architecture

MDPI

Article

Quality of Public Housing in Singapore: Spatial Properties of Dwellings and Domestic Lives

Junko Tamura *,† and Kent Fang

Department of Architecture, School of Design and Environment, National University of Singapore, Singapore 117566, Singapore; kentfang7@gmail.com

* Correspondence: junko@meiji.ac.jp; Tel.: +81-3-5343-8118

† Current Affiliation: Organization for the Strategic Coordination of Research and Intellectual Properties, Meiji University, Tokyo 164-8525, Japan.

Abstract: Singapore's public housing policies are widely known for their success in providing housing for over 80% of the residential population, with most owning homes. Extensive housing schemes generally offer a set of fixed housing layouts; yet, at the microscale of an individual dwelling, alterations to the units can be made by rearranging the floor plans to reflect the usage patterns of the household, thus adding diversity to the fixed configuration. The aim of this paper is to identify associations among a housing unit's spatial properties by analysing fixed configurations and altered floor plans as well as determining the spatial preferences of the inhabitants. The research methodology applied in this paper has been divided into two parts: spatial network analysis and survey analysis. In the spatial network analysis, the configurations of individual housing units and altered units were compared by translating floor plans into graphs. The survey functions as a qualitative analysis to relate the lifestyle patterns of contemporary society to housing configurations.

Keywords: Singapore; public housing; HDB; design survey; network analysis

Citation: Tamura, J.; Fang, K. Quality of Public Housing in Singapore: Spatial Properties of Dwellings and Domestic Lives. *Architecture* **2022**, *2*, 18–30. https://doi.org/10.3390/architecture2010002

Academic Editor: Miguel Amado

Received: 5 December 2021
Accepted: 20 January 2022
Published: 25 January 2022

1. Introduction

The provision of large-scale public housing represents a major aspect of the welfare system. Expansive housing development schemes have made an important contribution towards increasing savings and homeownership rates as well as sustaining economic growth through the development of the housing sector. However, when the Housing and Development Board (HDB) was established as the national housing authority in 1960, only nine percent of the population enjoyed low-cost public housing [1]. Today, Singapore is able to provide accommodations for over 80 percent of the residential population, with more than 90 percent owning homes [2].

Singapore's housing policies have been labelled 'phenomenally successful' by other countries [3] because of their ability to provide home ownership, which explains the considerable number of studies on Singapore's public housing programme [4,5]. For example, Sim, Lim, and Tay [1] present the key success factors in the strategy for full home ownership, and Chua [6] discusses the difficulties of maintaining property values when every family in the society has its own home. Furthermore, Sim, Yu, and Han [7] evaluate the success of the implemented public housing policy in dispersing ethnic enclaves and integrating the multi-ethnic population, which enables the social resilience needed by Singapore as a multiracial nation. The literature indicates how the Singapore government has used public housing as a policy instrument to manage and integrate the multi-ethnic population, whereas in the period before 1960, various ethnic groups were spatially segregated and concentrated in certain parts of the island, thereby creating enclaves.

Since achieving its main goal of providing shelter for Singapore's increasing population, the HDB has become more concerned with the type and quality of the housing it offers. As noted by Teo and Huang [8], this concern was in response to strong criticism that

HDB housing was uniform and monotonous; by the 1980s, Singapore came to be described as 'another modern metropolis' [9], that is, international in style but homogeneous in space. In other words, despite the success of Singapore's housing policies that led to greater home ownership and ethnic integration, the HDB's efforts resulted in the mass production of homogeneous space that lacked any sense of place [10].

Attempts to create that sense of place have been implemented at the precinct level. Facilities such as courtyards, walkways, and pavilions are designed to enable interactions among the residents of the area, thus creating opportunities for them to get to know one another better. However, a study by Teo and Huang [8] of Pasir Ris, a neighbourhood in Singapore, showed that this locale was successful in creating a distinct identity as a precinct, although a strong sense of bonding and belonging had not been established. Another attempt was made at the construction phase to differentiate the flats by adding variety in the form of highly visible architectural designs. Previous designs have represented the humble modernist style that was typical of the industrialized production of buildings, while also contributing to the standardized appearance of public housing in Singapore [11]. As a result, to aid in the identification of buildings, the facades of street blocks were decorated with motifs, dormers, and colours to make each estate unique so that residents could have a sense of identity [8].

The development of Singapore public housing over many decades has shifted from the production of homogeneous space to heterogeneous space and from the creation of quantity living to quality living. These developments have prompted interest in studying residents' living experiences with a focus on the subject of liveability. Yuen, Yeh, Appold, Earl, Ting, and Kurnianingrum Kwee [12] analysed the increasingly important question of liveability by discussing the satisfaction and concerns of the occupants of high-rise HDB buildings; Utsumi, Takai, and Suzuki [13] and Suzuki, Takai, and Utsumi [14] focused on common spaces located at sky-deck level and argued the usability of shared space utilized as a viewing gallery, whereas Teo and Kong [15] focused on quality improvements, namely, the physical upgrading of older estates, made along four lines. The first line is the demolition of old flats that can be used for redevelopment; second is the conversion of old one-room flats into larger three- and four-room flats; third is the provision of additional facilities similar to those found in the newer estates, such as a commercial complex as well as lifts and balconies in buildings; and fourth is the liberalization of rules on alterations to individual flats, which allows owners to make minor changes themselves. In this way, the HDB has had a positive impact on Singapore's public housing by using innovative, sustainable, and effective management [15] that provides for quantity but also quality housing.

