatial information nor tools for urban planning monitoring and evaluation. However, there is a consistency between regulations and between regulation and function of spatial information requirements and citizen participation. This study found that Geospatial Information Act and Public Information Openness Act support the Spatial Planning Act in fulfilling the functional requirement of participatory urban planning monitoring. The harmony between regulation and functional aspects has simplified the construction of spatial information requirements for urban planning monitoring, as well as governance in spatial information management.

Table 1. Score from three chains: regulation, functional, and user-centered requirements.

No.	Layers	Regulation	Functional			User-Centered				Score			
						Planner		Contributor		Planner		Contributor	
			a	b	c	2D	3D	2D	3D	2D	3D	2D	3D
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	Public Facility	1.00	1.00	1.00	1.00	1.00	0.85	0.95	0.85	5.00	4.85	4.95	4.85
2	Building	1.00	1.00	1.00	1.00	1.00	0.96	0.95	0.85	5.00	4.96	4.95	4.85
3	Utilities	1.00	1.00	1.00	1.00	1.00	0.85	0.95	0.79	5.00	4.85	4.95	4.79
4	Land Cover	1.00	1.00	1.00	1.00	0.93	0.89	0.95	0.77	4.93	4.89	4.95	4.77
5	Coastline	1.00	1.00	1.00	1.00	0.93	0.89	0.92	0.85	4.93	4.89	4.92	4.85
6	Transportation	1.00	1.00	1.00	1.00	0.96	0.85	0.92	0.82	4.96	4.85	4.92	4.82
7	Land Use	1.00	1.00	1.00	1.00	1.00	0.93	0.92	0.77	5.00	4.93	4.92	4.77
8	Urban Zoning	1.00	1.00	1.00	1.00	1.00	0.96	0.90	0.82	5.00	4.96	4.90	4.82
9	Toponym	1.00	1.00	1.00	1.00	0.96	0.56	0.79	0.28	4.96	4.56	4.79	4.28
10	High Resolution Satellite Imagery	0.00	1.00	1.00	1.00	0.93	0.89	0.92	0.79	3.93	3.89	3.92	3.79
11	Digital Elevation Model	0.00	1.00	1.00	1.00	0.85	0.93	0.87	0.87	3.85	3.93	3.87	3.87
12	Land Value	1.00	0.00	1.00	1.00	0.93	0.81	0.85	0.64	3.93	3.81	3.85	3.64
13	Land Tenure	1.00	0.00	1.00	1.00	0.93	0.81	0.77	0.72	3.93	3.81	3.77	3.72
14	Soil	1.00	0.00	0.00	1.00	0.89	0.81	0.74	0.72	2.89	2.81	2.74	2.72
15	Geology	1.00	0.00	0.00	1.00	0.89	0.81	0.64	0.62	2.89	2.81	2.64	2.62

6.2. The Importance of GIS Knowledge in User-Centered Requirements

However, there were some respondents identified as contributors had difficulty relating spatial information to a specific task in participatory urban planning monitoring. It is consistent with Nyerges and Jankowski [33] that assessment for a decision by 'phase–construct–aspect' will require a detailed understanding of the whole urban planning process to select spatial information requirements. Spatial information shared in participatory urban planning monitoring should assist contributors in performing these tasks by:

(a) Describing the general situation in urban planning (column 4 in Table 1).

Spatial information was designed to be used only to represent the real-world situation and to assist in navigation, orientation, and simple assessment. For this purpose, potential contributors should be able to select some spatial information, such as water bodies, toponym, transportation, utilities, buildings, public facilities, land use, land tenure, administrative boundary, urban zonation, aerial ortho-photo, and satellite imageries to be used for urban planning monitoring.

(b) Providing information for phase and task outcomes in urban planning (column 5 in Table 1).

Decision assessment by phase requires a spatial representation of the real world and information of the object in urban development. Potential contributors were able to recognize the importance of land cover, land suitability, urban plan maps, critical area, and disaster risks information to assess urban planning.

(c) Providing arguments in problem representation of urban planning (column 6 in Table 1).

A conformance approach in decision situations by the phase-construct assessment approach requires spatial information in decision assessment by phase and additional maps for representing characteristics of phase in urban development to perform a specific function in urban planning monitoring.

