

## ASSESSMENT TOOLS: MATHEMATICAL FACTORIAL AND ADJACENCY DISTRIBUTION THEORY FOR HOUSING TYPOLOGY IN GAZA CITY

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### Abstract

There are few attempts to study the vernacular architecture in Gaza based on indoor space distribution. No attempts, so far, has been made to analyze Gazan indoor housing spaces from the perspective of adjacency distribution. This study aims to provide specialists with future design that meets the demand and requirement of Gazan people. A survey conducted in 2005 by the main author on some semi-detached houses built by people themselves to fit with their culture and climate revealed that majority of these houses were categorized into two common types: type one: "Corridor-Type Plan" and type two: "Hall-Type Plan". To select the most flexible type that could be used in future housing development, evaluations and social analyses were carried out using the theory of Adjacency Distribution and part of the Space Syntax. As a result, the outcome of the analysis has shown that the number of alternatives of space distribution in the type one is greater than those of type two as the ratio between these types is 30 to 4 types consequently.

### Keywords:

Adjacency distribution theory; space syntax; corridor-type plan, hall-type plan, Gaza city

### Introduction

Housing condition in Gaza before 1994 was comprehensively characterized with terms of high density occupancy with little or no space for individual, shortages of land, high prices of land, insufficient social infrastructure, inadequate indoor planning and design, absence of legal framework, and high construction and material costs (UNDP/PAPP, 2003). Just after 1994, The Palestinian National Authority (PNA) built many housing units to reduce the shortage of housing units in Gaza city. During the construction process, researches on most common plans of housing units were not given high priority due to the increase demand on units.

Recently, the war 2009 on Gaza executed by the Israeli occupation has negatively resulted in thousands of destroyed and diminished housing units, which in turn deteriorated the crises and increased the number of homeless people.

The situation after the war 2009 is miserable and worse than before. It is mentioned at Aljazeera website that during the war on Gaza over 30,000 houses are partially damaged and over 4000

houses are totally damaged. As a result, the International committees have started an urgent call to alleviate the negative impact of the illegal war through the title: "Rebuilding Gaza". This inevitably urges specialists to propose a suitable designing plan for future units that respect the cultural distribution of indoor spaces. Architects would undertake practical steps to show their unlimited efforts and understandings of the situation by showing their valuable strategies, policies and designing approaches. Herein, the study would append an appropriate definition of architectural typology of housing units that might be considered in future development. The architectural typology of houses is widely understood that it is a circumstance of repeating characteristics of some elements and/or spaces regularly more than others in housing planning and design. These frequencies have been based on people satisfactions, psychological

feelings, and/or scientific theories that control the arrangement. This approach was applied the application of Analytic Hierarchy Process (AHP) (Mushtaha, 2006) as assessment tools, but in this study the assessment tools are the mathematical equation "Factorial" and the theory of "Adjacency Distribution Diagram", which is a product of analyzing the circulation and space distribution in plans (Ahmed & Kurosawa, 2005).

This study has used the approach of Prof. Kurosawa's research (Kurosawa, 1988) but excluded outdoor space (yard space) from the analysis as the study focuses on indoor spaces of housing units. On the other hand, it has also utilized the theory of Space Syntax, described at Khattab's study, to analyze internal spaces (Khattab, 2005). This is to show accessibility and circulation inside dwellings.

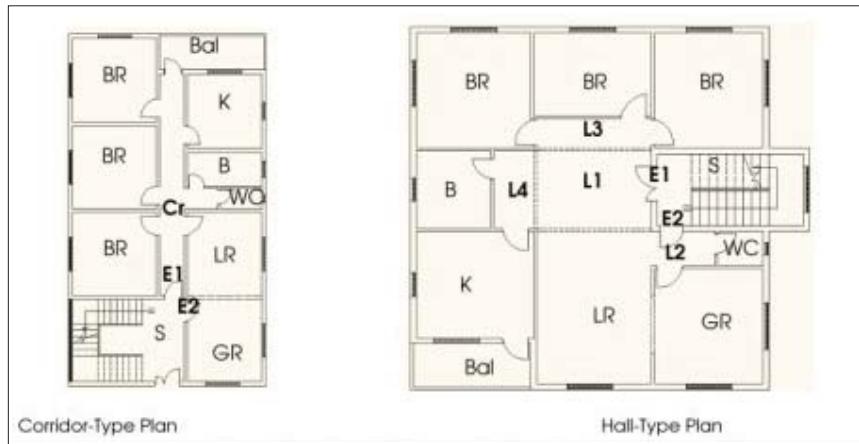


Figure 1: Shows the two common types, type one: "Corridor-Type Plan" and type two: "Hall-Type Plan" (Source: Authors).

