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## Socio-Spatial Analytic of Low-Income Housing Units in Egyptian New Cities, Case Study Teba city

Riam Mohamed-Elsagher Mahmud Elmorshedy

Assistant Professor, Architectural Department, Faculty of Engineering, Minia University,  
Minya, Egypt.  
riamelmorshedy@mu.edu.eg

### ABSTRACT

Housing is one of the most important buildings' typologies, by its universal nature and its relation to one of the most basic human needs, where "Home" reflects the "Human" socio-culture and lifestyle.

The issue for people who cannot afford buying their own homes is: "what kind of place they should live in" as their homes are determined by housing authorities, planners, architects, politicians, and social philanthropists, depending on universal and local standards. The standards used to define appropriate living spaces for a person impose significant constraints on personal choice, which would be reflected on housing projects, particularly in new cities, especially for middle- income and low-income families.

This paper considers the gap between the characteristics of residents' socio-culture and lifestyle on one hand, and the available residential units in the real estate market on the other hand, focusing on the housing of low-income families in Egypt. It presents an overview of universal and local standards, and reviews case study housing units according to design standards and residents' needs. Data is analysed and compared syntactically and statistically by using: "DepthmapX software" for the under-consideration models' syntactical analysis, and "SPSS software" for questionnaire statistical analysis. The results show that these models are not matching nor consistent as spatial structure, although all models represent Egyptian low-income housing typology, in addition to the residents' dissatisfaction with them. Accordingly, this paper results in some guidelines for a residential unit proposed design, while its syntactical and statistical analysis represent clear socio-culture and lifestyle manifests.

KEYWORDS: lifestyle, low-income housing, spatial structure, spatial design, DepthmapX software.

### تحليل اجتماعي مكاني لوحدات إسكان ذوي الدخل المنخفض في المدن المصرية الجديدة دراسة حالة مدينة طيبة

#### ملخص البحث

يعتبر السكن من أكثر موضوعات العمارة إثارة، لأهميته العالمية وعلاقته بأحد أبسط احتياجات الإنسان، حيث يعكس المنزل الثقافة الاجتماعية وأسلوب الحياة للمقيم.

المشكلة بالنسبة للأشخاص الذين لا يستطيعون شراء منازلهم الخاصة تتمثل في: ما هو نوع المسكن الذي سيعيشون فيه؟، فدايماً ما يتم تحديد منازل هذه الفئة من قبل مسؤولي الإسكان والمخططين والمهندسين المعماريين والسياسيين ومتخصصي الدراسات الاجتماعية، تحدد المعايير التي يستخدمها هؤلاء المتخصصون مساحة المعيشة المناسبة والتي تفرض قيوداً كبيراً على بدائل الاختيار الشخصي للمسكن، وذلك ما ينعكس خلال مشاريع الإسكان الضخمة في المدن الجديدة وخاصة للأسر المتوسطة والمنخفضة الدخل.

تتناول هذه الورقة الفجوة بين الثقافة الاجتماعية للسكان والوحدات السكنية المتاحة في سوق العقارات، تركيز بشكل رئيسي على إسكان الأسر ذات الدخل المنخفض في مصر. وتقدم الورقة لمحة عامة عن المعايير العالمية والمحلية وتعرض الوحدات السكنية لدراسة الحالة وفقاً لمعايير التصميم و رغبات السكان. تحلل البيانات تحليلاً بنائياً وإحصائياً؛ برنامج DepthmapX للتحليل البنائي (المكاني) للنماذج، وبرنامج SPSS للتحليل الإحصائي لاستمارة استطلاع رأس السكان. أوضحت النتائج أن النماذج المتاحة غير متطابقة في اتساق هيكلها المكاني، على الرغم من أن جميع النماذج

تستهدف المساكن المصرية لذوي الدخل المنخفض، بالإضافة إلى عدم رضا السكان عن هذه النماذج. وبناء على ذلك، تقدم الورقة المبادئ التوجيهية لتصميم وحدة سكنية إنسانية (تلائم أسلوب الحياة)، حيث يظهر التحليل البنائي للمسقط الأفقي للنموذج المقترح دلالات ثقافية واضحة.

الكلمات المفتاحية: أسلوب الحياة، إسكان ذوي الدخل المنخفض، البنية المكانية، التصميم المكاني، برنامج DepthmapX.

## INTRODUCTION

Houses are the oldest and the most important constructions humans ever built to keep themselves alive. Maslow's (1943, 1954) hierarchy includes five motivational needs, the shelter acts as a basic need in the second level: safety needs (Gawel, 1996). The house as a physical place should ideally match residents' mental needs. While considerations are physically given to site, form, and quality; other considerations are mentally given to set of emotions, sense of comfort and belonging. (Blunt & Dowling, 2006; Leung, 2018).

The efficiency of a house depends on how it achieves the human needs, not only by room functions, but also by circulation patterns. (De Chiara & J. Crosbie, Time-Saver Standards for Building Types, 2001; Alexander, Ishikawa, & Silverstein, 1977). The spatial designs of houses should have the ability to regulate privacy according to the needs of users (Cooper, 1967; Mitton & Nystuen, 2007; Sebba & Churchman, 1986; Mustafa, Hassan, & Baper, 2010).

The privacy norms for any group of people reflect what they can afford within the socioeconomic system which they are a part of, and therefore the differences in the level of need for privacy relate to social group attitudes (Lang, 1987).

So, the efficiency of houses is based on areas sensible for room activities and convenient relationships between rooms as determined by local socio-cultures and lifestyle.

Over decades, Egypt has suffered from housing problems, gradually started after the republican government came into power, and the population growth, which prompted the government to create new cities since 1979. That decision included designing and constructing huge housing projects targeting different income groups and different housing types. Social housing is presented for middle-income and low-income citizens as apartment units. The recent definition of low-income citizens according to "The Central Agency for Public Mobilization and Statistics" is a person whose monthly income is less than 1,600 EGP. (CAPMAS, 2014).

The problem of social housing projects has some major manifestations such as design alterations of facades and plans, and sometimes the residents' reluctance to live in their houses. These huge projects always ignore the residents' needs and depend on decision makers' visions.

While the research tests the consistency of spatial structure, it hypothesizes that the alterations in houses reflect the design incompatibility with residents' socio-culture and lifestyle. The proof of hypothesis leads to design a new model for low-income population, matching with local socio-cultures and lifestyle (a proposed residential unit design).

The research syntactically analyzes the residential units. If the results show that their spatial configuration does not follow the same social pattern, then statistical analysis of population survey is performed to propose a new residential unit design.

