Area-based Physical Deprivation Index in an Urban Setting: A new approach

Current heightened national and international concerns for the welfare of the slum and poor areas dwellers and their right to safe and risk free environment in particular within the context of the developing countries have clearly shown the need for strong knowledge base on these areas. However, due to the informal and rapidly changing and growth nature of these areas, most governments and international agencies lack updated and accurate information base on these areas which can restrict their ability to extend their upgrading effort where they are most needed.

The main objective of the current study is to address one of the major impediments that commonly confront policy makers and national and international agencies concerned with the living conditions of the dwellers of these areas; namely the identification of the most physically deprived small areas in an urban setting. The current study uses information available on the most basic GIS layers in order to produce an index of physical deprivation that provides a gradient of small geographical zones in the urban settings. This gradient provides policy makers and program officers with a tool that enable them to zoom on the most deprived zones that are most likely to be obscured by their reliance on aggregated figures on the level of the larger administrative units.

1. Data Sources

1.1 Data for Construction of the Area-based Physical Deprivation Index:

Cairo governorate is used as a case study for the construction of the Area-based Physical Deprivation Index (APDI). Cairo is one of the most populous city in Africa and the Arab world. Its rapid growth intensified since World War II. Between 1947 and 2006, the city's population grew from 1.5 million to more than 7.8 million (within the city's corporate limits) that comprises about 11.5 % of the total population and 26 % of the urban population in Egypt according to the latest census in 2006. The total inhabited area of Cairo is 190 km^2 which yield a population density of 41,000 inhabitants per one Km^2. Administratively, Cairo

is divided in to 292 shiakhas. The shiakha is the minimum administrative unit for which CAPMAS publishes census and other data. These shiakhas are viewed by local residents to be equivalent to socially identified neighborhoods.

Construction of the Area-based Physical Deprivation Index (APDI) is based on the information obtained from two different groups of GIS layers for Cairo Governorate. The first group of layers is usually referred to as the surface objects layers. It includes two different types of layers:

a) Administrative layer: It shows the administrative boundaries of all shiakhas[1] in Cairo

b) Roads and irrigation systems layers: It shows the network of streets, roads as well as irrigation systems

The second group of layers usually referred to as the linear objects layers. It also includes two different types of layers;

a) Residential buildings Layers. It shows the area and positions of the main residential building within the administrative boundaries for each shiakha

b) Landmark layer: It shows the area and positions of the main landmarks within the administrative boundaries for each shiakha.

The current study uses 2004 GIS layers for Cairo governorate.

- **Steps for Building the Data base for the Index**

i. Subdivision of large shiakha

Since the main idea of the construction of the current index is to produce a gradient for small geographic zones within Cairo governorate, it was important to identify the size of this "small" zone. An area size of 0.7km^2 was selected since it was the minimum size of an area that contains both residential building as well as some services within its boundaries.

[1] Shiakhas are viewed by local residents to be equivalent to socially identified neighborhoods

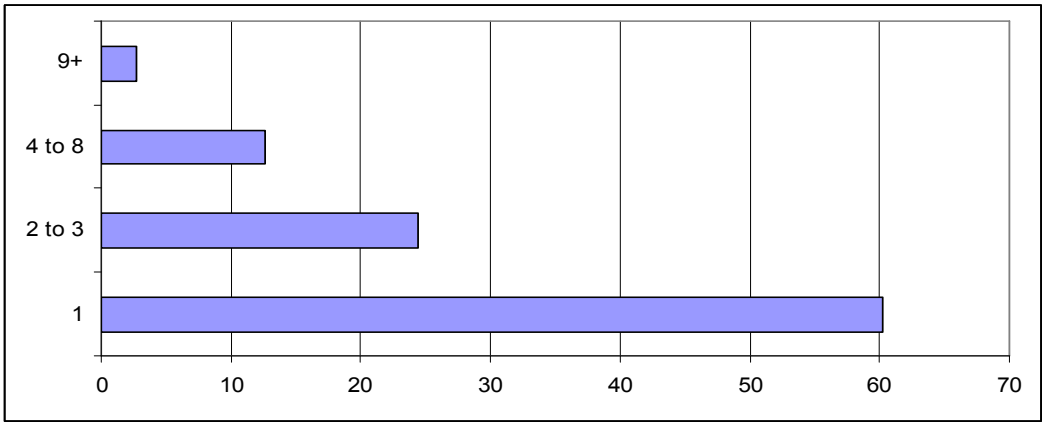
Accordingly, the 292 shaikhas of Cairo governorate underwent this geographical subdivision process. The subdivision process was carried out starting from the north east towards the south west of each shiakha with some flexibility to accommodate the shape of the shiakha. The boundaries of the new subdivisions "zones" were matched to the inter-sections of the main streets that encircle a squared area of the predetermined size. Based on this process, the 292 shaikhas of Cairo was subdivided into 668 zones. The average size of zones was 0.424 with standard deviation of 0.221 (table 1). About 61% of the shiakhas (178 shiakhas) were not subdivided since their area was within accepted size range (figure 1). About 25% of all Shiakhas (73 shiakhas) were subdivided into 2 and 3 zones and rest were subdivided into 4 or more zones. The largest number of subdivisions was for the El Mokatum shiakha which was subdivided into 26 zones followed by Berket el Nasr shiakha which was subdivided into17 zones.

