Decoding space syntax on the translation of site cluster permeability into building courtyard

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Abstract. An urban environment leads to tropical building adaptation by providing sufficient thermal comfort and energy efficiency. For generating the physiological cooling, interconnected attribute of site cluster permeability is translated into lower context such as building scale to provide optimal wind speed to restore thermal comfort. It will be expected to find the critical factor which most influences the performance. Meanwhile, the encoding of the space connectivity to accelerate air movement has been evaluated by previous studies. In this paper, the counter reading of visibility relationships analysis on computational fluid dynamics is conducted and decoded by DepthmapX simulation. The site clusters type of grid, cul-de-sac, and the open area plan of a loop represent housing estates in some tropical regions as the cases. The results highlighted that 50% or more translated air movement from the site to the building scale environment is determined by the dominated warmest connectivity of open space. The potency of energy efficiency is indicated by the capability of accommodating both social connectivity and environmental performance. Furthermore, the code of irregular building patterns by increasing air movement has low spatial and social connectivity because of space depthless. Providing open space for site planning encourages both environmental and social qualities.

Keywords: site planning, thermal comfort, urban environment, visibility relationships

1. Introduction

Recently, an urban issue indicates the complexity problem of thermal, noise, and optimization of eco-friendly energy use with the broader considered aspect of social factors. In a dense city environment, urban or sub-urban terrain roughness requires wind acceleration for generating physiological cooling. Therefore, the space continuity in real estate should be considered. The site mass permeability converted into building arrangement is also provided. In the other perspective, human interaction as an interface of social living is a syntax of spatial integration [1]. The problem of distinctions between inner-city and socio-spatial understanding and dilemmas is solved in its future housing planning.

Meanwhile, social interactions are directed by the scale of the site cluster permeability [2]. The conflict between promoting air for the high permeability site cluster and social interaction occurs in which the low one gives the better increased social interaction and activities. The spatial order of urban housing estate is directed using transparent and combined opaque materials, which builds different degrees of privacy. This is manifested in a diverse combination of visibility and permeability levels in various building areas [3].

Both thermal and noise simultaneous problems have been conducted in the previous study. It is extended to evaluate wind speed requirements and propose updating physiological cooling in the tropics in restoring thermal comfort [4]. Meanwhile, the strategy for predicting the spatial system and potential...
environmental intervention should be proposed through an analytical investigation. Deliberate solutions were created for each of the associated problems. The specific and cumulative influences of all the urban conversions were reviewed by the spatial pattern on the local and broader context on global features [5]. The urban scale assessment will be sufficient for building or environment courtyard, and the environmental concerns are embedded in physical urban transformation [6]. However, for analyzing the critical factor to review the housing estate related to the site cluster and its environment, all previous findings have not proposed the decoding of the spatial language associated with the site analysis on environmental issues. Therefore, this research conducts the translation of space syntax for the site cluster context's permeability into the building scale's courtyard.

2. Methodology
In urban estate housing, street models can be categorized into the grid, radial, irregular, and combined patterns, among others [7]. Figure 1 shows the site cluster prototypes based on the evaluation, such as grid, cul-de-sac, and the open pattern-loop, taken from East Surabaya typical real estate planning. By 6 m street width as the representative unit, the models are related to wind speed in different wind path and Mean Radiant Temperature or MRT as typical of a thermal state in the tropical climate region.

This research examines related literature inquiry out of Ecotect Analysis as MRT tool and Ansys Fluent models for air movement prediction computational fluid dynamics. Although the air moves fluctuating and changes every season, the lowest critical wind site inlet coming from the diagonal direction (315° or -45°) is taken in this study. Based on the field study dan previous research, this inlet has 8 m/s of wind speed [8]. The model transformation and ideal courtyard could accomplish the standard or prerequisite as optimized by the preceding study. Related to the potential activities, the DepthmapX simulation is used for the analysis of spatial programming recommendations. To simplify the relation, the additional program, Pajek, will estimate the network prediction.

3. Results and Discussion
Site planning of urban real estate requires the decoding of space syntax optimization through visibility analysis, recapped network code, and connectivity relationships. In this study, the spatial discussion is enriched through an environmental perspective to enhance all the context. In addition to the previous finding [9], the investigation conduct to evaluate how geometrically site cluster configurations occur
from the product of one set of generative formulation possess systematic in dealing on a network the factor relationships.

3.1. Visibility analysis
When the high MRT arises in the pedestrian path in the grid site cluster evenly, the wind speed has a role as a medium of heat transfer (Figure 2). The quality of on-site syntax space indicates that the site junction is the warmest area of visibility. It shows that the accumulation of accelerating wind has potential consideration of space programming. The longer distance of the grid reducing physiological cooling potential from similar MRT is not referred to as strategical space or lower visibility. In urban design, the environmental contribution relates to the wind direction. However, the grid arrangement is planned to be adequate space, and the wind will be quite different in all parts of the site.

The high MRT in the opened area is coded as a windy path to reach the building courtyard. Looking back on the visibility space, the grid cluster street's cross-line is potential as the highest social space and outdoor comfort area the most. The even distribution of wind contour and temperature will be particular for specific social interactions. It will be a flat response from the occupants because there is no sufficient shading even supported by adequate wind speed for outdoor activities.

The grid cluster can best be conceptualized by decomposing the inspection of intimacy implication into two systems, such as the mean directional distances connected with the grid patterns as a single system and the mean directional gaps from injected roads to the nearest section [10]. As mentioned by this study, decomposition will respond to a theoretical idea on a cognitive chart consisting of a frame system comparative to which other elements can be 'placed' and linked. Decomposition also replies to a practical objective to design one must operate with accessible factors that can be regulated within the site design capacity.

