

Spatial characteristics of campus areas in West Kalimantan using figure-ground mapping

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ARTICLE INFO	ABSTRACT
<i>Article history:</i> Received October 22, 2025 Received in revised form Dec. 25, 2025 Accepted June 06, 2026 Available online September 01, 2026 <i>Keywords:</i> Cluster Figure-ground Spatial characteristics Urban campus West Kalimantan *Corresponding author: Yudi Purnomo Department of Architecture, Faculty of Engineering, Universitas Tanjungpura, Indonesia Email: yudipurnomo@teknik.untan.ac.id ORCID: https://orcid.org/0000-0001-6626-1199	Urban campuses frequently encounter spatial imbalances between building mass and open space, limited accessibility, and inadequate integration with their surrounding urban contexts. The expansion of academic programs and increasing student enrollment intensify demands for additional facilities, while the availability of developable land remains constrained. A figure-ground theory approach, which examines the spatial relationship between building mass (figure) and open space (ground), can be utilized to identify typologies of spatial utilization within urban environments. This study aims to identify the spatial characteristics of urban campuses through the application of this approach. The research adopted a sequential mixed-methods design integrating qualitative spatial analysis with exploratory quantitative analysis. Spatial data were utilized to generate Nolli maps, which were subsequently evaluated based on variables including form, organization, orientation, composition, and spatial quality. The resulting data were then analyzed using Z-scores, K-Means clustering, and ANOVA techniques. The research objects consisted of eight state university campuses located in West Kalimantan Province. The findings reveal three principal typologies of campus morphology in West Kalimantan Province: the planned-responsive campus, the transformational-clustered campus, and the adaptive radial-axis campus. The variables contributing most significantly to the formation of these typologies include composition (symmetry and rhythm), form (transformation), orientation (climatic responsiveness), and organization (grid structure). This study contributes to the field by systematically formulating a typology of campus spatial morphology through the integration of figure-ground analysis and statistical approaches.

Introduction

Kalimantan Barat Province constitutes the third-largest province in Indonesia, encompassing a territorial extent of 147,307 km² and accommodating approximately 5.695 million inhabitants (PPID Pemprov KalBar 2024). Nevertheless, the province's Human Development Index (HDI) continues to remain

below the national average, particularly in indicators associated with expected years of schooling and life expectancy. Pontianak City records the highest educational expectancy at 15.06 years, equivalent to Diploma III attainment, whereas the remaining regencies demonstrate substantially lower educational performance (BPS-Statistics Indonesia and Province 2025). The limited participation rate in higher education

outside Pontianak represents a critical obstacle to institutional expansion and campus development, primarily due to restricted accessibility, elevated educational expenditures, and insufficient public awareness regarding the transformative role of higher education in social mobility (Admin UT Pontianak 2024).

Within the framework of regional development, universities function not merely as educational establishments but also as environments for the construction of social identity, the generation of knowledge, and catalysts of economic growth (Alnaim et al. 2025; McNeill 2024). Parallel to the increase in student enrollment and the diversification of academic disciplines, university campuses have experienced substantial spatial expansion through the addition of buildings and supporting facilities. Such growth emerges through both formally planned interventions and organic developmental processes, generating complex and dynamic spatial configurations characterized by the coexistence of older and newer architectural expressions while simultaneously necessitating adaptive and flexible planning strategies to accommodate future demands (Lartey and Marful 2021; Wen 2011). As an integrated spatial system, the campus accommodates diverse functions, including education, research, administration, residential facilities, and recreation, within a unified territorial setting (Nassar 2021; Popov and Syrova 2021).

Comparable to urban environments, campuses embody intricate spatial systems (Tallo, Pratiwi, and Astutik 2014), and scholars generally interpret their configurations through three principal morphological components: ground plan, building form, and land use structure (Birkhamshaw and Whitehand 2012). Street networks typically exhibit the greatest resistance to transformation, whereas land-use patterns remain the most susceptible to change. Consequently, the interrelationship among these elements reflects the developmental dynamics of a given territory. Within urban and regional design discourse, the relationship between built and unbuilt elements establishes the conceptual foundation for understanding spatial character. The figure-ground approach examines the interaction between building mass (figure) and open space (ground) to identify patterns, density, and the regularity of spatial composition within a particular environment (Trancik 1986; Zahnd 2006).

Although extensively employed in urban morphological studies, the application of this approach within Indonesian campus environments remains relatively underexplored. Existing studies on campus planning have predominantly concentrated on facility provision and institutional growth management without systematically investigating campus spatial morphology. However, the equilibrium between building mass and open space substantially influences environmental quality within campuses, particularly regarding social interaction and spatial sustainability (Agrawal and Yadav 2021; Calvo-Sotelo 2014; Phramesti and Yuliastuti 2013; Sugiarto, Lee, and Huruta 2022). Accordingly, this study seeks to identify the spatial characteristics of campus environments in West Kalimantan through the integration of figure-ground mapping techniques and statistical analysis.

The existence of physical structures, open spaces, and supporting infrastructural systems including public facilities and circulation networks positions university campuses as urban-like entities, frequently inviting comparisons with cities due to their autonomous spatial and functional characteristics (Alnaim et al. 2025; Lartey and Marful 2021). Their study formulates six campus planning principles derived from urban design theory: 1) identity and character, wherein campus identity emerges through distinctive buildings and landscape compositions that collectively establish coherent and aesthetically unified environments; 2) site arrangement and land use, in which planners organize core zones and circulation systems to maximize functional efficiency and land productivity while ensuring that building scale, massing, and proportion remain responsive to human dimensions and surrounding contexts; 3) architecture, whereby campus architecture should incorporate historical references, embody distinct character, and articulate aesthetic intentions; 4) orientation, emphasizing the placement of campus buildings to strengthen surrounding streetscapes and pedestrian pathways while responding to solar orientation to reduce thermal gain and glare and optimize natural illumination; 5) landscape, streets, and signage, focusing on the creation of safe and vibrant public spaces supported by active surveillance and user engagement; and 6) circulation and accessibility, ensuring equitable access across campus areas and transportation

modes despite maintaining a pedestrian-oriented environment.

