Spatial Structure at the Room-level of Squatter Urbanism in Metropolitan Cairo

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Abstract
In Metropolitan Cairo, squatter urbanism is common in superimposing building blocks and streets on agricultural land subdivisions at the city edge of rural migration phenomenon. However, the socio-economic dimension of residential spaces is undermined in the management of squatters. This study attempts to clarify the social diversity of spatial structuring that can only be conceived at the room-level of Cairo squatters in contrast to the constant image of outdoor rural-urban transformation. Buildings selected from the 'Bigam' and 'Zinin' squatters that absorb rural migrants are studied according to their spatial room-connection. The application of spatial measurements on the sample buildings is processed through statistical programming to view their patterns of room connection. In 'Bigam', rural migrants from Lower Egypt structure a 'Reception' core of global flow of choice to connect four-cornered room attachment. The spatial structure diversifies by introducing a 'Living' space of visible connectivity with the 'Reception' and control over the bedroom corners. In 'Zinin', the Upper Egypt migrants structure a linear pattern of residential space. The cellular connection of rooms diversifies the coring role by the 'Reception' to become an optional secondary choice. Nevertheless, both zones of 'Zinin' lack 'Living' spaces to dissolve the grouping pattern of rooms without variety of choice. Instead, 'Bedrooms' allow visibility for socializing through the conceptual merging of living and bedroom spaces into one.

Keywords: Metropolitan Cairo; Bigam area; Zinin area; room-connection

Introduction
Low-income squatter housing sprawls along the periphery of Metropolitan Cairo. The outdoor urbanism lacks public amenities such as pavements and façade enhancement. Buildings are constructed without consent or supervision by the government, and without information on interior building, causing technical hazards. The households are mixed between rural migrants and Cairo residents seeking shelter. This study attempts to clarify the socio-economic dimension of squatter formation in Metropolitan Cairo on the micro-level of room spaces and households. The objective is to assist future management from the social point of view. In urbanism, the methodologies of spatial analysis are interdisciplinary. In particular, the concept of space syntax defines convex and axial spaces for syntactic calculations such as connectivity and global choice measures. The method, however, infers a single layout rather than statistical input of multiple cases at a time. On the other hand, multi-dimensional space analysis constructs the 'Voronoi Diagram' to associate all locations in a space with the closest member of a set point for space partitioning analyses. It overlaps with the space syntax method in the preliminaries of convex and axial network shaping, but privileged by statistical and spatial stochastic layout processes. Having both methods in perspective, this study adopts statistical approaches to the concept of space syntax on sample buildings of Metropolitan Cairo's squatters. After an urban overview, the samples of a total of 40-buildings are detailed in terms of room-connection, with their patterns identified in the conclusion.

1. Overview of Metropolitan Cairo
The Islamic urban fabric on the east-bank of the Nile River defines Cairo's historical and irregular street pattern. Adjacent to the Islamic town, and since the French expedition by Napoleon in 1798, new colonial quarters of European urbanism had been founded in the city until the Revolution for nationalization in 1952. The national development was characterized by a rapid urban sprawl, especially after the open economic policy of 1973. The open policy maintained a steady increase in population of about 15-million at present. The attribution of census data to the digital map of Metropolitan Cairo correlates information such as the population density and the GDP per capita with the spatial layout of the city (Figs.1 and 2). The major observation is the concentration of high population densities at the north and west edges of the metropolis. This is associated with the lowest level of income and a high rate of illiteracy. Meanwhile, the dense low-income areas possess up to 77% of buildings under construction in Metropolitan Cairo. The process of development transforms the preexisting agricultural basins at the edge of the city into urbanized areas. Urbanization, however, is taking place as a socio-economic pressure of booming squatters rather than institutionally planned development.