Table1: The distribution of the 668 Cairo governorate zones by their area

Area of the zone	No. of zones	Distribution(%)
Empty zones *	6	0.9
Greater than 0 and less or equal to 0.1	55	8.23
Greater than 0.1 and less or equal to 0.2	82	12.28
Greater than 0.2 and less or equal to 0.3	69	10.33
Greater than 0.3 and less or equal to 0.4	84	12.57
Greater than 0.4 and less or equal to 0.5	81	12.13
Greater than 0.5 and less or equal to 0.6	100	17.97
Greater than 0.6 and less or equal to 0.7	157	23.50
Greater than 0.7 and less or equal to 0.8	29	4. 34
Greater than 0.8	5	0.75
Total	668	100

- An empty zone is the zone that does not encompass any residential building or land marks.

Figure 1 Number of shiakha's subdivisions into zones



i. Database structure

In this step, information available from the four GIS layers of maps was structured in a form appropriate for the construction of an area-based physical deprivation index. Originally, data in these layers are expressed in terms of geographical areas, e.g the residential building layer showed the area of these residential building, while the landmark layer showed the area of the landmarks such as the area of each school, factory ...etc in the specified geographical area. Tests for the most appropriate form of different items to be included in the construction of the index, in particular whether we should best use areas versus counts were carried out. Repeated trials revealed that the most appropriate way to deal with the data is to distinguish between two types of measures; namely surface land (residential building, agriculture land, space…etc) and landmarks in the area (Hospitals, factories, workshops…etc). The most appropriate form for the surface land type of data was as proportion of the total area, while for the landmarks, counts were more likely to capture the variations between the various zones.

This step was carried out by over laying the four layers of maps (residential buildings, landmarks, roads and administrative boundaries) for each zone and the required data were extracted. Since the main concern of the current study is the living conditions of the slum dwellers, one restriction was imposed on the zones to be included in the index construction step, namely the existence of residential building or housing facilities. Accordingly, thirty-four zones were excluded from the index construction step, leaving 634 zones.

Two exceptions for this restriction were the two cemetery zones/ shiakha, namely "El Emameen" and "El Basateen." These two zones contain no residential areas and under the previous restriction, they have to be excluded from the database. Nevertheless, these two zones are the clearest example of the "city of the dead," and therefore, we assigned 50% of their cemetery area to the residential areas.

1.2. Data for Testing the Validity of the Index

In order to assess the validity of the new proposed methodology, a sample of zones was selected with the purpose of having sufficient representation covering the whole gradient of zones in Cairo governorate. Based on the index scores, a stratified random sample of all

zones was selected. Stratification of the zones was based on applying 3-means cluster analysis using the index scores in order to classify the zones into three distinctive clusters. Taking in consideration the three broad clusters identified in the cluster analysis as strata, the appropriate sample size was estimated to include 155 zones (almost one fourth of all (634) inhabited zones) including 78 zones in the low cluster, 47 zones in the medium cluster and 30 in the high cluster.

Each selected zone in the sample was visited with a team of field workers. Each team consists of three observers, map drawers and a supervisor. The observers were responsible for collecting observations on the various characteristics of the zone included in the questionnaires, while the map drawers were responsible for updating the GIS maps. Teams were provided with two GIS maps which include

a) main road directions to the selected zone, shiakha boundaries, and boundaries of surrounding areas
b) detailed description of the selected zones including main roads, land marks as well as the zone boundaries

The questionnaire three main sections namely neighborhood characteristics, environmental services and social services. The neighborhood characteristics cover description of the conditions of the buildings, main and side roads and streets. Environmental services section addresses the zone's access to electricity, safe drinking water and sewerage systems. It also investigates the zone's exposure to other environmental risks. Social services section includes a count of the various social services available in the zone, namely educational services, health facilities, access to transportation and other public services (see Appendix B for both translated and Arabic version of the community questionnaire)
The final output of the field work was a completed questionnaire and an updated list of the landmarks for each zone.