6.3. Determination of Spatial Information Requirements

In Indonesian cases, most cities, including Jakarta and Bandung, lack resources to perform urban planning monitoring. Local governments are often overwhelmed with the need to produce adequate information in monitoring the urban dynamics in densely populated cities, particularly for Jakarta and Bandung. They have limited resources, personnel, and budget to perform continuous observations. Moreover, these local governments have often failed to perform self-evaluations of urban planning implementation, particularly in identifying urban changes that failed to conform to the requirements. Although the Spatial Planning Act [62] and government regulations require spatial information at a general level, because of lack of detail, it is still difficult for contributors, especially citizens, to select them. Developing specifications for spatial information based on regulations is considered similar to the phase–construct decision approach. It was confirmed from the literature study that spatial planning regulations intend to provide spatial information to serve urban planners and other power holders to perform decision-making. From these findings, the regulation aspect is suitable for the supply driven for participatory urban planning monitoring. User-centered and functional requirements are appropriate as a demand chain. This paper recommends the supply–demand driven approach, based on Malinowski and Zimányi [14], to assess the relationship between aspects in spatial information requirements. There are possibilities of incorporating citizens in urban monitoring; for example, a facilitated VGI can be implemented to facilitate citizens to monitor specific information. The supply–demand driven approach can be used to construct a priority list for spatial information services in a participatory monitoring system according to a specific task to be performed by the contributor.

6.4. Summary

There are twelve thematic themes (see Table 1) that score more than three from the proposed selection method. If the authority defines data specification in a regulation-based functional aspect, their value will be consistent. In this case, we can use the proposed method to analyze the consistency between the functional and regulation requirements chains. We found that participants are very receptive to 3D spatial information. However, part of this selection method (user-centered chain) is still exposed to biases since each respondent has different skills and knowledge in selecting appropriate data.

7. Conclusions

The provision of spatial information to support localization of the UN's Agenda 2030 is a great challenge. Cities have to prioritize a new approach in providing the new fundamental dataset in monitoring urban planning and its practice. Indonesian cities should develop a new strategy to provide up-to-date spatial information to support critical problem-solving in urban development and to achieve goals and indicators prescribed in the SDGs. Planners and decision-makers have broadened their attention not only on statistical data but also on spatial information to predict urban growth. This shifting is essential for achieving sustainable development in cities and monitoring stakeholders in using their rights, restrictions, and responsibilities over their land and spaces.

This article aimed to help facilitators and system developers of VGI in selecting spatial themes in developing an application interface for participatory activities. In many cases, facilitators share data via their application in a Facilitated-Voluntary Geographic Information (F-VGI) based on a data producer's point of view only, disregarding regulation, functional, or user's demand. This article proposes to include these three chains for constructing data specifications. This can be considered a new approach since facilitators or app developers disregard one or more chains. In most of the cases, they provide spatial data in their application based on their own assumptions, ignoring a holistic understanding of the PUPM system, including users' needs. In Jakarta, Open Street Map provides road networks and point of interest in their F-VGI for participatory flood mapping, but data on utility network and drainage layers (sewers and canals) are not provided and identified as the cause of the flooding [70]. In a similar case in Bandung city, the local government published a mobile GIS-based

"*Panic Button*" application, an F-VGI for reporting crime by sharing Google Map layers only. In this interface, they omit police station distribution [71]. This article offers a method to determine which spatial information to be shared with all stakeholders and what the specifications of the spatial data shall be to support PUPM in Indonesian cities.

7.1. Developing a Selection Method

This paper successfully introduced a new method to select priorities of spatial information to be shared with stakeholders to support PUPM in the Indonesian cities of Jakarta and Bandung. This method is addressing the spatial information requirements from three chains or sources: the requirements for regulation, requirements from a functional perspective, and requirements of users of the system. The first chain derives the spatial information specifications as specified in urban planning regulations. The second chain contains the spatial information requirements for PUPM, as described in the literature. The last chain provides the requirements of the actual users in participatory urban planning monitoring. A variety of criteria can examine each of the chains. In reality, not all layers needed are available in appropriate quality (geometry, temporal, and thematic). Therefore, this method can reformulate the criteria to examine which spatial information is suitable for participatory urban planning monitoring.

