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A JUSTIFIED GRAPH ANALYSIS OF PRAYER SPACE IN FLOODED HOMES

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ABSTRACT

Indonesia's risks of natural disasters force its people to live and adapt. It happens in Samarinda's urban settlements, which flood annually. Indonesia, a religious country, applied religion to most aspects of life. The religious element is persistent even in homes being inundated by floods. Devout Muslims consistently perform the five daily *Shalah* and sometimes *Sunnah* prayers in flooded conditions. This paper analyzed the spatial configuration of the Muslim prayer space in the flooded residence from different phases. The study method was based on Justified Graph analysis, and the sample was a stilt house in some periods. The research locus was in the most settlement area covering frequent floods. This research found that Integration and Mean Depth were the critical factors in prayer spaces in flooded homes due to the connection with other spaces, visual control, and interaction. Muslim home renovations should have a prayer space with high Integration value and low Mean Depth. High Integration connects the prayer space to numerous rooms, making controlling and interacting with others during a flood easier. Low Mean Depth allows easy access to the prayer space from the main entrance. A prayer space will ensure the house has a safe area during a flood.

KEYWORDS:
Justified-Graph; spatial configuration; prayer-space; flooded homes; flood

INTRODUCTION

Every time the rainy season hits, flooding has been like an annual routine in Samarinda for the last twenty-five years. Bengkuring is one of the settlements which is mainly affected by floods. The most severe flooding submerged Bengkuring in 2019 and 2020, and its floodwater depths ranged from 20 centimetres to over 1 meter. Inundation in a few neighbourhoods of Karang Mumus Watershed (still in Bengkuring) reached up to two meters. The flood tended to decrease from 2021 to mid-2023 due to the improvement of the drainage system by the Samarinda government, but it still negatively impacted people in Bengkuring.

Flooding can majorly impact people's livelihoods [1]. Floods, as one of the environmental pressures, negatively affect individuals, communities, property, and the environment every time. It causes feelings of discomfort, loss of orientation, or loss of attachment to a particular place. If the pressure is continuous, it can cause stress. One ability to deal with environmental pressures is adaptation (adjustment, reaction, and withdrawal) [2].

Most people deal with flooding by renovating their homes to be more resilient. At least the houses have a mezzanine, attic, or higher furniture that will keep people and some goods away from water [3] [4] [5].

According to our recent observation, single-story homes are the most popular house type in Bengkuring. Unfortunately, single-story homes are vulnerable to flooding compared to two-story properties [6]. For a two-story home, the upper level provides a safe refuge and all requirements to sustain habitation during a flood, such as shelter, food, and water.

Although people have renovated their properties due to flooding, sometimes the unexpected flooding covers their homes higher than the newly renovated floor. If the water goes waist and chest high, it is categorized as a high-risk flood for the locals. That means they must be evacuated to a shelter or emergency building due to the risky situation.

The owners of single-story homes mostly refuse to leave if it is a knee-deep flood. When their homes are habitable, people will find a dry place to sleep, cook or even have spiritual needs (like Shalah).

One of the categories of spiritual needs is spiritual practice [7]. Sometimes, the spiritual practice requires an area to pray. Shalah, as a spiritual practice, reflects that it is a means of connecting with Allah SWT. During a crisis, spirituality aids victims in their ability to manage themselves [8].

For Muslims, praying during a flood might be difficult. The Quran and the Hadith stress the importance of praying five times daily. It needs to be done whether things are easy or hard [9].

In the early phases of the flood in Bengkuring in 2008, the prayer space in the bedroom was submerged in flood water, making it quite difficult for residents to pray. For people who do not have a prayer space, they must go to the nearest mosque to pray. Residents usually stay at home if they still have an area suitable enough to be used for prayer.

The first flood that occurred throughout Bengkuring was in 2008. At that time, most homes had no adjustments to mitigate unexpected floods. Only two-story occupants stayed safe during the flooding on the second floor. All rooms in single-story homes were submerged, such as the prayer space that merged with the bedroom. As flood victims, devout Muslims found no place to pray but in shelters or mosques.

In the years that followed the initial flood, a single-story residence got multiple renovations. Renovation may result in modifications to the spatial configuration. In line with [**10**], space is the centre of social and cultural incidents—variations in space configuration result in adjustments to occupant activities. Access, circulation, space integration, and depth of space can cause these alterations [**11**].

According to Minister of Public Works and Housing No. 24/2008, rehabilitation is a partial improvement with a fixed house structure. At the same time, reconstruction is repairing a building that has been severely damaged in part using a specific function that can remain or change. Dwelling renovation impacts the Justified Graphs of the dwelling.

Many researchers analyzed some dwelling eras using Justified Graphs from the Space Syntax Theory. Erman used Justified Graphs to analyze single-family houses from different periods. Erman's study examined the impact of adjustments in spatial neighbouring relationships on the spatial configuration, utilization, significance, and placement of space as a whole object [**12**].

Ostwald analyzed Early Houses (1975-1982) by Glenn Murcutt using the Justified Graph method in order to demonstrate the development of a sequence of "inequality genotypes" and a limited "statistical genotype", and a limited "statistical archetype" for the homes [**13**].

Monteiro examined domestic duties' spatial configuration among various social communities. This investigation involved analyzing the structure and arrangements of individual households [**14**]. Related to this paper, the domestic activity we observed was the praying of the Muslims during and in the aftermath of the floods.

Numerous researchers examined the floods with the Space Syntax Theory. Generally, research on the relationship between Space Syntax theory and flooding produces themes such as street network performance, economics (estimating losses due to natural disasters), regional and city resilience, planning a green infrastructure network, architecture heritage, flood resilient design and others.

Esposito and Pinto employed the Space Syntax theory as a foundational framework to examine flood risk scenarios, drawing upon urban resilience as an overall characteristic [**15**].

J. Gil and P. Steinbach introduced a technique created by Space Syntax Limited to assess and show flooding's larger impact on the urban street network. Its primary objective is to measure the performance of the street network in order to enhance the effectiveness of response strategies in such situations [**16**].

