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Integrating Space Syntax and User Movement Observation to Identify Potential Human Activity Energy Harvesting Zones in Campus Buildings

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Abstract

Energy consumption in campus buildings continues to increase with the intensity of building use and user activities, while research on human activity-based energy harvesting remains predominantly focused on energy conversion technologies, with limited attention to the relationship between spatial configuration and the distribution and concentration of user movement. To address this gap, this study integrated Space Syntax analysis and field observation to identify candidate circulation zones for future human activity-based energy harvesting applications.in the HC-A Building of Soegijapranata Catholic University Semarang. The spatial configuration analysis was carried out using DepthmapX through Visibility Graph Analysis (VGA), with Connectivity and Visual Integration analysed independently. Connectivity was used to determine preliminary candidate circulation areas based on the internal spatial configuration, while field observation was used to identify the distribution of actual user movement, particularly at main access points influenced by external movement sources. The Connectivity-based analysis identified 631 m² (67.85%) of the total analysed circulation area as preliminary candidate areas. Afterintegration with field observations, the final candidate area increased to 661 m² (71.08%), representing an additional30 m² or 3.23 percentage points primarily around the main access zones, with relatively high observed movement that was observed but was not fully captured by the preliminary Connectivity-based classification. The findings indicate that the distribution of actual user movement is associated not only with the internal spatial configuration but also with building access functions and their connections to external movement sources. Thus, integrating spatial configuration analysis with field observation provides a spatial basis for identifying candidate circulation zones for subsequent technical assessment of energy output, device performance, and installation feasibility of human activity-based energy harvesting applications.

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INTRODUCTION

Energy consumption in the building sector is one of the major contributors to global energy use, including in educational buildings such as university campuses. Campus buildings have the characteristics of user movements that are routine, repetitive, and concentrated at certain hours, so theyare characterized by routine, repetitive user movements that tend to be concentrated during particular periods, creating conditions that may support human activity-based energy harvesting..Activities such as walking generate, indirectly generates mechanical energy can potentiallybe converted into electrical energy (Marzuki, Sanjaya, and Ardiyanto 2026), (Zhang, Fisher, and Wang 2023), (Bäcklund et al. 2023). This potential provides an opportunity to utilize human activities as an additional energy source to support building energy strategies.

However, previous research on human activity-based energy harvesting has predominantly focused onenergy conversion technologies and device performance, particularly piezoelectric devices and other systems for converting

mechanical energy into electrical energy(Long Chua et al. 2016), (He et al. 2019), (Elhalwagy, Ghoneem, and Elhadidi 2017), (Jintanawan et al. 2020) Zhao et al. 2022; Oguntosin and Ogbechie 2023. Although these studies are important for improving energy conversion performance, the application of energy harvesting technologies in buildings also requires an understanding of where repetitive user movements are concentrated. From an architectural perspective, this raises a spatial issue that has received relatively limited attention in energy harvesting research: how to identify circulation areas with relevant spatial characteristics and actual movement patterns as candidate locations for future human activity-based energy harvesting applications.

Space Syntax provides a quantitative approach for analyzing spatial configuration and its relationship with movement patterns within buildings (Hillier and Hanson 1984; Hillier 1996; Turner et al. 2001). In this study, *Connectivity* represents direct spatial connections associated with local accessibility and circulation continuity, whereas *Visual Integration* represents the relative visual accessibility of a space within the overall spatial system. These parameters have been used in various studies to examine spatial accessibility, movement tendencies, and users' spatial behaviour (Mahfoudh and Ghabra 2023) (Lee 2020) (Latha, Patil, and Kini 2023) Can and Heath 2016; Nurhalimah and Astuti 2020). An important characteristic of this approach is its ability to quantitatively analyze spatial configurations under both existing and proposed conditions, allowing spatial characteristics to be evaluated without relying on the presence of actual user activity. However, analysis based solely on the internal spatial configuration of a building may not fully represent actual user movement, which may also be associated with access functions, operational conditions, and external movement sources such as parking areas and adjacent buildings.

Therefore, field observation was used to complement the spatial configuration analysis by providing empirical information on actual user movement in an operational building. In this study, the two approaches serve different but complementary analytical roles. *Space Syntax* was used to characterize the internal spatial configuration of the building, whereas field observation was used to identify the actual distribution of user movement, particularly at main access points associated with functional conditions and external movement sources that are not fully represented in the internal spatial model. The integration of these two approaches therefore enables the identification of candidate circulation zones by considering both internal spatial configuration and actual user movement patterns, without treating field observation as a validation of or replacement for the *Space Syntax* results. Based on this research gap, this study addresses the following research question: How can the integration of *Space Syntax* analysis and observed user movement be used to identify candidate circulation zones for future human activity-based energy harvesting applications? Accordingly, this study aims to identify candidate circulation zones for future human activity-based energy harvesting applications by integrating *Space Syntax* analysis with field observation of user movement within the circulation spaces of the HC-A Building, Soegijapranata Catholic University, Semarang. C*onnectivity* and *Visual Integration* were analyzed independently to represent different spatial characteristics. *Connectivity* was used as the operational parameter for determining preliminary candidate circulation areas, while *Visual Integration* provided complementary information for interpreting the overall spatial configuration. The spatial analysis was subsequently integrated with field observation to account for actual movement patterns, particularly those associated with building access functions and external movement sources. The resulting identification provides a spatial basis for selecting candidate locations for further technical evaluation of potential energy output, device performance, and installation feasibility.