However, although studies have been performed on the qualitative aspects of public housing in Singapore, the HDB's focus on the design of housing floor plans, which deserves documentation and analysis, has not yet received much attention. The extensive housing schemes generally offer a set of fixed housing layouts, and five phases of building layout improvements have been observed in the history of the HDB, as indicated in the annual reports from 1960 to 2008. The five phases are summarized in Table 1, which shows that over time, the public housing system was redesigned to cater to the changing needs of its people. At the microscale of an individual dwelling, alterations made to the units in accordance with one of the four upgrading schemes mentioned by Teo and Kong [15] were carried out by rearranging the floor plans to meet the lifestyle of the household.

Focusing on individual dwellings, identifying the society of a specific location, culture, and era represents an important factor that can be assessed using a bottom-up approach. Thus, the modern-day spatial organization of dwellings can be used to illustrate the current approach to living and vice versa. Therefore, this paper attempts to provide another dimension of quality by focusing on the relationship between inhabitants and their dwelling space, which can be accomplished by mapping the morphological changes in its configuration. Within this framework, this paper evaluates the existing public housing standards in Singapore using two approaches: spatial network analysis and qualitative measures. Furthermore, this study explores possible methods of examining the relevance

of fixed configurations in Singapore's public housing over various time periods, with a focus on the microscale of an individual dwelling, which has the greatest impact on residents' daily lives. This study examines floor plan designs from different time periods in chronological order and analyses spatial feedback from the survey to determine the association between satisfaction levels and housing floor plans.

Table 1. Description of HDB Housing organised in five phases of building layout.

Phase	Period	Description
1	1960–1966	The basic design period. This period started in 1960 when the Housing Development Board (HDB) of Singapore was established, and it lasted until 1966. Since the HDB's main objective was to construct as much low-cost housing as possible within the shortest time, the main consideration was to produce basic low-cost rental housing units, which led to the one- or two-room 'emergency' types and then standard one-room, two-room, and three-room flats.
2	1967–1976	The layout variation period. The standard one- and two-room and 'emergency' types of housing were replaced with standardized prototype units, namely, improved one-room, two-room, and three-room flats. In 1973, new prototypes of three-room, four-room, and five-room flats were introduced in slab blocks known as new generation flats (new gen). By 1977, a total of 20 different variations were developed from the initial 5 prototype flats.
3	1977–1981	The period of holistic urban design through overall built form. In this period, the precinct concept was introduced to create a neighbourhood estate together with fixed flat types on the same block, thereby mixing people from different socio-economic backgrounds.
4	1982–1990	The intensification of land use period. This period represents the fourth phase of the HDB's planning and is focused on meeting future housing demands caused by the increasing rate of population growth. Model 'A' flats were initially introduced: three-, four-, and five-room flats. In 1984, three- and four-room simplified flats were introduced.
5	1991–Present	The period of diversification through privatisation. During this period, various public housing schemes were introduced based on different income brackets: Build-to-Order (BTO) flats, Design, Build and Sell Scheme (DBSS), and Executive Condominiums (EC). In short, the BTO is a system in which the project begins construction only after the demand is met. Thus, this scheme helps to alleviate the problem of excess unsold units. DBSS and EC are similar in their development and sale by private developers, and their aim is to enhance the diversity of housing designs. With respect to EC, these units are targeted towards applicants who do not qualify for the purchase of BTO flats (due to their higher income bracket) and cannot afford private property, i.e., 'sandwiched' homebuyers.

2. Research Methods

The quality of living involves the characteristics of users and the developed physical environment, while the quality of space can be evaluated based on residents' satisfaction with their housing environment [16]. Tibesigwa, Hao, and Karumuna [17] examine this distinction through resident characteristics, space characteristics, and performance requirements. Employing this conceptual framework, the research methodology of this paper is divided into two parts: a spatial approach using a network analysis and a qualitative approach using survey data. Spatial network analysis applies the social logic of space [18] and translates building layouts into graphs for comparison purposes according to social position. Under the qualitative approach, case studies are conducted on flats from the

different phases in the development of public housing to gather information on the basic characteristics of the residents and their spatial satisfaction level.

2.1. Survey Approach

The survey approach applied in this research attempts to relate contemporary space usage habits (considering both the original and altered plans) to how residents evaluate their dwellings. The interviews were structured to capture two aspects of housing. The first aspect involves the quantitative data collection of residents' information by classifying the household type in terms of the number of inhabitants, ownership, units with tenants and any alterations to the home. The second aspect involves a more in-depth qualitative approach to understanding how residents rate their satisfaction with their dwelling.

2.1.1. Survey Area

As a case study, this paper focuses on one neighbourhood in Singapore: Woodlands. Woodlands is a mature neighbourhood in which villages were founded as early as the 1920s, when the Singapore Causeway that connects the country with Johor, Malaysia was opened. The first HDB flats were constructed starting in 1972, although the development of the area truly began in 1981. Due to its important position as an interchange with Malaysia, Woodlands will continue to grow and represent the Northern Gateway to Singapore because of the future cross-border rail link. In this neighbourhood, we find various housing types of different phases from old to new in relatively close proximity of one another in an area with a diameter of 1 km.

2.1.2. Survey Size

Housing units with seven different types of floor plans from various time periods were selected to obtain information on the residents' spatial usage pattern via alterations and their satisfaction with their rooms based on different indicators. Shown in Table 2, the flats were designated by housing type I to VII, and altered floor plans were indicated with an apostrophe (e.g., Type I' in Table 3) to differentiate them from the originals. A total of 210 flats and 30 occupants from each of the 7 types of floor plans were surveyed.

2.1.3. Survey Methods

The different types of households and their satisfaction with their dwelling space were examined by considering the following pieces of information: (1) floor plan, which included the design phase (classified in Table 1), flat size, and number of rooms; (2) occupants, which included the household type, first owner, years of occupancy, number of occupants, and any tenants; (3) alterations to the house; and (4) households' evaluations of different room attributes.

