كلية الهندسة بشبرا
FACULTY OF ENGINEERING AT SHOUBRA
ERJ
PRINT ISSN 3009-6049
ONLINE ISSN 3009-6022

ENGINEERING RESEARCH JOURNAL (ERJ)
Volume (52),Issue (4)
October 2023, pp:131-138
https://erjsh.journals.ekb.eg

COMPACT DESIGN CONCEPT AS AN ALTERNATIVE FOR ADAPTING SCHOOL BUILDINGS TO SMALL PLOTS IN SLUMS AND UNPLANNED URBAN AREAS

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Abstract: Education is a fundamental right of every human being and should be available to all children, regardless of their socioeconomic background or geographical location. The provision of school buildings in slums or unplanned urban areas presents many challenges. These include overpopulation and smaller plots of land remaining for services. However, it is necessary to understand the needs of marginalized groups, and to provide them with a minimum level of community services, especially educational services which are the most important element of community development. The study highlights the difficulties facing the provision of school buildings in these areas, especially with the small size and scarcity of land, it explores the features of compact design as a flexible and effective tool in adapting school buildings to small plots of land and enables the architectural designer to provide spaces such as schoolyards and playgrounds. The study presents a design model for a compact educational building, then actual site models are developed from the study area, and the results of the hypothetical application are analyzed to determine the effectiveness of the results and to find the appropriate recommendations. This contributes to finding suitable alternatives to provide educational buildings in those areas in a manner appropriate to the current conditions while developing flexible requirements in determining the suitability of the site for building schools, to make the most of small plots of land in the future.

Keywords: Slums, School building, Small plots, Compact design, Schoolyard.

1. Introduction

Providing a suitable living environment, including housing, job opportunities, and services (health, education, etc.), is one of the most important requirements for building sustainable human settlements. It is a way of life for social mobility in an integrated urban environment. Thus, the search for a better and safer life was the main motive for many groups of Egyptian people to migrate from rural areas to the cities. Growth was concentrated in the central cities, especially Cairo, as it is the administrative and economic capital, and industrial activities are concentrated there. This led to increased rates of rural migration, and consequently, slums were created in Greater Cairo over the agricultural areas around the Nile Basin. [1]

The Ministry of Local Development estimated in 2007 that there are 1,171 slums with a population of 15 million, 40% of whom live in Greater Cairo. This verifies that it is not an exceptional phenomenon or a subsidiary issue in Egypt [2]. The annual report of the United Nations Population Fund for the year 2008 indicates that more than 15.5 million Egyptian citizens live in slums. [2]. As for the latest statistic, it was found that in Greater Cairo, which has a population of more than 20 million people (about 20% of the country's population) [3], 65% of its population live in informal settlements. [3], Even though the area of slums is only 20.9% of Cairo's area. [4]

Cairo, the sprawling capital of Egypt, is facing a major challenge with the spread of slums one of the most important consequences of the spread of slums is the impact on the provision of adequate school infrastructure. The availability of suitable school buildings is very limited. There is a lack of space to build schools or expand existing schools. Classrooms are often overcrowded, which makes it difficult to get quality education.

The study introduces the concept of compact design, as a flexible and effective tool for adapting school buildings to small plots. Then conducts a comparative analytical study, by applying a proposed visualization of a combined model and clarifying the comparison between its applications to models from the study area, which were chosen according to the determinants that reflect the problem of small plots in slums. To clarify the flaws of the design pattern used, to make the most of small plots of land, then analyze the results to determine the effectiveness of the application. Accordingly, the site suitability requirements for building schools can be developed and appropriate recommendations can be made. This contributes to finding suitable alternatives for providing educational buildings in those areas, commensurate with the current situation, and enables the architectural designer to provide school yards.

1.1 Research Goal

The research aims to explore the problem of small plots of land available in slums and unplanned areas, to highlight the negative effects of this phenomenon on the erosion of open spaces in schools such as schoolyards and playgrounds, and propose flexible solutions and modifications to the building requirements of possible schools to improve the chances of establishing schools that fit local standards despite their small size.