As “miniature cities,” campuses likewise encounter spatial complexities, particularly within urban contexts. The planning and development of urban campuses must respond proactively to land scarcity, dense metropolitan conditions, and multifaceted environmental challenges. Consequently, it becomes essential to investigate how campuses contribute to uneven spatial development through the university’s role in shaping territorial organization (Popov and Syrova 2021). A study by Agrawal and Yadav (2021) demonstrates that the balance between building mass and open space exerts significant influence on environmental quality, social interaction, and campus sustainability. Within campus planning discourse, this theoretical framework assists in identifying the necessity for spatial optimization, more effective utilization of public spaces, and increasingly inclusive urban design strategies. Through examination of physical structures and spatial patterns analogous to those of small cities, planners may identify future directions for spatial development. The physical characteristics of a territory can be represented through the relationship between built and unbuilt forms, thereby revealing existing morphological patterns (Wortham-Galvin 2010).

The conceptual basis of this representation resides in the figure-ground relationship articulated through the Nolli map. Figure-ground representation adopts a minimalist visual language. By reducing spatial environments into solid masses and voids, this method excludes social, cultural, visual, ecological, and aesthetic variables. Figure-ground mapping also eliminates most information commonly represented in urban cartography, including topography, road infrastructure, administrative boundaries, landscape elements, and street nomenclature, leaving only building masses visible. To develop a concrete understanding of the spatial interaction between built and open areas while excluding both physical and non-physical boundaries, researchers analyze two-dimensional spatial configurations. This method further facilitates the identification of building-block arrangements and their relationships with circulation networks, thereby enabling classification of the variations in form and pattern generated through the interaction of solids and voids (Hebbert 2016; Jordan, Sherlia, and Dewi 2023). The application of figure-ground maps represents one of the most

significant principles in visual communication, as the human cognitive system not only interprets but also stores spatial information using geometric, semi-symbolic, and minimalist vocabularies analogous to cartographic representation (Eu and Jen 2018; Trancik 1986).

Six principal typological configurations emerge within figure-ground analysis: angular, axial, grid, curvilinear, concentric radial, and organic patterns (Nassar 2021; Ramdlani, Soekirno, and Giriwati 2013; Trancik 1986; Zahnd 2006). Campus typologies are generally classified according to spatial arrangements such as grid, radial, or organic configurations. Each typology possesses distinct characteristics that differently influence accessibility and spatial connectivity within campus environments. Calvo-Sotelo (2014) demonstrated that grid patterns are highly efficient in distributing academic facilities and supporting infrastructure, whereas organic configurations more effectively facilitate social interaction and integration with natural landscapes. Spatial patterns, as proposed by Ching (2007), may be shaped by functional requirements, spatial flexibility, privacy considerations, and accessibility demands. Spatial organization is categorized into five primary types: centralized, linear, radial, clustered, and grid systems. Within visual communication theory, figure-ground principles are applied to establish order within spatial compositions. Order refers not solely to geometric regularity but to a condition in which every component is appropriately positioned in relation to other elements and their functions, thereby generating harmonious spatial organization.

The principles underlying spatial composition include axis, symmetry, hierarchy, rhythm, datum, and transformation (Ching 2007). An axis constitutes an imaginary line established between two points in space. Symmetry denotes the balanced distribution of equivalent forms and spaces across opposing or corresponding sides. Hierarchy refers to the articulation of importance among forms or spaces according to their size, shape, or placement relative to other elements within an organizational system. Rhythm signifies patterned repetition. Datum represents an organizing element that unifies spatial and formal compositions. Transformation refers to the principle through which architectural concepts, structures, or organizations may be modified in response to contextual conditions without forfeiting their inherent identity. Another critical

concern within figure-ground theory involves orientation. In urban contexts, orientation refers to the arrangement of figure-ground components relative to one another, influencing navigability, legibility, and the experiential quality of place (Asarzadeh, Ghazanfari, and Gholinejad Pirbazari 2020).

Urban designers arrange buildings, streets, and landscape components to establish coherent and legible spatial systems. Orientation represents the directional relationship of a form to the ground plane, cardinal directions, surrounding forms, or the observer (Ching 2007). In land development, orientation must consider movement systems, circulation efficiency, and accessibility (Youssef 2024). Fundamental elements in figure-ground formation include solids, represented by building masses, and voids, represented by open spaces. The visual characteristics of form emerge primarily through solids. The unique outline or surface configuration of a form constitutes a critical aspect in recognizing and categorizing architectural forms. Perception of form depends upon the visual contrast established between figure and background (Ching 2007). Ching (2007) further classifies forms into basic, transformed, and irregular categories.

Furthermore, ground as a spatial void possesses both planned (positive) and unplanned (negative) spatial characteristics. Negative spaces frequently lack openness, exhibit limited connectivity with surrounding structures, and generally reflect low architectural vitality, thereby generating numerous adverse impacts on both individuals and the urban environment. Negative space refers to neglected or overlooked dimensions within architectural design, characterized by unclear function, weak organization, limited accessibility, and poor connectivity (Bai et al. 2024).

As integral components of urban territories, campuses require comprehensive examination of their spatial organization. The figure-ground theoretical framework clarifies the relationship between building mass and open space, while the Nolli map assists in identifying solid-void configurations within spatial environments. Concepts of spatial composition and organization proposed by Francis D. K. Ching and other scholars provide an analytical basis for investigating spatial form, structure, and interconnectedness. Simultaneously, theories regarding open-space quality and spatial proportion emphasize the importance of campus

morphology, particularly concerning accessibility, connectivity, and territorial vitality. Collectively, these theoretical perspectives establish an integrated framework for correlating spatial variables with empirical findings observed in the field.