This research aimed to analyze the Justified Graph of the prayer spaces in different phases of the stilt house. The wooden stilt house is one of two house types in Bengkuring, especially in the locus of research, which includes neighbourhood number 37.

METHODS

A Justified Graph is a graphical and mathematical framework for scientific investigation of the space syntax approach. The Justified Graph was the initial method constructed within the framework of the Space Syntax theory [17], claiming to develop a graphic, numerical, and related theoretical model for examining the spatial configuration of dwellings [18]. This methodology can be applied for particular periods of building object research, such as in urban settlements or social housing [19] [20] [21]. The house plan is converted into a Justified Graph in the first stage of the research analysis. The Justified Graph can also be mathematically analyzed as a whole system.

Figure 1 (section I) below shows the spatial configuration according to Space Syntax concepts. The configuration is complete rather than a separate concept. Logically, it refers to a network of interconnected links between objects.

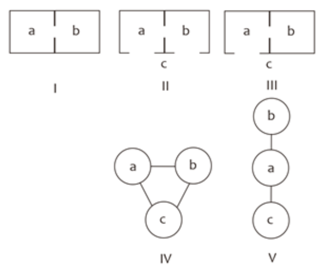


Figure 1. Floor Plans and Justified Graphs

Figure 1 illustrates floor plans with two cells ('a' and 'b') separated by a wall. The cells are represented as rooms or spaces in the floor plan. It is obvious that the relationship is formally symmetrical in that room 'a' is to room 'b' as 'b' is to 'a'.

Figure 1 (I-II-III) depicts a floor plan with two rooms and exterior doors. Justified Graphs can not be produced from the floor plan (I) because there is no entrance from the outside. Figures 1 (II) and 1(III) show the 'c,' representing the outdoors (veranda/terrace or yard) in the floor plan. Using the Justified Graphs, as drawn in Figures 1(IV) and 1(V), corresponding to Figures 1(II) and 1(III), we can demonstrate and clarify the nature of such configurational differences. We can see that Figure 1(V) has more 'depth' than Figure 1 (IV) because of the permeability difference.

The root of the Justified Graph was then changed to all cells/rooms. The first root in Figure 1 (II and III) is 'c' to construct the first Justified Graph, the second root may be 'a', and the last is 'b.' The procedure for numerically analyzing a building using a Justified Graph includes steps, typically as follows. The Total Depth, Mean Depth, Relative Asymmetry, and degree of Integration are calculated after the number of nodes within a group has been counted.

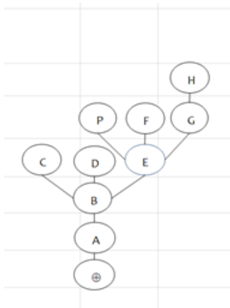
Table 1. The procedure for conducting a mathematical analysis [18]

Steps	Note
Step 1: Calculate the nodes or spaces in a set (K)	The number of nodes corresponds to the overall amount of Justified Graphs with different roots.
Step 2: Count the Total Depth (TD)	Total depth is calculated as the total of the topological distances between each node.
Step 3:Compute the Mean Depth (MD)	The Mean Depth is calculated by assigning each node a depth score based on its distance from the original nodes.
Step 4: Count the Relative Asymmetry (RA)	Relative Asymmetry compares the depth of the structure in a point to the possible depth or height of the system, with the least depth when all spaces are directly connected to the initial nodes.
Step 5: Count the degree of Integration	Integration is an adjusted distance measurement from any system's initial node to all other nodes.

Real Relative Asymmetry (RRA) is an alternative to Relative Asymmetry (RA). RRA defines a node's level of isolation or depth relative to its entire set of results and an appropriately scaled and idealized benchmark configuration. Consequently, whereas the outcomes of RA are appropriately normalized or standardized relative to a specified range of results (0–1), RRA results are relativized relative to a standard configuration.

The samples of single-family houses constructed in different periods in Bengkuring were considered in the study to analyze the changing spatial of prayer spaces before/after and during a flood. The house is owned by Muslims who perform Shalah five times a day.

Figure 2 below is The Justified Graph (left) of the annotated plan in Phase 1 (see Figure 4). The nodes ⊕ A, B, C, D, E, F, G, P, and H are represented as rooms of the floor plan. Node ⊕ represents the veranda and lies on Depth O, while node H is on Depth 5. Several nodes are counted per depth, and total nodes are represented by the symbol 'K.' Total Depth (TD) is equalled by depth multiplied by the number of nodes.



Depth	Number of nodes	Total Depth (Depth x Number of Nodes
5	1	5
4	3	12
3	3	9
2	1	2
1	1	1
0	1	0
	K=10	TD=29

Figure 2. The Justied Graph of House Plan (Phase 1) and findings of K and TD

After finding the values for K and TD, the next phase involves calculating the MD, RA, and I.

$$MD = \frac{TD}{(K-1)} = 3.22$$

$$RA = \frac{2(MD-1)}{(K-2)} = 0.56$$

$$I = \frac{1}{RA} = 1.79$$

The outcomes of the variables K, TD, MD, RA, and I are organized into a table row to facilitate an easy and systematic analysis (as seen in Table 3, Phase 1).

Table 2. Variable, Parameter, and Indicator

Variable	Parameter	Indicator
Prayer space	Guidance from Qur'an and Sunnah	Free from *naajis* (impure) Forbidden to pray in toilet/ bathroom
	Prayer concession (Rukhsah)	Dry ablution (*Tayammum*) Combining two *Shalah* (Jamak)
	House Plan	House plan in different phases before/after flooding House plan in different phases during a flood Justified Graph Summary of Justified Graphs
	Layout	Capable of being merged with other rooms
	Dimension	60 cm wide by 120 cm deep [22]
Flood	Duration	Not more than three days
	Water level	Average knee height for adult

RESULT AND DISCUSSION

PRAYER SPACE AND FLOOD

Based on Table 2, the research variable was the prayer space and the flood. Muslims can pray almost anywhere in the world, but some areas are prohibited (graveyards and washrooms). The Prophet said :

> *"The entire earth has been made a place of prayer, except for graveyards and washrooms" (HR. Tirmidzi no. 317, Ibnu Majah no. 745, Ad Darimi no. 1390, dan Ahmad 3: 83).*

The prayer space should be free from urine and filth, as mentioned in Sahih Muslim 285.