1.2 Research Methodology

In this context, the right of children to receive a quality education in an appropriate environment must be taken into account as described in the text of the United Nations Educational, Scientific and Cultural Organization (UNESCO) on the right to education as follows: " We re-affirm the vision of the World Declaration on Education for All [5], supported by the Universal Declaration of Human Rights and the Convention on the Rights of the Child, that all children, young people, and adults have the human right to benefit from an education, that will meet their basic learning needs in the best and fullest sense of the term, an education that includes learning to know, to do, to live together and to be. It is an education geared to tapping each individual's talents and potential, and developing learners' personalities so that they can improve their lives and transform their societies". [6]

First. Reviewing the problem of slums and its impact on the possibility of providing suitable school buildings, and identifying the requirements of the GEAB regarding the validity of land plots and the percentage of construction on the site.

Second. Choosing and documenting models that reflect the problem of small sites available in random and unplanned areas, and analyzing problems that reflect the negative aspects of site design.

Third. Proposing a model as an illustrative example of the possibility of using the compact design concept as an appropriate alternative to providing suitable school buildings to small plots of land.

Fourth. The application of the proposed model to the schools of the selected sample as a method for post-evaluation with a comparative analysis, and drawing conclusions and recommendations, in a manner that demonstrates the efficiency of applying the concept of compact design.

2. REVIEWING THE CONCEPT OF ILLEGAL AREAS AND VALIDITY OF SCHOOL SITES

2.1 Slums and Unplanned Areas

Slums, informal settlements, and unplanned areas are common in many regions of the world, often arising from rapid urbanization, poverty, and inadequate housing policies. Characterized by a lack of basic infrastructure, limited access to services, and insecure living conditions, these settlements pose significant challenges for both residents and the wider community. In the following, we will review the concepts related to slums and unplanned areas and the requirements for the validity of sites:

2.1.1 Informal Settlements Definition

The word "slums" is the term used in Egypt to express informal settlements, which can be defined in a simplified way: "It is all that was created by self-effort, whether one or more buildings, especially in degraded areas. As a result of the weakness of the role of supervisory agencies and urban planning, they are built on land not intended for construction as outlined in the cities' master plans. The state of the buildings may be good, but can be environmentally or socially unsafe and lack basic services and facilities". [2]

2.1.2 Unplanned areas Definition

They are the areas that were not established according to detailed plans and land division plans. And are not subject to planning and construction requirements, often consist of structurally acceptable buildings built on agricultural lands of private ownership, and are provided with utilities upon completion of the construction. [7]

2.1.3 Informal settlements classification

The classification of informal settlements varies according to some elements, such as origin, age, location, size and boundaries, source of threat, construction, and urban mass. [8] But in the research, we rely on dividing them according to Law No. 119 of 2008 which states that [9]:

Unplanned areas haven't been developed according to detailed plans or subdivision plans and aren't subject to planning and construction requirements. They are mostly buildings that are structurally acceptable and built on privately owned agricultural land and were provided with facilities later on. Areas, whose uses are unsuitable for their distinct location include degraded areas, and parts of cemeteries, which are used for housing, some of which are unsafe areas. Also, they are classified according to the nature of the lands established by the urban pattern as follows: [10].

- The areas that were deserts, built according to topography, and characterized by irregular fabric. Fig 1
- Areas established on agricultural lands, and are clearly shown in the regular division of urban fabric, which takes the form of agricultural holdings. Fig 2

The research is concerned with informal and semi-regular planned and safe areas. They include communities built on state land or encroachments on agricultural land. This is the nearest model to a community system suitable at the urban, social, and economic levels. It is the foundation that can be developed by the least possible means, and we can reach the urban output governed by the requirements of formal construction and customary rules that are respected by all. [11]

Fig. 1 Irregular urban fabric. 2/5/2023 [9].

Fig 2. Regular urban fabric. 2/5/2023 [9]

2.2 A review of site suitability requirements for building schools

When considering the suitability of a site for building schools, many factors must be taken into account. It can vary depending on local regulations, educational standards, and specific project requirements. In the following table are some of the considerations according to the requirements of the GEAB in Egypt for the suitability of the site for building schools. Table 1.