## 1. LITERATURE REVIEW

Housing has many studies in different fields and from different points of view. From the Socio-Spatial field, Elmorshedy and her colleagues presented a new method to assess housing units depending on residents' opinions. Included in that study, resident's satisfactions for each element were weighed according to their importance to himself/herself. The housing units' assessment in that study act as one of three axes of the neighborhood's physical components (planning, urban, housing unit). The research used the statistical analysis for residents' questionnaire. (Elmorshedy, Ibrahim, & Kamel, 2018).

Živković & Jovanović focus on the flexibility of housing units for improving the residential space organization. The evaluation of internal flexibility is assessed through a number of physical criteria. This research is aimed to determine the best combination of criteria parameters and guidelines in flexible housing design. (Živković & Jovanović, 2012). While Binthabet studies social aspects from an economic view, where the components of the housing units of middle-income real estate projects were studied and analyzed, achieving principles of cost reduction. The results considered a variety of elements, such as architectural spaces, sustainability, number of occupants per unit and other aspects of housing. (Binthabet, 2019). Both researches did not take residents' opinions into account in any stage, although they were referred to in the housing units design and in some of its physical criteria.

Al-Jokhadar and Jabi have very important research, which considers spatial analysis and simulates vernacular neighborhoods as models for socially-sustainable models (social needs and cultural values). their research aims to benefit from potentials of such horizontal clusters for generating socially-sustainable tall residential buildings that trace the cultural values of the society. (Al-Jokhadar & Jabi, 2017). Although the research divided the space into public spaces and private open spaces at outside area of units, it did not study functional space distribution inside units (the research focuses on the spaces between units and how the units are clustered or configured).

Generally, every building type has unique socio-spatial configuration (Asif, Utaberta, Sabil, & Ismail, 2018). The residential unit as a house building type must have a socio-spatial configuration matching with residents' socio-culture and lifestyle.

In the residential unit's plan: the functional relationships between different activities explain the links between them and the impact of these links on their functions. The relationships between activities appear in different ways according to the residential unit genotype. (Genotype is a sequence of functionally defined spaces, ranked in accordance with their integration values (Ostwald & Dawes, 2018).)

The design of residential units is subject to universal and local standards, which describe each element in the unit, its requirements, and display local determinants of the residential unit's efficiency.

### 1.1 The Unit's Elements Criteria (Universal Standards)

The unit plan contains architectural elements, which are divided into public and private according to its uses and privacy level (Pickard, 2002). Table 1 shows each element and its design requirements:

Table (1). The Requirements of Unit Plan

The functional space	Description	Criteria	Notes
Reception room	An area for relaxation, social activities, and entertainment	<p>Good natural light and views.</p> <p>Preferably over a garden and away from noisy areas such as the front road etc.</p> <p>It should be at entrance level.</p>	
Living room	An area for general family life and should allow for group activities as well as individual relaxation; entertaining, reading, writing, listening to music, children's play area, and watching television	<p>The size:</p> <ul style="list-style-type: none"> <li>- In larger dwellings, more than one living room may be provided, possibly both self-contained or alternatively divided by double doors.</li> <li>- In small dwelling: combined living-reception space.</li> </ul> <p>It is the most impressive and largest of all rooms in the apartment, which prefer it to be visible from the entry-hall.</p> <p>It is not a part of circulation, except in the smallest dwellings.</p> <p>Southerly direction is preferred, and overhang will be used to prevent direct sunlight from entering the room in hot climates.</p>	<p>Direct access from living room to private open space.</p> <p>Two separate living areas is recommended.</p>
Dining room	An area for eating meals.	It is often combined with the living room in smaller dwellings.	Easterly direction is recommended for those who prefers entering sunlight during the morning and westerly or south-westerly direction for those who prefer seeing sunset or sunlight during the afternoon.
Kitchen	A place for meal preparation and serving, utensil storage, eating (occasional meals).	<p>Direct access to the dining area.</p> <p>Separate area or dining-kitchen.</p> <p>When the kitchen area is a small: it will be used an area opening off or adjacent to the living room as a kitchen.</p>	<p>Kitchens should be equipped with a small eating space, as possible.</p> <p>Direct access from kitchen to private open space, as possible.</p> <p>Ancillary activities can include clothes washing.</p> <p>North direction for nonglare light, while many people prefer some sunlight in</p>

The functional space	Description	Criteria	Notes
			kitchen. Generally, its orientation depends on the personal preference of the individual.
Bedroom	Mainly a place for sleeping, and some secondary activities; relaxation, reading, writing, studying, working, leisure (e.g., watching television, home computing/internet, listening to music, children's play, drawing and painting, sitting and entertaining, exercising, resting and convalescing, hobbies and crafts).	With direct access to washing and WC. Sunlight streaming should be into it upon waking up in the morning. (east and south east direction recommended, and west should be avoided).	
Main bedroom	Master bedroom for parents.		
Bathroom	A place for washing and bathing.	Economy in services arrangement (bathroom and kitchen), it is recommended to be in same zoon horizontal and vertical.	WC may be in separate compartment.
Entry-hall	The area beside entries which the door open in.	The entry-hall has connection with kitchen.	The ideal location for the second exit is in the kitchen.
Study, office	A place for working at home.	The location on the first floor if the house has more than a floor. Need to privacy, quiet and security. It is necessary for this room to be apart from the general living area.	The required facilities are computers, internet links, and fax machines etc. Office, close to main entrance.
Specialist room	It may be required in a special dwelling; this room may be used as a guest room, a library, music room, playroom, games room (e.g., for billiards, darts, table tennis: see sports section), breakfast room, dance room.		Twin bed guest room with basin, heated and comfortably furnished, and near to a WC.

(Source: Pickard, 2002; De Chiara and J. Crosbie, 2001; De Chiara, 1984; Neufert and Neufert, 2002.)

## 1.2 The Residential Unit's Efficiency (Local Standards)

According to Egyptian "Law No. 119 of 2008," the residential unit must be provided with a private bathroom that includes at least one toilet and sink and required that each functional space must have a window at least for ventilation and lighting.

Code No. 602 "Egyptian code for housing design and residential compounds" focuses on visual and voice privacy, and dividing the unit's spaces according to the privacy levels into private space (sleeping zone and family living), and semi-private (space for receiving guests). In addition, two other measured variables reflecting the house efficiency: (HBRC, 2009)

- The efficiency of the residential unit, which refers to the ratio of efficiency in area depending on the distribution of functional spaces. Where the lobby areas should not be more than 20% of the residential unit area.
- Overcrowding rate, which is the value of the residents' number per room in residential unit. This rate should not be more than 1.5 person/room.

