Advances in Social Science, Education and Humanities Research, volume 671
International Webinar on Digital Architecture 2021 (IWEDA 2021)

Spatial Configuration Approach for Predicting Office Layout Plan
(Case Study: Government Office, Kab. Tulang Bawang Barat in Architectural Design Competition)

Nova Asriana[1,*] Nova Chanda Aditya[2] Melania Lidwina Pandiangan[3]

[1] *Architecture Department, Faculty of Engineering, Universitas Langlang Buana, Bandung, Indonesia*
[2] *Architecture Department, Faculty of Engineering, Universitas Komputer Indonesia, Bandung, Indonesia*
[3] *Architecture Department, Faculty of Engineering and Design, Universitas Pembangunan Jaya, Tangerang Selatan, Indonesia*
[*]*Corresponding author. Email: novaasriana@gmail.com*

ABSTRACT
This study investigates the spatial programming approach for designing a government shared-office masterplan in architectural design. This case study takes part in an architectural competition, which is to attain schematic design as-built environment. The location is posited Tulang Bawang Barat (Tubaba) district, Lampung province, Indonesia. The office complex has eleven departments to facilitate official government activities. This paper studies simulative programming in spatial configuration for offices planning based on spatial hierarchies and structural organizations that define and depict the level of spatial depth. The purpose is to develop a design strategy for architects to predict a possible configuration spatiality based on variables of space syntax, which is analyzed by additional plugin tools in grasshopper. There are vital four parameters to analyze in this simulation, such as integration analysis, control analysis, entropy analysis, and choice analysis. The following results, reveals permeability and accessibility patterns, which present the index level of spatial depth to presume a possible spatiality layout plan then leads to suitable zoning for government office masterplan in schematic design planning, especially in Indonesia. Experimenting with this method in predesign process is mainly a tool for designers and could evaluate the configurative space as the design strategy to optimize spatial programming.

Keywords: *Spatial programming, Spatial configuration, Spatial depth, Space syntax.*

1. INTRODUCTION

Designing multi/shared office has been developed and varied in years, especially in Indonesia. Formal offices, peculiarly public government of Indonesia, still concern on hierarches and systematic position in organization. Other facts that, the offices also have not obtained standard in building requirements, such as a functional performance. The proposed government's office should be adjusted to office building type A or B based on Indonesia's Ministry of Finance issued Regulation No. 248/PMK.06/2011 about the standard of the needs rooms for government's building. Regarding this fact, this design approach, spatial configuration, aims to encourage official government activities more compact, efficient, and more integrated for users in working environment. Hence, this case study is selected to predict the layout plan for government office in Indonesia, which has significant challenging for new design.

Configuration is a set of relationships between spaces that involve in particular circumstances at a provided time [1]. It provides visual and physical connections, while humans use artificial environments to structure and control [2]. Spatial configuration refers the whole components, not only in architecture, but also in a set of relationships between objects that have complex and internal relationships in the overall structural space [3]. In other words, the spatial structure is highly important to create a well-functioning space in functionality [4]. It also investigates and evaluates the relationship spaces independently between in architectural and urban design [1]. The initial idea in this design methodology is to give life to the bubble diagrams of spatial arrangement conventionally to provide interaction between designers and computers [5]. Spatial configurations is not only enforcing in the human activity but also spatial cognition in what shapes and organizes the spaces [6].

This method in this paper is to examine a possible developing strategy for office programming through spatial configuration approach. Thus, this study can be applied a design strategy for designers or architects considering the possibility in early stage of spatial configuration to optimize spatial programming [7] in office design that determines the permeability, accessibility, connectivity [8] for users. These index levels identify the spatial interconnection of networks [9]. Experimenting this method in predesign process is mainly as tools for designers and can evaluate the configurative space as the design strategy [10]. In addition, this result indicate how users can adapt and conduct usable space [11], moreover it can determine the walkability in the office neighborhoods [12].

2. LITERATURE REVIEW AND METHODOLOGY

Space syntax has experienced well-known in the fields of architecture, urban design, urban planning, and so on. In addition, space syntax method provides techniques for the analysis, forecasting, and post-diction that affects social aspects and built environment [4]. Using Space Syntax methodology can interpret spatial organization and arrangement which is drawn as a bubble diagram, and it also will give feedback on the potency of social functions and social properties [13]. The completely configurable spatiality includes accessibility, centrality, and probability through spaces. Therefore, the study employs spatial planning using Space Syntax-based modelling and generates alternative spatial configuration that will represent accessibility, spatial depth [7], and spatial programming.