To facilitate the study of the varying types of households in different housing types, five different household categories were used: single, couple, single with children, couple with children, and multiple adult (tenants/grandparents). The multiple adult category covers households of two or more adults who are not married, such as multiple tenants sharing a housing unit, which is why a question about tenants is included. The multiple adult category could also apply to a multi-generational family with grandparents or even households with several adult relatives living together. The categories of single adult with children and couple with children include situations where elderly parents live with their children.

With respect to the evaluations of different room attributes, some of the quality indicators for the unit and design details related to the size and space organization/layout, as summarized by Tibesigwa, Hao, and Karumuna [17], were used. For this paper, quality is evaluated through satisfaction and dissatisfaction with the space in three aspects: privacy, location, and size. The survey for occupants includes more than two possible alternatives, as well as not answering all the questions. Therefore, one can be satisfied with the privacy while dissatisfied with the size. The different aspects were carefully explained to ensure a

clear understanding of the options. The notion of privacy varies in relation to the bedroom, living room, and kitchen and can be relative to neighbours and/or occupants of other rooms. The location of rooms focuses on the positioning of a room in relation to another, such as the location of the bedroom adjacent to the kitchen or the bathroom or too far from the kitchen, which may lead to dissatisfaction. The size of the rooms can be understood as satisfied when the room is large enough and dissatisfied when the room is too small.

Table 2. Summary of Survey.

House Type	I		II		III		IV		V		VI		VII	
	%		%		%		%		%		%		%	
Floor Plan														
Design Phase	2		2		4		5		5		5		5	
Apartment Size in sqm	67		91		105		127		146		123		174	
Number of Rooms [1]	3		4		4		5		6		5		5	
Occupants														
Household Type														
Single	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Couple	3	10.0	0	0	4	13.3	0	0	1	3.3	0	0	0	0
Single with Children	7	23.3	0	0	2	6.7	0	0	0	0	1	3.3	0	0
Couple with Children	20	66.7	16	53.3	10	33.3	18	60.0	19	63.3	18	60.0	18	60.0
Several Adults	0	0	14	46.7	14	46.7	12	40.0	10	33.3	11	36.7	12	40.0
First Owners	4	13.3	22	73.3	13	43.3	7	23.3	12	40.0	13	43.3	8	26.7
Avg. Years of Occupancy	11.5		22.5		10.9		11.0		8.8		8.9		10.2	
Avg. Number of Occupants	3.4		4.7		4.8		5.1		5.3		4.9		5.7	
Any Tenants	1	3.3	10	33.3	10	33.3	9	30.0	5	16.7	6	20.0	9	30.0
Avg. sqm per person	19.9		19.4		22.0		25.1		27.5		25.1		30.7	
Alterations														
Living Room	0	0	4	13.3	5	16.7	15	50.0	14	46.7	19	63.3	4	13.3
Study	0	0	0	0	0	0	3	10.0	5	16.7	0	0	0	0
Bedroom	0	0	0	0	0	0	0	0	3	10.0	2	6.7	1	3.3
Kitchen	4	13.3	3	10.0	6	20.0	4	13.3	3	10.0	2	6.7	6	20.0
Toilet	0	0	0	0.0	3	10.0	0	0	4	13.3	0	0	3	10.0
No Alterations	26	86.7	23	76.7	19	63.3	12	40.0	10	33.3	11	36.7	22	73.3
Satisfaction/Dissatisfaction														
Living Room														
Satisfied: Privacy	0	0	2	6.7	10	33.3	13	43.3	11	36.7	2	6.7	6	20.0
Satisfied: Location	0	0	2	6.7	4	13.3	11	36.7	10	33.3	2	6.7	8	26.7
Satisfied: Size	24	80.0	24	80.0	24	80.0	24	80.0	25	83.3	19	63.3	19	63.3
Dissatisfied: Privacy	5	16.7	4	13.3	6	20.0	9	30.0	2	6.7	0	0	2	6.7
Dissatisfied: Location	0	0	0	0.0	1	3.3	0	0	0	0	0	0	0	0
Dissatisfied: Size	4	13.3	0	0.0	1	3.3	2	6.7	0	0	2	6.7	2	6.7
Kitchen														
Satisfied: Privacy	0	0	3	10.0	5	16.7	10	33.3	0	0	2	6.7	6	20.0
Satisfied: Location	0	0	4	13.3	5	16.7	9	30.0	9	30.0	0	0	6	20.0
Satisfied: Size	25	83.3	25	83.3	21	70.0	20	66.7	9	30.0	10	33.3	6	20.0
Dissatisfied: Privacy	0	0	0	0	0	0	3	10.0	5	16.7	0	0	0	0
Dissatisfied: Location	0	0	0	0	1	3.3	0	0	4	13.3	0	0	0	0
Dissatisfied: Size	2	6.7	0	0	1	3.3	5	16.7	9	30.0	13	43.3	4	13.3
Bedroom														
Satisfied: Privacy	0	0	3	10.0	7	23.3	12	40.0	18	60.0	15	50.0	8	26.7
Satisfied: Location	0	0	2	6.7	4	13.3	14	46.7	5	16.7	1	3.3	6	20.0
Satisfied: Size	20	66.7	12	40.0	18	60.0	23	76.7	11	36.7	13	43.3	11	36.7
Dissatisfied: Privacy	0	0	0	0	3	10.0	3	10.0	1	3.3	0	0	2	6.7
Dissatisfied: Location	0	0	0	0	0	0	0	0	0	0	0	0	1	3.3
Dissatisfied: Size	5	16.7	6	20.0	4	13.3	2	6.7	5	16.7	4	13.3	2	6.7
Others (Toilets/Balcony)														
Satisfied: Privacy	0	0	1	3.3	5	16.7	10	33.3	2	6.7	6	20.0	3	10.0
Satisfied: Location	0	0	1	3.3	4	13.3	9	30.0	2	6.7	0	0	2	6.7
Satisfied: Size	10	33.3	15	50.0	15	50.0	20	66.7	2	6.7	14	46.7	4	13.3
Dissatisfied: Privacy	0	0	1	3.3	0	0	3	10.0	6	20.0	3	10.0	1	3.3
Dissatisfied: Location	0	0	0	0	0	0	0	0	5	16.7	0	0	1	3.3
Dissatisfied: Size	12	40.0	6	20.0	2	6.7	0	0	11	36.7	0	0	4	13.3