2. Methodology for the Construction of the Index

The main aim of the current study is to construct an index that reflects the levels of physical deprivation in these different zones in all Cairo governorate's shiakhas. The main issue in constructing this index is to form a linear index using the available information in the data

base. In line with the previous effort of Filmer and Pritchett (1998), the principle component factor analysis was used to identify the weights for various items in the proposed index. Technically, principle components is a statistical methodology for assist in extracting from a large number of variables a limited number of orthogonal linear combinations of variables that best capture the common information. The first principle component is the linear index of variables with the largest amount of information common to all of the variables. The result of the principle component is an index of physical deprivation for each zone based on the formula

$$Ij = \sum_{i=1}^{N} \frac{fi(aji - ai)}{Si}$$

Where f_i is the scoring factor for the i^{th} item as determined by the procedure,

a_{ji} is the j^{th} zone's value for the i^{th} characteristic,

a_i and S_i are the mean and the standard deviation for the i^{th} characteristic over all zones.

3. APDI: Main Results

Table 2 presents the results of using principle component analysis to construct the Area-based Physical Deprivation Index. The mean value of the index was 0.032 with a standard deviation of 0.892. The index ranges between -0.338 to 2.282. The total explained variance for the first component was 49.7%. Since all the characteristics are expressed in a continuous form, the weights are easily interpreted. One unit change in the characteristic changes the index by f_i/S_i. For example, an increase of 1% in the residential building results in adding 0.007 to the index value and having cemetery in the zone would increase the index with 0.088.

Table 2: Scoring factors and summary statistics for the items included in the area-based physical deprivation

Items	Scoring factor	Mean	Std. Dev.	Min	max	Scoring factor / std. dev
Physical characteristic of area						
% residential building of total inhabited	0.143	27.88	19.14	0.024	85.77	0.007
% of street area of total area	-0.257	12.45	5.454	0.278	38.76	-0.047
Dominant type of roads narrow	0.209	0.492	0.500	0	1	0.418
% of garden of total area	-0.036	1.423	3.667	0	40.94	-0.010

% of agriculture area of total area	0.053	1.937	7.512	0	73.15	0.007
% of space area of total area	0.048	2.972	6.348	0	54.96	0.008
Presence of cemetery area	0.030	0.135	0.342	0	1	0.088
No. of agricultural canal	0.067	0.143	0.438	0	3	0.153
Sources of pollutions						
No. of factories	0.084	1.178	3.387	0	35	0.025
No. of workshops	0.138	0.683	1.409	0	10	0.098
No of storages	0.141	1.125	1.800	0	14	0.078
Services in the area						
No. of governmental offices	-0.054	1.914	2.473	0	23	-0.022
No. of banks	-0.035	0.189	1.261	0	24	-0.028
No. of hotels and motels	-0.134	0.172	0.850	0	16	-0.158
No. of academic institutes	-0.074	0.266	0.687	0	5	-0.108
No. of hospitals	-0.038	0.651	1.060	0	9	-0.036
No. of bakeries	0.110	0.391	0.708	0	5	0.155
No. of entertainment sites (cinemas,	-0.079	0.424	1.359	0	16	-0.058
No. of social and sport clubs	-0.066	0.578	1.006	0	7	-0.066
Presences of security						
No. of embassies	-0.058	0.187	1.338	0	20	-0.043
No. of military sites	-0.051	0.660	1.136	0	7	-0.045
Physical deprivation index		0.032	0.892	-3.338	2.282	

3.1 Testing the Reliability and validity of the Area-based Physical Deprivation Index

In order to test the reliability of the APDI, it was important to evaluate its performance in differentiating between the different types of zones. A 3-means cluster analysis was conducted using the index score as the clustering dimension. Table 3 shows that based on the cluster analysis of APDI index, three statistically significant distinguished categories are produced. For the purpose of distinction, these categories will be referred to low, medium and high. The average score for the high cluster (-1.17) and it ranges between -3.34 and -0.67, while the medium cluster average was (-0.17) and ranges between -0.66 and 0.34. Low cluster showed an average of (0.85) with a range of 0.35 to 2.28.