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causing chaos in management. Among the major social phenomena is the rural migration from the regions of Upper and Lower Egypt to Cairo in search of employment. The rural migrants form the poorest social stratum of Cairo, who tend to settle in the peripheral squatters of the city. In the governmental efforts to improve these settlements, new infrastructures such as water supply, drainage system and communication facilities lag behind the settlers. However, the absence of socio-economic policies results in the continuous process of squatter development.

In order to reveal the urban characteristics of dense squatters, two study areas named 'Bigam' and 'Zinin', respectively, are selected from the north and west edges of Metropolitan Cairo for closer overview. These were agricultural lands and joined to Cairo City after the 1952 revolution. The area of 'Bigam' gained potential for industrial land use development, while 'Zinin' was a favorable low-income housing area near central Cairo. However, after the extension in 1995 of the Cairo subway line to terminate in 'Bigam', the area attracted low-income residential settlers. The process of urbanization was common in shaping blocks on the pre-existing property lines of agricultural basins. In Egypt, the inheritance of agricultural land is subdivided among the heirs in a direction perpendicular to the canals (Fig.3). After generations, the oblong shaping of land properties results. The urbanization superimposes streets on the infill of canals with blocks following the property lines. The oblong blocks bound by curving streets in 'Bigam' and 'Zinin' is a typical rural-urban spatial transformation (Figs. 4 and 5). Streets between the rows of blocks are minimized by landlords to an average of 3m for maximum building investment. The blocks are subdivided into double rows of square-shaped plots, with the total build able area-forming buildings attached side-by-side and back-to-back. The buildings are common in being of a concrete frame structure, with brick partition walls. Heights vary from two to eight typical apartment floors with one or more flats per floor. Public open spaces are lacking in the study areas, where the major streets are used for open markets and social activities such as weddings/funeral and children's playgrounds (Photos 1-7).

The socio-economic structure in 'Bigam' and 'Zinin' is detailed by household survey in four zones of blocks (Figs.6,7,8 and 9). Questionnaire data included information on: 1) household profile, 2) employment, 3) migration, 4) income and expenditure, 5) assets and 6) attitude questions. Attribution of the household questionnaire data to the digitized building map viewed the socio-economic settlement patterns. In 'Bigam' as many as 32.5% of the households consist of rural migrants compared to 23.4% in the 'Zinin' area. Meanwhile, 69% of 'Bigam' migrants came from the region of Lower Egypt, while in 'Zinin' 68% migrated from Upper Egypt. These migrants are found to settle in clusters due to social networks. The rate of household size differs slightly between 'Bigam' and 'Zinin' with 26.3% having a majority of 5-members. The percentage of rental flats totals 61.3% in 'Bigam' and 67.8% in 'Zinin' to mix with the owner/occupier pattern. The illiteracy rate is 29.9%
Fig. 4. Bigam Study Area

Fig. 5. Zinin Study Area

Fig. 6. Zone-one Buildings

Fig. 7. Zone-two Buildings

Fig. 8. Zone-three Buildings

Fig. 9. Zone-four Buildings

Fig. 10. Building Samples: Zone-one (B1–12), Zone-two (B13–20), Zone-three (21–30), Zone-four (B31–40)
and 33%, respectively, in the 'Bigam' and 'Zinin' areas. Moreover, 86.4% of the total migrant households in the two areas consist of a labor force earning an average of 2US$ per day. This is the lowest level of poverty in the urban areas of Egypt as defined by the World Bank.

2. Spatial Structure of Building Rooms

Further to the household survey, the social aspect of squatters is determined based on the amount of residential space. In the same four zones of the household survey in 'Bigam' and 'Zinin', 40 buildings are selected from the various blocks according to the criterion of household rural migration. The objective is to investigate the problem of squatter development at the lowest socio-economic stratum. The measurements and sketches of the architectural survey covered a typical floor for each of the building samples since they have repetitive room subdivision in the vertical section. All of the surveyed flats compromised rooms among the following: 1) shared staircase [S], 2) reception [R], 3) living [L], 4) dining [D], 5) kitchen [K], 6) toilet [T], 7) bedroom-one [B1], 8) bedroom-two [BII], 9) bedroom-three [BIII], and 10) bedroom-four [BIV]. Through this room-set, the spatial structure of room-connection is defined (Fig.10).