The goal of this study is to identify the spatial depth to determine how to configure the space in a simulative programming, especially the public government office in Tubaba district. The spatial configuration and spatial depth apply a methodology space syntax basis that focus on four parameters, such as integration analysis, control analysis, entropy analysis, and choice analysis. In this study, this method can also assess further the connectivity, which is based on the axial network patterns. Experimenting this simulation tools is to determine the permeable, accessible, and connectable spaces in predesign phase, in which the spatial configuration affects the flow of human movement in urban space.

Space Syntax is qualitatively interpretable measurements and distributions into two concepts, such as privacy and community [3]. The spatial modelling based on the space syntax theory that reckon relationships of spatial prerequisite by using programming. Through analyzing the network will apply for four analysis parameters; integration [14], entropy, control [2], and choice [15]. These four parameters simulate all given facilities program by generating the Space Syntax modelling.

- Entropy analysis, it refers to reachable spaces, the higher the entropy value identifies the more difficult to reach other space, vice versa.
- Integration analysis, it refers to private or communal space, the higher the integration value, the more likely for a space to be communal or public, while if the integration value is lower, then the space is more private.
- Choice analysis, it identifies how often a node happens to be on a shortest path between other space and it also measures the choice degree each space, which reveals how likely it is passed through on all shortest routes from all spaces to all other spaces in the system.
- Control analysis, it refers to show how strongly the vertex in graph is linked to others points in a superior manner, especially in a spatial configuration.

Above is mentioned explanation, this study consists of three stages that would be likely to generate simulation: (a) identifying variables for spatial modelling, (b) generating spatial configuration modelling simulation, and (c) resulting spatial configuration and spatial depth.

Spatial depth will calculate the connectivity using this plugin and implements the concept of distance or topological distance [3], in which can be accessible by users. This concept identifies that the distance of 1 step depth connects between two rooms directly, while the distance of 2 steps depth means that room A and room B must pass through 1 piece of intermediate space (Figure 1) [16].

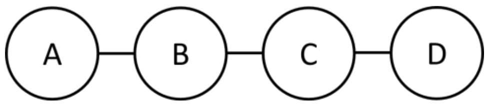

Figure 1 The concept depth of connectivity distance.

2.1. Setting Spatial Modelling Variables

The process using spatial modelling from grasshopper is plugin space syntax to determine alternatives and possibilities of spatial configuration, which is a simulative programming to figure out the optimum accessibility. There are several guidelines to a set of tools to implement our design methodology as a toolkit for a designer. This proposal office needs some rooms for 11 departments according to structural organization, they are Manpower and Transmigration Office; Population and Birth Control Office; Youth, Sport, and Tourism Office; Education Office; Social Office; Community and Village Empowerment Office; Women and Children Empowerment Office; Cooperatives, Small and Medium Enterprise and Trade Office; Transportation Office; Health Office; Public and Social Facilities. However, this simulation will only exemplify and simulate three departments because other departments have similar rooms, such as Manpower and Transmigration Office and Population and Birth Control Office. Moreover, Public and Social Facilities is included due to the main aspect that need to consider deeply based on the requirement needs during competition.

To commence with, starting the modelling configuration needs some fixed variables, such as the given room lists (Table 1), the restriction total area, the area each room, and then the connecting room should be inputted and drawn to the spatial modelling base as main variables. The plugin will translate and set up these variables in some tools for spatial configuration modelling in *grasshopper* (Table 2) and it purposes to simulate the spatial configuration.