Methods

This study adopted a sequential mixed-methods design. Qualitative analysis was utilized to interpret and quantify variables, which were subsequently examined through exploratory quantitative approaches to formulate clusters and identify variables demonstrating significant differences among clusters. More specifically, the research consisted of three primary stages: the preparation of figure-ground maps or Nolli maps for campus environments, the visual assessment of the resulting Nolli maps according to the designated research variables, and the classification or formulation of campus typologies. The investigated campuses comprised the principal campuses of state higher education institutions located within West Kalimantan Province. Indonesian higher education institutions are categorized into three types: state universities, ministry or institutional universities, and religious universities. In West Kalimantan Province, eight state higher education institutions were identified, namely:

1. Universitas Tanjungpura (Untan)
2. Institut Agama Islam Negeri (IAIN) Pontianak
3. Politeknik Negeri Pontianak (Polnep)
4. Politeknik Kesehatan Kemenkes (Poltekkes) Pontianak
5. Institut Pemerintahan Dalam Negeri (IPDN) Kampus Kalimantan Barat
6. Sekolah Tinggi Agama Katolik Negeri (Stakatn) Pontianak
7. Politeknik Negeri Sambas (Poltesa)
8. Politeknik Negeri Ketapang (Politap)

Cartographic techniques employed in Nolli map production utilized aerial imagery data derived from Google Earth Engine (Bustamante 2021). The imagery datasets originated from the years 2020, 2024, and 2025. Google Earth satellite imagery was considered sufficiently accurate for medium-scale spatial analysis, exhibiting an RMSE value of approximately ± 0.14 m (E. Martoyo et al. 2017). Following the production of Nolli maps for each campus,

researchers conducted systematic visual assessments using structured evaluation guidelines for each variable (see Figure below) based upon the theoretical principles and indicators described in table 1. Assessment employed a Likert scale ranging from 1 (very low) to 5 (very dominant). ArcGIS was subsequently utilized to identify, quantify, and observe variable and sub-variable components for each research object, as specified in table 1 and represented within the resulting Nolli maps.

To maintain consistency across campus assessments, every indicator within this study was constructed upon explicit and measurable operational definitions, as presented in table 1. The assessment process adopted a standardized scoring rubric in which each Likert-scale value (1–5) corresponded to a clearly defined condition level. All research objects were examined using the same spatial database and figure-ground representations generated from consistent imagery sources, thereby minimizing interpretive

discrepancies resulting from data variation. Because all Likert-scale evaluations were conducted directly by the researchers, methodological accountability required explicit operational definitions as shown in table 1. These indicators functioned as the principal guidelines for the assessment process and were grounded in the theoretical basis of each spatial variable, thereby reinforcing the validity and reproducibility of the findings. To minimize subjective bias, the assessments underwent repeated iterations until consistent results were achieved across variables and research objects.

Furthermore, the assessment procedure was systematically conducted across all campuses using identical procedures supported by secondary-data verification and GIS-based spatial observation. This approach enabled triangulation between visual interpretation, spatial datasets, and supporting references, thereby enhancing the reliability and consistency of the scores employed within the cluster analysis.