> *...These mosques are not places meant for urine and filth but are only for the remembrance of Allah, prayer, and the recitation of the Qur'an, or Allah's Messenger said something like that. He (the narrator) said that he (the Holy Prophet) then gave orders to one of the people who brought a bucket of water and poured It over"* (Sahih Muslim 285).

Prayer during emergencies certainly has *rukshah* or concessions, including prayer can be combined and *tayammum* if people do not find water (clean). The Prophet (*PBUH*) guides the people in performing the combined prayers (*Salāh jama'*) (Reported by Muslims). The report in *Hadith* clearly says that the Prophet performed *Jama's* prayers for no reason other than to facilitate the society (*rukhsah*). It is not in a state of danger but in normal times. Therefore, an emergency case may cause permissibility to perform *Jama*'s prayers [23].

During a disaster (e.g., flood), people often face difficult situations to get water in many cases, such as a water crisis or illness that causes them to avoid water use. In such a situation, people tend to choose not to perform prayers. It normally happens because of the lack of knowledge about *fiqh* and a strict prohibition to leave the prayers. In any case of inability to perform ablutions and shower, Allah has facilitated the people by giving way out, namely *tayammum* (dry ablution), as a substitute – An-Nisa 43 [**23**].

All Muslim homes must have prayer spaces [24] that can be merged with other rooms or have a dedicated prayer room (*Mushola*). The last one is not a requirement in Islam. Considering the frequency with which Muslims pray, having Mushola can be a considerable convenience, but not all Muslims can. So Muslims can set up the prayer space with a bedroom or private proper room. The minimum size of each person's prayer space is about 60 cm x 120 cm [**22**].

Flood heights are generally converted in sizes familiar to local communities. They are more familiar with knee-length, waist-length, chest-length, and others. If the flood is knee-deep, some residents are more likely to stay indoors if they still have a safe space from flooding. If the flood inside the house is more than knee-deep, some residents tend to evacuate to a safe place.

Local people express the level of flooding, with ankle knee deep (associated with the low flood), knee-high, waist and chest level, or more. The knee-waist level is described as the mid-flood. At the same time, the severe flood explains chest level or more. These rating scales are more understandable to local people than the metric system.

People could survive in their homes for days during flood events before. Local people believed that normal life would resume after several days of flooding. However, unpredictable floods made women and children more likely than men to evacuate to the nearest shelter. In 2019 and 2020, Bengkuring residents survived for five days before some people finally evacuated.

JUSTIFIED GRAPH ANALYSIS

Analysis of the Justified Graph was generated from the floor plans of a wooden stilt house as a research sample. It is about 400 m from the Karang Mumus watershed. The house was built on wetlands, and the original floor level is two meters above the swamp surface.

The owners renovated their homes about four times due to the needs of residents and to reduce the flood risk. Some floors were elevated off the old floors. The home renovations aimed to have a higher floor that prevents floodwaters. So, it can improve the value of the homes.

Figure 3. Perspective view of the stilt house (Phase 5)

Like Erman and Ostwald's studies [**12**] [**13**], which utilized a series of houses from various periods as research objects, this study analyzed the single-story house from different phases/periods using Justified Graphs.

Figure 4. Annotated plan for the stilt house

In Phase 1, the original home was built in 2004. The home had ten rooms for five residents (parents and three children). The house is made of *Ulin* / ironwood, a common flood damage-resistant local material. The home currently had one designated prayer space in their bedrooms.

In the second phase, the renovation began by adding three new rooms in the new structure, one meter above the terrace. Residents prayed in the dining room when the flood submerged lower areas. The spaces that could be used for prayer in Phase 2 were the clothesline area and kitchen.

The Phase 3 residence elevated the main bedroom one meter above, used as a prayer space during the flood. Other rooms that could be used for worship were the clothesline area, the dining room, and the kitchen. In Phase 3, residents did not renovate the home, only elevate the main bedroom, which was used as a place of prayer during a flood.

In the next Phase 4, there was a change in the function of the child's bedroom two into a semi-open space that functions as a warehouse. As a result of changes to the space's function, residents will no longer pray there. It is more practical to pray in the bedroom.

The homeowner rebuilt bedroom three on the mezzanine floor in Phase 4, which was more proper to merge with the prayer space. The residents chose to pray in available bedrooms. Access and circulation to the mezzanine floor are difficult because of uncomfortable stairs and the narrow indoor 'bridge.' The teenagers who owned bedroom 3 dealt with the current situation. During a flood, residents performed *Shalah* in the main bedroom and bedroom three rather than in the new rooms (the clothesline room, the dining room, and the kitchen).

The uncomfortable stairs were rebuilt in Phase 5 to make walking safer and easier. The narrow indoor bridge or corridor was reconstructed to be wider and can be used as a prayer space.

Through the Justified Graphs of the wooden house over time (Figure 5), the nodes increased from 10 (Phase 1) to 15 in Phase 5. It was similar to other research which used Justified Graph analysis to find the transformation of urban housing with different cases. According to [**20**], there was a significant increase in the number of nodes from the original plans to the transformed plans in all research samples.

Nodes represent a space where multiple activities can take place. For example, in node C, the main bedroom had a prayer space for the elderly too. The addition of the new nodes was the adaptation to the needs of the increasing number of residents and the need for a safe space during a flood. Zigzag lines illustrate the difference in floor height [**13**]. The difference in the room height in the wooden house sample ranges from 80 cm to 200 cm, so it required the stairs.

Yellow nodes (Figure 5) symbolize the prayer space before/after a flood. The prayer spaces were always placed in the occupant's bedroom. They chose a prayer space that would make them concentrate on performing *Shalah*. Residents do not have a special room for prayer (*Mushola)* due to limited space and finances of residents. Even though the homeowners usually pray in bedrooms, sometimes they pray in the living room.