[1] Method of counting room types: the number of rooms includes the living-dining room and bedrooms. The kitchen and bathrooms are excluded from the count. For example, a three-room flat includes a living-dining room, kitchen, bathrooms, and two bedrooms.

2.2. Spatial Approach

2.2.1. Morphological Analysis of the Housing Units

In recent years, the HDB's emphasis has mostly been on improving public housing through a more macro approach, such as precinct planning and policy changes. However, limited research and analyses have been performed at a micro level. The social logic of space—space syntax—is a method of analysis focusing on the micro-level scale, and it represents an alternative approach to describing the spatial configuration of buildings. This approach was introduced as a theory of space that translates building plans into networks that can be used for studying the notion of its social position. However, due to the complex nature of the raw network data, the social logic of space is effective as a method of comparing various types of buildings with different historical timelines and contexts. Therefore, after translating building plans into graphs, this paper first attempts to identify the structural characteristics of the network by measuring the sum, mean depth, and degree centralization, and then the closeness centrality is determined. These methods have been employed to analyse the relationship between the social aspect of inhabitants and the spatial patterns of housing plans [19,20]. Hence, this paper focuses on public housing development and the spontaneous alterations made to individual units to understand the spatial characteristics in relation to the characteristics of the residents according to their expressed level of satisfaction.

2.2.2. Network Analysis Using Translated Housing Plans

Housing plans from different generations and alterations were translated into graphs. Rooms were conceptualized as vertices represented by circles with relations of permeability represented by lines showing connectivity with other vertices or spaces. The space that connects the outside or the entrances was also reflected as a vertex and represented by a circle with a cross [18]. By translating the floor plans of each unit into graphs, each unit can be studied as a network, thereby allowing for cross comparisons despite the diversity of designs in both qualitative and quantitative methods. Therefore, the mean depth, sum, degree centralization, and closeness centrality of each network were measured to understand the structural attributes of the network.

2.2.3. Mean Depth, Sum, Degree Centralization, and Closeness Centrality of a Network

The mean depth, sum, and degree centralization can be useful in identifying social activities defined by space. Mean depth is measured by obtaining the shortest route between all pairs of nodes, summing them, and then dividing the value by the total amount of pairs. This process helps to identify the average number of steps from one node to another. Sum is the aggregate of existing connections and represents the size of a network. Degree centralization shows how unequal the distribution of centrality is in a network. In other words, centrality, which in this case means a focal point that will specify important structural characteristics of communication networks [21] and the degree centralization of a network can be used as an index for accessing the potential communal interactions in the network. Closeness centrality emphasizes the distance of a node to all others in the network, and although it measures position globally, it is a characteristic of a node's position in a network. Therefore, every node is measured at the micro level so that a greater proximity of one node to others in the network indicates greater centrality of the node's position globally.

3. Results

3.1. Survey Results

3.1.1. Resident Information

Table 2 provides a summary of the survey results with the average for each housing type. The results show that in general, few first-time owners occupy these flats, which implies that HDB occupants tend to move frequently from one place to another. The interview results show that only housing type II has a high percentage of owners at 73%,

whereas the other types show ownership at below 50%. Furthermore, the average year of occupancy for housing type II is 22.5 years, whereas the other types fall in the range of 8 to 12 years. This indicates that most homeowners do not intend to live in their units for life, and a possible factor could be due to the changes in household structure and increasing or decreasing size over time. The average household for each housing type is also shown in Table 2. Although the average household size in Singapore is 3.3 [2], the survey results show a rather high average size ranging from 4.7 to 5.7 in housing types II to VII. The number of occupants in certain individual units is as high as eight or nine, such as in units with multiple adult residents, which may refer to a multi-generational family of adults living together or cases in which unrelated tenants live in the same household. We found tenants in 50 units, which is almost a quarter (24%) of the total units. No single households were included in the 210 households surveyed, which may be related to the eligibility conditions for the purchase of HDB flats stipulating that only families can purchase [22].

3.1.2. Alterations to Housing

The number and percentage of homes that have not altered their configuration, or have kept the original plan, is shown in Table 2. The results show that 41% of the total households (87 out of 210) made alterations to their units by changing the configuration. Housing types I, II, and VII had a high proportion of non-altered units. Thus, housing I and II, which are two of the oldest buildings, did not have many alterations, while housing IV to VI, which are relatively new, had more configuration changes. In terms of the relationship between household type and alterations, couples with children (48 units or 55.2%) and multiple adults (34 units or 39.1%) accounted for the majority of total households altered. Of the households with tenants, 24 units (27.6%) were altered. However, when looking at all the surveyed households, the correlation between housing alteration and household type is very low overall with couple: 0.03; single with children: 0.14; couple with children: 0.03; and several adults: 0.08 (a value between 0 and 0.1 is none or very weak, 0.1 and 0.3 is weak, 0.3 and 0.5 is moderate, and 0.5 and 1.0 is strong). These findings indicate that no clear pattern can be found in alterations according to the housing population, which also suggests that the association with satisfaction can be very little.