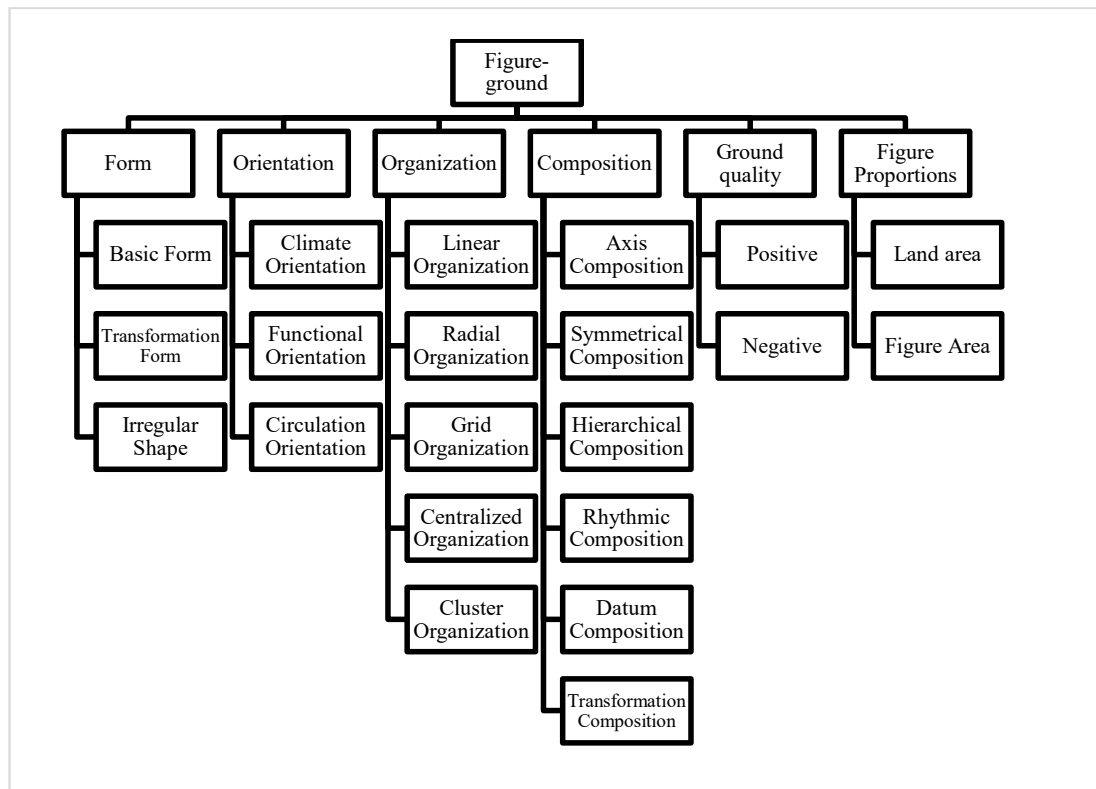


Figure 1. Research variables and sub-variables of figure-ground characteristics

Table 1. Variables, sub-variables, and assessment indicators

No	Variables	Sub variables	Definition of indicator	Likert scale (1–5)
1	Figure Proportions		Percentage of building mass to total campus area (figure-ground ratio).	1 = very low, 5 = very high
2	Ground Quality	Positive	The quality of open space is defined by the building mass (enclosure).	1 = undefined, 5 = very clear and high quality
		Negative	The clarity and dominance of the building mass as a space former.	1 = weak, 5 = very strong and structured
3	Form	Basic Form	Consistency and readability of the main geometric forms of the building.	1 = random, 5 = consistent and directed
		Transformation Form	The degree of modification of the basic form to respond to function and context.	1 = none, 5 = complex and integrated
		Irregular Shape	The existence of non-geometric forms as contextual or adaptive expressions.	1 = none, 5 = dominant and integrated
4	Orientation	Climate Orientation	Mass system response to wind direction, sun, and local climate.	1 = unresponsive, 5 = very adaptive
		Functional Orientation	Clarity of zoning and distribution of the main functions of the campus.	1 = random, 5 = highly structured
		Circulation Orientation	Clarity and efficiency of movement paths between functions.	1 = unclear, 5 = very focused
5	Organization	Grid Organization	The use of a checkerboard pattern as a basis for spatial design.	1 = none, 5 = dominant and structured
		Radial Organization	The mass arrangement pattern is centered and radially distributed.	1 = none, 5 = dominant and directed
		Linear Organization	Arrangement of masses along a straight line as an axis or corridor.	1 = none, 5 = dominant and directed
		Centralized Organization	The existence of a central element as a spatial focal point.	1 = none, 5 = very dominant
		Cluster Organization	Grouping of masses based on function or spatial proximity.	1 = none, 5 = highly structured
6	Composition	Axis Composition	The existence of a visual or functional axis as the main guide.	1 = none, 5 = very dominant
		Symmetrical Composition	The level of visual and spatial balance between elements.	1 = asymmetrical, 5 = very symmetrical
		Hierarchical Composition	The order or level between mass elements based on function or scale.	1 = none, 5 = very clear and structured
		Rhythmic Composition	Regular repetition of spatial elements to create visual dynamics.	1 = none, 5 = very rhythmic and regular
		Datum Composition	The presence of a consistent binding element or spatial reference.	1 = none, 5 = very dominant
		Transformation Composition	Changes or adaptations of spatial composition between zones or functions.	1 = none, 5 = very flexible and responsive

Using statistical software, the researchers subsequently applied cluster analysis to formulate campus characteristics. Cluster analysis constitutes a method for grouping research objects, in this case, the eight state universities within West Kalimantan Province, according to homogeneous characteristics derived from observed variables (Santoso 2014; Usman and Sobari 2013). Through the non-hierarchical K-Means method, researchers first determined the number of groups before conducting the clustering procedure. This method organizes research objects so that the distance between each object and the center of its assigned cluster is minimized. Subsequently, the analysis identifies variables contributing most significantly to cluster differentiation.

Results and discussion

As described in the research methodology, the observed campus environments comprise several categories of higher education institutions, including universities, institutes, polytechnics, and colleges. Universities are higher education institutions that provide academic education and may additionally offer vocational education across diverse scientific and technological disciplines. When institutional requirements are fulfilled, they may also provide professional education. Institutes provide academic education and may likewise offer vocational education within specific scientific or technological fields, including professional education where requirements are satisfied. Colleges provide academic and vocational education within more

specialized disciplinary domains and may also administer professional education. Polytechnics, meanwhile, primarily provide vocational education in diverse scientific and technological fields and may offer professional education when institutional standards are fulfilled (Pemerintah Republik Indonesia 2012).

Table 2 illustrates the profiles of higher education institutions in West Kalimantan Province. Untan represents the oldest state university within the province and currently accommodates nine faculties, 43 departments, and 103 active study programs. IAIN Pontianak,

Polnep, and other institutions established their campuses following the establishment of Untan. Several campuses possess multiple locations beyond their primary campuses, including Untan, Polnep, and Poltekkes Kemenkes Pontianak. Institutions frequently operate branch campuses within the same municipality or regency as the main campus, whereas others expand beyond district boundaries. Meanwhile, the IPDN West Kalimantan Campus constitutes one of several IPDN campuses distributed across seven regions in Indonesia.

Table 2. Profile of state of higher education institutions in West Kalimantan Province

No.	Name of Institution	Year of Establishment	Year of State University	Faculty	Department	Study Program	Active Students	Land Area (ha)	Figure Area (ha)
1	Universitas Tanjungpura (UNTAN)	1959	1963	9	43	103	41.629	147.31	21.35
2	Institut Agama Islam Negeri (IAIN) Pontianak	1965	2001	5		25	8.681	4.45	1.82
3	Politeknik Negeri Pontianak (POLNEP)	1985	1997	-	8	36	8.114	7.55	3.62
4	Poltekkes Kemenkes Pontianak	2001	2001	-	6	16	2.614	3.31	1.30
5	IPDN Kampus Kalbar	1920	2004	1		2	108	28.33	1.79
6	Stakatn Pontianak	2006	2017	-	1	5	1.066	1.52	0.40
7	Politeknik Negeri Sambas (POLTESA)	2008	2014	-	3	11	2.575	8.79	1.42
8	Politeknik Negeri Ketapang (POLITAP)	2009	2014	-	4	9	1.351	7.92	1.15

Active student data for the academic year 2025 (Untan, Polnep, Poltekkes, Stakatn, Poltesa, Politap) and 2024 (IAIN, IPDN)

Figure 2 presents digitized representations of Google Earth satellite imagery prepared according to Nolli map cartographic standards. The figure illustrates the figure-ground relationships of each campus and reveals varying proportions of land utilization. Table 3 summarizes the quantitative and qualitative assessment results derived from the campus Nolli maps. Polnep, IAIN Pontianak, and Poltekkes Pontianak are located within urbanized city-center contexts, where built-up land utilization approaches 50%. Land utilization within these campuses demonstrates relatively high intensity, with several medium- and high-rise structures occupying the sites.