Following abbreviations used in housing plans, the Space Syntax, and Adjacency Diagram (AD).  
 LR= living room, LA= living area (the living room with its balcony (Bal))  
 GR= guest room, GA= guest area (the guest room with its spaces, W.C and sink)  
 KB = kitchen and bathroom, (wet spaces were found close to each other in many cases).  
 BR = bedrooms (one master bedroom for parents, and two bedrooms for children).  
 E, E1, E2 = entrances, S= staircase  
 Cr =Corridor, L1, L2, L3, L4= lobby

## Study Objectives

### The study aims to:

1. Show the circulation and connection of internal spaces of Gazan houses visually rather than verbally by using concept of socio-spatial analysis of Hillier and Hanson (1984) described at Kattab's study.
2. Achieve a common plan that is possible to consider in future housing development by using the Adjacency Distribution Theory.
3. Explore the variety of different layout plan, which enhances people to have more opportunity in selecting housing choices.

## Characteristics of Indoor Spatial Spaces

Statistics done in mid 2000 revealed that household size was approximated to 6.9 persons and 50.20% of the population is less than 15 years of age (Afifi, 2002). Architects, planners and specialists have been challenged to define what a house design is needed to get people satisfied. Explanations on current housing design and the activities performed inside spaces are under research. From the study, it is found that four zones of guest, living, sleeping, and services areas formed indoor spaces which are connected by a link either in a shape of a corridor or living space.

### Guest Area (GA)

The guest area consists of additional spaces for a special toilet and sink. The majority of Gazan houses have a special room for guests only. This space has to match the culture of Muslims, where privacy and separation between visitors

and inhabitants are a must. Visitors, strangers or foreigners are welcomed in this specified area. Basically, western style furniture is used by over a half of the society, while the remaining percentage uses Arabic style due to its simplicity and rearrangement within the space Figure.2.

### Living Area (LA)

The living area consists of a living room in addition to its required spaces such as corridors and balconies. Activities occur inside the living space are mainly enhancing family communication, informally used as a guest space for close relatives, dining space, and a place for practicing cultural activities. A wide utilization of light Arabic futons "Mattress" in the living spaces has given flexibility to the living style Figure.2. This space has been positioned mainly beside the entrance, which has two opposite routes for the living and guest rooms. In the same context, a kitchen has been set beside the living space increasingly, where people have meals within the space.

### Sleeping Area (SA)

The sleeping area consists of bedrooms and its services. Over a half of the society has three bedrooms for parents and children (female and male). Most master bedrooms have been furnished western style, while children's bedrooms by Arabic style for flexibility since the number of children in these families are numerous Figure.2. Children's bedrooms represent their first living space where most of the children spend more than 8 hours daily inside bedrooms that are managed to deal with activities of studying, dining, and living.

### Services Area (KB)

The service area consists of wet areas such as

(kitchen and bathroom or toilet). Kitchens are devoted to directly serve people in living spaces where people practice different activities within the same space Figure.1. The living space or bedrooms are commonly used for meals or

drinks as the majority of houses do not have a separate dining room.