3.1.3. Room Satisfaction

With respect to satisfaction with the living room, kitchen, and bedroom size, the feedback was generally good. In particular, the living room in housing types I to V received high satisfaction ratings of above 80%. The low alteration rate of living rooms for housing types I to III implies that the original size was sufficient. A similar conclusion was reached for the kitchen size in housing types I and II. On the other hand, the privacy and location of these housing types received rather low satisfaction ratings of below 30%. However, certain households did show slight satisfaction with privacy and location, although not to a great extent. For example, the rating for the bedroom location in housing type V was above 60%. Greater satisfaction with the privacy and location of various rooms was observed for housing type IV, where ratings ranged between 30% and 50%. In terms of dissatisfaction, no situations stood out. However, the occupants of housing types I, V, and VI showed dissatisfaction with the size of the kitchen and/or other rooms at a rate over 30%.

3.2. Network Analysis Results

Figure 1 shows the original housing plans of different eras and graphs of the original and the altered plans. Information collected on alterations of individual units was compiled to model the altered layout. The typical alterations (either the removal or addition of walls) were accumulated and recorded for the altered network configuration. The units were evaluated by comparing the original and altered configurations. An analysis was performed of the network attributes of mean depth, sum, network centralization, and closeness centrality of the original and altered layouts, and the results are summarized in

Table 3. These attributes allow us to understand the different social connections between various units.

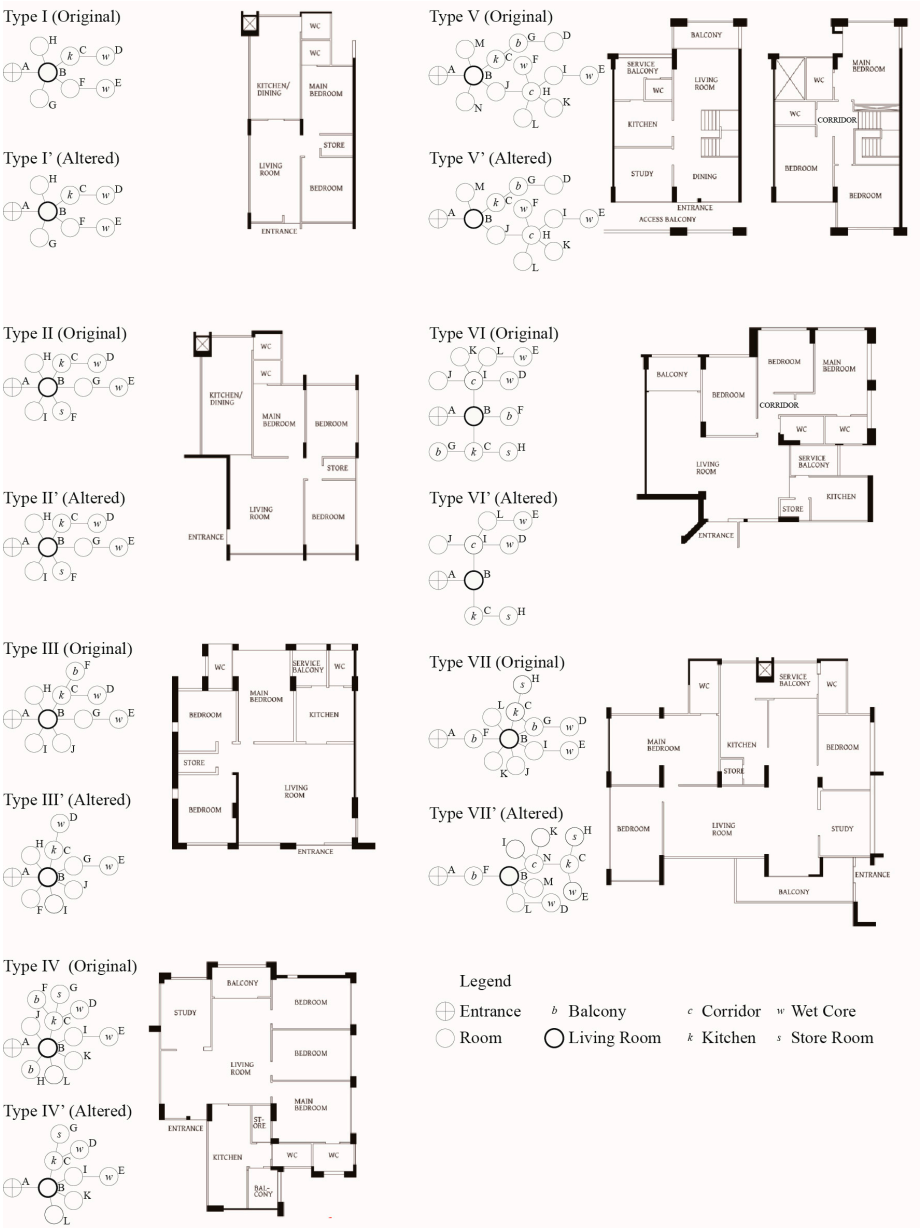

Figure 1. The original housing plans and graphs of the original and the altered plans.

3.2.1. Mean Depth

Table 3 indicates that different units have an average mean depth of 1.8 to 2.0. This small range demonstrates consistency in HDB planning, and each room can be accessed within two nodes from the other rooms. The altered units also have a mean depth that falls within the same range as the original unit plans, showing that changes to the configuration do not alter the average mean depth.

3.2.2. Sum

The sum shown in Table 3 represents the aggregate value of different connections in a given unit type and signifies the network size. When comparing two networks with the same number of nodes, the sum can be used to differentiate and assess the interconnectedness. Networks with a higher sum can be assumed to be more connected.