2.1. Methodology

Statistical matrices of the room-set are constructed to determine the architectural language in terms of: 1) functional, 2) physical, and 3) spatial relationships. In conclusion, correlating these issues sieves the patterns of room-connection. The functional relationship constructs the axial circulation network to measure the distance between any two room-fronts of a flat. The same circulation network counts the strength of choice to pass through a room when connecting between the others. The measured distances are represented by ordinal scaling in serial numbers, one being the strongest (shortest) rank of functional relationship. However, the rank between any two rooms in a flat is not necessarily reciprocal to result in a complete matrix format. The same procedure is applied to all the survey flats for statistical matrix processing. The other two architectural relationships of physical and spatial connectivity occupy a half matrix for each. The implementation on a flat sample clarifies the methodology (Fig.11 and Tables 1 and 2). The sample is located in the first zone of the 'Bigam' study area (building no. 7) of one flat per floor. The flat consists of: 1) Staircase, 2) Reception, 3) Living, 4) Kitchen, 5) Toilet, 6) Bedroom-I, 7) Bedroom-II, and 8) Bedroom-III, out of the ten room-set. As a rule of thumb, the bedrooms are numbered in sequence in a clockwise direction from the left-hand-side of the flat's entrance door. The measurement of the 'Staircase', for example, opens to the front of the 'Reception', after that the circulation line measures sequential distances to the 'Living, Bedroom-I, Bedroom-II, Bedroom-III/Toilet, and kitchen' room-fronts. The distances are ranked by serial numbers in ascending order. Nevertheless, the 'Toilet and Bedroom-III' measured equal distances from the 'Staircase', and so are given the same rank 'S' of equal functional connectivity. Meanwhile, the circulation passes through the 'Reception' to reach all other rooms, in addition to the 'Living' room for the case of 'Bedroom-I'. Obviously, this indicates a strongest choice for the 'Reception' room. The rest of the rooms are measured using the same system until the functional room-matrix is completed, with the choice identified. On the other hand, the physical and spatial relationships, respectively, occupy the upper-right and lower-left triangular matrices of Table 2. In this table, any two rooms sharing a partition wall (or part of it) imply their physical attachment. Alternatively, the spatial relationship is coded as 'yes' relationship if a permanent view integrates two rooms. This is observed

Table 1. Functional Relationships

| Rm. | S | R | L | D | K | T | B1 | BII | BIII | BIV |
|-----|---|---|---|---|---|---|----|-----|------|-----|
| S   | 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1   | 1    | 1   |
| R   | 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1   | 1    | 1   |
| L   | 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1   | 1    | 1   |
| D   | 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1   | 1    | 1   |
| K   | 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1   | 1    | 1   |
| T   | 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1   | 1    | 1   |
| B1  | 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1   | 1    | 1   |
| BII | 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1   | 1    | 1   |
| BIII| 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1   | 1    | 1   |
| BIV | 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1   | 1    | 1   |

I ==>Yes 2 ==> No

Table 2. Physical/Spatial Relationships

| Rm. | S | R | L | D | K | T | B1 | BII | BIII | BIV |
|-----|---|---|---|---|---|---|----|-----|------|-----|
| S   | 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1   | 1    | 1   |
| R   | 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1   | 1    | 1   |
| L   | 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1   | 1    | 1   |
| D   | 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1   | 1    | 1   |
| K   | 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1   | 1    | 1   |
| T   | 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1   | 1    | 1   |
| B1  | 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1   | 1    | 1   |
| BII | 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1   | 1    | 1   |
| BIII| 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1   | 1    | 1   |
| BIV | 1 | 1 | 1 | 1 | 1 | 1 | 1  | 1   | 1    | 1   |

Fig.11. Typical Floor Plan of Building No.7
between the 'Reception' and 'Living' rooms through the permanent opening in their shared wall partition.