## 2. METHODOLOGY

The research tests the consistency of spatial structure for low-income residential units. It is used the logical argumentation method based on the space syntax theory. Where syntactical analysis explores topological and social relations implicit in the architectural setting (Hillier & Hanson, 1984). The extracted results from this analysis are presented mathematically (as control and integration values), which are useful for interpreting the social life and the overall configuration of the selected cases (Al-Jokhadar & Jabi, 2017).

Also, the research uses survey strategy for a sample of the population, where statistical analysis displays the matching level in socio-economic characteristics for the residents as low-income society and gives an estimation for residential units from the residents' point of view. Based on the results of the syntactical and statistical analysis, new residential unit design model for low-income residents (a new residential unit) is proposed and the model is logically tested.

Testing the hypothesis and the analysis use two software: the DepthmapX software for syntactical analysis and Statistical Package for the Social Sciences (SPSS software) for statistical analysis.

### 2.1 Case Study

The research discusses low-income housing units which were constructed in "Teba city", Upper Egypt. The houses under considerations include five types of housing (they were constructed at different intervals, starting from 2000s until now). Some of these types have more than a unit model, with variety in their genotypes and areas, table 2 and table 3.

Table (2). Low-income Housing Types in "Teba City"

The housing type	The unit model		The unit total area (m <sup>2</sup> )	The number of functional spaces	
	The number of models	The model's name		Residential rooms	Service room
Kawemy	1	Kawemy	60.00	3	2
Motawar	1	Motawar	52.00	3	2
Egtmaey	1	Egtmaey	70.00	4	3
El-Shabab and El-Mostakbal	2	Kamar-Elden	63.00	3	2
		Bondok	63.00	3	2
El-Hor	2	Hor75m <sup>2</sup>	75.00	3	2
		Hor95m <sup>2</sup>	95.00	4	3

Source: The author. The data source: "Teba City" Authority, 2020.

Table (٣). The Functional Spaces' Areas for Models

The models	The area (m <sup>2</sup> )							Net area of residential unit (m <sup>2</sup> )	The ratio of efficiency area●
	Living room combined with dining	Kitchen	Bedroom	Bathroom	Water circle	Entry-hall	Lobbies		
Kawemy	18.75	4.26	11.79	3.19	-	2.55	1.86	51.50	8.56%
Motawar	14.32	3.88	9.48	3.06	-	1.29	2.04	43.00	7.74%
Egtmaey	21.55	5.77	9.22	3.78	-	0	5.42	65.00	8.34%
Kamar-Elden	17.90	6.45	10.01	2.83	-	0	1.21	48.50	2.50%
Bondok	18.40	4.73	10.98	2.98	-	3.09	1.51	52.50	8.76%
Hor75m <sup>2</sup>	21.90	5.56	9.61	4.84	-	2.36	2.69	58.00	8.70%
Hor95m <sup>2</sup>	25.60	6.00	9.73	5.00	2.98	2.55	5.20	76.00	10.20%

●The ratio of efficiency area= ((lobbies + entry-hall) areas / the residential unit area) \*100, should not be more than 20%.

(Source: The author.)

The functional spaces at each unit are included in a group according to its privacy zoning; semi-public, semi-private, private, and service, table 4.

Table (4). The Privacy Zoning for Unit Models and Their Numbers of Functional Spaces

Privacy zoning	Function	Key	Code No.	Kawemy housing	Motawar housing	Egtmaey housing	El-Shabab and El-Mostakbal housing		El-Hor housing	
				Kawemy model	Motawar model	Egtmaey model	Kamar-Elden	Bondok model	Hor 75m <sup>2</sup>	Hor 95m <sup>2</sup>
Semi-public	Entry	E	-1-	1	1	-	-	1	1	1
Semi-Private	Living-dining room	LD	-2-	1	1	1	1	1	1	1
	Lobby	O	-3-	1	1	1	1	1	1	2
Service	Kitchen	K	-4-	1	1	1	1	1	1	1
	Laundry	Ld	-5-	-	-	1	-	-	-	-
Private	Bedroom	B	-6-	2	2	3	2	2	2	3
	Bathroom	b	-7-	1	1	1	1	1	1	1
	Water circle	W	-8-	-	-	-	-	-	-	1
Total				7	7	8	6	7	7	10

(Source: The author.)

### 2.2 Data Analysis and Results

The research has two types of data with different analysis methods. The first type is the topological properties -spatial features-; used syntactical analysis. The second are the population characteristics and their evaluation for their residential unit; used statistics analysis. Figure 1 shows the unit models and their layout.