However, when comparing the sum between original and altered configurations, the original configuration usually has more nodes and, therefore, offers more ties within the network. The original configurations have a sum ranging from 14 to 26, whereas the altered configurations have lower values ranging from 14 to 22. This difference could be due to the simplification of the network because altered units usually involve the removal of intermediate nodes; however, this lower sum value does not imply that altered configurations are less connected than the original ones.

Table 3. Results of network analysis [1].

Type	MD [2]	Sum	DC [3,4]	Closeness Centrality													
			%	nCloseness and (Node)													
I	1.8	14.0	61.9	77.8 (B)	53.8 (C)	53.8 (F)	46.7 (A)	46.7 (G)	46.7 (H)	36.8 (E)	36.8 (D)						
I′	1.8	14.0	61.9	77.8 (B)	53.8 (C)	53.8 (F)	46.7 (A)	46.7 (G)	46.7 (H)	36.8 (E)	36.8 (D)						
II	1.8	16.0	67.9	80.0 (B)	53.3 (C)	53.3 (G)	47.1 (H)	47.1 (A)	47.1 (F)	47.1 (I)	36.4 (D)	36.4 (E)					
II′	1.8	16.0	67.9	80.0 (B)	53.3 (C)	53.3 (G)	47.1 (H)	47.1 (A)	47.1 (F)	47.1 (I)	36.4 (D)	36.4 (E)					
III	1.8	16.0	51.8	72.7 (B)	57.1 (C)	50.0 (G)	44.4 (H)	44.4 (A)	44.4 (I)	38.1 (F)	38.1 (D)	34.8 (E)					
III′	1.8	18.0	72.2	81.8 (B)	52.9 (C)	52.9 (G)	47.4 (I)	47.4 (A)	47.4 (F)	47.4 (J)	47.4 (H)	36.0 (D)	36.0 (E)				
IV	1.8	22.0	56.4	73.3 (B)	57.9 (C)	47.8 (I)	44.0 (A)	44.0 (J)	44.0 (K)	44.0 (H)	44.0 (L)	37.9 (G)	37.9 (D)	37.9 (F)	33.3 (E)		
IV′	1.8	16.0	51.8	72.7 (B)	57.1 (C)	50.0 (I)	44.4 (K)	44.4 (A)	44.4 (L)	38.1 (G)	38.1 (D)	34.8 (E)					
V	1.9	26.0	28.2	46.4 (B)	46.4 (J)	43.3 (H)	36.1 (C)	32.5 (A)	32.5 (M)	32.5 (N)	32.5 (I)	31.0 (L)	31.0 (K)	31.0 (F)	28.3 (G)	25.0 (E)	22.4 (D)
V′	1.8	22.0	34.6	50.0 (H)	50.0 (J)	45.8 (B)	36.7 (I)	34.4 (K)	34.4 (F)	34.4 (L)	34.4 (C)	32.4 (A)	32.4 (M)	27.5 (E)	26.2 (D)		
VI	1.8	22.0	34.6	57.9 (B)	57.9 (I)	44.0 (C)	40.7 (L)	37.9 (A)	37.9 (D)	37.9 (K)	37.9 (J)	37.9 (F)	31.4 (H)	31.4 (G)	29.7 (E)		
VI′	1.8	16.0	35.7	61.5 (I)	57.1 (B)	44.4 (L)	42.1 (C)	40.0 (D)	40.0 (J)	38.1 (A)	32.0 (E)	30.8 (H)					
VII	2.0	24.0	54.6	73.3 (B)	52.4 (G)	52.4 (C)	47.8 (F)	47.8 (I)	44.0 (J)	44.0 (K)	44.0 (L)	35.5 (D)	35.5 (H)	33.3 (A)	33.3 (E)		
VII′	1.8	22.0	23.6	55.0 (B)	55.0 (N)	42.3 (C)	39.3 (L)	39.3 (F)	36.7 (M)	36.7 (I)	36.7 (K)	30.6 (H)	30.6 (E)	28.9 (A)	28.9 (D)		

[1] Network measures were computed in Ucinet version 6.0 [23]. [2] Mean Depth. [3] Degree Centralization. [4] A network with 100% centralization will be a star-shaped network and represents when one node in the centre is the only one tied to the rest. The opposite network is a wheel-shaped linear network and has a degree centralization of 0%, where all nodes are equally connected to each other and, thus, a central area is not observed [24].

3.2.3. Degree Centralization

Degree centralization measures the level of centralization in a network, with network centralization demonstrating the efficiency of conveying information from one node to another. Essential social attributes within network structures can then be easily identified using network centralization. A higher value indicates a more centralized network and, thus, signifies greater interconnectedness between the nodes. As shown in Table 3, degree centralization is the same for housing types I and II and increases for housing types III, V, and VI after configuration alterations. The values for housing types I to IV for both the original and altered configurations are high at above 50%, suggesting that this enhanced network supports greater opportunities for communication.

3.2.4. Closeness Centrality

Closeness centrality can be considered an index of the expected time-until-arrival for items flowing through the network with optimal paths. Therefore, a larger value corresponds to a node that is closer to the centre of a network. For a more comprehensive analysis, the rooms in Table 3 are arranged in the order of closeness centrality. Table 3 clearly shows that node B, which is a living room, is always ranked the highest amongst all other rooms in the original housing plan. For housing types I to IV, the living room is followed in rank by node C, which is the kitchen. The kitchen in housing types V to VII is ranked either third or fourth. For nodes D and E, which are bathrooms, one will always be ranked last and the other will be ranked relatively close to last, except in the case of housing type VI. This finding is because node D in housing type VI is an independent bathroom that can be accessed directly from common spaces, and it is located adjacent to node I, a corridor, which creates a high closeness centrality within the unit. Limited differences are observed with the altered versions of housing types I to IV and VII. For housing types V and VI, the alterations show a decline in the closeness centrality value for node B, the living room, and node C, the kitchen. Node H of housing type V and node I of housing type VI, which are both corridors, present the highest closeness centrality.