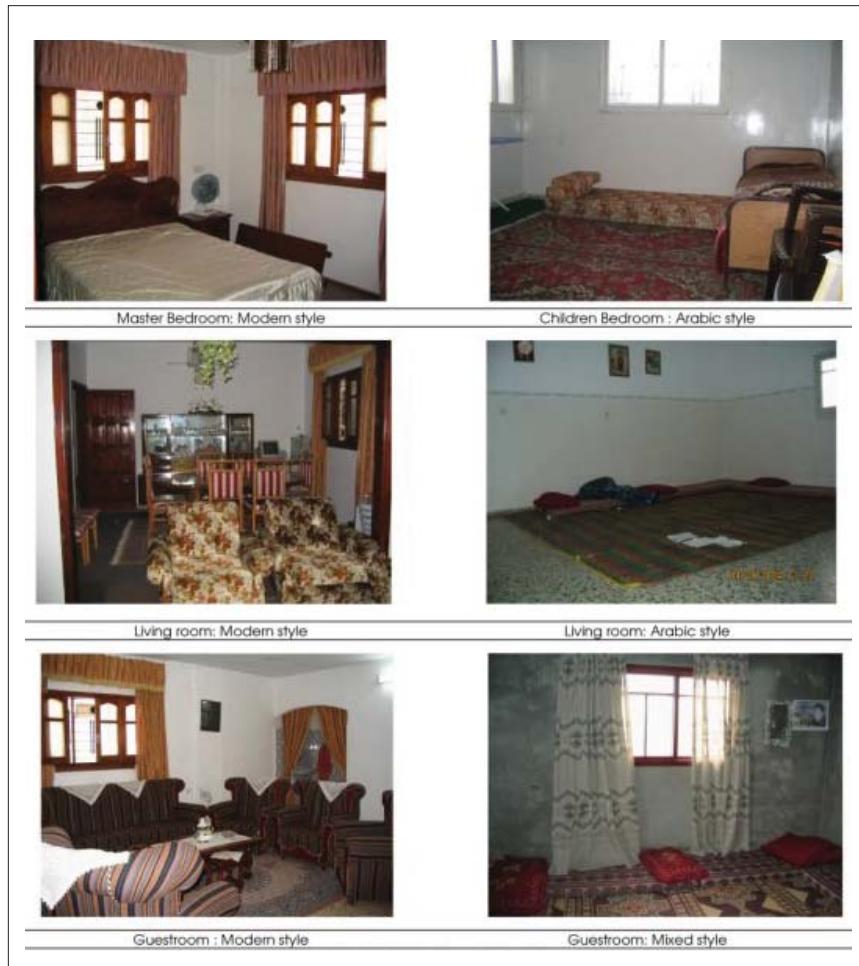


Figure 2: Living Style and Spatial Distribution of Indoor Spaces (Source: Authors).

## Methodology

Partial concepts of the Space Syntax and Adjacency Distribution Theory are introduced herein.

### Gamma Analysis of Indoor Spaces

This aims to show the social analysis of internal cells, i.e. rooms in a house, accessibility and circulation inside Gazan houses. Khattab called it gamma map, which represents interior habitable subdivisions of a cell in a hollow circle. While circulation spaces, i.e. corridors and lobbies, are represented by a line. Moreover, permeability graphs, which interpret how accessibility and movement are controlled by the arrangement of cells, are shown in numbers right side of the gamma map. Figure.3, which describes the social analysis of the two-type plans, shows that "Hall-Type Plan" has more numbers of circled cells if compared to the Corridor-Type Plan", 16 and 14 cells distributed in 6 and 5 levels respectively. Also, it shows that two separate entrances form the plans, one for inhabitants (E1) and second for visitors (E2). This proves that privacy lies in the core of Gazan culture and tradition.

In Corridor-Type Plan, the corridor has replaced the lobby and gathered all spaces around it and shifted all cells down one level from level-6 to level-5. This made the plan is more compact, effective, efficient, reachable and accessible as the circulation appears easier than the other type. Gazan people saw it comfortable so that most of the samples in the survey 2005 were from this type. This could be an excellent designing approach for a high-density area.

To simplify reading figure.3, codes (122551

and 12272) are given to the Hall-Type Plan and Corridor-Type Plan respectively. Herein, the 6 digits of 122551 interpret the number of permeability graphs or levels of a plan, while the code number itself represents number of cells located at each level. Therefore, the more digits found in a plan, the more scattered spaces and bigger internal spaces enlarge the size of homes. Also, the higher number of the cells accounted, for example; 122551= 16, the more complicated circulation inside a home. As the outcome of 12272 is 14 less than 16, then this proves that the Corridor-Type Plan is more compact and reachable than the other type.

### The Adjacency Diagram Theory (AD)

The Adjacency Diagram shows the circulation and space distribution in the plans. This method is different from the previous one as it expects to typologize and categorize architectural plans. To draw the A.D, several drawings are to be done as follows:

#### Circulation Diagram

The diagram shows the distribution of internal zones: living area, guest area, and wet area indicated by KB, also shows circulation process from the entrance to another. To simplify reading the main access to the house, we consider one main entrance for a house from the staircase directly instead of two separate entrances as this study focuses on internal zones rather than the external one figure 4. In the figure lines represent the access from one zone to another.

#### Grid Diagram

To simplify understanding the process, figure 5 shows the distribution of zones and the possible circulation from one zone to another in a grid.

### Circulation-Grid Diagram

The previous two diagrams are combined together in figure 6, which represents the direct access from one zone to another in bold lines, while the possibility of access from one zone to another in dashed lines.

### The Adjacency Diagram (AD)

Zones are rearranged in a circumference where the adjacent zones are shown in sequence Figure 7. The corridor (Cr) in the Corridor-Type Plan or living area (LA) in The Hall-Type Plan is the central cell of the house that has possible access to all other spaces and zones.