7.2. Does Spatial Information Determined by Regulation Meet Contributor Demands?

This paper shows that the availability of spatial information services is essential in performing participatory urban planning monitoring. The selection method has successfully selected nine layers that are critical for PUPM in two Indonesian cities. These datasets need to be available and shared among all stakeholders in participatory urban planning monitoring to successfully monitor urban planning. Spatial information mentioned in regulation is not the only source but, when shared to the contributors of participatory urban planning monitoring, are useful to perform conformance evaluation by comparing them to reality.

7.3. Implications and Future Research Direction

In her well-known article, Arnstein suggests that sharing information is the basic prerequisite for participatory activities [72]. Thus, Open Government Data is essential in PUPM and has real potential to improve LSK of stakeholders. The idea of open government at the city level is to promote democratic principles by enabling interested citizens to have access to information and become a contributor in a meaningful way to their neighborhood. Today, many cities are settling into participatory or collaborative activities as part of a SII initiative. The emergence of open data and SII allows society to participate in urban development. Most of the initiatives seem to be expanding open data towards and beyond the Internet of Things (IoT) and harvesting quality citizen contributions. However, amidst open data and smarter city initiatives that are being developed, many essential challenges in providing spatial information have appeared. This paper recommends the selection method be implemented to analyze the suitability of spatial information shared in the SII. As the open data movement is gaining momentum, a higher level of participation needs to be applied in a data-sharing system in cities. Open SII has real potential to be integrated into a smart city ecosystem, particularly for accessing and contributing large-scale maps and 3D spatial information. Furthermore, spatial information support for participatory planning monitoring is not valid to urban areas; it is also valuable in rural areas, as well as to fulfil the 2030 Agenda of Sustainable Development.

Supplementary Materials: The following are available online at http://www.mdpi.com/2220-9964/8/7/305/s1.

Author Contributions: This research articles is produced collaboratively by several authors. Agung Indrajit is responsible in Conceptualization, Validation, Formal Analysis, Investigation, Resource, and Writing-Original Draft Preparation.; Methodology, Writing-Review & Editing and Supervision was performed by Bastiaan van Loenen.; and Peter van Oosterom contributes in Conceptualization, Writing-Review & Editing and Supervision.

Funding: The first author was supported by the Program for Research and Innovation in Science and Technology Project (RISET-Pro), Ministry of Research and Higher Education, Republic of Indonesia

Acknowledgments: The first author acknowledges *Badan Informasi Geospasial*, Republic of Indonesia for coordination support in this study.

Conflicts of Interest: The authors declare no conflict of interest. The funding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

Appendix A

Table A1. List of spatial information required urban planning process at map scale 1:5000 or better (Ministry of Public Works Regulation, 2011) which are produced by government institutions.