3. DETERMINING THE SCOPE OF THE STUDY

The Greater Cairo area is one of the most densely populated areas in Egypt. This includes three governorates (Cairo, Giza, and Qalyubia). It is also characterized by the rapid growth of slums, which represent 38.6% of Egyptian slums. [4] And the diversity of the urban fabric accumulated over decades, which made it a model worthy of study.

By reviewing the general census data of Cairo city over the past three decades, Fig.3, the impact of rapid growth is evident in two main regions, north-east and south of Cairo, Fig. 4. As they are distinguished by a unique location located on the most important traffic axes in Cairo. They are near the metro that connects the south of Cairo with its north. They are located near the downtown, which includes all ministries, administrative and commercial services, and transport stations of all kinds for all governorates. Its unplanned areas have grown to keep up with this population increase.

Therefore, three models were chosen that represent a sample of schools in those areas, which are characterized by small plots of land available for building schools as a result of random urban expansion or based on previous studies, as follows:

- Al-Marg (Mahmoud Shukry Primary School), northeast of Cairo. Table. 4
- Al-Mataria (Ahmed Orabi Preparatory School), northeast of Cairo. Table. 5
- Dar Al-Salam (Ahmed Orabi Preparatory School), south of Cairo. Table. 6

The selected areas mostly represent a semi-regular fabric of unplanned urban encroachment on agricultural lands, and their buildings are generally suitable structurally, but the streets are narrow and the available plots of land are small. However, they are safe areas that can be developed in the long term and are therefore a good model for study and analysis, from which alternatives can be put forward for how to adapt to the conditions of the sites available for the construction of schools. This may reduce the possibility of wasting areas of sites, in the inter-spans between multiple buildings or between the school building and the street and fences.

TABLE 1: site suitability requirements for building schools. [12]

Site validity requirements elements	Basic school	Secondary school	Basic & Secondary school
Min. Total site area	1200.0 m^2	1250.0 m^2	1500.0 m^2
Min. site area/student	4 m^2	6 m^2	5 m^2
Min. length of the least side of the site	25 m	25 m	25 m
Min. Yards, playgrounds, and open areas / student	2.5 m^2	3.0 m^2	2.75 m^2
Min. Yards, playgrounds, and open areas / student - for existing cities	2.0 m^2	2.5 m^2	2.25 m^2
Max. student intensity / class	40	36	
The school overlooks at least one street with	6.0 m	6.0 m	6.0 m
Max. aspect ratio of the school site (L/W) school overlooks one street	1:3	1:3	1:3
Max. aspect ratio of the school site (L/W) school overlooks two streets	1:4	1:4	1:4
The shaded area as a proportion of the actual Yard	20%	20%	20%
Min. distance between building and fence to be considered a courtyard	7.0 m	7.0 m	7.0 m
Min. distance to be left from the boundaries of the school site	3.0 m	3.0 m	3.0 m
Min number of entries to the school site	2	2	2
Min. number of Playgrounds (double Playground)	1	1	2
Max. number of floors allowed	5	5	5