Figure 2 further demonstrates the figure-ground patterns of eight existing campuses. In general, campus building figures predominantly retain basic rectangular geometries despite

modifications in mass composition. Nevertheless, irregular forms are more evident within the IAIN and Politap campuses compared to other institutions. A dominant axial composition is observable within the Untan campus, characterized by a clearly articulated grid structure. Polnep and Poltekkes, both exhibiting strong linear organization, demonstrate elongated building arrangements aligned with principal circulation corridors. Stakatn, which achieved the highest score in centralized organization, displays a dominant centralized building mass.

In contrast, several other campuses exhibit relatively low built-up intensity. Table 3 additionally indicates that the application of building massing in terms of form, organization, composition, and open-space quality demonstrates considerable variation. Among the observed variables, very few indicators emerged

as overwhelmingly dominant except for several sub-variables. This dominance suggests that although certain sub-variables appear visually

prominent, additional sub-variables remain present to varying extents.

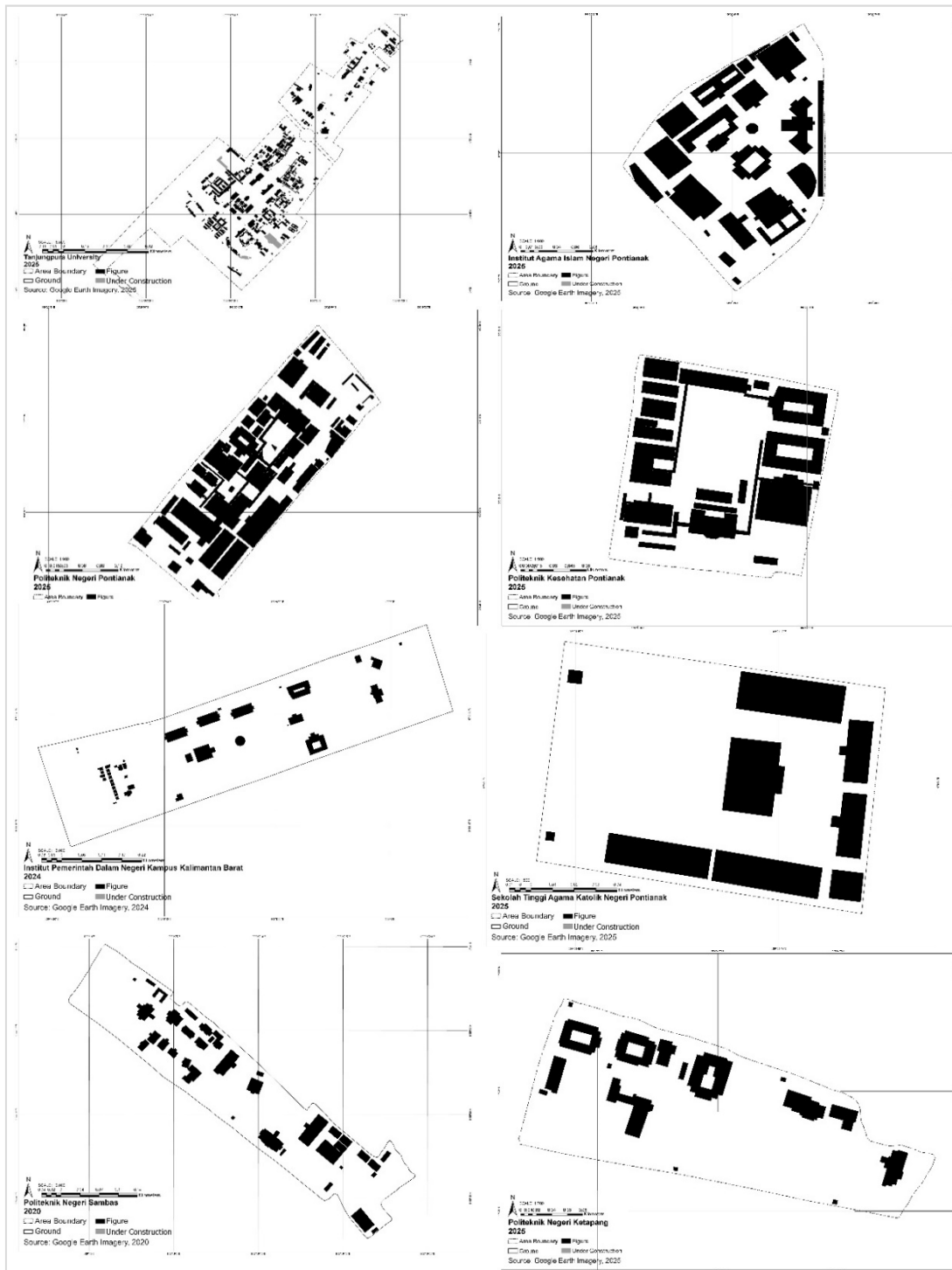


Figure 2. Nolli Map of State Higher Education Institutions in West Kalimantan Province

Table 3. Figure-ground mapping assessment results for research variables

No	Name of Institution	Proportion_figure	form_primaryshape	form_transformation	form_irregular	orientation_climate	orientation_functional	orientation_circulation	organization_grid	organization_radial	organization_linear	organization_centralized	organization_cluster	composition_axis	composition_symmetrical	composition_hierarchy	composition_rhythm	composition_datum	composition_transformation	ground_positive	ground_negative
1	Untan	14,50	5	2	1	3	4	3	1	3	4	3	3	5	3	4	2	3	1	3	2
2	IAIN	40,92	4	3	3	2	4	3	1	1	2	3	4	1	1	4	1	3	2	3	2
3	Polnep	47,99	5	2	1	2	3	3	1	1	4	1	4	1	1	2	1	4	1	3	3
4	Poltekkes	39,17	4	3	1	4	5	2	1	2	5	2	1	1	3	2	2	4	1	4	2
5	IPDN	6,32	4	1	1	4	4	4	3	2	3	1	1	3	3	4	4	3	3	5	1
6	Stakatn	26,02	5	1	1	4	4	3	2	1	2	5	4	1	3	3	4	3	1	3	1
7	Poltesa	16,15	4	2	1	3	2	5	2	3	4	1	2	3	2	2	2	3	1	3	2
8	Politap	16,57	2	3	2	3	2	4	1	2	4	1	2	2	1	2	3	2	1	3	1