Table 1. A given sizeable number of room and zoning

No.	Manpower and Transmigration Office	Occupancy	Zoning
1	Lobby	25 persons	Semi-private
2	Living room	10 persons	Semi-private
3	Room of Head Department	1 person	Private
4	Room of Secretary	1 person	Private
5	Room of Head General and Employee Department	1 person	Private
6	Room of Head Program Planning Department	1 person	Private
7	Room of Head Training Department and Staff	7 persons	Private
8	Room of Head Transmigration and Staff	7 persons	Private
9	Room of Head Industrial Relationship Department and Staff	7 persons	Private
10	Meeting Room	25 persons	Semi-private
11	Mini Library	N/A	Semi-private
12	Open Space for Ceremony Event	N/A	Semi-private
13	Lavatory room	N/A	Private
14	Lactation room	N/A	Private
15	Storage room	N/A	Private
16	Kitchen	N/A	Private
17	Archive room	N/A	Private
18	Parking	1-3 units	Private
No.	**Population and Birth Control Office**	**Occupancy**	**Zoning**
1	Lobby	25 persons	Semi-private
2	Living room	10 persons	Semi-private
3	Room of Head Department	1 person	Private
4	Room of Secretary	1 person	Private
5	Room of Head General and Employee Department	1 person	Private
6	Room of Head Program Planning Department	1 person	Private
7	Room of Head Population Control Department and Staff	7 persons	Private
8	Room of Head Family Empowerment Department and Staff	7 persons	Private
9	Room of Head Birth Control Department and Staff	7 persons	Private
10	Meeting Room	25 persons	Semi-private
11	Mini Library	N/A	Semi-private
12	Open Space for Ceremony Event	N/A	Semi-private
13	Lavatory room	N/A	Private
14	Lactation room	N/A	Private
15	Storage room	N/A	Private
16	Kitchen	N/A	Private
17	Archive room	N/A	Private
18	Parking	1-3 units	Private

Table 1. (Cont.)

No.	Public and Social Facilities	Occupancy	Zoning
1	Main Lobby	50 persons	Public
2	Living Room	20 persons	Public
3	Meeting Room	100 persons	Public
4	Customer Service	30 persons	Public
5	Canteen	50 persons	Public
6	Mosque	40x40 m2	Public
7	Public Toilet	N/A	Public
8	Public Hall	50 persons	Public
9	Parking	N/A	Public
10	Power House	N/A	Public
11	Plaza	N/A	Public

Source: Competition TOR (Term of Reference)

Table 2. Spatial configuration tools in grasshopper

Parameters control tools for spatial modelling (space syntax Grasshopper)	
Node link graph	Representation and connecting of nodes and links
P (Points)	Representation of nodes (points) space
L (Link)	Representation of links (lines) space
T (Labels)	Representations names of space
A (Areas)	Areas of spaces, an average area relative to the size of connectivity diagram will be assumed
S (Total Area)	Total area of the whole configuration, area values will be normalized to satisfy this amount exactly
Analysis simulation	
Entropy analysis	Represent the spatial accessibilities
Integration analysis	Represent the private or communal space
Control analysis	Represent nodes to be on shortest routes from all spaces in the system
Choice analysis	Represent the vertex in graph to be linked other points

2.2. *Spatial Configuration Modelling Simulation*

Starting the process simulation, authors initially identify some room lists, the size per room, the classification zoning and the restriction of total area in these facilities, especially Manpower and Transmigration Office, Population and Birth Control Office, and Public and Social Facilities. Regarding this, it will show a navigation graph (Figure 2 and 3), which refers a link between rooms to other rooms.

After making the boundary lists, authors continue to create a pseudocode to simulate the spatial configuration (Figure 4 and 5), and then the control tools and analysis tools will generate a spatial depth to guide designers in spatial organization. Thus, the simulation produces four given aspects from syntax tools, such as integration, choice, entropy, and control analysis, into spatial depth that will refer the spatial arrangements and hierarchies.

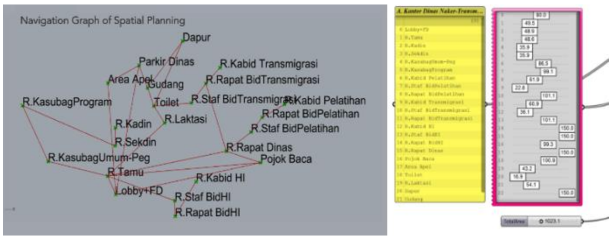

Figure 2 Spatial navigation graph that is resulted by the room lists, the restriction total area, and the sizeable room from Manpower and Transmigration Office.

Figure 3 Spatial navigation graph from three departments; Manpower and Transmigration Office, Population and Birth Control Office, and Public and Social Facilities.

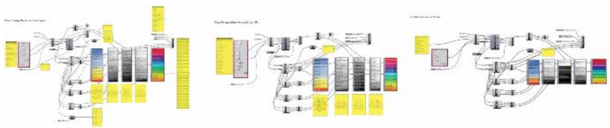

Figure 4 The pseudocode of spatial configuration from three departments; Manpower and transmigration office, population and birth control office, and public and social facilities.