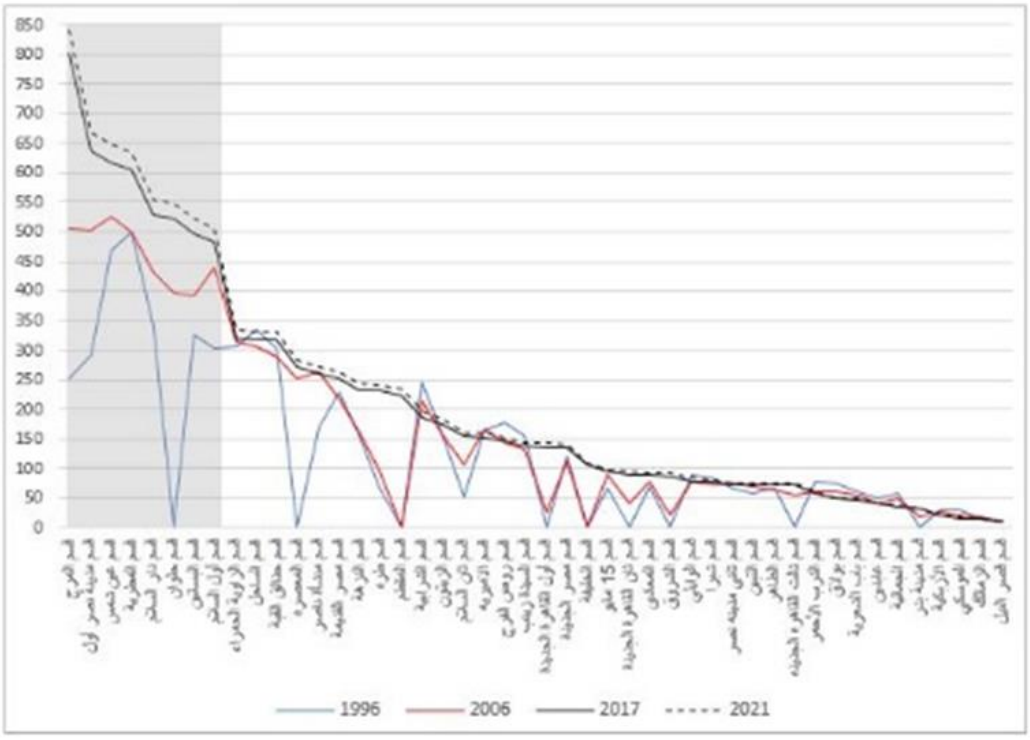


Fig 3. Rate of population growth in Cairo. [4] , [17]

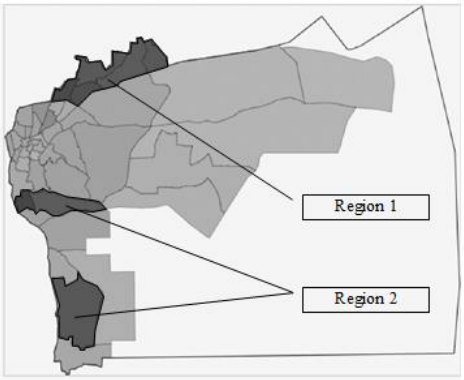


Fig 4. Regions of population growth in Cairo. [17]

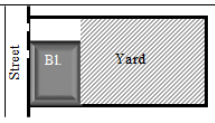
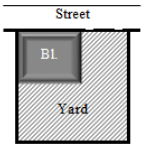
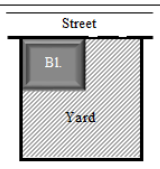
4. COMPARISON BETWEEN THE PROPOSED MODEL AND AN EXISTING MODEL

It is better to illustrate the concept of compact design through comparison between the proposed model and an existing model while reducing the proportions of the classrooms to be closer to a square ratio to allow it to be accommodated in minimum width (25 m to the smallest sides) small plots of 1200.0 m2 area as a minimum for basic education schools and 1500.0 m2 area as a minimum to Secondary schools. So that the length of the building does not exceed around 20 m, to leave a suitable distance beside building for students to pass from the street to the schoolyard.

To achieve the possibility of accommodating all the educational and service spaces in one building, it is possible to take advantage of the maximum height allowed for the building, which is within the requirements of the General Authority for Educational Buildings to be five floors.

The study suggests the possibility of benefiting from the distance between the building and the street and between it and the neighbor by designing the side adjacent to the neighbor without openings and designing the spaces on the ground floor directly overlooking the street for services (a shaded area, a multi-purpose hall, etc.) , and in the typical floors Laboratory spaces and activity rooms are placed on one side in direction of the street , and classrooms in direction of the courtyard on the other side. This is to allow for reduction of the wasted areas between the buildings and between them and fences.