Table 3 The average, minimum, maximum values for the 3-mean cluster analysis of the APDI scores

Cluster	Average	Min	Max
Low	0.85 (0.80 0.90)	0.35	2.28
Medium	-0.17 (-0.21 -0.13)	-0.66	0.34
High	-1.17 (-1.26 -1.09)	-3.34	-0.67

*Confidence intervals are in parenthesis

- **Internal coherence:**

Table 4 compares the distribution and the averages across the low, medium and high zones. On the one hand, table 4 shows that there no significant differences in the area among the three clusters. On the other hand, the index produces sharp differences across clusters in every variable included in the index. Table 4 clearly shows the distinct characteristics of the low category compare to the other categories. The low cluster is typified with high percentage of residential buildings, agriculture area, space area; low percentage of street area and garden area; most of the streets that cut across this category of zones are very narrow; presence of cemetery and agricultural irrigation canals; large number of factories, workshops, storage building, bakeries; and small number of governmental offices, banks, hotels and motels, academic institutes, hospitals, entertainment centers, social and sports club, military sites and embassies. In other words, this category of zones manifests some of the main attributes of slum areas, namely high population density; lack of green areas; the interlock of agricultural and industrial activities with the high density of residential areas; lack of various social; health and entertainment services as well as governmental presence and intense presence of environmental pollution manifested in large numbers of workshops and factories.

Table 4 Distribution and Averages of the Variables Included in the APDI by the Three Clusters

Variables	Low	Medium	High	
No. of zones	268	220	146	
Physical characteristic of area				
Area of zone	0.41	0.44	0.43	ns
	(0.38 0.43)	(0.41 0.47)	(0.40 0.46)	
% residential building of total inhabited	46.35	25.39	15.20	***
	(44.37 48.36)	(23.14 27.64)	(13.23 17.18)	
% of street area of total area	8.07	12.55	19.16	***
	(7.84 8.29)	(12.05 13.04)	(18.42 19.89)	
Dominant type of roads narrow	0.99	0.35	0.01	***
	(0.92 0.97)	(0.30 0.42)	(-0.01 0.03)	
% of garden of total area	0.46	1.48	2.39	***
	(0.29 0.63)	(1.09 1.87)	(1.44 3.34)	
% of agriculture area of total area	3.75	2.04	0.00	***
	(2.44 5.05)	(0.78 3.30)	(0.00 0.00)	
% of space area of total area	3.89	2.48	0.57	***
	(3.00 4.78)	(1.63 3.33)	(0.31 0.83)	
Presence of cemetery area	0.17	0.1	0.07	***
	(0.12 0.21)	(0.06 0.14)	(0.03 0.11)	
No. of agricultural canal	0.23	0.07	0.01	***
	(0.16 0.30)	(0.03 0.11)	(0.00 0.03)	
Sources of pollutions				
No. of factories	1.75	0.66	0.11	***
	(1.26 2.23)	(0.43 0.90)	(0.03 0.18)	
No. of workshops	1.08	0.35	0.04	***

	(0.88 1.27)	(0.24 0.46)	(0.00 0.08)	
No of storages	1.79	0.63	0.12	***
	(1.52 2.05)	(0.47 0.79)	(0.05 0.18)	
Services in the area				
No. of governmental offices	1.45	1.82	2.75	***
	(1.24 1.67)	(1.54 2.11)	(2.17 3.32)	
No. of banks	0.10	0.12	0.59	***
	(0.04 0.15)	(0.04 0.20)	(0.12 1.06)	
No. of hotels and motels	0.02	0.13	0.77	***
	(0.00 0.05)	(0.04 0.21)	(0.43 1.11)	
No. of academic institutes	0.07	0.20	0.66	***
	(0.03 0.10)	(0.14 0.27)	(0.48 0.83)	
No. of hospitals	0.47	0.52	0.90	***
	(0.37 0.57)	(0.40 0.65)	(0.70 1.11)	
No. of bakeries	0.65	0.16	0.06	***
	(0.55 0.75)	(0.10 0.21)	(0.02 0.10)	
No. of entertainment sites (cinemas,	0.10	0.25	1.08	***
	(0.06 0.14)	(0.16 0.35)	(0.73 1.43)	
No. of social and sport clubs	0.30	0.42	0.91	***
	(0.22 0.38)	(0.33 0.52)	(0.69 1.13)	
Presences of security				
No. of embassies	0.01	0.07	0.68	***
	(0.00 0.02)	(0.02 0.13)	(0.24 1.13)	
No. of military sites	0.24	0.55	1.12	***
	(0.17 0.30)	(0.41 0.69)	(0.90 1.35)	

- **Testing index validity**

To assess the validity of the APDI, a stratified random sample of 155 zones were selected and visited by a team of field workers who completed a detailed questionnaire on the main physical structure characteristics and the availability of services for each zone. The sample was selected to reflect the three types of zones "Low" (78 zones), "medium" (47 zones) and "High" (30 zones). The following subsections compare the various physical and structural characteristics as well as availability of services in these three types of zones to assess the power of the proposed index to classify the various zones in those three types of zones.