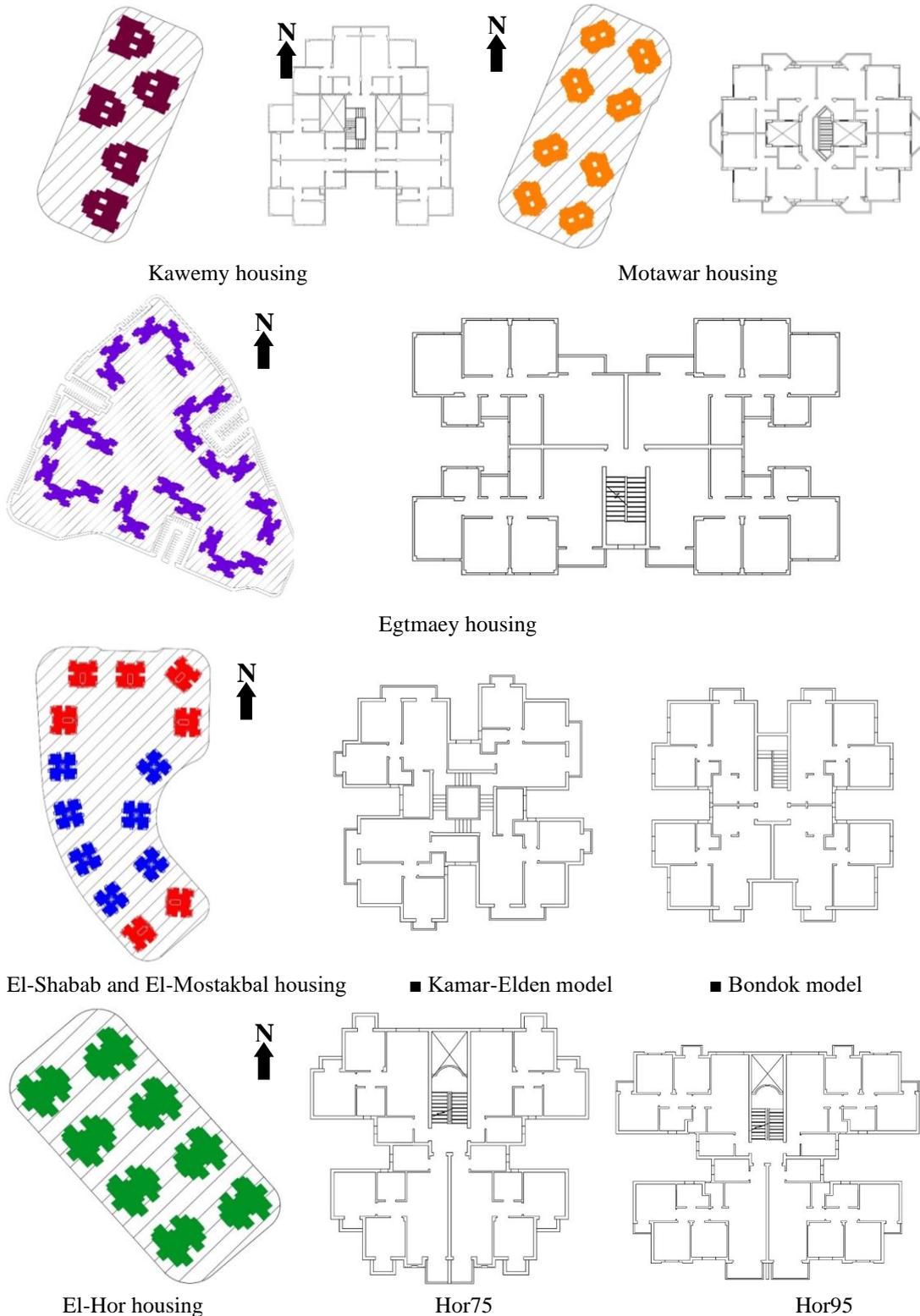


Figure (1). The unit models and their layout.  
 (Source: Teba City Authority, 2020.)

### 2.2.1 Syntactical analysis

The space syntax theory is used to examine the topological properties of low-income housing units' plans and spaces, which use mathematical tools to convert the plans into quantitative values and explain them.

Each functional space is represented by a node where a diagrammatic system of nodes' set and the connections between them is called justified plan graphs (Bondy & Murty, 1976). The spaces are abstracted into a graph for presenting the definition, measurement, and analysis of connections' networks mathematically and visually (Yu & Ostwald, 2018).

The consistency of spatial structure for residential units means that their spatial configurations have a consistent underlying social pattern. The plan graphs and total depth display a consistent configurational structure to show whether units' spatial configuration is shallow or deep, and the relative difference factor  $H^*$  displays whether the inequality genotypes possess a consistent ordering and grouping of spaces for all units or not.

The relative difference factor  $H^*$  is used to compare the difference factor for models which have not the same number of spaces (Ostwald & Dawes, 2018).  $H^*$  is an indicator for the inequality genotype, which can be used to demonstrate how a "culture manifests itself in the layout of space by forming a spatial pattern in which activities are integrated and segregated to different degrees" (Hillier & Tzortzi, Space Syntax: The Language of Museum Space, 2006). The levels of genotype as following: (Ostwald & Dawes, 2018).

- When  $H^* > 0.5$  refers to a weak genotype. Which mean more homogenized with only limited configuration.
- When  $H^* < 0.5$  refers to a strong genotype. Which mean a higher level of dispersal of spaces, implying a more distinct topological configuration has been produced.

Certainly, a distinct configuration in an individual case can be either random or deliberate. So, in order to confirm which of these it is, a majority of cases are required to confirm a level of determination; the value of  $H^*$  must be less than 0.5 in, at least, 60% of the tested models (Ostwald & Dawes, 2018).

The comparison among the units depending on the space syntax results show the matching levels in "Consistency of spatial structure" and confirm if the models refer to the same "Social structure of space" or not.

#### 2.2.1.1 The consistent configurational structure

Figure 2 shows five different justified plan graphs, where Kawemy, Motware and El-Hor housing ( $Hor75m^2$ ) have the same graph, while El-Shabab and El-Mostakbal (Kamar-Elden, Bondok model), Egtmaey, and El-Hor housing ( $Hor95m^2$ ) have anisotropic graphs.