TABLE 2: site suitability requirements for building schools. [13]

Stage	Basic school stage	General secondary school stage
Area	Plot area 1200 m^2	Plot area 1500 m^2
Ratio 1:2		
Dim.	25.0 m * 48.0 m	25.0 m * 60.0 m
Ratio 1:1		
Dim.	34.6 m * 34.6 m	37.7 m * 37.7 m

According to the requirements of the General Authority for Educational Buildings, the ratio of length to width should not exceed 1:3. By applying the minimum plots of

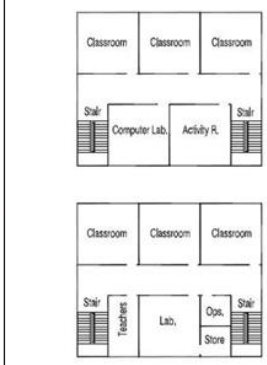
land, it becomes clear that the available alternatives are as follows: Table. 2

Therefore, a model of the compressed design method can be put forward and compared with an actual compressed model used by the GEAB, where its advantages and the elements that increase the use of these features can be identified.

A comparison between the two models with the same width of the façade and difference in the depth of the building. The most important characteristics of the two models can be reviewed in the following: As mentioned in Table. 3

- The proposed model: The square ratio of the classrooms (6.5 m * 6.5 m) was chosen, which made it possible to provide 5 study spaces on the typical floors with an increase in the depth of the building. Table. 3
- The GEAB model: only 4 study spaces were provided as a result of the rectangular shape (5.0 m * 7.5 m). Fig. 4
- The proposed model: the location of the classrooms is unified on one side with a floor plan that allows them to be directed in the appropriate direction (in terms of lighting, good ventilation, and avoiding periods of exposure to direct sunlight), and the placement of other elements (science laboratories, computer laboratories, fields, etc.). Opening windows in the opposite direction is undesirable. Because classrooms should have good lighting and ventilation without precautions to reduce effect of sunlight on the facades of the building, which may affect the quality of the physical comfort factors. Fig. 3
- Model of the GEAB: Classrooms are distributed on both sides of the floor plan, leading to appropriate lighting and ventilation on the one hand, with the need to treat the facades of the classrooms on the other, therefore some classrooms are well ventilated, and others are in an uncomfortable area. Fig.4
- The proposed model: Limiting the direction of the building's openings in two directions, front and back, allows for the possibility of attached construction on the sides of the building, and thus it is possible to benefit from the following: Fig. 3
  - Not leaving voids between the school buildings and neighboring buildings or having walls around the perimeter of the plot of land, which reduces about 4% of the land area.
  - Orientation on the street directly without a space between the building and the fence on one hand and the building and the school yard on the other. Area is reduced by a large percentage that may reach about 7% of the land area.
- Educational Building Authority Model: On the ground floor there are openings in the side walls of the building. Fig. 4
- The proposed model: 5 study spaces were provided on four floors with a total of about 20 spaces that allow containing most of the classrooms and service spaces in one building, which saves a lot of wasted spaces between different buildings. Fig. 3
- The GEAB model: 4 study spaces were provided on four floors, with a total of about 16 spaces, which are not sufficient to contain most of the classrooms and service spaces in one building. The designer may have to provide another building to cover all educational needs. Fig. 4

TABLE 3: Site suitability requirements for building schools. [12], [13]

	Design model suggested by the author Fig. 5	Model 15 classroom of basic education stage - General Authority for Educational Buildings Fig. 6.
Floor plans		
Model dimension=20.0 *16.0 m		Model dimension = 19*14.5 m
Model area = 320.0 m^2		Model area = 275.5 m^2

5. APPLYING THE PROPOSED MODEL TO THE STUDY SAMPLES

Schools acts a vital role in the all-round development of students, focusing not only on academic growth but also on their general well-being. It is necessary to emphasize the role of school yards, playgrounds, and open spaces within educational institutions. These areas provide invaluable opportunities for students to engage in physical activity, and social connection, and enhance their cognitive abilities. Regular physical activity is essential to maintaining good health. Furthermore, these outdoor areas allow students to release pent-up energy, and reduce stress.

It is necessary to assess the effectiveness of existing school buildings and identify areas for improvement. By understanding user experience and taking advantage of it in post-occupancy evaluation (POE).

The study is approached in terms of highlighting the ratio of open areas to the school plot area, allowing future designs to address current problems.