METHODS

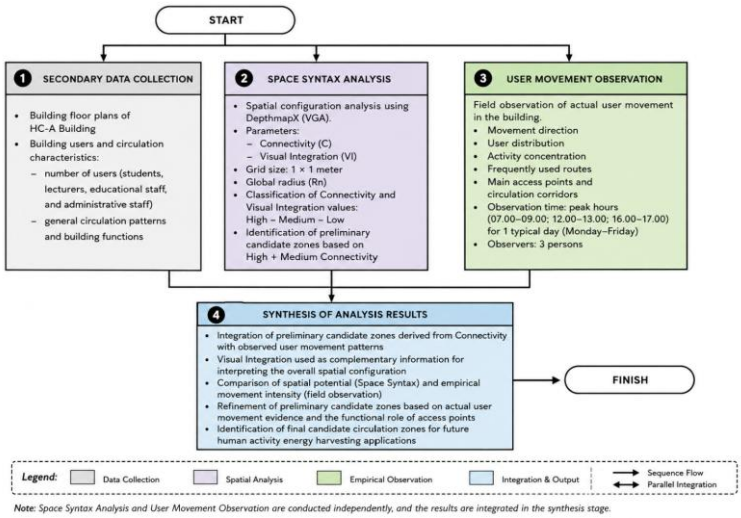


Fig 1. Research Methods

This study employed an approach that integrates *Space Syntax* analysis to identify candidate circulation zones for future human activity-based energy harvesting applications.

The research procedure consisted of four stages:(1) secondary data collection, (2) *Space Syntax* analysis, (3) user movement observation, and (4) synthesis of the analytical result as shown in Fig.1.

Secondary data were used as the basis for understanding the characteristics of the building and its users. *Space Syntax* analysis and user movement observation were then conducted independently to obtain information on the internal spatial configuration and actual user movement patterns, respectively. In the final stage, the results of the two analyses were integrated to determine the final candidate circulation zones. This procedure enabled the identification of candidate zones by considering both the spatial configuration of the building and the actual user movement patterns observed during building operation.

Secondary Data Collection

The first stage involved the collection of secondary data, whichincluded the architectural floor plansof the HC-A Building at Soegijapranata Catholic University Semarang as well as data on the number of building users consisting of students, lecturers, educational personnel, and administrative staff. The architectural floor plans wereused as the basis for modelling the internal spatial configurations *using DepthmapX*, while the user population data were used as baseline data to determine the proportional distribution of users across each access point based on the field observation results. In this study, the user population data were not used to calculate energy output but rather to support the interpretation of actual user movement distribution at the building access points.

Analysis *Space Syntax*

Spatial configuration analysis was performed using *DepthmapX* software through *the Visibility Graph Analysis (VGA) method*. The floor plan of each level of the HC-A Building was modelled using a 1 × 1 m grid1 × 1 meter with a global radius (Rn) The analysis focused on the building circulation spaces to generate *Connectivity* and *Visual Integration* values for each grid cell. The two parameters were analyzed independently and visualized using colour gradients to represent the distribution of spatial characteristics on each floor Fig 2.