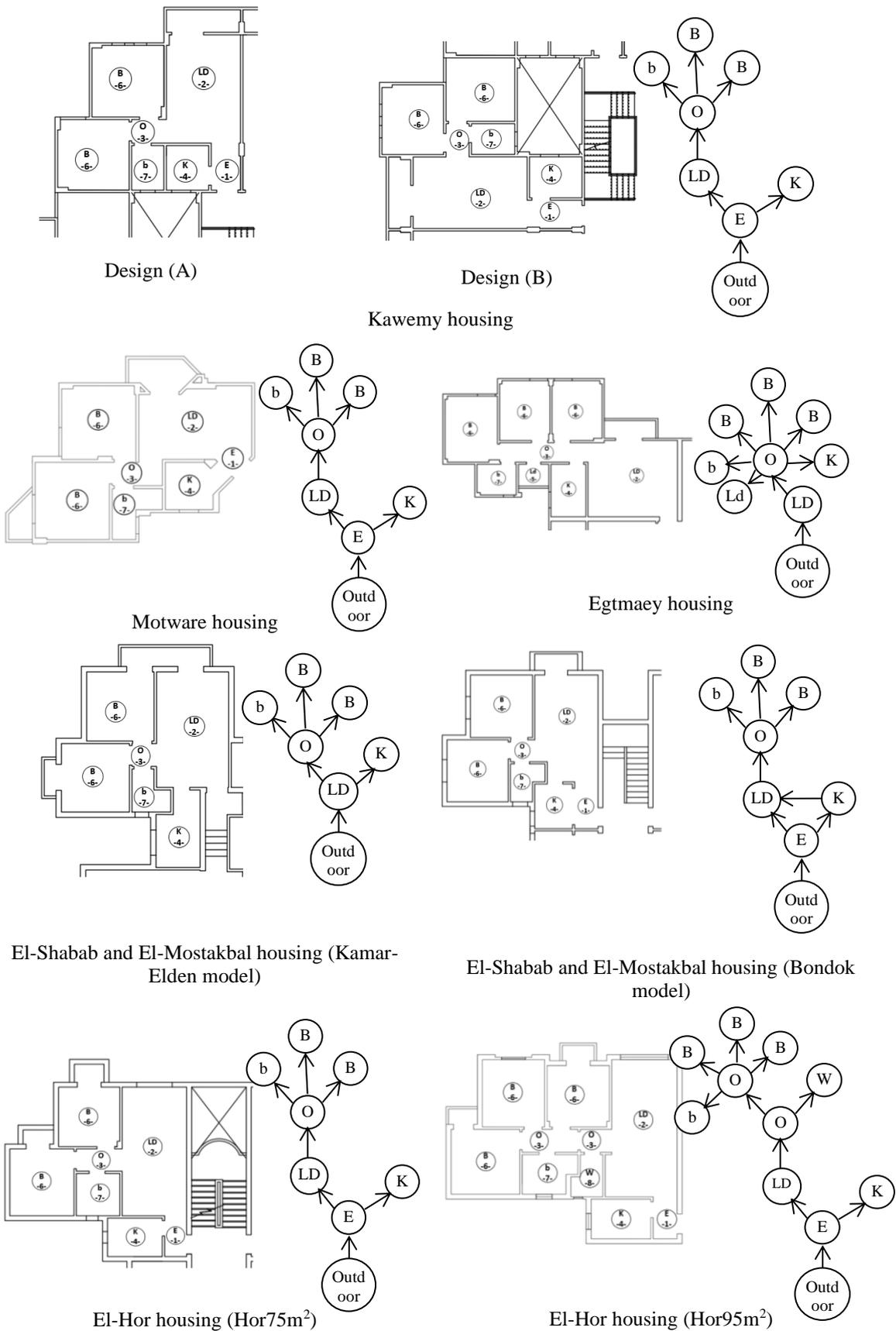


Figure (2). Justified plan graph of the convex spaces.  
(Source: The author.)

The models' depth results: Figure 3 shows; Kamar-Elden is the shallowest model and Hor95m<sup>2</sup> the deepest one. Kamar-Elden lacks the privacy gradient, where most of the room connected directly to living-dining room. Other models have very similar depth value; Kawemy, Motawar, Egtmaey, Bondok, and Hor75m<sup>2</sup>.

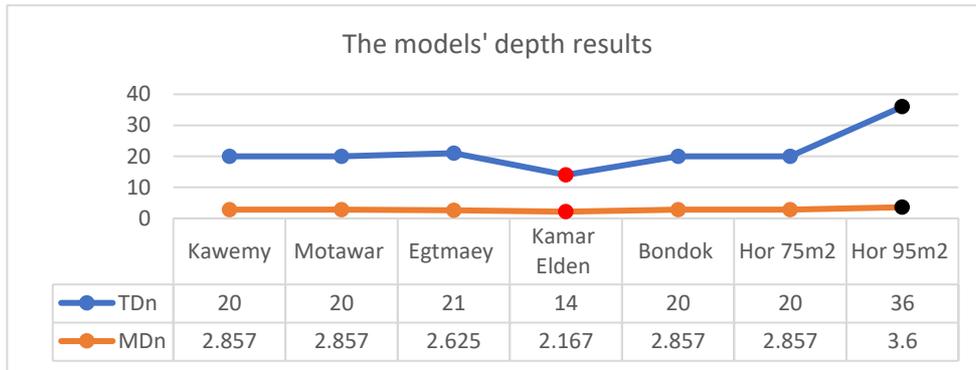


Figure (3). The models' depth values.  
(Source: The author.)

**2.2.1.2 The inequality genotypes -The relative difference factor H\*-**

Figure 4 shows H\* values for all models is higher than 0.5 except Egtmaey model. That confirms the undifferentiated quality of the plan -the planning structure- for Kawemy, Motawar, Bondok, Hor75m<sup>2</sup>, and Hor95m<sup>2</sup>. These models are homogenies with limited configuration and unclear culture manifests. Kamar-Elden's H\* measure of 0.69 is slightly more balanced than the results for the previous, although it still indicates a lack of configurational determination. H\* values confirms that the set plan graphs do not display evidence of a deliberate strategy to produce a particular configuration.

The Egtmaey model's H\* value is 0.3, the plan graph is slightly more deliberate in its structure than a generic graph of a similar size and confirming that it is the most differentiated of other models. But that is an individual case between all models, so it acts as a random configuration.

Generally, conclusion of studying H\* shows that designed models for low-income have not consistency of spatial structure and its culture manifests are unclear. While Egtaemy model appears as a random configuration among other models, it is not a deliberate structure. The residents' survey will show if Egtaemy model reflects the local socio-cultures manifests or not.

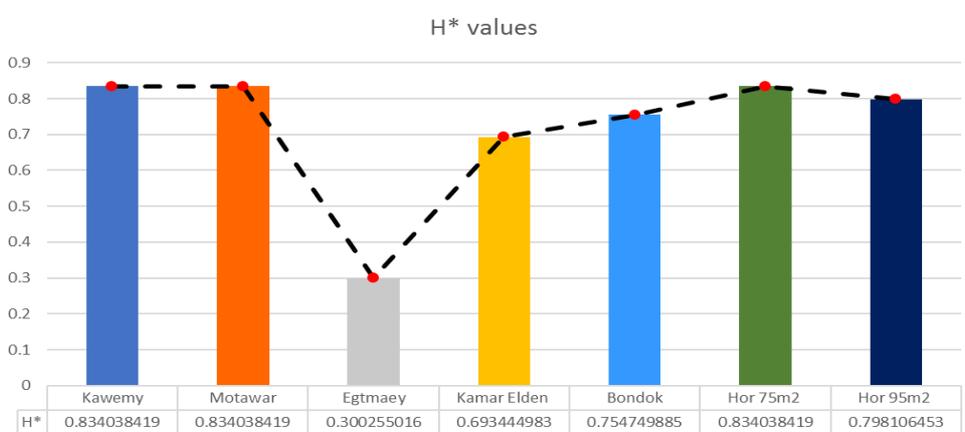


Figure (4). H\* values.  
(Source: The author.)

According to syntactical analysis, the units do not match in the consistency of spatial structure. They do not belong to the same socio-cultural level, although all models plan targets Egyptian low-income housing typology. Where the units' models have not the same depth value, and H\* measure for all models are higher than 0.5 except Egtmaey model, which acts as a random configuration among the other models.

So, the research hypothesis "the alterations in houses are a reflect the design incompatibility with residents' socio-culture and lifestyle" is accepted.