From the documentation of models of schools with small plots of land, especially in slums, it is clear how unfair the buildings are on the open area, which makes it difficult to take advantage of it for playing games, movement activity, gathering areas for the students during break times or to do any organized sporting activity.

Therefore, the study deals with possible alternatives for maximizing the use of the remaining space as open spaces after the construction of the school building, through the post-occupancy evaluation of the study sample schools and deducing the factors that led to dwarfing the percentage of open spaces and fragmenting it, which is evident in the following:

- The multiplicity of buildings on the school site, which is already small, creates very small inter-spaces that cannot be exploited and wastes a lot of the remaining space, which was supposed to be playgrounds and schoolyards. Table. 6, Fig. 17
- Breaking down of open spaces in the distances between buildings and each other and between walls with a width of less than 7 meters. Thus, the remaining spaces are small and irregular, so it is difficult to use them as schoolyards. Fig. 9
- The use of the rectangular ratio in the design of the classrooms led to an increase in the elongation of the building and the wasting of a large area of the school site. Whereas, if the square proportion is used in the design of the classrooms, this will eventually contribute to the formation of a compact design that reduces the total area occupied on the facade of the building. And reduce the length of the building to fit the minimum width of the plot of land of 25 m. Fig. 15
- Loading the spaces on single loaded corridor in the design of the building increases the percentage of the building's elongation and wastes more of the space of the corridors, although it would be appropriate in the field of ventilation and lighting, it is possible to study the flow of lighting and ventilation in acceptable proportions in the case of loading the voids in a double manner on the corridors. Fig. 5
- Leaving a distance of at least three meters around the entire perimeter of the building between the building, the fences, and the neighbor. This represents a waste of area and contributes to reducing what is left of the school yard and playgrounds. Fig. 9
- These factors combined led to the failure to utilize the small sites optimally, which is evident from the comparison of the actual open spaces in the proposed model on the one hand and in the GEAB model on the other hand:
  - It is necessary to use only one school building to reduce wasted areas between buildings and some of them in the layout and to avoid fragmentation of the rest of the open spaces. (Ahmed 2018), which may range from 20 to 30% of the land area.
  - In this context, after reviewing the characteristics of the sample schools, it becomes clear that there are no suitable open spaces available for practicing sports or entertainment activities, and open spaces for students may reach less than 1.0 m2 (Mahmoud Shukry School - Al Marj educational administration, Fig. 13. Ahmed Orabi - educational administration Dar al-Salam), Fig. 9 and sometimes there is no courtyard in the School location, but rather inter-spaces between scattered buildings (as in Ahmed Orabi School in Al-Mataria educational administration. Fig. 17

TABLE 4: Site suitability requirements for building schools [12], [13], [14]

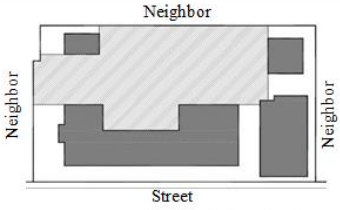
Ahmed Oraby School Dar-El-salam governorate	 **FIG** 7. Dar-ElSalam Edu. Adm. 7-2022 [14]	 **FIG** 8. Ahmed Oraby School 7-2022 [14]
School open areas comparison	 **FIG** 9. Actual school site [13]	 **FIG** 10. Proposed school site [13]
	Open area 848.0 m^2 (53.6% from Site)	Open area 1583.5 m^2 (79.0% from Site)
	Wasted area 495.0 m^2 (31.3% from Site)	Wasted area 0.0 m^2 (0.0% from Site)
	Footprint area = 628.8 m^2	Footprint area = 462.8

TABLE 5: Site suitability requirements for building schools [12], [13], [14]