2.2. Results

Statistical dataset processing of the 40-building samples sorts the functional, physical and spatial matrices by study zone. The purpose is to display the statistical graphs of room correlations for the 40-samples together, as well as the four zones of 'Bigam' and 'Zinin' study areas separately. In this process, the statistical scatter-plot matrix of the room-set identifies the functional correlations between rooms. Meanwhile, the statistical box-plot matrix of the same room-set weighs the physical and spatial correlations per room. In these graphs, the point pattern of the scatter-plot matrix indicates the statistical relationship between room-pairs. The more the points accumulate on an imaginary line, the more the correlation of functional room-connection. On the other hand, the box-plot graph weights the frequencies of each room's observations to spread in correlation with other rooms.

Overview of the scatter-plot matrix perceives the room-set characteristics (Fig. 12). Densities of low to medium in 'Dining, Bedroom-IV, and Living' room existence contrast with higher ones for the remaining room-subset. The significance of functional correlation emphasizes the 'Reception' across the room-set. The straight lining in point pattern of the first-rank functional relationship distinguishes the coring role of the 'Reception' room as the most integrating space. In addition, 86% of the 40-layouts identify the 'Reception' space as a global choice to pass through for the shortest connections between rooms.

The diagonal point-pattern of the ellipse shape in the statistic scatter-plot indicates the functional correlation of rank inversely related to the ellipse's width. This elliptical point-pattern is observed for the 'Staircase' to correlate with other rooms. In particular, it connects with the 'Living, Bedroom-I & Bedroom-II' in higher ranks than the rest of the rooms. Duet of room connection is apparent in 'Kitchen-Toilet, 'Bedrooms I & II,' 'Living-Bedroom-I,' and 'Bedrooms II & III' of closer functional ranks. It indicates a chaining connection of bedrooms with living space, and utility rooms tying for technical matters. A less functional correlation is found in 'kitchen-Bedroom-III' to assess their tolerance. The dispersed point pattern results in segregated room-connection of uncorrelated functions. This is seen in 'Living-Bedroom-III' of either repulsing connectivity or, alternatively, one room replacing the other. The latter interpretation is enforced by the lessened density of their point-pattern. However, the uncorrelated case between 'Bedrooms I & III' has only one interpretation of distant functional depth, but they cannot replace each other due to 'Bedroom-III' being in sequence. The few entries in the scatter-plot of 'Bedroom-IV' and 'Dining' rooms are viewed as special cases without statistic generalization. An overview of the room-set's functional characteristics approaches the grouping of rooms (Fig.13.).

The 'Reception & Staircase' correlate with all rooms to be considered as statistical outliers. Also the 'Dining' and 'Bedroom-IV' are outliers as per existence. The remaining rooms correlate the 'Living, Bedrooms I, II & III' in a closer functional depth to form group-one rooms. On the other hand, group-two includes the 'Toilet, Kitchen & Bedroom-III' correlations. The coring role of the 'Reception' integrates the two groups of the room-set. The 'Staircase' forms an average functional depth to both room-groups, with preference towards group-one. Meanwhile, 'Bedroom-III' overlaps in the two room-groups to suggest its transitioning role from one group to the other. Consequently, the bedrooms can be seen as grouped together, and also distributed between the two room-groups.