### 2.2.2 Statistical analysis -questionnaire for residents-

Interviews and questionnaires were conducted with a random sample within the study area. To ensure the accuracy of the questionnaire results, sample size 30 of inhabitants at least have to be questioned (Charles & Mertler, 2002; Creswell, 2002; Gall, Borg, & Gall, 1996; Gay & Airasian, 2003; McMillan & Schumacher, 2001). Thus, the final sample size taken in this research is 58 residents with different distribution over all housing types because; the number of building houses and their units is not the same for all types, the people densities are not the same, and there are some buildings are used as the rest houses for government institutions or administrative buildings. Table 5 shows the number of buildings for each housing type, the size of sample and some notes about the building current uses.

Table (5). The Sample Size Distribution According to The Housing Model.

The unit model	No. of all building	The sample size	Notes
Kawemy model	9	14	
Motawar model	12	2	low occupancy rate. Rented to use for labor accommodation. Families are very low.
Egtmaey model	11	30	High occupancy rate with families. There are other buildings under construction.
Kamar-Elden model	37	3	Low occupancy with families. Rented for university students for housing.
Bondok model	38	6	Low occupancy with families. Rented for university students for housing. Government institutions (university staff rest house).
Hor75m <sup>2</sup> model	6	2	Four buildings are administrative buildings.
Hor95m <sup>2</sup> model	2	1	

(Source: The author.)

The questionnaire was conducted by the author during multiple visits and interviews with the residents, and it contains two main parts. The first gives data about the social level (job, education, income, the number of family members, unit ownership). The second gives data about evaluating the design of unit (the residents were asked to give a degree for each space from 1 to 5 about its area adequacy and another degree for space efficiency: ventilation, daylight and privacy), at the end the resident adds some comments about the relationship between different spaces and what he/she prefers or dislikes.

Statistical Package for the Social Sciences (SPSS software), the basic application of this program is to analyze scientific data related to social science. SPSS is used to determine whether the residents of all housing types have the same social level or not, and to evaluate the residential units from residents' viewpoints. The Kruskal-Wallis H test, is non-parametric technique, allows comparing more than two groups and testing if there is a difference among them according to one or more characteristics or not. At Kruskal-Wallis H test outputs; if Asymp. Sig.<0.05 then there are significant differences among the groups, while if Asymp. Sig.>0.05, there are no significant differences (Pallant, 2005).

#### **2.2.2.1 The residents' homogenies (The same social level)**

The Kruskal-Wallis H test was used to test the characteristics of social level according to units' models.

The result shows that Asymp. Sig. range between 0.113 and 0.634 (Asymp. Sig.>0.05) for social level characteristics, that confirms the residents for all housing types have the same social level.

#### **2.2.2.2 The evaluation of unit's area adequacy**

The Kruskal-Wallis H test for rooms number and functional space area of the housing units' types. The result shows that Asymp. Sig. range between 0.00 and 0.022 (Asymp. Sig.<0.05) for the room number, the second children bedroom, dining-living, kitchen, and bathroom. Which means there are significant differences among the residential units.

The evaluation of area for each functional space accordingly was tested individually. The mean and mode values are calculated, table 6.

Table (6). The Mean and Mode Values for The Unit's Area Adequacy. (According to housing types)

The Space	Kawemy housing		Motawar housing		Egtmaey housing		El-Shabab and El-Mostakbal housing				El-Hor housing			
	Kawemy model		Motawar model		Egtmaey model		Kamar-Elden model		Bondok model		Hor75m <sup>2</sup> model		Hor95m <sup>2</sup> model	
	Mean	Mode	Mean	Mode	Mean	Mode	Mean	Mode	Mean	Mode	Mean	Mode	Mean	Mode
Master bedroom	2.64	3	2	1	2.6	3	2	1	2.17	1	2.50	2	3	3
Children bedroom (1)	2.86	3	1	1	2.27	2	2	1	2	2	1.50	1	3	3
Children bedroom (2)	0	0	0	0	2.23	2	0	0	0	0	0	0	3	3
Dining area	3.79	3	1.50	1	4.40	5	3	3	2.50	2	4.00	3	4	4
Living area	3.79	3	1.50	1	4.40	5	2.67	3	2.50	2	4.00	3	4	4
Kitchen	2.07	1	1	1	3.30	3	2.00	1	2.50	2	3.50	3	2	2
Bathroom	2.57	2	1	1	3.30	3	1.33	1	2.17	1	4.50	4	2	2

Note: The numbers refer to area adequacy level where: **(0)** Means that functional space is not available in this model. **(1)** very small. **(2)** below moderate. **(3)** moderate. **(4)** above moderate. **(5)** excellent.

(Source: The author.)

Generally, most mean and mode values are below moderate level. Egtmaey and Hor95m<sup>2</sup> models have the highest evaluation, while Motawar model has the lowest one. The most frequent values of adequacy evaluation show some functional spaces that need review below:

- Kawmy model; kitchen and bathroom their areas need to increase.
- Motawar model; all areas need to increase.
- Egtmaey models; children bedroom areas need to increase.
- Kamar-Elden model; the bedrooms, kitchen, and bathroom areas need to increase.
- Bondok model; all areas need to increase.
- Hor75m<sup>2</sup> model; the bedroom areas need to increase.
- Hor95m<sup>2</sup> model; kitchen and bathroom areas need to increase.

### 2.2.2.3 The evaluation of unit's spaces functional efficiency

Kruskal-Wallis H test's result shows that Asymp. Sig. range between 0.113 and 0.262 (Asymp. Sig.>0.05) except for the second child bedroom where it is available only in two models (Egtmaey and Hor95m<sup>2</sup>). Which mean there are no significant differences among the residential units.

The spaces' efficiency is similar in all models, so this evaluation is tested for all models as a group (except the second children bedroom). Mean and mode values are calculated, table 7.

Table (7). The mean and mode values for the unit's spaces functional efficiency. (For all housing type)

The efficiency evaluations	Master bedroom	Children bedroom (1)	Dining area	Living area	Kitchen	Bathroom
Mean	3.74	3.71	3.81	3.83	4.12	4.19
Mode	4	4	5	5	5	5

(Source: The author.)

The results show; Mean values are above moderate (between 3.74 to 4.19). Mode values are above moderate and excellent (4 and 5).

### 2.2.2.4 The residents' preferences

Statistical analyzes show that 81% of the sample did not make any modifications and 19% made minor modification, although 55.2% of sample want to find new homes.

(a) Residents attributed the reasons for no modification to:

- They rent and they may leave anytime according to the owner opinion,
- The owners ask them not to make any modification,
- The city's administrative authorities prohibit any modifications.

The residents who made minor modification used light materials (as drapes) to merge (balcony with room) or to divide (separate the dining-living area into two parts for privacy). At The first-floor flats and Egtmaey housing, the residents used metal to close balconies or part of it to protect from theft.