The assessment results presented in [table 3](#) were subsequently processed using SPSS version 26 through cluster analysis. The resulting findings are displayed in tables 4 through 9. The eight analyzed campuses constitute the entire population of state universities within West Kalimantan Province; therefore, the analysis does not represent sample generalization but instead establishes the basis for determining three clusters. Considering the limited population size, three clusters were deemed optimal, since fewer clusters would obscure meaningful variation while additional clusters would excessively fragment the data. Consequently, the clustering outcomes serve as an exploratory typology for mapping institutional spatial profiles and establishing a baseline for subsequent comparative analysis.

Table 4. Cluster membership

Case number	Nama Kampus	Cluster	Distance
1	Untan	3	2.670
2	IAIN	2	3.031
3	Polnep	2	3.428
4	Poltekkes	3	3.510
5	IPDN	1	3.089
6	Stakatn	1	3.089
7	Poltesa	3	3.046
8	Politap	2	3.924

The “Cluster” column identifies institutional membership within one of three clusters formed

according to shared spatial or typological characteristics. [Table 4](#) demonstrates that IPDN and Stakatn belong to the same characteristic cluster, while IAIN, Polnep, and Politap occupy another cluster, and Untan, Poltekkes, and Poltesa form a third cluster. [Table 5](#) provides a simplified overview of these groupings.

Table 5. Universities in Clusters

Cluster	Cluster members
1	IPDN, Stakatn
2	IAIN, Polnep, Politap
3	Untan, Poltekkes, Poltesa

The “Distance” column indicates the Euclidean distance between each institution and the center of its assigned cluster, thereby reflecting the degree to which each institution represents its cluster characteristics.

- The smaller the distance, the more suitable or "fit" the institution is to the characteristics of the cluster.
- The larger the distance, the more "peripheral" or less uniform it is within its cluster.

For example:

- Untan (Cluster 3, Distance 2,670) → reasonably representative of Cluster 3.
- Politap (Cluster 2, Distance 3,924) → furthest from the cluster center → may be an outlier or have mixed characteristics.

Interpretation of these findings suggests that Cluster 1 exhibits relatively consistent spatial characteristics, as reflected by the uniformity of its distances. Cluster 2 demonstrates substantial internal variation and is therefore more heterogeneous, whereas Cluster 3 exhibits moderate stability and relative uniformity.

The classifications presented in tables 5 and 6 not only illustrate statistical grouping but also represent the morphological typology of campuses within broader regional spatial dynamics (Fleischmann and Arribas-Bel 2022). Cluster 1 reflects the pattern of newly established campuses developed within the last decade. This cluster demonstrates centralized and consolidated configurations with minimal physical transformation since initial construction and

operational commencement. The relatively recent campus environments reflect planned and uniform development within previously undeveloped territories.

Conversely, Clusters 2 and 3 exhibit more organic and adaptive forms of growth responding to environmental conditions. Cluster 2 demonstrates fragmented morphology which, in spatial-planning contexts, reflects incremental development driven by increasing spatial demands and land constraints within urban areas. Cluster 3 may be interpreted as a transitional developmental pattern situated between incremental and consolidated growth. This condition emerges from increasing spatial demands while relatively sufficient land reserves remain available for expansion.

Table 6. Final Cluster centers

	Cluster		
	1	2	3
Zscore(proportion figure)	-.65025	.61171	-.17821
Zscore(form primaryshape)	.37839	-.46248	.21022
Zscore(form transformation)	-1.34808	.64907	.24964
Zscore(form irregular)	-.50402	.84003	-.50402
Zscore(orientation climate)	1.04850	-.94865	.24964
Zscore(orientation functional)	.46771	-.46771	.15590
Zscore(orientation circulation)	.13644	-.04548	-.04548
Zscore(organization grid)	1.32288	-.66144	-.22048
Zscore(organization radial)	-.44936	-.64907	.94865
Zscore(organization linear)	-.93541	-.15590	.77951
Zscore(organization centralized)	.60025	-.31441	-.08575
Zscore(organization cluster)	-.09597	.54384	-.47986
Zscore(composition axis)	-.08575	-.54308	.60025
Zscore(composition symmetrical)	.88292	-1.13518	.54657
Zscore(composition hierarchy)	.63066	-.21022	-.21022
Zscore(composition rhythm)	1.36815	-.59637	-.31573
Zscore(composition datum)	-.19505	-.19505	.32508
Zscore(composition transformation)	.84003	-.05600	-.50402
Zscore(ground positive)	.84003	-.50402	-.05600
Zscore(ground negative)	-1.06066	.35355	.35355

The Final Cluster Centers table within the K-Means output displays the mean value of each variable for each cluster in the form of Z-scores, thereby representing the typological characteristics of each cluster according to the spatial and compositional variables employed. For example, within the climate orientation sub-variable, Cluster 1 demonstrates strong responsiveness to climatic conditions, whereas Cluster 2 exhibits relatively weak climatic orientation and Cluster 3 display moderate characteristics. Accordingly, the following conclusions may be formulated:

- Cluster 1 (IPDN and Stakatn)
 - Has dominant or high variables and sub-variables in orientation climate, organization grid, composition symmetric, composition rhythm, composition transformation, and ground positive.
 - Variables and sub-variables that are low in form_transformation, ground negative
 - Characteristics: Formal, structured, climate-responsive, strong, and symmetrical spatial composition

- Cluster 2 (IAIN, Polnep, and Politap)
 - Variables and sub-variables that are dominant or high in form irregular, organization cluster
 - Variables and sub-variables that are low in composition symmetric, organization grid, and orientation climate.
 - Characteristics: Organic, asymmetrical, tending to be informal, less climate-responsive.
- Cluster 3 (Untan, Poltekkes, Poltesa)
 - Variables and sub-variables that are dominant or high in organization radial, organization linear, and composition axis
 - Variables and sub-variables that are low in orientation climate, composition symmetric.
 - Characteristics: Adaptive, semi-structured, with more flexible and diverse spatial patterns.