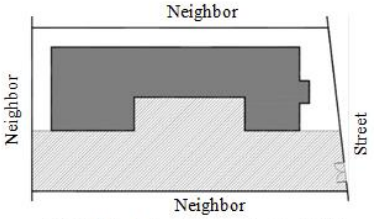
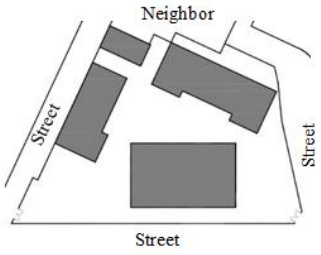
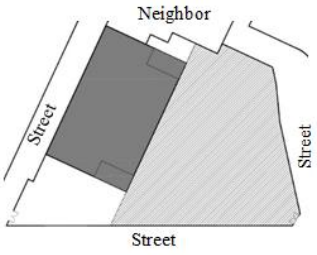
Mahmoud Shokry School El-Marg governorate	 **FIG** 11. El-Marg Edu. Adm. 7-2022 [14]	 **FIG** 12. Mahmoud Shokry School - 7-2022 [14]
School open areas comparison	 **FIG** 13. Actual school site. [13]	 **FIG** 14. Proposed school site [13]
	Open area 544.0 m^2 45.2% from Site	Open area 755.0 m^2 62.7% from Site
	Wasted area 245.0 m^2 20.3% from Site	Wasted area 133.6.0 m^2 11.1% from Site
	Footprint area = 416.6 m^2	Footprint area = 462.8

TABLE 6: Site suitability requirements for building schools. [12], [13], [14]

Ahmed Oraby School El-Mataria governorate	 **FIG** 15. El-Mataria Edu. Adm. 7-2022 [14]	 **FIG** 16. Ahmed Oraby School location. 7-2022 [14]
School open areas comparison	 **FIG** 17. Actual school site. [13]	 **FIG** 18. Proposed school site. [13]
	Open area 0.0m2 (0.0% from Site)	Open area 777.5m2 (55.2% from Site)
	Wasted area 985.1.0m2 (70.0% from Site)	Wasted area 207.9.0m2 (14.8% from Site)
	Footprint area = 561.1 m^2	Footprint area = 462.8

In case of all educational spaces being accommodated in one building, even if it is at the expense of increasing the width of the building, and also not leaving a distance between the school building and the neighbor or between it and the street, this will lead to maximizing the use of open spaces, as shown in the following:

- In Ahmed Orabi School - Dar Al Salam Administration, the area of open areas as schoolyards increased from 53.6% to 70.0% as shown in Table. 4
- In Mahmoud Shukry School - Al-Marj administration, the area of open areas as schoolyards increased from 45.2% to 62.7% as shown in Table. 5

- In Ahmed Orabi School - El Matareya Administration, the area of open areas as schoolyards increased from 0.0% to 55.2% as shown in Table. 6

Not only has the area of the schoolyard been increased, but the length-to-width dimensions have been adjusted regularly or semi-regularly, allowing for better practice of sports activities in schoolyards.

6. Conclusions

It is clear from the study that the method of selecting building models does not suit small sites, although the Educational Building Authority has models that follow the concept of compact design, and they may be suitable for such sites, but in the study sample, the characteristics of these models were not exploited. Therefore, the study recommends that the GEAB should study the possible alternatives for each case separately.

Schoolyards and playgrounds should not be neglected, even if the available plots of land are relatively small, as they are essential spaces. These outdoor areas allow students to release pent-up energy and reduce stress.

Emphasizing the importance of post-occupancy evaluation (POE) and its role in avoiding problems that may occur as a result of not planning for the growth of demand for education and thus building expansions that make the site lose its ability to provide schoolyards.

In small sites the GEAB may resort to canceling the distance between the school building and the side overlooking the street, to save wasted spaces in the presence of already existing small plots of land. As in Fig 17, therefore, the study recommends amending the requirements for the validity of small sites for building schools and eliminating the distance between the school building and the main street, exclusively on small sites, in slum areas ,Allocating the ground floor overlooking the street as a shaded area or a multi-purpose room and spaces not designated for study. As for the typical floors classrooms can overlook the street or schoolyard to reduce waste in the distance between the school building and the neighbor and between it and the street. Which saves “between” (15% to 20%) of small spaces that can be used as schoolyards.