3.3. Summary of Satisfaction and Dissatisfaction by Housing Type

Housing types I and II generally show rather high satisfaction ratings for all rooms, despite having fewer square metres per person (20 m^2 per person) than the other housing types. However, the bathroom size, especially for type I, is dissatisfactory. Housing types II and III have the highest number of tenants. However, both types are consistent in the satisfaction level for all rooms. The survey of all interviewed households also shows that the influence of room satisfaction by the tenants is very little. Dissatisfaction with privacy for the living room has less impact with the presence of the tenants, which suggests that privacy is affected by the spatial relationship between the living room and the exterior rather than its location in the interior plan. A possible explanation for this privacy issue is the location of the living room window, which typically faces the communal corridor outside. This can be seen from the type IV housing plan shown in Figure 1. For housing types I to IV, the degree centralization values of both original and altered plans are relatively high at above 50%. Moreover, the same results were obtained for closeness centrality, with the living room and the kitchen presenting the highest values and the two bathrooms presenting the lowest value. This finding indicates that the central areas of the household are the living room and the kitchen.

Housing type V, which is a maisonette, has one of the largest square metres per person (28 m^2 per person). However, satisfaction with the size of this type is not significant, and it has a relatively higher rate of dissatisfaction compared with other housing types with respect to the privacy, location, and size of the kitchen and other spaces, plus it presents a high alteration rate. Both housing types VI and VII do not register strong satisfaction or dissatisfaction. Although the square metres per person in these two housing types is significant (25 m^2 per person for type VI and 31 m^2 per person for type VII), even the level of satisfaction with the living room size is below 70%, which is relatively low compared with that of the other housing types, which are above 80%. One commonality of housing types V to VII is that the degree centralization is low compared with that of types I to IV (although the degree centralization for the original plan of type VII is above 50%). Moreover, for housing types V and VI, the closeness centrality of the living room is not the highest among the altered plans, and the kitchen and living room are not located next to each other in the original and altered plans. A review of the closeness centrality of the altered plans indicates that the most central place within the household becomes the corridor space.

4. Discussion and Conclusions

The aim of this study is to provide insights into the existing housing configurations and the spatial preferences of the inhabitants. Other issues can also affect housing selections,

such as the property value, the type of flat, the amenities nearby, and the travel time from home to work, school, or another daily commute. In-depth studies of both the circumstances of specific families and the social status of residents may provide additional insights into dwelling preferences. However, this study focused on the design of HDB housing floor plans, which previously had not received much attention, in an attempt to provide another dimension of quality through the relationship between inhabitants and their dwelling space. To determine the relevance of this relationship, the study examined 210 flats with 30 occupants from the 7 types of floor plans using a two-pronged research methodology: spatial network analysis and qualitative measures.

The survey found that 59% of households had not altered their homes, and among the 41% that altered, almost no association was observed between the alteration and changes in the family situation, such as an increase or decrease in household size or a change in household type. Thus, alterations and satisfaction may not be associated. The reason for the low rate of alterations might be certain limitations that increase the difficulty of performing such changes. HDB homeowners who wish to modify their unit are often hindered by restrictive regulations imposed by the housing authorities. For example, the main structural elements in the layout of the housing unit itself cannot be modified drastically, thereby reducing the ability of residents to reorganize their interior spaces. In addition, the Housing and Development (Renovation Control) Rules 2006 require flat owners to select renovation contractors who have been registered with the HDB to conduct any renovations in the flat.

Surprisingly, 24% of households share their flat with tenants, and not much influence can be observed between the privacy of rooms and the presence of tenants in these units, which might be related to the relatively large households. However, this finding does not mean that a larger flat size leads to greater satisfaction. The size aspect has a greater relationship with other factors. Our survey shows that certain associations occurred between satisfaction with size and the positioning of the rooms. We observed a higher percentage of satisfaction in units where the living room and kitchen were the most central areas of the home. This result is clearly observed in the flats with the older designs, which suggests that these housing plan designs are more suited in terms of spatial relationship to the lifestyle of Singaporeans.

Moreover, alterations to housing do not necessarily increase spatial satisfaction, which is further illustrated by the finding that only 38% of surveyed occupants were the first owners of their units. An inference can be made that most homeowners do not intend to live in their units for life and will move to another place when their households undergo changes in structure and size over time. Nevertheless, the ability to make minor alterations to a housing plan and renovation rules that allow for individual preferences are always desirable.

In addition, because households may include tenants, which was observed in 24% of the surveyed occupants, current housing plans may not adequately cater to diversified occupant configurations. The survey of households in the studied housing configurations reveals that certain households are restricted to specific unit types, and this information was further substantiated when comparing the types of alterations performed. Units with a smaller household indicated a decreased need for extra space, such as multiple bathrooms and balconies. Hence, such households could be restricted to smaller living spaces and units. Larger households, on the other hand, could also be restricted to living in units with a limited number of rooms. Therefore, because of the expectation of Singaporeans that they will not live long in the same flat, as well as the diversity of family structures and the possibility of households with tenants, more options must be provided for differentiated fixed configurations that consider the spatial relationship between dwellings and the domestic lives of their residents. Moreover, a spatial system that allows occupants to make minor alterations is required, and all of these features can be easily accomplished. The appropriation of space such as the placement of furniture may also provide effective impact on creating ephemeral alterations that can lead to increasing spatial satisfaction. Offering differentiated housing plans will not only expand the selection of housing units

for potential homeowners but will also be beneficial for architectural development and built space at any scale.