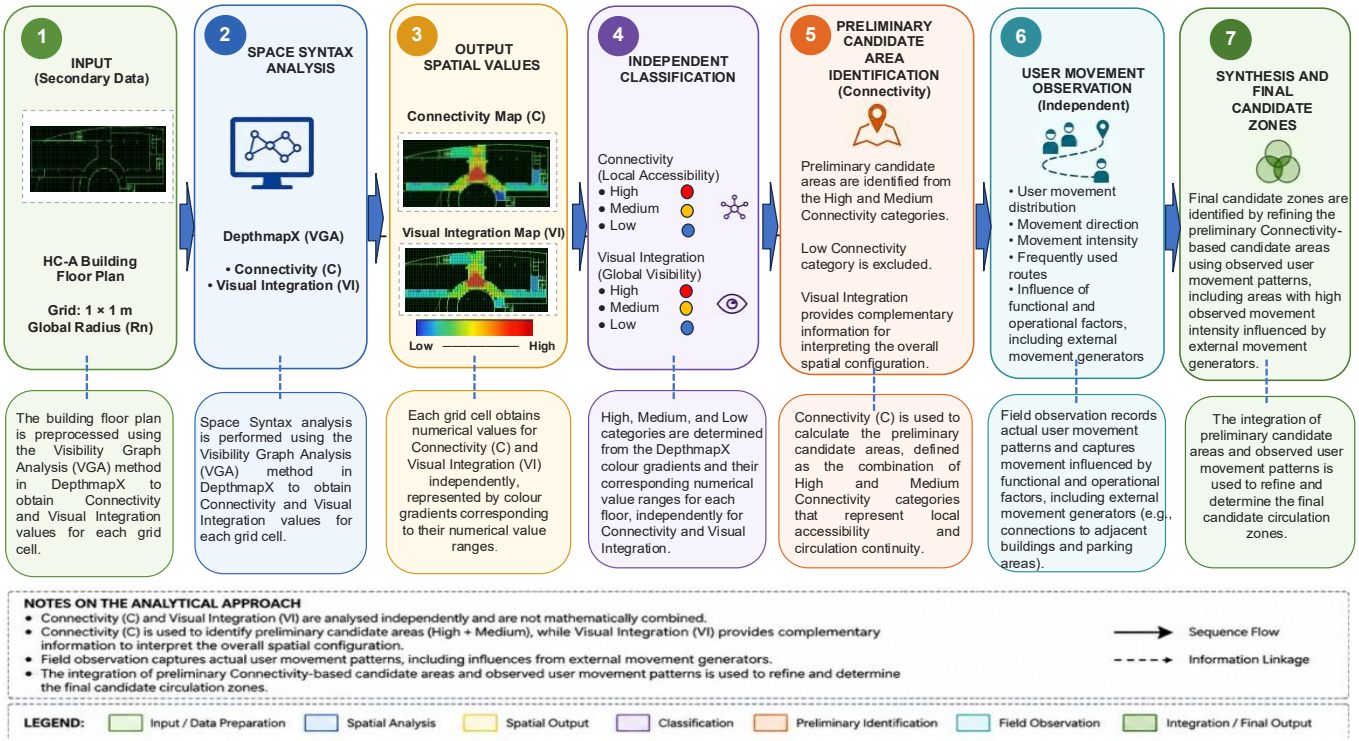


Fig 2. Analytical Framework for Integrating Space Syntax and User Movement Observation to Identify Candidate Circulation Zones

The *Connectivity* and *Visual Integration* results were subsequently classifiedinto three categories, namely High, Medium, and Low. The classification was based on the colour gradients generated by *DepthmapX* and matched with the corresponding numerical value ranges associated with each colour group. The classification was performed separately for each parameter and each floor because the resulting spatial value ranges varied across the analyses.

Using this approach, the colour maps were used to identify the spatial distribution of each category, while the numerical values were used to define the ranges representing the *High*, *Medium*, and *Low* categories. In this study, the preliminary candidate circulation area was determined by combining the *High* and *Medium* categories of the *Connectivity* parameter, while the *Low* category was excluded. The preliminary candidate area was calculated based on the number of grid cells classified as *High* and *Medium*, with each 1 × 1 m grid cell representing an area of 1 m². *Visual Integration*, meanwhile, was analyzed independently as complementary information for interpreting the overall spatial configuration and was not mathematically combined with *Connectivity* in determining the preliminary candidate circulation area.

User Movement Observation

User movement observation was conducted to obtain empirical data on actual movement patterns along the corridors and at the main access points of the HC-A Building, Soegijapranata Catholic University, Semarang. The observation focused on the number and distribution of users, movement direction, movement intensity, and frequently used circulation routes. Particular attention was given to building access points connected to external movement sources, such as parking areas and adjacent buildings, because these influences were not fully represented by the internal spatial configuration analysed using *Space Syntax*.

Field observation was conducted on one weekday under normal campus operating conditions during three peak activity periods: 07:00–09:00 for morning arrivals, 12:00–13:00 for midday activities, and 16:00–17:00 for afternoon departures. These three periods were selected to capture variations in user movement during the main periods of daily building activity.

The observation was carried out by three observers, consisting of the researcher and two students serving as research assistants. The observers were positioned at predetermined observation points and simultaneously recorded the number of users passing through each access point, their direction of movement, and the distribution of movement along the observed corridors. The records from the three observers were subsequently cross-checked and consolidated into a single observation dataset.

The observation data were then used to determine the percentage distribution of user movement at each access point. The percentage was calculated by comparing the number of users recorded at each access point with the total number of users recorded across all access points during the observation periods. Therefore, the resulting percentages represented the relative share of each access point in the overall observed movement rather than a percentage of the total building population. The results were subsequently used to identify access points and connecting corridors with relatively high movement intensity and to describe the influence of access functions and external movement sources on actual user movement patterns.

Synthesis of Analytical Results

The final stage of the study involved synthesizing the results of the *Space Syntax* analysis and user movement observation to determine the final candidate circulation zones for future human activity-based energy harvesting applications. The synthesis used areas classified as High and Medium Connectivity as the preliminary candidate areas, while Visual Integration was used as complementary information for interpreting the overall spatial configuration.