### Setting Bedrooms into the AD

Bedrooms average is approximated to 3 bedrooms in Gazan houses. The positions of those rooms are different as in Figure.8. To find out the possible permutation of bedrooms in a circumference of a house, the mathematical factorial equation is used.

and consider position of (LA) and (Cr) constant in the circle, then we have the other circled spaces changing positions. Therefore, to calculate the number of patterns we can use the simple mathematical formula of Factorial of 3 as follows:

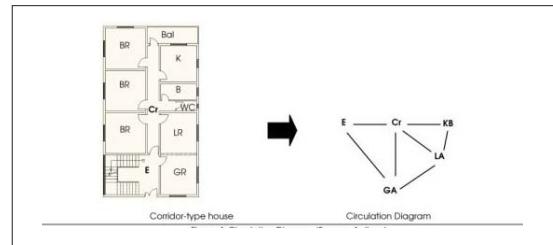


Figure 4: Circulation Diagram (Source: Authors).

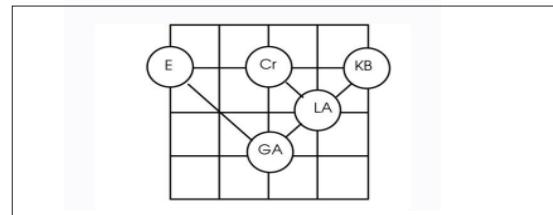


Figure 5: Grid Diagram (Source: Authors).

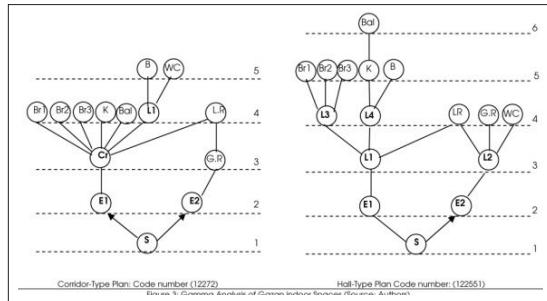


Figure 3: Gamma Analysis of Gazan indoor Spaces (Source: Authors).

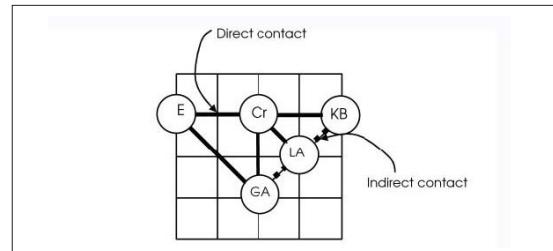


Figure 6: Circulation-Grid Diagram (Source: Authors).

### Calculate the number of housing patterns without bedrooms

If we do not add bedrooms (Br) to the circumference,

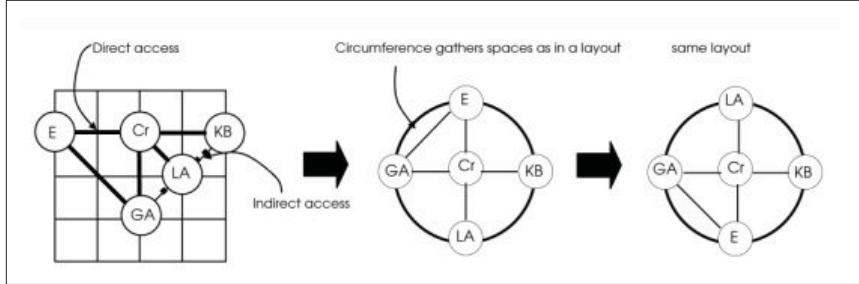


Figure 7: The Adjacency Diagram (Source: Authors).

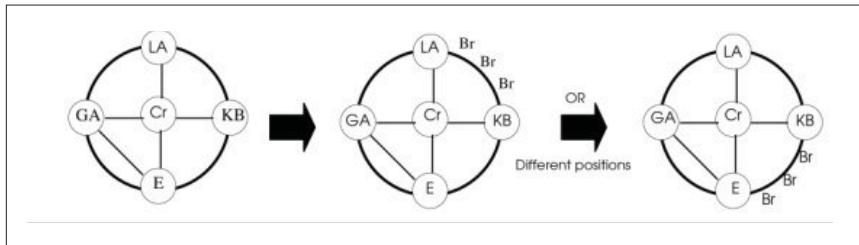


Figure 8: Bedrooms into the A.D (Source: Authors).