The comparison of room functions in the four zones of the 'Bigam' and 'Zinin' study areas divides the scatter-plot matrix by zone. In 'Bigam', zone-one includes the total room-rest. The sole 'Dining' room exists in this zone, with only one case of 'Bedroom-IV & Living' rooms. Three bedrooms are dense in this zone. The room-set of zone-two does not include 'Bedroom-IV', but adds more 'Living' spaces with two bedrooms. Meanwhile, zone-three of the 'Zinin' study area has a single 'Living' room, without 'Bedroom-IV' in the room-set. Zone-four has more 'Living' rooms, and one 'Bedroom-IV' case. Both zones of the 'Zinin' area have a decreased 'Bedroom-III' density. The comparison of room-sets in the four zones intersects in 'Staircase, Reception, Kitchen, Toilet, Bedrooms I, II & III' spaces. The statistical correlations of room functions in zone-one forms two groups of 'Staircase, Bedrooms I & II' apart from 'Toilet, Kitchen & Bedroom-III', and are cored by the 'Reception' space. This functional pattern, however, changes in zone-two into a 'Living' space of exclusive functional connection to bedrooms. The high degree of controlled access from 'Reception' to 'Living' and then to 'Bedroom' defines this function as of several spaces structured inside each other in a sub-spacing manner. It affords the opportunity of 'Living' spaces to function for multi-purposes such as living/bedroom or living/ reception space. The bedroom connection, nevertheless, correlates with the 'Staircase' as an alternative to the controlled access through the 'Living' room space. In 'Zinin', zone-three has room functions uni-correlated between each other. In other words, for any room the point-pattern in the scatter-plot tends to correlate with another single room, then starts to disperse the point-pattern randomly from one room to the other. This statistic reveals a linear pattern of functional connectivity between rooms. However, the dispersion of point-pattern is not gradual, which suggests a maze-like connection of rooms. Zone-four has a similar linear functional pattern, but of a smoother gradation in functional correlations, thus a more organized linearity. Here the 'Living' rooms are few due to limited areas.

Statistical box-plots of physical and spatial relationships approach the pattern of exposure between rooms (Figs.14 and 15). In the physical box-plot, the 'Reception' attaches to all rooms, except 'Kitchen & Toilet' together that attach to
Fig. 12. Functional Scatter-plot Matrix of Building Rooms

Fig. 13. Functional Grouping of Rooms

Fig. 14. Physical Box-plot Matrix by Building Room

Fig. 15. Spatial Box-plot Matrix by Building Room

S: Staircase  
R: Reception  
L: Living  
D: Dining  
K: Kitchen  
T: Toilet  
BI: Bedroom-I  
BII: Bedroom-II  
BIII: Bedroom-III  
BIV: Bedroom-IV
'Staircase & Bedroom II or III'. Also 'Bedroom-I' attaches to 'Staircase, Living & Bedroom-II' on equal bases. The scenario of room-attachment may position the 'Staircase' between the two sides of 'Toilet-Kitchen & Bedroom-I', and back-to-back with the 'Reception', in addition to 'Living & Bedrooms II & III' attached to either sides. This physical pattern dominates zone-one of the 'Bigam' study area of the four-cornered wall subdivision. A template of 'Bedrooms I, II & III' occupies three-corners, and the 'Toilet' space is partitioned inside the 'Kitchen' in the fourth-corner. The addition of 'Living' rooms in zone-two changes the cornering subdivision into a permeable space in connection with the 'Reception' to form an open plan. In 'Zinin', the smaller size of flats squeezes the cornered room-connection of 'Bigam' into a cellular pattern of irregular room attachment. Zone-three maintains the 'Reception' as a coring space of direct attachment to the other rooms. Zone-four, however, lessens the controlling role of the 'Reception' due to the merge between attached rooms to overcome the compact situation of flats. The room attachment in the squatters of 'Bigam' and 'Zinin' depends on open-air shafts for window openings. The shafts, however, are so narrow (of 0.8m average width) to cause problems of natural light and ventilation. Besides, rooms without window openings represent 32-cases of the majority 'Reception & Bedroom-III' in the four zones.