Figure 2. Environmental Condition and Space Syntax Analysis for Grid Site Cluster.

Identic code for a wind holding area, the cul-de-sac order provides an opportunity for catching air movement. Translating in high MRT and low wind speed, that permeability cluster lacks visibility when the grid results in the warmest space in the cross street (Figure 3). Like recent results [11], the cul-de-sac pattern supporting the courtyard design, especially for the pattern identity, is surrounded by a
restricted quantity of housing estates units, with a single vehicle entry. This feature could further be settled and estimated in detail by separating the substances into technical and social appearances. It could then be explained inside of the technical perspectives into the orientation of general and specific cul-de-sac aspects such as courtyard dimension, street and hardscape design, and housing estate type. The social appearances represent additional characteristics of the more significant population factor and instant user inferences such as compactness, affordability, social interaction, privacy, openness, site penetrability, pedestrian, and vehicle way arrangement.

This cluster's typical intersection connectivity has a link-node ratio and street section investigation and adjustment of methods used in the latest Western system as recognized as the specific syntax of a cul-de-sac, particularly on its courtyards or street [12]. Moreover, the cul-de-sac clusters do not perform to fascinate more residents compared to the other sites [7]. However, different from this literature, which results in high risk and is often related to the street path's connectivity, this study recommends the potential cul-de-sac pattern in providing surroundings shadow. It also can capture wind through blocking and localizing the wind event the velocity lower and discontinue all parts of the site.

![Figure 3](image)

**Figure 3.** Environmental Condition and Space Syntax Analysis for Cul-de-sac Site Cluster.

The open space found in the loop site cluster is usually proposed as an extended sample of housing estates in resilient urban design [13]. In the definition of regeneration design for open spaces in a housing estate, the loop strategy's specific discussion is improved. As shown in Figure 4, the loop cluster results in enhanced performance of high prospective wind speed but high-level MRT all at once. The open space will be lack intimate but developing high visibility that interacts with social activities. Unlike the prior statement of the functional space aspects on physical and spatial assets that do not match the user's wishes and prospects [14], the open space in loop arrangement could accelerate 50% or more transformed air movement. It occurs from the broader context of the site to the smaller one of building an indoor environment when the planning results in the warmest connectivity of open space. The influence of energy efficiency is revealed by 25%. Moreover, the loop cluster obtained the highest exposed area and the most distributed visibility space by having the most massive permeability and
opened location. However, the increased visibility space has consequences in reducing another cross street as the grid has.

![Image of grid and thermal analysis](image)

**Figure 4.** Environmental Condition and Space Syntax Analysis for Loop Site Cluster.

### 3.2. Network analysis

Subsequent analysis through Pajek recapitulation from space syntax investigation for all clusters (see Figure 5-7), the network analysis for all sets recommends the performance and the potential factor that affects the most. The spaces with high "connectivity values" and "integration values" in space syntax can run more natural ventilation to increase the thermal comfort feeling in the tropic condition without using active cooling for energy efficiency. Similar to the previous study, the occupants prefer to move to an open space [15]. It is useful for successful thermal performance in a building environment, especially in the early stages of architecture spatial programming. This condition can be considered for better integration or connectivity, will obtain the low costs on active cooling [16]. This site model is analyzed, having a low closing index, exposing high compactness, and performing the best thermal comfort. The more spread out site clusters pattern should present an even higher closing index to control the air changes rate spreading through the definite zones as the cul-de-sac strategy has.

The spatial network arrangement would be as straightforward and wholesome and reduce the by-passes model [17]. To extend this finding, the spatial activities should attach to relative regularity strategy, support the spatial subject, and attempt to avoid people misplacing, which have an excessive fascination with an occupant. Those principles play at the neighborhood network and among convex spaces to recognize the actual discrepancies from the inhabiting view. Furthermore, additional argumentation by convex decomposition [18] will be the valuable source of a properties variation of
significant urban ambiance for a comparative test, with prospective to notify the site cluster design's involvement.

Figure 5. Network Analysis for Grid Site Cluster.

Figure 6. Network Analysis for Cul-de-sac Site Cluster.

Figure 7. Network Analysis for Loop Site Cluster.
3.3. Visual Integration and Connectivity

This study reveals the direct interactions between visual integration and connectivity relationships (Figure 8). The irregular pattern in cul-de-sac and loop site clusters could be potential for finding wind speed more. For urban density, vertical ventilation is considered the best strategy [19]. The regression analysis shows that the cul-de-sac cluster has the lowest relationships; it indicates that the irregular model may have spread out a pattern and has high required air movement. Meanwhile, the better trend line as a grid cluster, the close relationships between connectivity with visual integration indicates the regular pattern, evenly potential activities, and environment control performance. A similar result for loop design enriches the quantitative for both variables. Delivering the open space for site planning stimulates both environmental and social aspects.

![Figure 8. Comparison of Visual Integration-Connectivity Relationships.](image)

4. Conclusion

The critical factor that this study could suggest for urban development, especially how to arrange real estate, indicates compactness and regularity of the pattern. Two main issues involved, social and environmental, are contradictive based on previous similar discussion [2]. However, the outcomes that this research obtaining shows the large area as a loop cluster having potential on all issues. At least 50% of air moves freely from the site to the lower scale as the building can reach it. The optimum for reducing the active system has a high probability of commercial estate's energy efficiency. Furthermore, space depthless, providing by the cul-de-sac cluster, reveals the decode of varying building height, and capturing high air movement even has a lack of connectivity. Dealing with the environment parameter with social qualities, the loop site cluster performs the advantage through providing open space.

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