The preliminary Connectivity-based candidate areas were subsequently compared with the distribution and intensity of actual user movement obtained from field observation. Areas classified as Low Connectivity were not automatically designated as candidate areas. Such areas were considered for inclusion in the final candidate zones only when they were located at main building access points or along their connecting corridors and exhibited relatively high actual movement intensity associated with the functional role of the access point and its connection to external movement sources, such as parking areas or adjacent buildings. Accordingly, field observation was used to complement the spatial analysis by capturing actual movement conditions that were not fully represented by the building's internal spatial configuration, rather than to modify the Space Syntax classification itself. Based on this procedure, the final candidate circulation zones were determined by integrating the internal spatial characteristics with empirical evidence of actual user movement. The resulting zones represent candidate locations for future human activity-based energy harvesting applications rather than technically validated installation sites. The evaluation of energy output, device performance, and installation feasibility was beyond the scope of this study and requires further technical investigation.

RESULTS AND DISCUSSION

Space Syntax Analysis Results

The *Space Syntax* analysis using *Connectivity* and *Visual Integration* on the third to fifth floors revealed variations in the spatial configuration characteristics of the circulation areas within the HC-A Building (Fig. 3). The

numerical values generated by *DepthmapX* were interpreted according to the colour transitions displayed on the VGA maps, ranging from the blue–cyan spectrum, representing relatively low values, through green–yellow for intermediate values, to orange–red for relatively high values. For example, on the third floor, *Connectivity* values of 5–47 corresponded to the blue–cyan range and were classified as Low, values of 48–106 corresponded to the green–yellow range and were classified as Medium, while values of 107–132 corresponded to the orange–red range and were classified as High. The same classification procedure was consistently applied to the other floors and to the *Visual Integration* parameter according to the numerical value distributions and colour transitions generated on the respective VGA maps. As shown in Table 2, the High and Medium *Connectivity* categories were used to identify the preliminary candidate circulation areas. The preliminary candidate area was 235 m² (78%) on the third floor, 176 m² (67%) on the fourth floor, and 220 m² (59%) on the fifth floor. Accordingly, the total *Connectivity*-based preliminary candidate area across the three floors was 631 m², or 67.85% of the total analyzed circulation area. The differences in proportions among the floors indicate that their circulation configurations exhibited different spatial characteristics, with the third floor having a greater proportion of areas characterized by relatively higher local accessibility and circulation continuity than the fourth and fifth floors. Meanwhile, *Visual Integration* resulted in High + Medium areas of 176 m² (58%) on the third floor, 165 m² (63%) on the fourth floor, and 219 m² (59%) on the fifth floor. These results were analyzed independently and were not mathematically combined with *Connectivity* in determining the preliminary candidate area. *Visual Integration* was used as complementary information for interpreting relative visual accessibility within the overall spatial configuration, whereas *Connectivity* served as the operational parameter for identifying preliminary candidate areas based on local accessibility and circulation continuity. Therefore, the differences in the areas identified by the two parameters reflect the distinct spatial characteristics represented by each parameter rather than indicating that one parameter had a greater influence on user movement than the other. The *Space Syntax* results therefore served as a preliminary spatial identification based on the internal configuration of the building. This analysis did not fully represent actual user movement influenced by access functions and movement sources located outside the spatial analysis boundary, such as parking areas and connections to adjacent buildings. This condition was particularly relevant at the main building access points, where movement intensity could be relatively high even when internal *Connectivity* values were relatively low. Therefore, the *Connectivity*-based preliminary candidate areas were subsequently synthesized with the results of actual user movement observation to identify relevant circulation areas not captured by the preliminary classification and to determine the final candidate circulation zones.