No.	Type of Spatial Data	Description
1.	**Coastline**	A line of land-to-sea encounters that are affected by tides. The coastline consists of: the lowest receding coastline; highest tidal coastline; and coastline average sea level.
2.	**Hypsography**	A height data that can be described in various ways, such as high points, digital elevation models, lines connecting dots of the same height (contour lines), or colors that reflect altitude.
3.	**Water bodies**	The area that indicates the surface of the water body (water mass) in a particular region, such as the sea, rivers, lakes, and swamps.
4.	**Toponym**	The name was given to topographic elements, whether in the form of natural or artificial elements.
5.	**Administration boundaries**	An imaginary line that describes the limits of the inter-village and village, inter-district, inter-regency/city, interprovincial, and interstate.
6.	**Transportation and utilities**	Physical infrastructure for the movement of people and goods from one place to another.
7.	**Buildings and public facilities**	Contains the artificial objects and various kinds of public facilities that intangible buildings.
8.	**Land cover**	Describes the cover above the earth's surface consisting of landscape and an artificial landscape.
9.	**Physiographic**	Describes physical patterns and processes of the Earth or a description of the features and phenomena of nature.
10.	**Demographic**	Population size and structure, including fertility, mortality and international migration.
11.	**Economy and Financial**	Describes the location and zone of economic and financial activity, including public services, such as markets, shopping centers, banks, ATM, and others.
12.	**Land use**	The functional dimension of land for different purposes or economic activities.
13.	**Rainfall**	The amount of water that falls on the ground surface flat for a period measured by unit height (mm) above the horizontal surface in the absence of evaporation, runoff, and infiltration.
14.	**Slope/Morphometry**	"A slope is the rise or fall of the land surface" [73]; a rising or falling surface. This data describes the process of measuring the external shape and dimensions of landforms, living organisms, or other objects
15.	**Morphology**	The physical features of the earth and their relation to its geological structures.
16.	**Soil**	A geographical representation showing the diversity of soil types and soil properties (e.g., soil pH, textures, organic matter, depths of horizons).
17.	**Geology**	Depicts the distribution of different kinds of rock, surficial deposits, and locations of geologic structures, such as faults and folds.
18.	**Land tenure**	Represents the relationship, whether legally or customarily defined, among people, as individuals or groups, concerning land.
19.	**Hazard**	Highlights areas that are affected by a hazard or an unsafe to a particular hazard. The hazard map typically contains information related to natural hazards, such as earthquakes, volcanoes, landslides, flooding, and tsunamis. Hazard maps help prevent severe damage and deaths.
20.	**Critical Area**	Describes land or land that is currently unproductive due to the management and use of land that is not or is less concerned with soil and water conservation requirements, so that the land is damaged, lost, or reduced function to the already established or expected limits.
21.	**Land suitability**	The level of suitability of a plot of land for a particular use. The classification of land suitability is the matching between the land quality and the desired land use requirements.

Table A2. List of urban zonation maps produced in the urban planning processes at map scale 1:5000 or better (Ministry of Public Works Regulation, 2011) which are produced by city government.

No.	Type of Spatial Data	Description
A		**Profile Planning**
1	Orientation Map	The geographical position of a planning area.
2	Administration Boundary	A delineation or demarcation lines of a planning area.
3	Land Use	A delineation of existing land use types (in reality) throughout the planning area.
4	Disaster Risk	A delineation of disaster-prone areas classified by level the danger.
5	Population Distribution	Distribution of population density of each planning area to illustrate where population concentrations exist.
B		**Urban Infrastructure Plan**
1	Transportation Development plan	A network of mobility plan describes the entire primary network and secondary network in the planning area which includes arterial road, collector road, local road, environmental road, and another road network.
2	Energy infrastructure Development plan	An energy and power plan map that describes all sub-transmission networks, primary distribution networks (High Voltage Cable, Extra High Voltage Cable, and Ultra High Voltage Cable), secondary distribution networks, oil and gas pipelines, and all other supporting buildings included in those networks.
3	Telecommunication and Information Infrastructure Development Plan	A map of telecommunication network development plan containing basic telecommunication infrastructure development plan. This map contains the central location of telecommunication connection and cable network of cable (primary and secondary cable networks).
4	Drinking (Clean) Water Development Plan	A map containing water-supply network development plan includes the drinking water supply system of the planning area, pipeline network system instead of the pipeline network, raw water pickup building, raw water transmission pipes and production installations, distribution pipelines, and related buildings.
5	Drainage Development Plan	A map of the drainage network development plan contains a primary, secondary, tertiary, and neighborhood drainage plan.
6	Waste/Sewage Development Plan	A map containing Wastewater Sewage Development Plan includes on-site and off-site disposal systems in the planning area along with all wastewater treatment buildings.
7	Specific Development Plan	A map containing another type of infrastructure which is needed in the planning area, e.g., the disaster evacuation route plan.
C		**Urban Zonation**
1	Conservation	A map containing zonation for to preserve ecosystem includes: 1. protected forest zones; 2. protection against the underlying zones, including peat zones and water catchment zones; 3. local protection zones, including coastal borders, river borders, zones around lakes or reservoirs, zones around springs; 4. urban green opening zones, including parks, city parks, and cemeteries; 5. nature reserve and cultural preservation zones; 6. disaster-risk zones, including landslide prone zones, tidal prone zones, and flood-prone zones; and 7. other protected zones.
2	Cultivation	A map containing zonation for to support cultivation activities includes: 1. residential zones, 2. trade and services zones, 3. office space zones, 4. public service facility zones, 5. industrial zones, 6. special zones, including defense and security purposes zone, Wastewater Treatment Wastewater zones, Waste Processing zones, and other special zones; 7. other zones include agricultural zones, mining zones, and tourism zones; and 8. mixed zone, which contains several functional and integrated functions (housing and trade/services, housing, trade/services and offices).