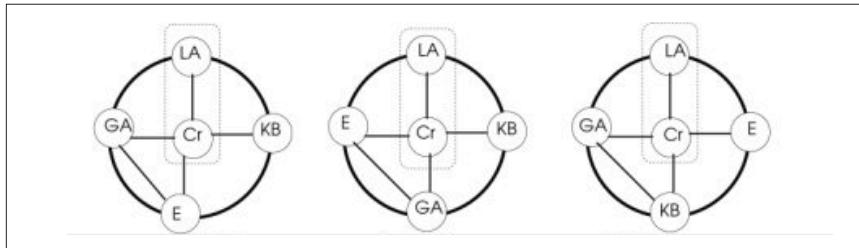


Figure 9: Basic diagrams of housing units (Source: Authors).

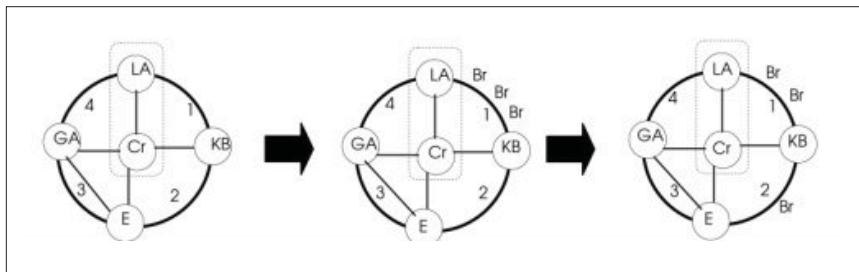


Figure 10: Sub-types of the Adjacency Diagram of Type.A (Source: Authors).

Then, the number of patterns of the factorial of 3 is 6. But, in fact those 6 patterns are actually 3 patterns and their mirrored forms; therefore we consider only 3 basic patterns: A, B, and C as shown in Figure 9. It is noticed that most Gazan houses have the direct access to the guest area (GA) through the staircase (S), which is the main entrance to the house (E). So (GA) and (E) should be adjacent in the circumference of the circle. This is to suit with the culture of Muslim-Gazan people.

### Calculate the Number of Housing Patterns with Bedrooms

Locations of bedrooms are different and might be gathered within one or two zones between spaces. There are spaces in the circumference of the circle between four of the five basic requirements of the house, (LA, KB, E, GA), those space are numbered (clock-wise) from 1 to 4 to mark the locations of bedrooms (Br), when they are added to the diagram.

When bedrooms (Br) are added, then the sub-types of each pattern can be easily named. For example, if 3 bedrooms are added in position (1) of Type A, then the sub-type is named as Type A1-1-1 as in Figure.10. Also, if two bedrooms were added in positions (1) and one bedroom was added in the position (2) of Type A, then the sub-type could be named as Type A1-1-2.

To calculate the number of sub-types of each basic type (from Type A to Type C), 19 sub-types for each of our 3 patterns are found. For instance, for Type A, types are as shown in Table.1.

From table 1, it is found that 9 types within brackets are not found where no bedrooms are located between the entrance or staircase and

guest room. It was mentioned above that the access to the guest area (GA) would be always through the staircase (S). Therefore, there would be 10 sub-types for each basic type (3 basic types from Type A to Type C) and the total number of types would be 30 types. On the other hand, the calculation for the Hall-Type plan used the same aforementioned process and accordingly found that the number of housing units for that type patterns is only 4 patterns.

A1-1-1	A2-2-2	(A3-3-3)
A1-1-2	(A2-2-3)	(A3-3-4)
(A1-1-3)	A2-2-4	A4-4-4
A1-1-4	(A2-3-3)	
A1-2-2	(A2-3-4)	
(A1-2-3)	A2-4-4	
A1-2-4		
(A1-3-3)		
(A1-3-4)		
A1-4-4		

Table.1: Matrix of the Adjacency Diagram of Type.A (Source: Authors).

### Conclusion

Throughout the analysis covered both housing units, conclusion can be drawn for future design of Gazan residences as follows:

1. Corridor-Type plan is more compact, flexible and accessible, as it has more alternatives than those of the other type. It is recommended to implement it into future housing projects. This adds a newly practical definition of high-density buildings where people satisfied of the form.
2. The approaches described previously help specialists understand their architecture by

having all types summarized in a small table. As a result, people can locate their plans on the table and it would be easy to recognize the common types of Gazan housing units.

3. The need to study and analyze more existing contemporary, vernacular, and traditional plans and compare them to the figures expressed previously would strengthen the finding. This enables researchers and specialists to prove their hypotheses.

4. The approaches used in this study could be further developed to include the geographic directions, which might increase the number of housing patterns. The authors would undertake this issue in their future researches.

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