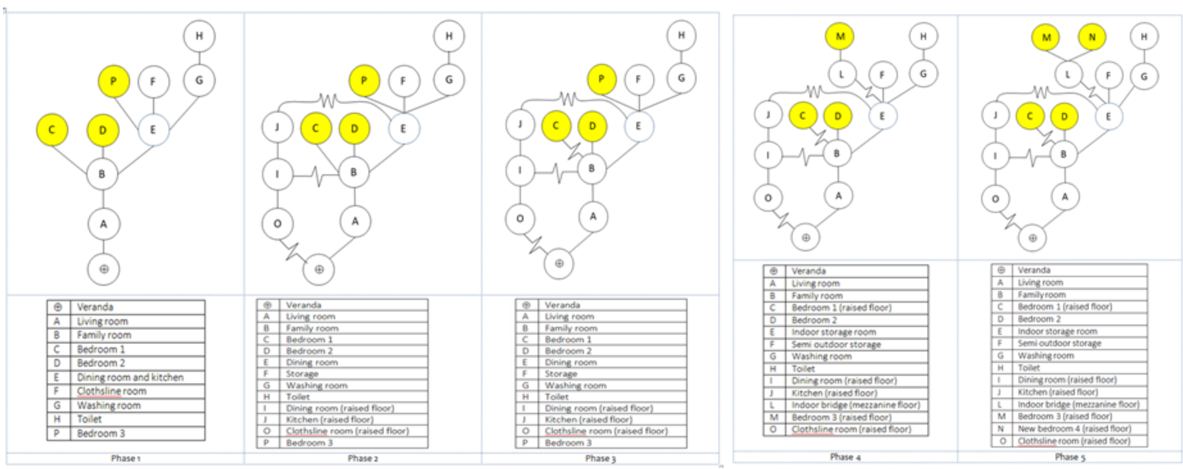


Figure 5. Justified Graphs of the sample house (before/after a flood) with the exterior (the veranda) as a root

Table 3. Summary of Justified Graphs results of Phases 1-5 before/after a flood

#	Space	⊕	A	B	C	D	E	F	G	H	P	Total Depth	Mean depth	Relative Asymmetry	Integration
0	⊕	0	1	2	3	3	3	4	4	5	4	29	3.22	0.56	1.79
1	A	1	0	1	2	2	2	3	3	4	3	21	2.33	0.33	3.03
2	B	2	1	0	1	1	1	2	2	3	2	15	1.67	0.17	5.88
3	C	3	2	1	0	2	2	3	3	4	3	23	2.56	0.39	2.56
4	D	3	2	1	2	0	2	3	3	4	3	23	2.56	0.39	2.56
5	E	3	2	1	2	2	0	1	1	2	1	15	1.67	0.17	5.88
6	F	4	3	2	3	3	1	0	2	3	2	23	2.56	0.39	2.56
7	G	4	3	2	3	3	1	2	0	1	2	21	2.33	0.33	3.03
8	H	5	4	3	4	4	2	3	1	0	3	29	3.22	0.56	1.79
9	P	4	3	2	3	3	1	2	2	3	0	23	2.56	0.39	2.56
											Mean	**22**	**2.47**	**0.37**	**3.16**

Phase 1

#	Space	⊕	A	B	C	D	E	F	G	H	P	J	I	O	Total Depth	Mean depth	Relative Asymmetry	Integration
0	⊕	0	1	2	3	3	3	4	4	5	4	3	2	1	35	2.92	0.35	2.86
1	A	1	0	1	2	2	2	3	3	4	3	3	2	2	28	2.33	0.24	4.17
2	B	2	1	0	1	1	1	2	2	3	2	2	1	2	20	1.67	0.12	8.33
3	C	3	2	1	0	2	2	3	3	4	3	2	2	1	28	2.33	0.24	4.17
4	D	3	2	1	2	0	2	3	3	4	3	3	2	3	31	2.58	0.29	3.45
5	E	3	2	1	2	2	0	1	1	2	1	1	2	3	21	1.75	0.14	7.14
6	F	4	3	2	3	3	1	0	2	3	2	2	3	4	32	2.67	0.30	3.33
7	G	4	3	2	3	3	1	2	0	1	2	2	3	4	30	2.50	0.27	3.70
8	H	5	4	3	4	4	2	3	1	0	3	3	4	5	41	3.42	0.44	2.27
9	P	4	3	2	3	3	1	2	2	3	0	2	3	4	32	2.67	0.30	3.33
10	J	3	3	2	3	3	1	2	2	3	2	0	1	2	27	2.25	0.23	4.35
11	I	2	2	1	2	2	2	3	3	4	3	1	0	1	26	2.17	0.21	4.76
12	O	1	2	2	3	3	3	4	4	5	4	2	1	0	34	2.83	0.33	3.03
														Mean	**30**	**2.47**	**0.27**	**4.22**

Phase 2

#	Space	⊕	A	B	C	D	E	F	G	H	P	J	I	O	Total Depth	Mean depth	Relative Asymmetry	Integration
0	⊕	0	1	2	3	3	3	4	4	5	4	3	2	1	35	2.92	0.35	2.86
1	A	1	0	1	2	2	2	3	3	4	3	3	2	2	28	2.33	0.24	4.17
2	B	2	1	0	1	1	1	2	2	3	2	2	1	2	20	1.67	0.12	8.33
3	C	3	2	1	0	2	2	3	3	4	3	2	2	1	28	2.33	0.24	4.17
4	D	3	2	1	2	0	2	3	3	4	3	3	2	3	31	2.58	0.29	3.45
5	E	3	2	1	2	2	0	1	1	2	1	1	2	3	21	1.75	0.14	7.14
6	F	4	3	2	3	3	1	0	2	3	2	2	3	4	32	2.67	0.30	3.33
7	G	4	3	2	3	3	1	2	0	1	2	2	3	4	30	2.50	0.27	3.70
8	H	5	4	3	4	4	2	3	1	0	3	3	4	5	41	3.42	0.44	2.27
9	P	4	3	2	3	3	1	2	2	3	0	2	3	4	32	2.67	0.30	3.33
10	J	3	3	2	3	3	1	2	2	3	2	0	1	2	27	2.25	0.23	4.35
11	I	2	2	1	2	2	2	3	3	4	3	1	0	1	26	2.17	0.21	4.76
12	O	1	2	2	3	3	3	4	4	5	4	2	1	0	34	2.83	0.33	3.03
														Mean	**30**	**2.47**	**0.27**	**4.22**