It is necessary to use only one school building and not construct multiple buildings of different heights with relatively small areas, to reduce wasted areas between buildings and each other in the site which should have been Schoolyards.

It is essential to make use of the square classroom layout as much as possible to reduce the overall length of the school building, and ultimately contribute to creating a compact design that minimizes the total space occupied with the building. Thus, allowing open spaces to exist more regularly in the overall site.

Study spaces can be loaded on a double corridor with lighting and ventilation flow rates being studied in acceptable proportions, which significantly reduces the space of the corridors and reduces the total area occupied by the building in the site layout, and leads to increasing the remaining space which can be used as spaces for schoolyards and playgrounds.

To facilitate the possibility of benefiting from small plots of land, especially in slum areas, it is better to suggest some design alternatives as guidelines. This makes it easy to take advantage of the limited capabilities of the site, as shown in the previously proposed design model and can be further developed through in-depth studies later.

7. References

[1] K. Regina, Cairo’s Informal Areas betwwen Urban Challenges and Hidden Potentials,Facts.voices.vision, op.cit, 2009, p. P.17.

[2] Information and Decision Support Center, "Informal Areas in Egypt: facts and figures," Ministers' Affairs, No. 12793, Cairo, 2014.

[3] S. Magdi, "Towards Sustainable Slum Development: A Performance Evaluation Approach for Slum Upgrading Plans in Egypt," in Cities’ Identity through Architecture and Arts, 1st ed., London, Taylor & Francis, 2017, p. 317–331.

[4] Central Agency for Public Mobilization and Statistics, "Population for the years (1996, 2016)," Cairo, 1996, 2016.

[5] UNESCO, "World Declaration on Education for All and Framework for Action to Meet Basic Learning Needs," in World Conference on Education for All - Meeting Basic Learning Needs, Jomtien, 1990.

[6] UNESCO, " Dakar Framework for Action Education for All: Meeting Our Collective," in World Education Forum Dakar, Senegal, 2000.

[7] C. A. f. P. M. a. Statistics, "Study of the Development and Growth of Slums in Egypt," Central Agency for Public Mobilization and Statistics, Cairo, 2016.

[8] H. N. M., "The efficiency of informal areas in Egypt - activating the relationship between the user group and the construction product," Cairo University, Cairo, 2015.

[9] Cairo Governorate, "Urban development and the challenges of Informal Areas," Cairo Governorate, Cairo, 2008.

[10] A. S. M. -. A. M. I., "Lessons Learned from Random Inclusion in Housing Facilitation Framework," in Facilitated Housing Seminar, Riyadh, 2004.

[11] H. A. S. &. E. M. A. &. Y. M. A., "Towards objective criteria for identifying areas of low-income housing in Egypt," in Housing Symposium 3, Riyadh, 2007.

[12] G. A. o. R. a. Studies, "Standards and requirements for the validity of school sites and buildings - Basic and general secondary schools (in existing cities and villages)," General Authority for Educational Buildings, Cairo, 2011.

[13] Author, Design model developed by author, 2023.

[14] Google Earth, "Maps," [Online]. Available: https://earth.google.com/web/@0,0,0a,22251752.77375655d,35y,0h,0t,0r.

[15] G. D. C. O. i. C. &. E. M. o. P. GIZ, "Development of informal areas of participation," urban participatory development program in Egypt, Cairo, 2011.

[16] S. Helmy, Towards an integrated methodology for evaluating and developing the performance of educational buildings using time management - a special mention for the basic education stage, Cairo: Cairo university - faculty of engineering, 2010.

[17] Citypopulation, 1 7 2021. [Online]. Available: http://www.citypopulation.de/en/egypt/greatercairo/.

[18] A. Ahmed, Analysis and evaluation of the elements of interior design of educational buildings through the concept of sustainability - primary schools -, Cairo: Faculty of Applied Arts - Helwan University, 2018.

[19] D. o. E. a. S. Affairs, "World Urbanization Prospects: The 2018 Revision," United Nations, New York, 2019.

[20] C. A. f. P. M. a. Statistics, "The development of slums in Egypt," Central Agency for Public Mobilization and Statistics, Cairo, 2016.