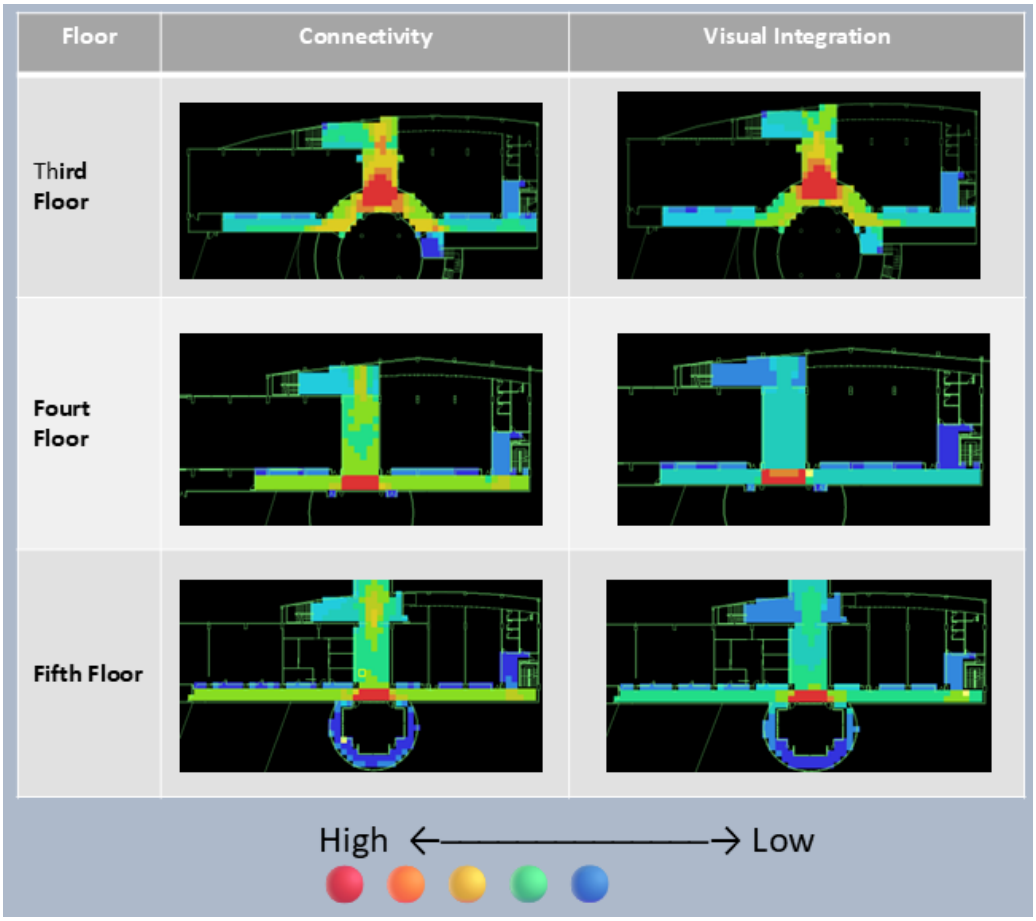


Fig 3. Results of Space Syntax Analysis Using Connectivity and Visual Integration Parameters on the 3rd–5th Floor of the HC-A Building

Table 1. Distribution of Connectivity and Visual Integration Categories and Connectivity-Based Preliminary Candidate Areas

Floor	Parameter	High (m²)	Medium (m²)	Low (m²)	High + Medium Area (m²)	Analyzed Area (m²)	High + Medium Area (%)
3rd Floor	Connectivity	43	192	67	235	302	78
	Visual Integration	45	131	106	176		58
4th Floor	Connectivity	32	144	85	176	261	67
	Visual Integration	20	145	80	165		63
5th Floor	Connectivity	38	182	147	220	367	59
	Visual Integration	12	207	148	219		59

User Movement Observation Results

Field observation showed that user movement within the HC-A Building was unevenly distributed across the four main access points, as shown in Fig. 4. Based on the user flows recorded at each access point during the observation periods, Access 2 accounted for the largest proportion of observed movement at 35%, followed by Accesses 1 and 4 at 30% each, while Access 3 accounted for 5%. These percentages represent the relative distribution of observed user movement across the four access points based on the field observation results. The building population of 1,403 users was used as contextual information on the overall number of building users and did not represent the number of users directly counted during the observation. Based on this distribution, Accesses 1, 2, and 4 exhibited relatively higher movement intensity than Access 3 and collectively accounted for 95% of the observed movement distribution.