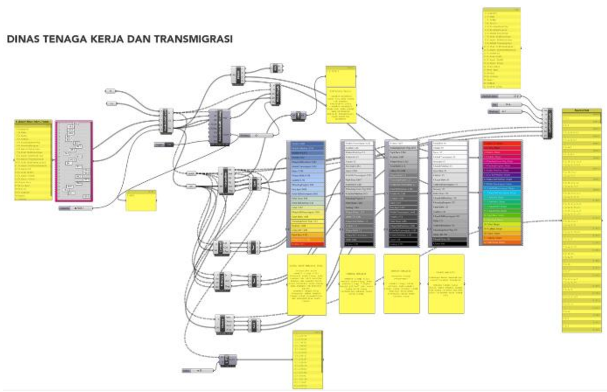

Figure 5 The pseudocode of spatial configuration from manpower and transmigration office.

3. RESULTS AND DISCUSSION

A spatial configuration modelling results the spatial navigation graph that visualizes the connection, the area through spatial syntactic color and the vertex linkage (Figure 6) between room and other rooms. In addition, based on the spatial modelling simulation, the spatial configuration will simulate some iterations and find an appropriate alternative programming that will be used and chosen for spatial layout planning. These simulative programming has gained iteration immensely since the selected iteration is chosen by designers. Given all that has been modelled scene so far, the color spatial configuration generates the result data through space syntax analysis, which reveals the index level of integration, control, entropy, and choice analysis (Figure 7-9).

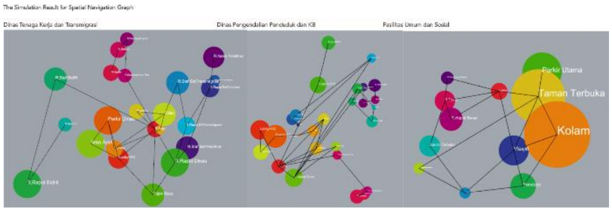

Figure 6 The spatial navigation graph result from three departments; Manpower and transmigration office, population and birth control office, and public and social facilities.

3.1. Manpower and Transmigration Office

This chosen iteration layout plan (Figure 7) show that the living room is the highest index in the integration analysis at 1.791 (red color), while the head department room is the lowest index at 0.488 (blue color). Regarding this result that living room is the most communal room, compared to other rooms that are more private. In addition, the living room also identifies the lowest index in the entropy analysis, at 1.857 (white color), and this room is the most reachable space, compared to other rooms, especially archive room. This room is the hardest part to reach area by some people and it has the highest index at 2.717 (black color). Then, the choice analysis shows that the living room is more selectable or choose area, in which is the highest level at 409 (black color) as it the shortest path to access other rooms. Meanwhile, the control analysis depicts that the living room has the highest index at 2.333 (black color), it means that this room has a strong vertex or node in spatial configuration to link other potential rooms.

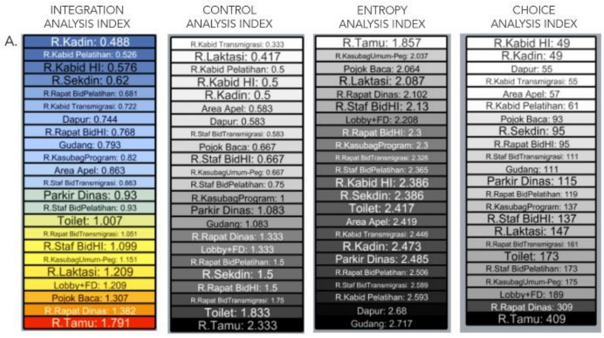

Figure 7 The index level of integration, control, entropy, and choice analysis for manpower and transmigration office.

3.2. Population and Birth Control Office

This given iteration layout plan (Figure 8) illustrates that the head department room is the lowest index at 0.516 (blue color) in the integration analysis, which is the most private room, while the meeting room shows the highest index at 2.00 (red color). Regarding this result (Figure 7), the meeting room is the most public room, compared to other rooms. In contrast, the meeting room also identifies the lowest index in the entropy and choice analysis, in which those figures show the level index at 1.843 (white color) and 701 (black color), respectively. It identifies that the meeting room is sequentially the most reachable and most the choice-able space since it is the shortest path to access other rooms. Meanwhile, the living room also identifies the highest index in the entropy analysis, at 2.867 (black color), then it means that this room has a strong vertex or node in spatial configuration to link other next rooms.