In conclusion, the network analysis performed here has helped in the evaluation of the relevance and applicability of today's housing configurations. In addition, by highlighting the associations between a housing unit's spatial properties and the spatial preferences and satisfaction level of its inhabitants, this paper supports and provides information that is relevant for housing design practice in the future. However, it can be deepened by questioning more social backgrounds of the inhabitants to explain in detail why homeowners do not intend to live in their units for life, their interactions with tenants, and identifying what alterations can lead to better spatial satisfaction, which may lead to new HDB plans. In all, this research demonstrates that an examination of dwellings through the network analysis approach is not simply a matter of incorporating theoretical concepts; it also offers a model that highlights attributes that are significant for contemporary domestic life.

Author Contributions: Conceptualization, J.T. and K.F.; methodology, J.T.; software, J.T.; validation, J.T. and K.F.; formal analysis, J.T.; investigation, K.F.; resources, J.T. and K.F.; data curation, J.T.; writing—original draft preparation, J.T. and K.F.; writing—review and editing, J.T.; visualization, J.T. and K.F. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Sim, L.L.; Lim, L.Y.; Tay, K.P. Shelter for all: Singapore's strategy for full home ownership by the year 2000. *Habitat Int.* **1993**, *17*, 85–102. [CrossRef]
2. Department of Statistics. *Yearbook of Statistics Singapore*; National government publication: Singapore, 2017.
3. Ramesh, M. One and a half cheers for provident funds in Malaysia and Singapore. In *Transforming the Developmental Welfare State in East Asia*; Palgrave Macmillan: London, UK, 2005; pp. 191–208.
4. Chua, B.H. *Political Legitimacy and Housing: Stakeholding in Singapore*; Routledge: London, UK, 1997.
5. Wong, A.K.; Yeh, S.H. (Eds.) *Housing a Nation: 25 Years of Public Housing in Singapore*; Housing Development Board: Singapore, 1985.
6. Chua, B.H. Maintaining housing values under the condition of universal home ownership. *Hous. Stud.* **2003**, *18*, 765–780.
7. Sim, L.L.; Yu, S.M.; Han, S.S. Public housing and ethnic integration in Singapore. *Habitat Int.* **2003**, *27*, 293–307. [CrossRef]
8. Teo, P.; Huang, S. A sense of place in public housing: A case study of Pasir Ris, Singapore. *Habitat Int.* **1996**, *20*, 307–325. [CrossRef]
9. Khoo, C.L. Conservation Moves into Top Gear. *Mirror* **1989**, *25*, 10.
10. Keys, P. Conservation as an integral part of urban renewal. *Planews J. Singap. Inst. Plan.* **1981**, *8*, 39–49.
11. Wang, J. The developmental state in the global hegemony of neoliberalism: A new strategy for public housing in Singapore. *Cities* **2012**, *29*, 369–378. [CrossRef]
12. Yuen, B.; Yeh, A.; Appold, S.J.; Earl, G.; Ting, J.; Kurnianingrum Kwee, L. High-rise living in Singapore public housing. *Urban Stud.* **2006**, *43*, 583–600. [CrossRef]
13. Utsumi, S.; Takai, H.; Suzuki, M. Habitability Evaluation of Residents in Super High-rise Apartments by HDB. In *Summaries of Technical Papers of Annual Convention*; Architectural Institute of Japan: Tokyo, Japan, 2017; pp. 1019–1020.
14. Suzuki, M.; Takai, H.; Utsumi, S. The Usage and Evaluation of the Common Space & Facilities in Super High-rise Apartment by HDB. In *Summaries of Technical Papers of Annual Convention*; Architectural Institute of Japan: Tokyo, Japan, 2017; pp. 1021–1022.
15. Teo, S.E.; Kong, L. Public housing in Singapore: Interpreting 'quality' in the 1990s. *Urban Stud.* **1997**, *34*, 441–452.
16. Ozsoy, A.; Altas, N.E.; Ok, V.; Pulat, G. Quality assessment model for housing: A case study on outdoor spaces in Istanbul. *Habitat Int.* **1996**, *20*, 163–173. [CrossRef]
17. Tibesigwa, B.M.; Hao, L.; Karumuna, B.V. The concept of spatial quality and its challenges on exercised affordable housing design typology in Dar es Salaam–Tanzania. *Habitat Int.* **2017**, *59*, 44–59. [CrossRef]
18. Hillier, B.; Hansen, J. *The Social Logic of Space*; Cambridge University Press: Cambridge, UK, 1984.

19. Hanazato, T.; Hirano, Y.; Sasaki, M. Syntactic analysis of large-size condominium units supplied in the Tokyo Metropolitan Area. *J. Archit. Plan. Trans. AIJ* **2005**, *591*, 9–16. [CrossRef]
20. Tamura, J. Spatial Patterns in Incremental Process of Low-Income Population—The Case of Lusaka Sites and Services Project. *J. Archit. Plan.* **2014**, *79*, 1995–2002. [CrossRef]
21. Freeman, L.C. Centrality in social networks conceptual clarification. *Soc. Netw.* **1978**, *1*, 215–239. [CrossRef]
22. Sin, C.H. Segregation and marginalisation within public housing: The disadvantaged in Bedok New Town, Singapore. *Hous. Stud.* **2002**, *17*, 267–288. [CrossRef]
23. Borgatti, S.P.; Everett, M.G.; Freeman, L.C. *Ucinet 6.0 for Windows: Software for Social Network Analysis*; Analytic Technologies: Harvard, IL, USA, 2002.
24. Beauchamp, M.A. An improved index of centrality. *Behav. Sci.* **1965**, *10*, 161–163. [CrossRef] [PubMed]