Spatial relationships identify the visible connections of rooms. The 'Reception' core concentrates the spatial connection with the 'Kitchen & Living' spaces. The 'Living' room, however, has a wide variety of visual connections that includes bedrooms as seen in the statistical box-plot. It supposes a transitional 'Living' space from the shared 'Reception' space to the private bedroom space. The comparison by zone shows only 'Kitchen-Reception' spatial connection in zone-one, with one special case of 'Dining-Reception' visual connection. Zone-two, however, expands the visibility by including the 'Living' space to connect with the 'Reception' space. In zone-three direct openings gain potential between bedrooms, especially between 'Bedrooms I & II' spaces. This is also found in zone-four, which clarifies a unique pattern in the 'Zinin'study area of spatial connections for bedrooms. It is interesting that the 'Zinin' of a majority of Upper Egypt regional migrants keep their social habit of preparing beds in the open-air to overcome the hot-dry climate of their region. The same habit is reflected in spatially open bedrooms when building their houses in Metropolitan Cairo. Meanwhile, the 'Bigam' study area of migrants coming from Lower Egypt is free from this phenomenon.

3. Conclusion
The spatial correlation using statistics of room-connections for building samples in the 'Bigam' and 'Zinin' squat areas in Metropolitan Cairo concludes the following:
1. On the collective statistical level of room-set in 'Bigam' and 'Zinin' buildings together, the functional room-connection cores a 'Reception' space to structure the
room-set into two-groups of lodging and utility rooms. However, both room-groups overlap in 'Bedroom-III' to chain the bedrooms with each other. Meanwhile, the physical connectivity positions the 'Reception' space in the center of the layout in direct contact with the surrounding rooms. The 'Staircase' is fixed in three-sided physical correlation with the 'Reception, Bedroom-I and Kitchen/Toilet' attachment. Furthermore, the visibility between rooms is limited to room-pairs, especially the 'Reception-Kitchen' case, in addition to some visual connection extending towards bedrooms. Nevertheless, a catalyst of 'Living' space is added to diversify the spatial connections with a permeable integration of space (Fig.16).

2. In 'Bigam', two zones of building samples differ in the spatial connection of rooms. In one zone, a template of four-cornered rooms connected through the 'Reception' space. Three-cornered bedrooms are dense in this zone, while the 'Kitchen & Toilet' utilities occupy one corner. Cross walls characterize the physical subdivision into corners, with exclusive 'Kitchen-Reception' spatial visibility. The other zone changes into a more dynamic control and choice of room-connection through the dense inclusion of 'Living' space. It replaces one bedroom corner to multifunction while expanding the gathering 'Reception' space as well as the possibility of individual bedrooms. The permanent spatial integration of 'Reception & Living' spaces converts the cross-wall physical pattern into open-plan potentiality. Nevertheless, the same 'Living' space changes position on either side of the 'Reception' to result in an alternate transpose of room-groups (Figs.17 and 18).

3. In 'Zinin', the two building zones are common in connecting rooms in a linear pattern. One zone forms a maze-like functional connectivity on broken axial lines. However, the 'Reception' cores a cellular physical connection of rooms in a decreased flow through the space. In the other zone, the dispersion of point-pattern in the statistic scatter-plot is gradual from one room to the other, to conclude a more rational linear pattern of rooms. The role of 'Reception' becomes marginalized due to the loss of control over rooms in line. Meanwhile, the lack of 'Living' spaces in 'Zinin' buildings dissolves the distinction between the family shared spaces and individual bedrooms. Alternatively, the bedrooms visualize with each other to suppose a social difference of Egyptian Lower and Upper regional migrants in 'Bigam' & 'Zinin' respectively (Figs.19 and 20).