Phase 3

#	Space	Å	A	B	C	D	E	F	G	H	J	I	O	L	M	Total Depth	Mean depth	Relative Asymmetry	Integration
0	Å	0	1	2	3	3	3	4	4	5	3	2	1	4	5	40	3.08	0.35	2.86
1	A	1	0	1	2	2	2	3	3	4	3	2	2	3	4	32	2.46	0.24	4.17
2	B	2	1	0	1	1	1	2	2	3	2	1	2	2	3	23	1.77	0.13	7.69
3	C	3	2	1	0	2	2	3	3	4	2	2	1	3	4	32	2.46	0.24	4.17
4	D	3	2	1	2	0	2	3	3	4	3	2	3	3	4	35	2.69	0.28	3.57
5	E	3	2	1	2	2	0	1	1	2	1	2	3	1	2	23	1.77	0.13	7.69
6	F	4	3	2	3	3	1	0	2	3	2	3	4	2	3	35	2.69	0.28	3.57
7	G	4	3	2	3	3	1	2	0	1	2	3	4	2	3	33	2.54	0.26	3.85
8	H	5	4	3	4	4	2	3	1	0	3	4	5	3	4	45	3.46	0.41	2.44
9	J	3	3	2	3	3	1	2	2	3	0	1	2	2	3	30	2.31	0.22	4.55
10	I	2	2	1	2	2	2	3	3	4	1	0	1	3	4	30	2.31	0.22	4.55
11	O	1	2	2	3	3	3	4	4	5	2	1	0	4	5	39	3.00	0.33	3.03
12	L	4	3	2	3	3	1	2	2	3	2	3	4	0	1	33	2.54	0.26	3.85
13	M	5	4	3	4	4	2	3	3	4	3	4	5	1	0	45	3.46	0.41	2.44
															Mean	**34**	**2.61**	**0.27**	**4.17**

Phase 4

#	Space	⊕	A	B	C	D	E	F	G	H	J	I	O	L	M	N	Total Depth	Mean depth	Relative Asymmetry	Integration
0	⊕	0	1	2	3	3	3	4	4	5	3	2	1	4	5	5	45	3.21	0.34	2.94
1	A	1	0	1	2	2	2	3	3	4	3	2	2	3	4	4	36	2.57	0.24	4.17
2	B	2	1	0	1	1	1	2	2	3	2	1	2	2	3	3	26	1.86	0.13	7.69
3	C	3	2	1	0	2	2	3	3	4	2	2	1	3	4	4	36	2.57	0.24	4.17
4	D	3	2	1	2	0	2	3	3	4	3	2	3	3	4	4	39	2.79	0.28	3.57
5	E	3	2	1	2	2	0	1	1	2	1	2	3	1	2	2	25	1.79	0.12	8.33
6	F	4	3	2	3	3	1	0	2	3	2	3	4	2	3	3	38	2.71	0.26	3.85
7	G	4	3	2	3	3	1	2	0	1	2	3	4	2	3	3	36	2.57	0.24	4.17
8	H	5	4	3	4	4	2	3	1	0	3	4	5	3	4	4	49	3.50	0.38	2.63
9	J	3	3	2	3	3	1	2	2	3	0	1	2	2	3	3	33	2.36	0.21	4.76
10	I	2	2	1	2	2	2	3	3	4	1	0	1	3	4	4	34	2.43	0.22	4.55
11	O	1	2	2	3	3	3	4	4	5	2	1	0	4	5	5	44	3.14	0.33	3.03
12	L	4	3	2	3	3	1	2	2	3	2	3	4	0	1	1	34	2.43	0.22	4.55
13	M	5	4	3	4	4	2	3	3	4	3	4	5	1	0	2	47	3.36	0.36	2.78
14	N	5	4	3	4	4	2	3	3	4	3	4	5	1	2	0	47	3.36	0.36	2.78
																Mean	**38**	**2.71**	**0.26**	**4.26**

Phase 5

In Phase 2, there are three new nodes (which changed the spatial configuration significantly. The number of spaces (nodes) increase from 10 spaces to 13 spaces. The prayer spaces are in the bedrooms of parents and children. Prayer areas were also in the middle of the spatial configuration.

Table 3 summarized Justified Graphs from Phases 1 to 5 of rooms of the sample house. Yellow rows represent the summary of prayer spaces. The presentation of the data is then recapitulated in the Table 4 by capturing the nodes used as prayer spaces.

Table 4. Recapitulation values of prayer space

Phase	Nodes	Total Depth	Mean Depth	Relative Asymmetry	Integration
Phase 1	C	23	2.56	0.39	2.56
	D	23	2.56	0.39	2.56
	P	23	2.56	0.39	2.56
	Mean	22	2.47	0.37	3.16
Phase 2	C	28	2.33	0.24	4.17
	D	31	2.58	0.29	3.45
	P	32	2.67	0.30	3.33
	Mean	30	2.47	0.27	4.22
Phase 3	C	28	2.33	0.24	4.17
	D	31	2.58	0.29	3.45
	P	32	2.67	0.30	3.33
	Mean	30	2.47	0.27	4.22
Phase 4	C	32	2.46	0.24	4.17
	D	35	2.69	0.28	3.57
	M	45	3.46	0.41	2.44
	Mean	34	2.61	0.27	4.17
Phase 5	C	36	2.57	0.24	4.17
	D	39	2.79	0.27	3.57
	M	47	3.36	0.36	2.78
	N	47	3.36	0.36	2.78
	Mean	38	2.71	0.26	4.26

Through Justified Graphs calculations in Phases 1-5, the prayer space at nodes C had a lower mean value of Depth and RA than the overall space average. It indicated that node C was the most accessible prayer space than nodes D, P, M, and N when viewed outside the house (i.e., veranda). In comparison, the prayer space in node P (Phase 1-3), node M (Phase 4), and node M&N (Phase 5) had a higher value of Mean Depth than the average overall space. It indicated that these nodes needed to be more reachable than node C.