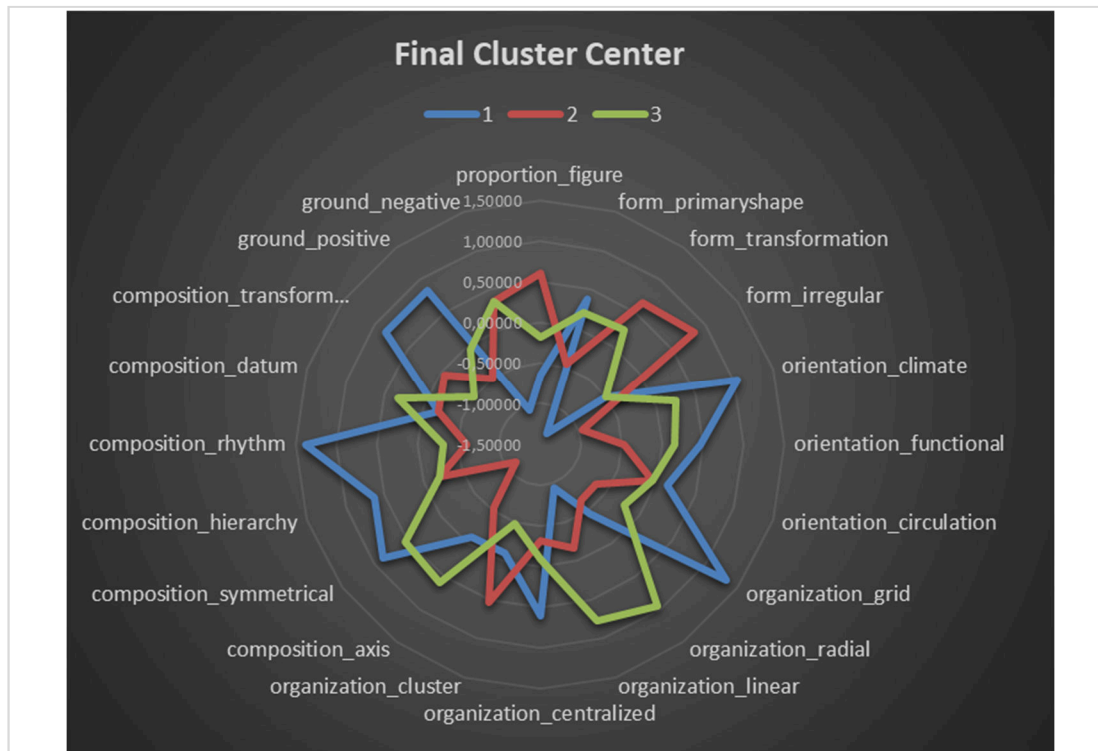


Figure 3. Final cluster center

Table 7. Distance between final cluster centers

Cluster	1	2	3
1		5.682	4.525
2	5.682		3.805
3	4.525	3.805	

The distances between final cluster centers reveal the degree of similarity among clusters. Larger numerical values indicate greater morphological distinction, whereas smaller values indicate stronger similarity between clusters. The analysis demonstrates that Clusters 1 and 2 possess substantial differences, Clusters 1 and 3 demonstrate moderate distinctions, and Clusters 2 and 3 exhibit comparatively similar characteristics.

The principal distinctions among clusters are primarily located within the dimensions of spatial organization and composition directly associated with campus morphology. Cluster 1, characterized by dominant grid structures and symmetrical composition, exhibits a high degree of spatial order associated with efficient orientation and social control. This condition is understandable considering the institutional function of campuses within this cluster, including a Government Training Institute operating under semi-military discipline. The absence, or near absence, of spatial transformation since construction contributes to a clearer and more systematically planned spatial

structure compared with other clusters. In contrast, other clusters have undergone spatial adaptation in response to increasing demands for academic space within fixed and limited territories. Campuses within Cluster 2, for example, have transformed their spatial structure through the construction of high-rise buildings, renovation of existing structures, and development of residual land parcels, thereby modifying earlier spatial configurations.

Cluster 3, meanwhile, tends to preserve its earlier spatial structure while accommodating expansion through infill development within open

spaces. Table 8 and subsequent analyses reveal two principal paradigms of campus development: planned development and emergent development. Planned development, characterized by systematic regional planning from the initial stages, is exemplified by Cluster 1. Clusters 2 and 3, however, demonstrate greater similarity. Although their initial development may have originated from planned frameworks, subsequent spatial evolution reflects emergent, organic, and incremental growth processes. Organic development, as demonstrated in subsequent studies, is both transformative and adaptive.