Table A3. List of urban zonation maps produced in the urban planning processes at map scale 1:5000 or better (Ministry of Public Works Regulation, 2011) which are produced by city government.

No.	Type of Spatial Data	Description
3	Specific	A map containing zonation for to support specific activities includes: 1. flight operation safety zone; 2. cultural or customary preservation zones; 3. disaster risk zones; 4. defense and security zone; 5. research zone; 6. nuclear development zone; 7. power plants zones; 8. electric substation zone; 9. clean water sources zone; and 10. wireless telecommunication zones.
D		**Priority Area**
1	Priority Area	A map contains delineation of prioritized zone in planning area.

Appendix B

QUESTIONNAIRE

Name of institution	:	....	Government entities :	◻ Yes ◻ No
Responsibility	:	....		
Management level	:	◻ Upper Develop objectives, strategic plans, policies direction, and organizational decision-making	◻ Middle Implement organizational plan compliances with policies and organizational objectives	◻ Lower Guiding and supervising employees in everyday activities

1. Do you or your institution have special and sustainable programs to produce, maintain, and update specific spatial information?

◻	◻
Yes	No

2. Do you or your institution need spatial information layer on detailed map scale (1: 5.000 or better) below? Which information layers do you or your institution need to be accessed via the Spatial Information Infrastructure?

No.	Themes	Needed?	Utilized?
1.	Digital Elevation Models/ DEM (include Contour lines)		
2.	Satellite Ortho-Imageries or Aerial Ortho-Photo		
3.	Toponym (place name) and Point of Interest		
4.	Coastline		
5.	Building		
6.	Public facilities		
7.	Transportation (include Roads, Runways, Ports, etc.)		
8.	Utilities (including, cables, pipes, hydrants, etc.)		
9.	Land cover (including, vegetation, etc.)		
10.	Land Use		
11.	Urban Zonation (include Permissions, restrictions, etc.)		
12.	Land rights (tenure)		
13.	Land value		
14.	Soil		
15.	Geology		

3. What is your expectation of geometric accuracy for decision making in urban planning?

☐ coarse (10 meters)	☐ secondary (5 meters)	☐ details (1 m)	☐ very detailed (Sub 1 m)

4. What is your expectation of geometric quality for law enforcement, engineering works, and land matters (example: to measure the length and calculate the area) in urban planning?

☐ coarse (10 meters)	☐ medium (5 meters)	☐ Sophisticated (1 m)	☐ very detailed (sub 1 m)

5. What kind of tools do you choose to perform participatory the of urban planning monitoring and evaluation?

☐ software installed on the PC	☐ web applications	☐ mobile app

6. Do you need maps or any relevant spatial information installed in participatory the implementation of urban planning monitoring and evaluation tools?

☐ Yes	☐ No	☐ Maybe

7. Do you think 3D spatial information will improve your spatial cognitive ability in the urban planning implementation monitoring and evaluation?

☐ Yes	☐ No	☐ Maybe

If your answer is "**YES**," which layers are needed?

No.	**Themes**	**Needed?**	**Utilized?**
1.	Digital Elevation Models/ DEM (include Contour lines)	☐	☐
2.	Satellite Ortho-Imageries or Aerial Ortho-Photo	☐	☐
3.	Toponym (place name) and Point of Interest	☐	☐
4.	Coastline	☐	☐
5.	Building	☐	☐
6.	Public facilities	☐	☐
7.	Transportation (include Roads, Runways, Ports, etc.)	☐	☐
8.	Utilities (including, cables, pipes, hydrants, etc.)	☐	☐
9.	Land cover (including, vegetation, etc.)	☐	☐
10.	Land Use	☐	☐
11.	Urban Zonation (include Permissions, restrictions, etc.)	☐	☐
12.	Land rights (tenure)	☐	☐
13.	Land value	☐	☐
14.	Soil	☐	☐
15.	Geology	☐	☐

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