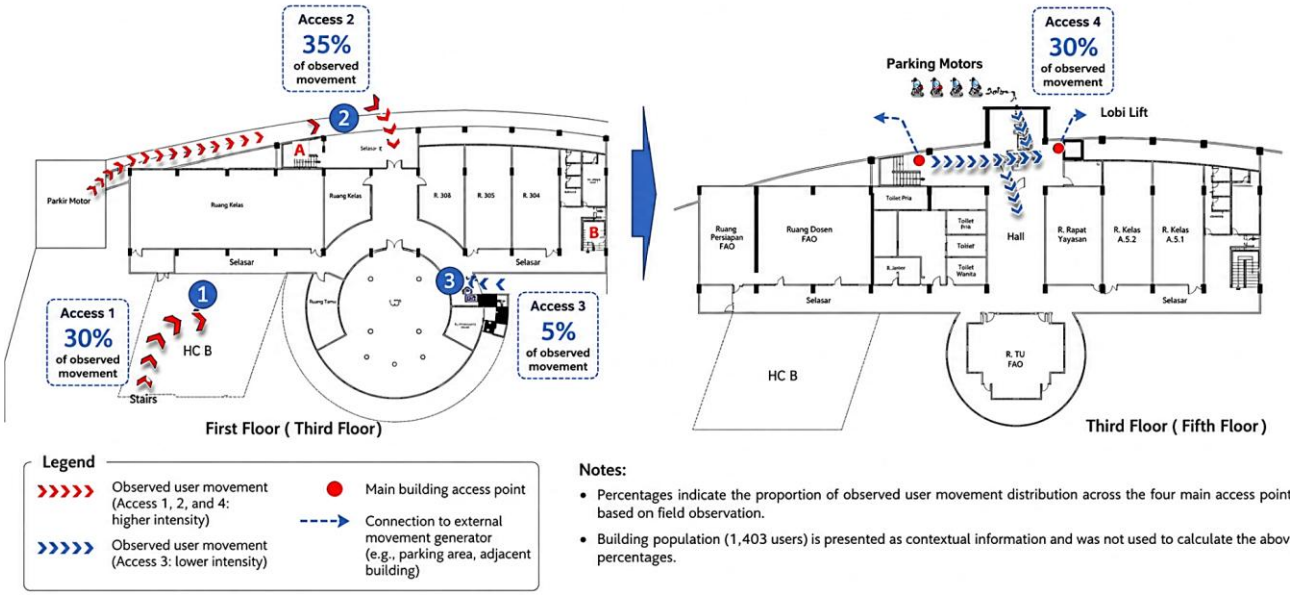


Fig 4. Observed User Movement Distribution across the Main Building Access Points and Their Connections to External Movement Generators

The differences in movement distribution were associated with the functional role of each access point and its connection to movement sources outside the building's internal spatial configuration. Access 2 accounted for the highest proportion of observed movement because it served as the main connection between the motorcycle parking area and the building's main corridor. Access 1 connected the HC-B and HC-A Buildings and therefore accommodated inter-building movement, whereas Access 4 was connected to the elevator lobby serving vertical movement between floors. In contrast, the low proportion of movement at Access 3 reflected its more limited role as a secondary access point. These findings indicate that actual user movement patterns at the access points were associated not only with the internal spatial configuration but also with the functional roles of the access points and their connections to external movement sources. This condition explains why some areas around the main access points exhibited relatively high actual movement intensity even though they were not fully included in the preliminary Connectivity-based candidate areas. Therefore, the observation results were subsequently used as empirical information in the synthesis stage to complement the preliminary candidate areas identified through the Connectivity analysis.

Integration of Space Syntax and User Movement

The results of synthesis of the *Space Syntax* analysis and field observation showed that the identification of candidate circulation zones considered not only the internal spatial configuration of the building but also actual user movement conditions. In this study, *Connectivity* was used to identify preliminary candidate areas based on local accessibility and circulation continuity, while *Visual Integration* was used as complementary information for interpreting visual accessibility within the overall spatial system. These results were subsequently synthesised with field observation data to account for actual user movement, particularly in areas influenced by access functions and external movement sources that were not fully represented by the *Space Syntax* model Fig.5.

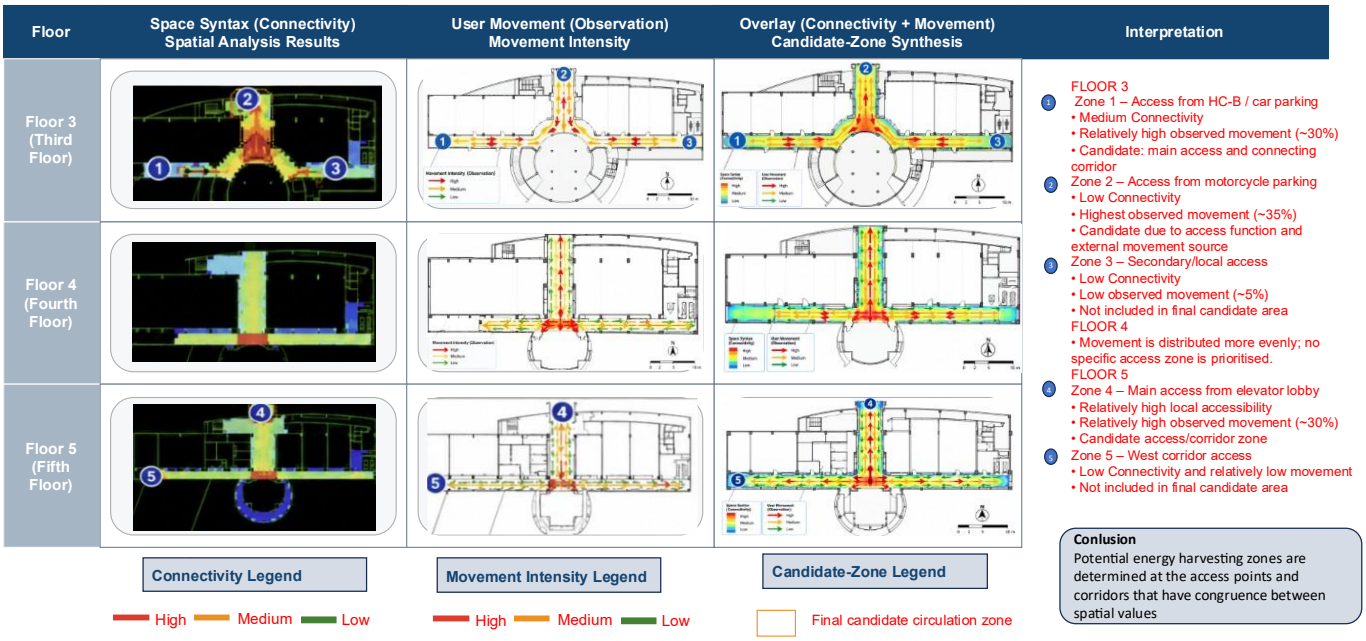


Fig 5. Integration of space syntax Analysis and User Movement Observation for Identifying Final Candidate Circulation Zones in the HC-A Building