Notes

1. Hillier, B. and Hanson, J. (1984) The Social Logic of Space, Cambridge University Press, UK.
2. Okabe, A. et al. (2000) Spatial Tessellations: Concepts and Applications of Voronoi Diagrams, New Edition, John Wiley & Sons Ltd.
3. This study is part of the research outcome of the joint project titled: "Spatial Mobility and Income Distribution in Egypt and China," between the Graduate School of Economics, Hitotsubashi University, and the Egyptian Statistical Department (CAPMAS).
4. The downtown area of Cairo is studied in: El-Shazly, A. (2003) A Study on the Cognitive Structure of the Historical European Quarter in Cairo, International Congress 'Enter the Past: The E-Way into the Four Dimensions of Cultural Heritage,' Vienna City Hall, pp.321-324.
5. Central Agency for Public Mobilization and Statistics of Egypt (2004) The Statistical Year Book on Population Census, Cairo, p. 6.
6. More details on Cairo's illiteracy and buildings under construction in: Kato H., Iwasaki E. and El-Shazly, A. (2004) Regional Labor Markets in Egypt After 1980's, Proceedings of the 20th Annual Conference of the Japan Association for Middle East Studies, Meiji University, Tokyo.
7. The socio-economic structure of the Cairo metropolis is studied in: Kato H., Iwasaki E. and El-Shazly A. (2004) Internal Migration Patterns to Greater Cairo - Linking Three Kinds of Data: Census, Household Survey, and GIS, Journal of the Mediterranean World, Hitotsubashi University, Tokyo, Vol. 17, pp.173-252.
8. The process of construction begins with the landowner who hires construction laborers on a private basis to erect the building without institutional licensing. The laborers (depending on their personal experience) execute the foundations and structural frame in reinforced concrete without knowledge of load calculations or proper techniques. The Cairo earthquake in 1992 caused serious damage to the squatter buildings including the 'Bigam' and 'Zinin' areas. Besides, not to standard building causes problems such as the improper water system.
9. The urban formation of 'Bigam' and 'Zinin' areas is studied in: Kato H., Iwasaki E., El-Shazly A., and Goto Y. (2003) Attempt of Linking Two Approaches: Household Survey and GIS – Migration to Greater Cairo, Proceedings of the 12th Annual Conference of the Geographic Information Systems Association of Japan, Center for Urban Studies, Tokyo Metropolitan University, pp. 111-114.
10. The socio-economic structure of 'Bigam' and 'Zinin' areas is studied in: Kato H., Iwasaki E., El-Shazly A. and Goto Y. (2005) Regional Diversity and Residential Development on the Edge of Greater Cairo – Linking Three Kinds of Data – Census, Household Survey and Geographical Data – With GIS, in the book: GIS-based Studies in the Humanities and Social Sciences, Francis & Taylor, UK, pp.191-209.
11. Families of 7 members or more per flat account for 12.2% in the study areas.
12. World Bank–Egypt office (2003) Poverty Reduction in Egypt, Vol. 1, p.12.
13. The author conducted the surveys in summer 2004.
14. The statistical processes apply STATA programming.
15. The current phase of the project in collaboration between Hitotsubashi University and CAPMAS covers 20 complete villages sending the most migrants from Upper and Lower Egypt to the 'Bigam' and 'Zinin' areas in Cairo. The life style and socio-economic characteristics of the migrants' place of origin, in addition to the residential space can be investigated in a separate study.

Figures

Fig.1: Prepared by the author, based on: The Central Agency for Public Mobilization and Statistics of Egypt 'CAPMAS' (2004) The Statistical Year Book on Population Census, Cairo, p. 47. (baseemap of Cairo's administrative divisions was obtained from the GIS Center of CAPMAS).
Fig.2: Prepared by the author, based on: United Nations (2003) Egypt Human Development Report, Cairo, pp.38-42.
Fig.3: Archives of Map Record, The Department of Survey, Cairo, Sheet 813/631.5, Scale 1:2500. (A copy obtained by the author in 2004)
Figs.4 and 3: Basemap of blocks obtained in 2004 from CAPMAS, Cairo.
Figs.6-9: Surveys of block subdivision by the author in 2004.
Figs.10 and 11: Surveys of building interiors by the author in 2004.
Figs.12, 14 and 15: Statistical matrices by the author.
Figs.13, 16-20: Analytical drawings by the author.
Tables 1 and 2: Samples of analytical matrices by the author.
Photos: All photos are taken by the author (summer 2004).