Related to the Integration value, the higher the value, the more nodes are connected to other spaces. In Phase 1, the Integration value of three prayer spaces was all the same (2.56), meaning that all these spaces had the same spatial connectivity aspects. Compared with the mean Integration value of all spaces (3.16), these three spaces were more isolated than the average of others.

In Phase 2, node C's Integration value (4.17) was higher than node D's (3.45). It hinted that the position of node C was more strategic than node D. Overall, in all phases, node C was more connected than other prayer spaces. The most isolated nodes or spaces were M and N, followed by node P. Isolated nodes implied that they connected with only a few or were separate from other nodes.

Figure 6 is the same Justified Graphs as Figure 5 with different conditions (flooded/not flooded). The water covered almost the entire space. Even though the house was raised about 2 m above the existing ground levels to prevent floodwater from entering the house, the unexpected flood raised to 2.5 m in 2019. It made the house covered by water about 50 cm on the floor. In the past five-phase, the number of prayer spaces has increased due to the spiritual needs of the occupants during the flooding.

Orange nodes (Figure 6) were prayer spaces used by residents when floods submerged their homes. The green nodes were the alternative to the prayer space. In the early period, the house did not yet have a prayer space because all the space was flooded.

In the second phase, residents built new spaces (the clothesline, the dining room, and the kitchen) on raised floors that could be used for prayer, but they preferred to pray in the dining room while flooding.

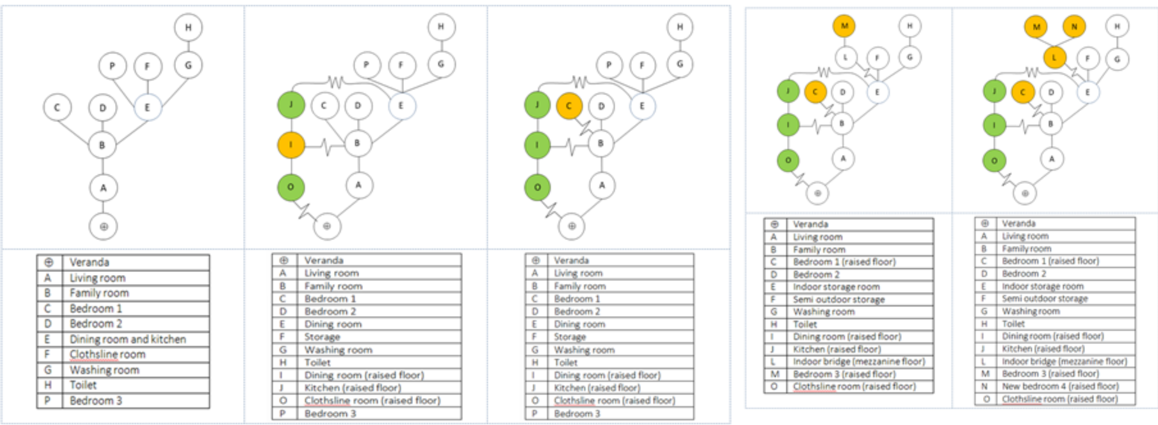


Figure 6. Justified Graphs of the sample house (during a flood) with the exterior (veranda) as a root

In Phase 3, the space configuration had not changed. Only bedroom No. 1 was raised higher than it was before. A higher floor is the basic consideration in flood-resilient homes. The owners placed bedroom No. 1 one meter above the lowest floor. So, it could be used as a prayer space before/after and during a flood.

The homeowners installed a new mezzanine floor at the back home in Phase 4, which was used as bedroom No. 3. The bedroom was merged with the prayer space as it used to be. In the last phase, the residents built another new bedroom and a transitional space on the mezzanine floor beside bedroom No. 3. The transitional space was expanded from the indoor bridge. Both were used to pray in any conditions.

Table 3. Summary of Justified Graphs results of Phases 1-5 before/after a flood

#	Space	⊕	A	B	C	D	E	F	G	H	P	J	I	O	Total Depth	Mean depth	Relative Asymmetry	Integration
0	Å	0	1	2	3	3	3	4	4	5	4	3	2	1	35	2.92	0.35	2.86
1	A	1	0	1	2	2	2	3	3	4	3	3	2	2	28	2.33	0.24	4.17
2	B	2	1	0	1	1	1	2	2	3	2	2	1	2	20	1.67	0.12	8.33
3	C	3	2	1	0	2	2	3	3	4	3	2	2	1	28	2.33	0.24	4.17
4	D	3	2	1	2	0	2	3	3	4	3	3	2	3	31	2.58	0.29	3.45
5	E	3	2	1	2	2	0	1	1	2	1	1	2	3	21	1.75	0.14	7.14
6	F	4	3	2	3	3	1	0	2	3	2	2	3	4	32	2.67	0.30	3.33
7	G	4	3	2	3	3	1	2	0	1	2	2	3	4	30	2.50	0.27	3.70
8	H	5	4	3	4	4	2	3	1	0	3	3	4	5	41	3.42	0.44	2.27
9	P	4	3	2	3	3	1	2	2	3	0	2	3	4	32	2.67	0.30	3.33
10	J	3	3	2	3	3	1	2	2	3	2	0	1	2	27	2.25	0.23	4.35
11	I	2	2	1	2	2	2	3	3	4	3	1	0	1	26	2.17	0.21	4.76
12	O	1	2	2	3	3	3	4	4	5	4	2	1	0	34	2.83	0.33	3.03
														Mean	**30**	**2.47**	**0.27**	**4.22**