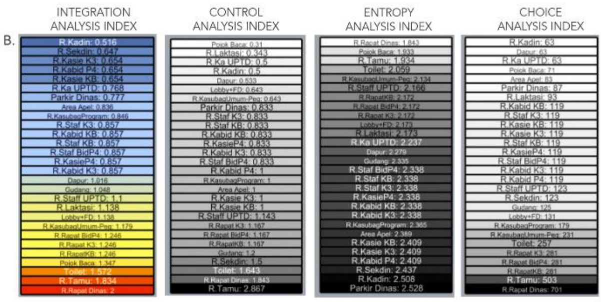

Figure 8 The index level of integration, control, entropy, and choice analysis for population and birth control office.

3.3. Public and Social Facilities

This provided iteration layout plan (Figure 9) depicts that the mosque is the highest index in integration analysis at 2.611 (red color), while the main parking is the lowest index at 0.922 (blue color). Regarding this result is that the mosque is the most communal, compared to other rooms, which are more private. Open space, on the other hand, shows a similar condition between the control analysis and choice analysis, in which these figures are the highest index at 2.233 (black color) and 79 (black color), respectively. This area has a strong vertex as central node in spatial configuration, and this area is more selectable to access choicely. Meanwhile, in the entropy analysis, the mosque is the lowest index at 1.026 (white color), which means that this room is the most reachable area, compared another room.

Figure 9 The index level of integration, control, entropy, and choice analysis for public and social facilities.

The next stage is to determine the spatial depth (Figure 10) in the level of connectivity and calculation of the total number of spatial configurations contained the axial line of rooms. The determination of spatial configuration is conducted by looking at the number of axial lines connected to the other axial lines, and then this will represent the number of possible interactions in the rooms. Hence, the total of spatial configuration will explain the connectivity value. It can be illustrated that the connectivity assessment will be measured by the number of spatial configurations. For the *Manpower and Transmigration Office*, this facility has 7 levels of step depths as whole. The final destination is the head of department room since users might access this room. It defines that these seven step depths depict this facility has the lowest flow of movement compared to other facilities. Moreover, 7 step depths identify depth 0, 1, 2, 3, 4, 5, 6, which has 6 spaces to be passed (Figure 10), and then it is considered that this room are less accessible. Meanwhile, the figure of *Population and Birth Control Office* reveals 6 step depths as whole. It also determines depth 0, 1, 2, 3, 4, 5, which has 5 spaces to be passed and to address the room of head of department. The figure of *Public and Social Facilities* shows 5 step depths in total, which defines the highest flow of movement. It depicts depth 0, 1, 2, 3, 4, which has 4 spaces to be accessed before visiting the cafeteria. Then, it is taken account that this area is more accessible and more communal for users.

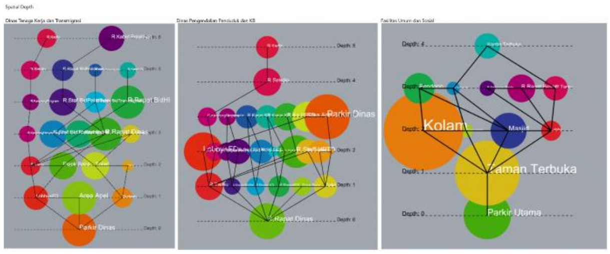

Figure 10 The spatial depth results.

4. CONCLUSION

All mentioned above are considering the findings that experimenting in spatial configuration approach is a developing strategy to understand deeply the spatial arrangement for the function programming of government's office.

This approach consists three fixed aspects that designers or architects should be considered, such as the sizeable rooms, the restriction each room and the total area, and the generator tools to analyze these variables. The total number, the analytical tools, and the final destination of room could be changed or adjusted based on the needs or designers' preferences in how to justify the spatial step depths. In term of this, it offers and helps designers to predict and calculate a simulative programming layout, which leads design to more appropriate, more accessible, well-functioning, and more users/pedestrians friendly in office designing. In addition, this tool is helpful and applicable for designers or architects in predesign phase to assess the room eligibility and validity, especially in early stage design process, that concerns on connectivity, permeability, and accessibility. They can apply and interpret the results into the next process design. This strategy can be taken account how to create the facilities more communal and accessible for users.