On the 3rd Floor, the synthesis revealed differences between internal spatial characteristics and actual movement intensity at several access points. Zones 1 and 2 were classified as Medium and Low *Connectivity*, respectively, although both served as main access points connected to movement sources outside the building's internal spatial configuration. Zone 1 was associated with movement from the HC-B Building and the car parking area, whereas Zone 2 served as the main connection between the motorcycle parking area and the building's main corridor. Field observation showed that these two access points accounted for approximately 30% and 35% of the observed user movement distribution, respectively. The most evident discrepancy occurred in Zone 2, which was classified as Low *Connectivity* but exhibited the highest proportion of actual movement. This condition indicates that movement intensity in this zone was associated with its access function and external movement sources located beyond the scope of the internal spatial configuration. Therefore, the observation results were incorporated as additional information in the synthesis without altering the *Connectivity* classification generated by *Space Syntax*.

In contrast, Zone 3 showed consistency between the spatial analysis and user movement observation. This zone was classified as Low *Connectivity* and accounted for only approximately 5% of the observed movement distribution. Given its relatively low spatial characteristics and low actual movement intensity, Zone 3 was not included in the final candidate area.

On the 5th Floor, Zone 4 showed consistency between its *Connectivity* characteristics and actual movement intensity. This zone served as the main access point connecting the elevator lobby to the building corridor and accounted for approximately 30% of the observed user movement distribution. Meanwhile, Zone 5 was classified as Low *Connectivity* and exhibited relatively low actual movement intensity; therefore, it was not included in the final candidate area. This pattern demonstrates that the synthesis did not automatically include all access points as candidate areas but instead considered their spatial characteristics, access functions, and actual user movement.

Based on Table 2, the preliminary candidate area identified from the High + Medium Connectivity categories was631 m² (67.85%) of the total analyzed circulation area. After these results were synthesized with the user movement observations, the final candidate area increased to 661 m² (71.08%) representing an increase of 30 m² or 3.23 percentage points. The additional 30 m² was primarily associated with circulation segments connected to access

points on the 3rd Floor that exhibited relatively high actual movement intensity but were not fully included in the preliminary Connectivity-based candidate area. This additional area was determined from 30 grid cells measuring 1 × 1 m within the circulation areas identified through the synthesis process, with each cell representing an area of 1 m². Thus, the additional 30 m² represents an increase in the spatial extent of the candidate area rather than walking distance or user travel-path length.

Table 2. Results of Synthesis of Energy Harvesting Potential Zones Based on Space Syntax Integration and User Movement Observation

Analysis Stage	Candidate Area (m²)	Percentage (%)
Connectivity (High + Medium)	631	67,85
Connectivity + Field Observation	661	71,08
Change	+30	**+3.23 percentage points**

Overall, the synthesis identified candidate areas primarily at the main access points and their connecting corridors by considering spatial configuration characteristics, actual movement intensity, and the functional relationship of access points with external movement sources. The integration of these two sources of information was not intended to demonstrate that the combined approach had greater predictive accuracy than Space Syntax alone, but rather to incorporate actual movement conditions that were not fully represented by the internal spatial configuration. Therefore, the resulting areas were interpreted as candidate circulation zones for further investigation of future human activity-based energy harvesting applications, rather than as technically validated installation sites.

Relationship between Spatial Configuration and User Movement

The results showed that internal spatial configuration was associated with the distribution of user movement, although this relationship was not consistent across all circulation areas of the HC-A Building. Areas with relatively high *Connectivity* were generally concentrated around the main circulation nodes and connecting corridors, some of which also exhibited relatively high actual movement intensity. These findings indicate an association between spatial accessibility and the tendency for user movement to concentrate in particular areas, although internal spatial configuration alone did not fully explain all observed movement patterns.

However, the most evident discrepancy was found in Zone 2 on the 3rd Floor, which was classified as *Low Connectivity* but recorded the highest proportion of actual movement, at approximately 35%. This condition was associated with the function of Zone 2 as the main access point connecting the motorcycle parking area to the building corridor. Because this movement source was located outside the boundaries of the *Space Syntax* model, the movement intensity in this zone was not fully represented by the internal spatial configuration. This finding indicates that access functions and external movement sources were also associated with the actual distribution of user movement.

Thus, the findings demonstrate that spatial configuration and the functional conditions of the building provide complementary information for explaining user movement patterns. *Space Syntax* provides information on internal spatial characteristics, whereas field observation captures actual movement conditions, including those associated with access functions and external movement sources. The integration of these two sources of information was therefore used to identify candidate circulation zones by considering both spatial conditions and actual user movement.