Phase 2

#	Space	⊕	A	B	C	D	E	F	G	H	P	J	I	O	Total Depth	Mean depth	Relative Asymmetry	Integration
0	⊕	0	1	2	3	3	3	4	4	5	4	3	2	1	35	2.92	0.35	2.86
1	A	1	0	1	2	2	2	3	3	4	3	3	2	2	28	2.33	0.24	4.17
2	B	2	1	0	1	1	1	2	2	3	2	2	1	2	20	1.67	0.12	8.33
3	C	3	2	1	0	2	2	3	3	4	3	2	2	1	28	2.33	0.24	4.17
4	D	3	2	1	2	0	2	3	3	4	3	3	2	3	31	2.58	0.29	3.45
5	E	3	2	1	2	2	0	1	1	2	1	1	2	3	21	1.75	0.14	7.14
6	F	4	3	2	3	3	1	0	2	3	2	2	3	4	32	2.67	0.30	3.33
7	G	4	3	2	3	3	1	2	0	1	2	2	3	4	30	2.50	0.27	3.70
8	H	5	4	3	4	4	2	3	1	0	3	3	4	5	41	3.42	0.44	2.27
9	P	4	3	2	3	3	1	2	2	3	0	2	3	4	32	2.67	0.30	3.33
10	J	3	3	2	3	3	1	2	2	3	2	0	1	2	27	2.25	0.23	4.35
11	I	2	2	1	2	2	2	3	3	4	3	1	0	1	26	2.17	0.21	4.76
12	O	1	2	2	3	3	3	4	4	5	4	2	1	0	34	2.83	0.33	3.03
														Mean	30	**2.47**	**0.27**	**4.22**

Phase 3

#	Space	⊕	A	B	C	D	E	F	G	H	J	I	O	L	M	Total Depth	Mean depth	Relative Asymmetry	Integration
0	Å	0	1	2	3	3	3	4	4	5	3	2	1	4	5	40	3.08	0.35	2.86
1	A	1	0	1	2	2	2	3	3	4	3	2	2	3	4	32	2.46	0.24	4.17
2	B	2	1	0	1	1	1	2	2	3	2	1	2	2	3	23	1.77	0.13	7.69
3	C	3	2	1	0	2	2	3	3	4	2	2	1	3	4	32	2.46	0.24	4.17
4	D	3	2	1	2	0	2	3	3	4	3	2	3	3	4	35	2.69	0.28	3.57
5	E	3	2	1	2	2	0	1	1	2	1	2	3	1	2	23	1.77	0.13	7.69
6	F	4	3	2	3	3	1	0	2	3	2	3	4	2	3	35	2.69	0.28	3.57
7	G	4	3	2	3	3	1	2	0	1	2	3	4	2	3	33	2.54	0.26	3.85
8	H	5	4	3	4	4	2	3	1	0	3	4	5	3	4	45	3.46	0.41	2.44
9	J	3	3	2	3	3	1	2	2	3	0	1	2	2	3	30	2.31	0.22	4.55
10	I	2	2	1	2	2	2	3	3	4	1	0	1	3	4	30	2.31	0.22	4.55
11	O	1	2	2	3	3	3	4	4	5	2	1	0	4	5	39	3.00	0.33	3.03
12	L	4	3	2	3	3	1	2	2	3	2	3	4	0	1	33	2.54	0.26	3.85
13	M	5	4	3	4	4	2	3	3	4	3	4	5	1	0	45	3.46	0.41	2.44
															Mean	**34**	**2.61**	**0.27**	**4.17**

Phase 4

#	Space	⊕	A	B	C	D	E	F	G	H	J	I	O	L	M	N	Total Depth	Mean depth	Relative Asymmetry	Integration
0	⊕	0	1	2	3	3	3	4	4	5	3	2	1	4	5	5	45	3.21	0.34	2.94
1	A	1	0	1	2	2	2	3	3	4	3	2	2	3	4	4	36	2.57	0.24	4.17
2	B	2	1	0	1	1	1	2	2	3	2	1	2	2	3	3	26	1.86	0.13	7.69
3	C	3	2	1	0	2	2	3	3	4	2	2	1	3	4	4	36	2.57	0.24	4.17
4	D	3	2	1	2	0	2	3	3	4	3	2	3	3	4	4	39	2.79	0.28	3.57
5	E	3	2	1	2	2	0	1	1	2	1	2	3	1	2	2	25	1.79	0.12	8.33
6	F	4	3	2	3	3	1	0	2	3	2	3	4	2	3	3	38	2.71	0.26	3.85
7	G	4	3	2	3	3	1	2	0	1	2	3	4	2	3	3	36	2.57	0.24	4.17
8	H	5	4	3	4	4	2	3	1	0	3	4	5	3	4	4	49	3.50	0.38	2.63
9	J	3	3	2	3	3	1	2	2	3	0	1	2	2	3	3	33	2.36	0.21	4.76
10	I	2	2	1	2	2	2	3	3	4	1	0	1	3	4	4	34	2.43	0.22	4.55
11	O	1	2	2	3	3	3	4	4	5	2	1	0	4	5	5	44	3.14	0.33	3.03
12	L	4	3	2	3	3	1	2	2	3	2	3	4	0	1	1	34	2.43	0.22	4.55
13	M	5	4	3	4	4	2	3	3	4	3	4	5	1	0	2	47	3.36	0.36	2.78
14	N	5	4	3	4	4	2	3	3	4	3	4	5	1	2	0	47	3.36	0.36	2.78
																Mean	**38**	**2.71**	**0.26**	**4.26**

Phase 5

The table 5 summarises Justified Graphs of Phases 2-5 of a wooden stilt house. The rows represented values of Justified Graphs for every single node. The orange rows represented prayer spaces in bedrooms or others. In comparison, the green rows calculated nodes that represented alternate prayer space.

In Phase 2 on Table 5, the orange raw described the calculation of node I (dining room). During a flood, the dining room was used as a prayer space because the flood did not enter the dining room. The green rows represented nodes J (kitchen) and O (clothesline area) as an alternate prayer space during a flood.