Physical Structure

Table 5 compares the characteristics of physical structure among the three types of zones. It shows that although the majority of the zones in Cairo have empty spaces between buildings, these empty spaces were more prevalent in the low zones than the other two types of zones. About 80% of the "low" zones have empty spaces between buildings compared to less than 57% in the "high" zones. The dominant character of these empty areas in all zones was being fenced empty areas in particular among high zones (78%) and medium zones (61%).

However, tuning these empty spaces into dump and litter areas was more prevalent in the case of the low zones and was found in 21% of these zones compared to less than 14% and 6% in the medium and high zones, respectively. Empty areas that turned into parking lots were also more common in the low zones than in both the medium and high zones (15% compared to 6% and 6%, respectively).

The presence of green areas or trees has always been recognized significant counter action against the high levels of air pollution widely spread in urban setting. Hence, the absence of these green areas is a good indication of high levels of air pollution. Table 5 shows that low zones are significantly lack any presence of these green areas or trees. Absence of any green areas or trees in the zones was most common theme among these zones with 41% of them low zones have no green area compared to less than 24% and 20% in the case of medium zones and high zones, respectively. Although 64% of the low zones had trees in front most of their buildings, this percentage was significantly smaller than its corresponding percentages in both medium zones (83%) and high zones (87%). Furthermore, green parks or green areas were found only in 27% of the low zones compared to more than 58% of medium zones and 48% in the high zones.

The fact that some of the low zones areas are the result of the city growth over neighboring agriculture areas is confirmed in Table 5. About 13% of the low zones either looks over or encompasses an agricultural plot and 8% of them have an agricultural canals or drainage. These features were also found in the medium zones, though less prevalent compared to the low zones. None of these features were found in the high zones.

Table 5 Main attributes of the zones' physical structure by the three types of zones

	Low	Medium	High
Sample size	(78)	(47)	(30)
General structure of the zone			
Presence of empty areas between buildings	79.5	74.5	56.7
Dominant character /use of the empty areas between buildings			
Fenced area	56.7	61.1	77.8
Dump and litter areas	20.9	13.9	5.6
Parking lot	14.9	5.6	5.6
Absence of green areas in the zone	41.0	23.4	20.0
Presence of trees in front of most of the buildings	64.1	83.0	86.7
Presence of gardens in the zone	26.9	57.5	46.7
The zone has or near an agricultural plot	12.8	10.6	0.0
The zone has or near agricultural canals or drainages	7.7	4.3	0.0