(b) According to the sample, 30% of Egtmaey residents, 50% of Hor75m<sup>2</sup>, 71.4% of Kawemy and 100% of Kamar-Elden, Bondok, Motawar, and Hor95m<sup>2</sup> residents want to find new homes.

Residents attributed the reasons for desiring to find new homes to:

- The small area, (25.9% of sample).

- The small number of rooms, (3.4% of sample).
  - Both the small area and the small number of rooms, (17.2% of sample),
  - Other reasons do not relate to the unit design such as harassment from neighbors, and the number of flats in building (four flats in each floor and 6 floors in building with total 24 flats are too many and in Kawemy housing 6 flats in floor), (12.1% of sample).
- (c) The first floor flats have no privacy from surrounding open spaces.
- (d) All units' models cause inconvenience for residents except Egtmaey model. The inconvenience is caused by the relationship between the unit's door and the kitchen and its door location.

While all people who live in Egtmaey model are very satisfied with the space distribution and they did not use drapes to achieve privacy for the wife's circulation between bedrooms zone and the kitchen.

(e) At Egtmaey housing:

- Each flat has one direction north or east. The north direction cannot receive the sunlight in winter (cold in winter), and on the contrary the east direction is very hot in summer.
- Laundry spaces for different flats are very close to each other, therefore residents do not have complete privacy.

The statistics analysis for the residents' questionnaire gives the evaluation for houses from population view, table 8.

Table (8). The Summary of Statistics Analysis

The model	The Unit's Area Adequacy	The Unit's Spaces Functional Efficiency	The Residents' Preferences
Kawemy	Some functional spaces' (kitchen, and bathroom) area needs to increase.	Different efficiency level according to the location of flat and building orientation. The privacy for first floor's flats is weak.	The area and the number of bedrooms is low. The number of flats (6 flats) in the floor and all building is many. The functional space distribution is not good.
Motawar	All functional spaces' area needs to increase.		The area and the number of bedrooms is low. The functional space distribution is not good.
Egtmaey	Children bedrooms' area needs to increase.		The area is low. The functional space distribution is good. The all-unit direction should not be one orientation. The laundry space lacks privacy from neighbors. The number of flats (4 flats) in the floor and all building (6 floors) is many.

The model	The Unit's Area Adequacy	The Unit's Spaces Functional Efficiency	The Residents' Preferences
Kamar-Elden	Some functional spaces' (bedrooms, kitchen, bathroom) area needs to increase.		The area and the number of bedrooms is low. The functional space distribution is not good.
Bondok	All functional spaces' area needs to increase.		The area and the number of bedrooms is low. The functional space distribution is not good.
Hor75m <sup>2</sup>	Bedrooms' area needs to increase.		The area and the number of bedrooms is low. The functional space distribution is not good.
Hor95m <sup>2</sup>	Some functional spaces' (kitchen, bathroom) area needs to increase.		The functional space distribution is not good.

(Source: The author.)

### 3. DISCUSSION OF FINDINGS AND DESIGN MODEL

The data analysis gives results in two levels: Socio-spatial (syntactical analysis) and residents' view (statistics analysis). The combination between them leads to the guidelines for the design of new residential unit model (a proposed residential unit design), table 9.

Table (9). The Summary of Analysis' Results

The model	Syntactical analysis results	Statistics analysis results
Kawemy	The models do not match in social structure of space and they have not consistency of spatial structure (culture manifests unclear). Except Egtmaey model has deliberate structure (a clear culture manifests), but it appears as a random configuration among other models.	Some functional spaces' area needs to increase (kitchen, bathroom). The number of bedrooms is low. The number of flats in the floor and all building is many. The unit's functional space distribution is not good.
Motawar		All functional spaces' area needs to increase (bedrooms, living, dining, kitchen, bathroom). The number of bedrooms is low. The unit's functional space distribution is not good.
Egtmaey		The children bedrooms' area needs to increase. The unit's functional space distribution is good. The all-unit direction should not be one orientation. The laundry space lacks privacy from neighbors. The number of flats in the floor and all building is many.

The model	Syntactical analysis results	Statistics analysis results
Kamar-Elden		Some functional spaces' area needs to increase (bedrooms, kitchen, bathroom). The number of bedrooms is low. The unit's functional space distribution is not good.
Bondok		All functional spaces' area needs to increase (bedrooms, living, dining, kitchen, bathroom). The number of bedrooms is low. The unit's functional space distribution is not good.
Hor75m <sup>2</sup>		The bedrooms' area needs to increase. The number of bedrooms is low. The unit's functional space distribution is not good.
Hor95m <sup>2</sup>		Some functional spaces' area needs to increase (kitchen, bathroom). The unit's functional space distribution is not good.

(Source: The author.)

Table 9 shows

- All models lack good orientation of different spaces, have diverse social structure of space and lessen the functional spaces' area (but the spaces are different according to the unit type).
- All models except Egtmaey lack consistency of spatial structure, and the suitability of the unit's functional space distribution.
- Kawemy, Motawar, Hor75m<sup>2</sup>, and Hor95m<sup>2</sup> models lack the correct relations between spaces (kitchen and dining).

Although Egtmaey model has notes about its design, however statistical analysis shows compatibility between the units' design and residents' hopes. It is unique among all models where its H\* value equals 0.3 (a strong genotype). Egtmaey model has deliberate structure and comfort of the unit's functional space distribution, so it has a clear culture manifests.

### 3.1 The Guidelines for Designing the New Residential Unit (A Proposed Residential Unit Design)

Depending on models' analysis especially Egtmaey model:

- Dining-living area is suitable, master bedroom and kitchen and bathroom preferably should be increased, and children's bedrooms should be increased.
- Functional space distribution acceptable and should be supported with direct access from kitchen to entry-hall and dining.

The new residential's guidelines include recommendations for unit's elements, areas, element distribution, element directions, and privacy in the unit.

- (a) The elements -functional spaces-: The unit should contain at least three bedrooms, dining-living space, kitchen, bathroom, lobby, and entry-hall.
- (b) The areas: The recommended minimum areas and dimensions are
  - Dining-living space 21.5m<sup>2</sup> (5\*4.3m),
  - Bedroom 12.25m<sup>2</sup> (3.5\*3.5m),

- Kitchen 6m<sup>2</sup> (2.4\*2.5m), and
  - Bathroom 3.96m<sup>2</sup> (1.8\* 2.2m).
- While lobby and entry-hall should achieve the ratio of efficiency area [(lobbies + entry-hall) areas/the residential unit area] \*100, should not be more than 20%].
- (c) The elements distribution -functional space's distribution and relation-:
- The bedrooms, bathroom, laundry (if available), and kitchen open from the same lobby.
  - Entry-hall direct access to both lobby and dining-living space.
  - The kitchen's entrance very close to entry-hall and may have direct access to dining space as a door or handling window.
- (d) The elements direction:
- The unit should have two or more orientations.
  - The bedrooms are oriented to easterly and south easterly direction.
  - The living space is oriented to the southerly direction.
  - The other spaces can be miscellaneous orientations and recommended avoid west and south westerly direction in the kitchen.
- (e) Privacy in Unit:
- The number of flats should be three per floor and five floors in building.
  - The first-floor level should be about +1.5m from the surrounding open area.
  - The plan for each unit should take shape provides privacy inside unit from neighbors.