Table 6 shows the recapitulation values of the prayer space when the flood entered the house. The three new spaces in Phase 2 have different Mean Depth summary values than all nodes' Mean Depth values. Nodes J and I had a Mean Depth value lower than the Mean Depth of node O, meaning J and I were more accessible than O.

Table 6. Recapitulation values of prayer space during a flood

Phase	Nodes	Total Depth	Mean Depth	Relative Asymmetry	Integration
Phase 2	J	27	2.25	0.23	4.35
	I	26	2.17	0.21	4.76
	O	34	2.83	0.33	3.03
	Mean	30	2.47	0.27	4.22
Phase 3	C	28	2.33	0.24	4.17
	J	27	2.25	0.23	4.35
	I	26	2.17	0.21	4.76
	O	33	2.75	0.32	3.03
	Mean	30	2.47	0.27	4.22
Phase 4	C	32	2.46	0.24	4.17
	J	30	2.31	0.22	4.55
	I	30	2.31	0.22	4.55
	O	39	3.00	0.33	3.03
	M	45	3.46	0.41	2.44
	Mean	34	2.61	0.27	4.17
Phase 5	C	36	2.57	0.24	4.17
	J	33	2.36	0.21	4.76
	I	34	2.43	0.22	4.55
	O	44	3.14	0.33	3.03
	L	34	2.43	0.22	4.55
	M	47	3.36	0.36	2.78
	N	47	3.36	0.36	2.78
	Mean	38	2.71	0.26	4.26

In Phase 3, during a flood, wooden houses tended to use only one room for prayer (the dining room). The home still had two other rooms higher than the flood level, but the occupant preferred to pray in the dining room. Bedroom 1 could not be used as a prayer space because a flood covered it.

From Phase 1 to Phase 5, prayer spaces in bedrooms C and D showed high connectivity compared to other prayer spaces (in bedrooms P, M, or N). The nodes C and D positions were more strategic and well-connected because they were in the middle area. While the prayer spaces in bedrooms P, M, and N were more isolated than those in C and D. It can be concluded from the discussion.

Table 7. Summary of discussion

Phase 1-5	Before/after a flood	During a flood
Nodes (K)	The increased nodes resulted from the owner's renovations to create flood-safe spaces at a higher elevation.	
Mean Depth (MD)	The prayer spaces' Mean Depth was higher than the average Mean Depth of the total space, indicating that the prayer spaces were "deeper" from the root (front veranda) of the road and created the private area. Nodes M and N on the mezzanine floor had the deepest Mean Depth.	The mean depth of prayer and alternate prayer spaces were likely lower than the average Mean Depth of the overall space, indicating that the space is 'not too deep' or closer to the root (front veranda) and the road. The prayer spaces were less private but more strategic and accessible.
Integration (I)	Integration value was lower in prayer spaces than the overall space average. It showed that prayer spaces were more isolated than typical. More isolated described that these prayer areas promised serenity for prayer. Nodes M and M were the lowest values of Integration. These two were the most isolated nodes.	Prayer rooms (The orange nodes in Figure 6) had a lower Integration value than the rest. It showed that prayer rooms were more isolated during a flood. When the water worsens, the residents may have trouble communicating or evacuating. In contrast, alternate prayer spaces (the green nodes in Figure 6) with high Integration values during a flood were strategically located and simple to control from/to other rooms.

Before/after and during a flood, prayer spaces with low Integration values created an isolated and private area. This result was comparable to Elizondo's (2022) finding that areas located below the average Integration were private spaces, such as bedrooms and restrooms, and exterior areas, such as the veranda.

Esposito and Pinto hypothesized the number of nodes (connectivity) and the length of paths (global choice). The nodes may explain the interaction, proximity, and the virtual direct route. The shortest paths refer to alterations in the area's visual appearance (Integration value). The integration value was crucial for making the core map [15]. Similar to this study, Integration was an important factor in prayer spaces in flooded homes during a flood due to the connection to other spaces, visual control, and interaction.

Similar to Elizondo's (2022) finding, all social housing transformations decreased overall Integration and increased Total Depth relative to the original housing [25]. The outcome was the same for prayer spaces before and after a flood but differed during a flood.

The value of the Mean Depth of prayer spaces was indicated to be higher than the overall space average for the last five phases before/after a flood. It implied that the prayer spaces were less accessible than the average of all rooms. Less accessible could be more private (*khusu'*) when praying because they were far from the main alley and street.

On the contrary, the value of the Mean Depth of the prayer spaces was lower during a flood. It indicated that those spaces were more accessible compared with an average of all rooms. During a flood, those prayer spaces were more reachable than other spaces. It was easier when the occupants should be evacuated from an unexpected flood.

The Integration value of prayer spaces was lower than the average Integration value of other rooms (before/after a flood). It was understood that the prayer spaces were more isolated than the average of entire spaces. The prayer places were characterized as being more isolated, offering a sense of peace for those practising prayer.

Similar to the Integration value of prayer spaces during a flood, it was lower than the average value of entire spaces. Lower Integration values implied the low connectivity of the prayer spaces. It indicated that prayer spaces merged with certain rooms located less strategically and less connected with other rooms.

The prayer space from Phase 1 to Phase 5 had different Mean Depth values when the area was inundated versus when it was not flooded. In contrast, integration values remained fixed across all conditions.

The limitation of this study is a small number of home samples, so we can not generalize the findings. However, it is the starting point to research such a limited topic. Further studies will examine a different housing typology within urban areas prone to floods.

CONCLUSION

This research aimed to analyze the Justified Graphs of the prayer spaces in different phases of the stilt house in flood-prone urban settlements. Integration and Mean Depth were the most important factors in prayer spaces in flooded homes due to the connection to other spaces, visual control, and interaction. The recommendation for home rehabilitation or reconstruction for the Muslim community is to place a prayer space in high Integration value and low Mean Depth. High Integration makes the prayer space connected to many rooms, not isolated, so it is easy to control to/from other rooms during a flood and interact with other people. Low Mean Depth allows the prayer space to be accessed from the main entrance easily. A prayer space will provide refuge in the home during a flood.

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