Building Access Function and User Movement Distribution

The results showed that building access functions also helped explain variations in actual user movement that were not fully represented by the internal spatial configuration. This condition was particularly evident in Zones 1 and 2 on the 3rd Floor, which had different *Connectivity* classifications but both exhibited relatively high actual movement intensity. This pattern was associated with the functions of these zones as main access points connecting the internal corridors of the HC-A Building with external movement sources, including the HC-B Building, the car parking area, and the motorcycle parking area.

In contrast, Zone 3 on the 3rd Floor and Zone 4 on the 5th Floor showed greater consistency between their spatial characteristics and actual movement patterns. Zone 3 exhibited relatively low *Connectivity* and movement intensity, whereas Zone 4 showed relatively high local accessibility and movement intensity because it served as the main route from the elevator lobby to the corridor. This comparison indicates that the correspondence between spatial configuration and actual movement tended to be more evident when movement patterns were primarily structured by the internal circulation system, whereas discrepancies could occur in zones influenced by external movement sources.

These findings emphasize that access function provides important contextual information for interpreting *Space Syntax* results. In identifying candidate circulation zones, internal spatial configuration provides a basis for

characterizing spatial conditions, while access function helps explain movement concentrations associated with the building's connections to its surrounding environment. Therefore, the relationship between building access points and external movement sources should be considered alongside spatial configuration when identifying candidate circulation zones for future human activity-based energy harvesting applications.

Implications for Identifying Candidate Circulation Zones for Future Human Activity Energy Harvesting Applications

The findings indicate that the identification of candidate circulation zones can serve as a preliminary step in narrowing the areas to be examined before conducting technical assessments of human activity-based energy harvesting applications. Integrating information on spatial configuration and actual user movement allows circulation areas to be prioritized based on their spatial characteristics and concentrations of user activity. Therefore, the identified areas do not directly indicate the feasibility of implementing an energy harvesting system but provide a spatial basis for selecting locations that require further assessment in terms of energy output, device performance, and installation feasibility.

This approach also offers opportunities for further development at the building design stage. *Space Syntax* can be used to evaluate planned spatial configurations before a building becomes operational, while the findings from the existing building highlight the importance of considering access functions and movement sources when interpreting circulation patterns. Future research could therefore extend this approach to evaluate candidate zones during the design stage by integrating spatial configuration with estimated user movement patterns, followed by validation after the building becomes operational.

Research Contribution and Limitations

This research contributes to research on human activity-based energy harvesting by positioning spatial identification as a preliminary stage prior to the technical evaluation of energy harvesting systems. The main contribution of this study lies in the integration of *Space Syntax* analysis and user movement observation to identify candidate circulation zones based on internal spatial configuration and actual movement conditions. This approach extends human activity-based energy harvesting research beyond its predominant focus on energy conversion technologies by incorporating spatial considerations relevant to the selection of locations for subsequent application studies.

However, this study has several limitations. First, the research was conducted in a single campus building, and user movement was observed during peak activity periods on one operational day; therefore, the findings cannot yet be generalized to different building configurations, user populations, or activity patterns. The *Space Syntax* model was also limited to the building's internal spatial configuration, meaning that the influence of external movement sources was not directly represented in the model. In addition, the study was limited to the identification of candidate circulation zones and did not include measurements of electrical energy output, energy harvesting device performance, installation feasibility, or economic aspects.

Therefore, further research should test this approach across different building types and spatial configurations, using longer observation periods, and further investigate the relationship between spatial identification, user movement measurements, and technical evaluation of energy harvesting systems. Such development is necessary to assess the consistency of the proposed approach and to determine the extent to which the identified candidate circulation zones can support future human activity-based energy harvesting applications.

CONCLUSION

In response to the research question, this study demonstrates that candidate circulation zones for future human activity-based energy harvesting applications can be identified by integrating internal spatial configuration with observed user movement. Space Syntax provided information on the spatial characteristics of circulation areas, while field observation complemented this analysis by capturing actual movement associated with building access functions and external movement sources. The main contribution of this framework is to position spatial identification as a preliminary screening stage before the technical evaluation of human activity-based energy harvesting applications. . The identified zones do not indicate the amount of energy that could be generated or the technical feasibility of energy harvesting system installation; rather, they provide a spatial basis for selecting relevant areas for subsequent technical evaluation. This study was limited to a single campus building, with field observations conducted during peak activity periods on one operational day. In addition, the internal Space Syntax model did not directly represent external movement sources, and the study did not evaluate energy output, device performance, installation feasibility, or economic viability.

DECLARATIONS

Declaration of AI Use

The authors used ChatGPT (OpenAI) to assist with manuscript structuring, language refinement, and improving the clarity and readability of the academic text. All research data, analytical findings, and scientific conclusions remain the responsibility of the authors. The authors reviewed, verified, and edited the AI-assisted content as necessary and assume full responsibility for the accuracy, originality, and integrity of the final manuscript.

Author Contributions

ZM: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Visualization, Writing - Original Draft, and Writing - Review & Editing.

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Conflict of Interest

The author declares no conflict of interest.

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