### 3.2 The Proposed Residential Unit (Model Design)

The author assumes (L) shape plan for these reasons:

- (L) shape gives varieties in joining units to form the building plan with three flats each floor.
- More than one direction for the unit orientation (at least two directions) is available.
- Achieving privacy among neighbors by dealing with the location of the balconies and windows.

The description of model plan: The unit's entrance at the intersection of the L shape's two wings, and the kitchen location is at the front of the entrance. The kitchen location supports two sides for connecting, one of them at the lobby of family zone and the other at the dining space, figure 5.

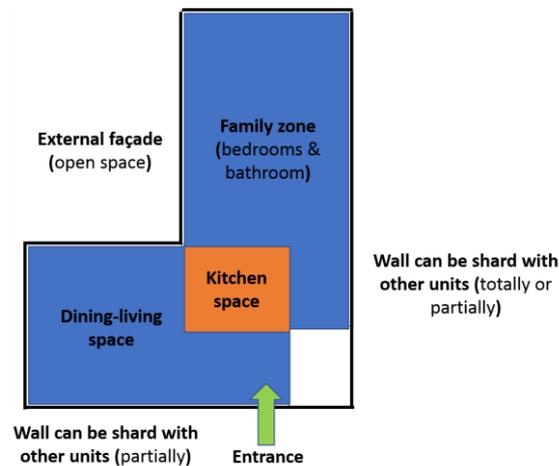


Figure (5). L shape varieties.  
(Source: The author.)

The unit plan's design and analysis: The plan is designed as a guide and for testing its  $H^*$  value (local culture manifests). Through designing each space is determined its function, dimension, and area at architectural plan, figure 6. The syntactic analysis results for the model include a total depth, mean depth, and  $H^*$  values, table 10.

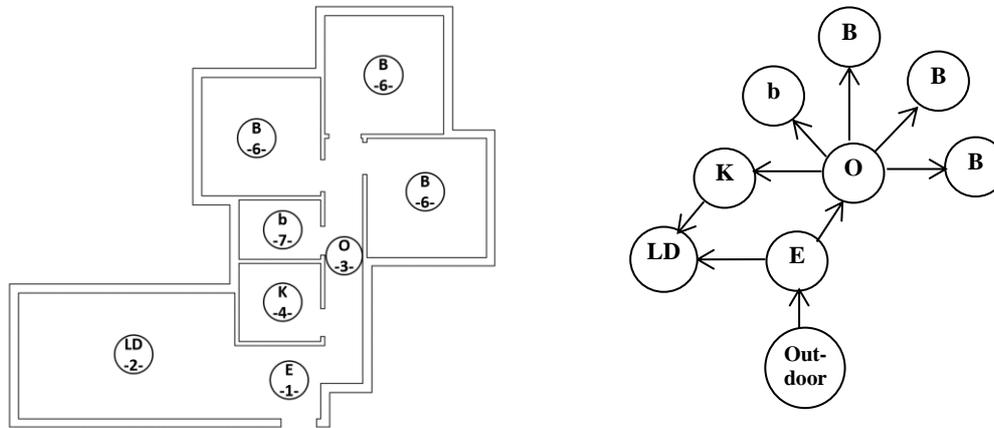


Figure (6). Designed model.

(Source: The author.)

Table (10). The Data and Results of Designed Model

Privacy zoning	Function	Dimension (m)	Area (m <sup>2</sup> )		
Public	Outside	-	-		
Semi-public	Entry (E -1-)	2.40* 2.03	4.88		
Semi-private	Living-dining room (LD -2-)	6.35* 3.70	23.48		
	Lobby (O -3-)	7.22*1.12	8.07		
Service	Kitchen (K -4-)	2.04* 2.42	5.81		
Private (family zone)	Bedroom <sub>1</sub> (B -6-)	3.50* 3.50	12.25		
	Bedroom <sub>2</sub> (B -6-)	3.50* 3.50	12.25		
	Bedroom <sub>3</sub> (B -6-)	3.50* 3.50	12.25		
	Bathroom (b -7-)	2.04* 1.74	4.17		
Results summary	Total area = 83.16 m <sup>2</sup>	The ratio of efficiency area = 15.57%	$TD_n = 20$	$MD_n = 2.25$	$H^* = 0.550769$

(Source: The author.)

Table 10 shows that  $H^*$  value ( $H^* = 0.5507689$ ) is very close to a strong genotype ( $H^* < 0.5$ ). If the design combines the entry-hall and dining-living space together the  $H^*$  value will decrease ( $H^* = 0.377884$ ). The designed model records lower  $H^*$  values than those current housing models, which prove that the designed model achieves local culture manifests and social level's needs

The designed model can be developed and upgraded by changing the rooms' dimension and distribution in the same lobby to increase area adequacy and efficiency.

#### 4. CONCLUSION

The research aimed to test the housing types for low-income (units' models) from achieving local culture manifests. The method takes syntactical and statistics analysis according to data types. The analysis results showed that all tested models have unclear local culture manifests and are uncomfortable for residents, except Egtmaey model.

Egtmaey model has notes about arranged spaces from standard criteria and Egyptian laws. Other notes come from residents' opinions. In view of the analysis results and notes the author proposes guidelines for designing proposed residential unit -new model-. The guidelines include

- Recommendation for the minimum area and dimension for each functional space.
- Description for functional space's distribution and their relationships.
- Determining the orientation for each functional space.
- Recommendation for achieving privacy from neighbors and surrounding open area.

Accordingly, the designing proposed residential unit design takes (L) shape form, where the entrance and entry-hall location at the intersection of the (L) shape's wings, and one of the wings use as private zone (family zone) and the other is semi-private, and the kitchen connects with both wings.

The proposed residential unit was analyzed (syntactical analysis). The results show that the model achieves the local culture manifests and social level's needs. The model can be upgraded for giving better results and different alternatives in buildings form and layout.

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