This method serves as a validator in finding optimum spatial configuration for office layout masterplan before developing design phase. Consequently, it modifies the mechanism to iterate and evaluate the impact of spatial design proposal into the accessibility and permeability levels based on route preferences.

REFERENCES

[1] H.H. Golshan, M. Ghasem, and M. Behzadfar, "The Relationship between Spatial Configuration and Social Interaction in Tehran Residential Areas: Bridging the Space Syntax Theory and Behavior Settings Theory," Int. J. Archit. Eng. Urban Plan., vol. 31, no. 4, 2021.

[2] B. Hillier and J. Hanson, "Syntactic Analysis of Settlements.," Archit. Comport. Behav., vol. 3, no. 3, pp. 217–231, 1986.

[3] B. Hillier, Space its the Machine. London, UK: Cambridge University Press, 2007.

[4] C. Yamu, A. van Nes, and C. Garau, "Bill Hillier's Legacy: Space Syntax—a Synopsis of Basic Concepts, Measures, and Empirical Application," Sustain., vol. 13, no. 6, 2021.

[5] P. Nourian, S. Rezvani, and S. Sariyildiz, "Designing with Space Syntax: A Configurative Approach to Architectural Layout, Proposing a Computational Methodology," in eCAADE - Spatial Performance and Space Syntax (Computation and Performance), 2013, vol. 1, pp. 357–365.

[6] A. Penn, B. Hillier, D. Banister, and J. Xu, "Configurational Modelling of Urban Movement Networks," Environ. Plan. B Plan. Des., vol. 25, no. 1, pp. 59–84, 1998.

[7] N. Asriana and A. Indraprastha, "Making Sense of Agent-Based Simulation : Developing Design Strategy for Pedestrian-Centric Urban Space," in CAADRIA 2016, 21st International Conference on Computer-Aided Architectural Design Research in Asia - Living Systems and Micro-Utopias: Towards Continuous Designing, 2016, pp. 343–352.

[8] M.P. Beck and B. Turkienicz, "Visibility and Permeability Complementary Syntactical Attributes of Wayfinding," 7th Int. Sp. Syntax Symp., pp. 1–7, 2009.

[9] L. Tambunan, M. Donny Koerniawan, N. Asriana, and N. Fathina Izmi, "The Study of Connectivity and Network Degree toward Mitigation Strategy for Resilient Kampung in Indonesia (Case Study: Kampung Taman Sari, Bandung)," in IOP Conference Series: Earth and Environmental Science, 2021, vol. 738, no. 1.

[10] N. Asriana, "Pedestrian Behavior For Developing Strategy in Tourism Area; Agent-Based Simulation," Dimens (Journal Archit. Built Environ.), vol. 48, no. 1, pp. 65–74, 2021.

[11] D.J.K. Beavon, P.L. Brantingham, and P.J. Brantingham, "The Influence of Street Networks on the Patterning of Property Offenses," Crime Prev. Stud. Vol 2, vol. 2, pp. 115–148, 1994, [Online]. Available: http://www.popcenter.org/library/crimeprevention/volume_02/06beavon.pdf.

[12] E. Leslie, N. Coffee, L. Frank, N. Owen, A. Bauman, and G. Hugo, "Walkability of Local Communities: Using Geographic Information Systems to Objectively Assess Relevant Environmental Attributes," Heal. Place, vol. 13, no. 1, pp. 111–122, 2007.

[13] P. Nourian, "Configraphics: Graph Theoretical Methods for Design and Analysis of Spatial Configurations," A+BE Archit. Built Environ., vol. 14, pp. 1–348, 2016.

[14] B. Hillier and J. Hanson, "The Social Logic of Space," 1984.

[15] L.C. Freeman, "A Set of Measures of Centrality Based on Betweenness," Sociometry, vol. 40, no. 1, p. 35, 1977.

[16] A.M. Navastara, M. Yusuf, and P. Navitas, "Application of Space Syntax Method to Measure Spatial Connectivity in Campus of Institut Teknologi Sepuluh Nopember (ITS)," in IOP Conference Series: Earth and Environmental Science, 2018, vol. 202, no. 1.