Table 8. Anova

	Cluster		Error		ig	
	Mean square	df	Mean square	df		
Zscore(proportion figure)	1.032	2	.987	5	1.045	.418
Zscore(form primaryshape)	.530	2	1.188	5	.446	.663
Zscore(form transformation)	2.543	2	.383	5	6.641	.039
Zscore(form irregular)	1.694	2	.723	5	2.344	.191
Zscore(orientation climate)	2.543	2	.383	5	6.641	.039
Zscore(orientation functional)	.583	2	1.167	5	.500	.634
Zscore(orientation circulation)	.025	2	1.390	5	.018	.982
Zscore(organization grid)	2.479	2	.408	5	6.071	.046
Zscore(organization radial)	2.184	2	.526	5	4.148	.087
Zscore(organization linear)	1.823	2	.671	5	2.717	.159
Zscore(organization centralized)	.520	2	1.192	5	.436	.669
Zscore(organization cluster)	.798	2	1.081	5	.739	.524
Zscore(composition axis)	.990	2	1.004	5	.986	.435
Zscore(composition symmetrical)	3.161	2	.136	5	23.281	.003
Zscore(composition hierarchy)	.530	2	1.188	5	.446	.663
Zscore(composition rhythm)	2.555	2	.378	5	6.758	.038
Zscore(composition datum)	.254	2	1.299	5	.195	.829
Zscore(composition transformation)	1.091	2	.963	5	1.133	.393
Zscore(ground positive)	1.091	2	.963	5	1.133	.393
Zscore(ground negative)	1.500	2	.800	5	1.875	.247

The F tests should be used only for descriptive purposes because the clusters have been chosen to maximize the differences among cases in different clusters. The observed significance levels are not corrected for this and thus cannot be interpreted as tests of the hypothesis that the cluster means are equal

The ANOVA results indicate that variables with high F-values and significance values below 0.05 contribute most strongly to cluster differentiation. The composition variable, particularly the symmetry sub-variable, emerges as the most influential differentiating factor. Additional significant variables include composition rhythm, form_transformation, orientation climate, and organization grid. Conversely, variables such as form_primaryshape, composition_datum, and orientation_circulation exhibit minimal differences among clusters and therefore contribute less significantly to cluster differentiation.

Table 9 presents the typology of campuses within West Kalimantan Province. Three

principal campus typologies emerge: the planned-responsive campus, the transformational-clustered campus, and the adaptive radial-axis campus. Planned-responsive campuses exhibit proportional and regular forms, adopt centralized and grid-dominant organizational structures, orient spatial layouts responsively toward climatic conditions, and apply predominantly symmetrical and hierarchical compositions. They also incorporate repetitive spatial arrangements and meaningful open spaces. The second typology, transformational-clustered campuses, develops organically through transformed and irregular forms. These campuses demonstrate clustered and non-hierarchical mass organization, weak climatic orientation, asymmetrical

composition, and fragmented outdoor spaces lacking coherent spatial structure. The third typology, adaptive radial-axis campuses, exhibits moderate forms with primarily linear characteristics while undergoing several transformations. These campuses demonstrate radial and linear organizational systems with

compositions tending toward symmetry and strong axial organization, thereby generating visual balance. Spatial orientation aligns with principal axes, responds moderately to climatic conditions, and directs the quality of outdoor spaces toward central corridors.

Table 9. Comparative analysis of variables between campus clusters in West Kalimantan

Morphological Aspects	Cluster 1 (IPDN, Stakatr)	Cluster 2 (IAIN, Polnep, Politap)	Cluster 3 (Poltekkes, Untan, Poltesa)
Form	Planned and proportional forms; low transformation and irregularity.	Forms develop organically; transformation and irregularity are high.	Radial-linear shape; follows the main axis with moderate variations.
Mass Organization	The dominant grid pattern and centering, which is emphasize spatial order.	Cluster and non-hierarchical patterns; relationships between buildings are loose and dynamic.	A combination of radial and linear, pivoting with directional spatial relationships.
Orientation & Climate	Pay close attention to climate orientation and natural lighting.	Low climate orientation: passive adaptation to the environment is not optimal.	Moderate; climate orientation is partly applied following the direction of the main axis.
Spatial Composition	Symmetrical, hierarchical, and rhythmic, emphasizing visual harmony and order.	Asymmetrical and adaptive, emphasizing flexibility and functional expansion.	Moderation between symmetrical and axis direction: produces visual balance.
Spatial Quality	Positive hierarchical open spaces; efficient and controlled massing.	Fragmented open space: visual relationships between masses are unstructured.	Directed Open spaces and focused on the main corridor or central plaza.
Campus Morphological Image	“Planned–Responsive Campus” – systematic, efficient, and climate-sensitive.	“Transformational–Clustered Campus” – organic, flexible, and dynamic.	“Adaptive Radial–Axis Campus” – directional, pivotal, and visually controlled.

Conclusions

This study classifies higher education campuses in West Kalimantan into three principal morphological typologies: planned-responsive campuses, transformational-clustered campuses, and adaptive radial-axis campuses. Planned-responsive campuses, associated with formal institutional environments such as IPDN, exhibit low-density spatial configurations and symmetrical composition reflecting institutional discipline and administrative order. Transformational-clustered campuses, interpreted as organic campuses, tend to emerge within environments characterized by dominant built-up proportions and asymmetrical spatial arrangements, particularly within vocational educational contexts. Adaptive radial-axis campuses demonstrate linear-radial spatial characteristics with balanced figure-ground relationships, representing both university and vocational campus environments. Consistent with the exploratory nature of this study, the resulting

typology should be interpreted as a morphological mapping of present spatial conditions, a snapshot, rather than a representation of historical campus development over time. Consequently, these classifications should be understood as partial descriptions of existing physical characteristics rather than definitive long-term developmental trajectories.

The variables employed within this study are limited to visual observations based upon predetermined indicators and do not establish correlations between institutional profiles and figure-ground variables. Nevertheless, this limitation does not reduce the validity of the exploratory typology. Future studies investigating campus developmental processes and broader campus morphological transformations remain essential for formulating effective planning strategies.

Acknowledgments

This research was funded through the Budget Implementation List (DIPA) of the Faculty of Engineering, Universitas Tanjungpura, for the 2025 fiscal year with contract number 2945/UN22.4/PT.01.03/2025.

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Yudi Purnomo contributed to the research concepts preparation, methodologies, investigations, data analysis, visualization, articles drafting and revisions.

Agustiah Wulandari contribute to the research concepts preparation and literature reviews, data analysis, of article drafts preparation and validation.

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