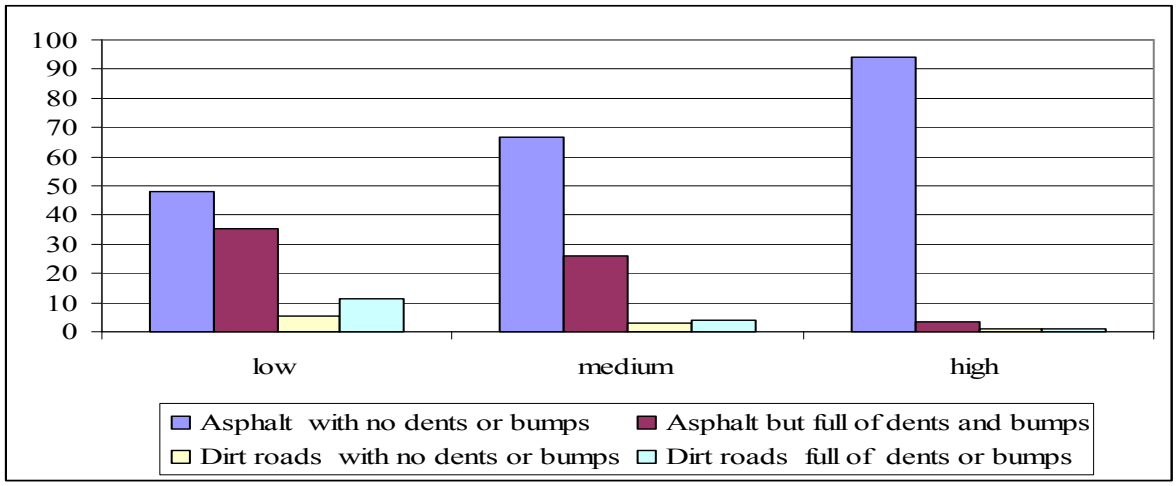
Streets and roads conditions

Main streets

Table 6 shows that although the average number of main streets did not differ among the three types of zones, the condition of these streets vary markedly. While the majority of the main streets in all zones are asphalt streets, their conditions vary significantly. Being unleveled and having many dents or bumps was more common in the low zones and was observed for more than 35% of all main streets in this type of zones, compared to less than 4% of all streets in the high zones.

Dirt street captured more than 16% of all main streets in the low zones and was only found in two main streets in the high zones. Dirt streets that are in bad conditions also comprised 11% of all main streets in the low zones (Figure 2)

Figure 2 **The condition of the street pavement by the type of the zone**



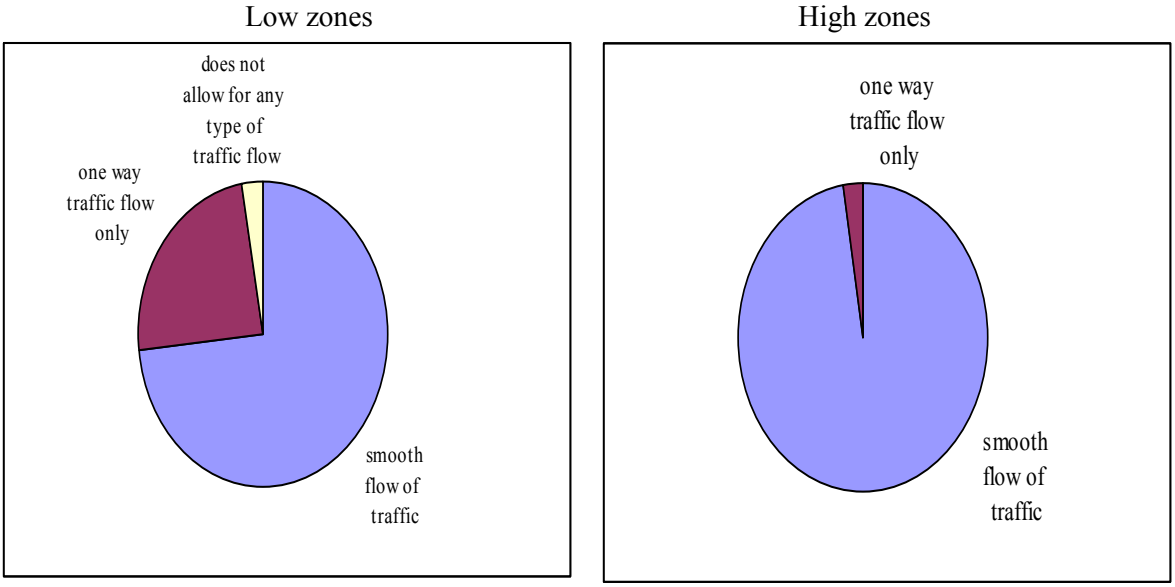
The presence of working light poles on the main streets was found almost universal in the case of the main streets in the high zones (96% of all streets), while only 69% of all main streets in the low zones had working light poles. Having no street lights was observed in 17% of all streets in the low zones, while in the case of the high zones this was only observed in less than 4% of their main streets.

Table 6 Main attributes of the main streets by the three types of zones.

Characteristics of main Streets and roads			
Mean Number of main streets in the zones	2.6	2.7	2.8
Std dev.	(0.14)	(0.19)	(0.28)
All main streets have names	62.8	58.7	86.7
The condition of the light poles in the side street			
Presence of working and good conditions	69.0	86.3	96.4
There is no light poles on the street	16.9	8.0	3.6

Figure 3 compares the width of the main streets between the low and high zones. While more than 97% of all main streets in the high zones allow for smooth flow of the traffic, this percentage was less than 74% in the low zones. Streets that allow for one way traffic only comprises 2% of high zones streets, while they were observed in 24% of all streets of the low zones. Streets that are too narrow to allow for traffic was found in 3% of the main streets of the low zones and non existing in the high zones.

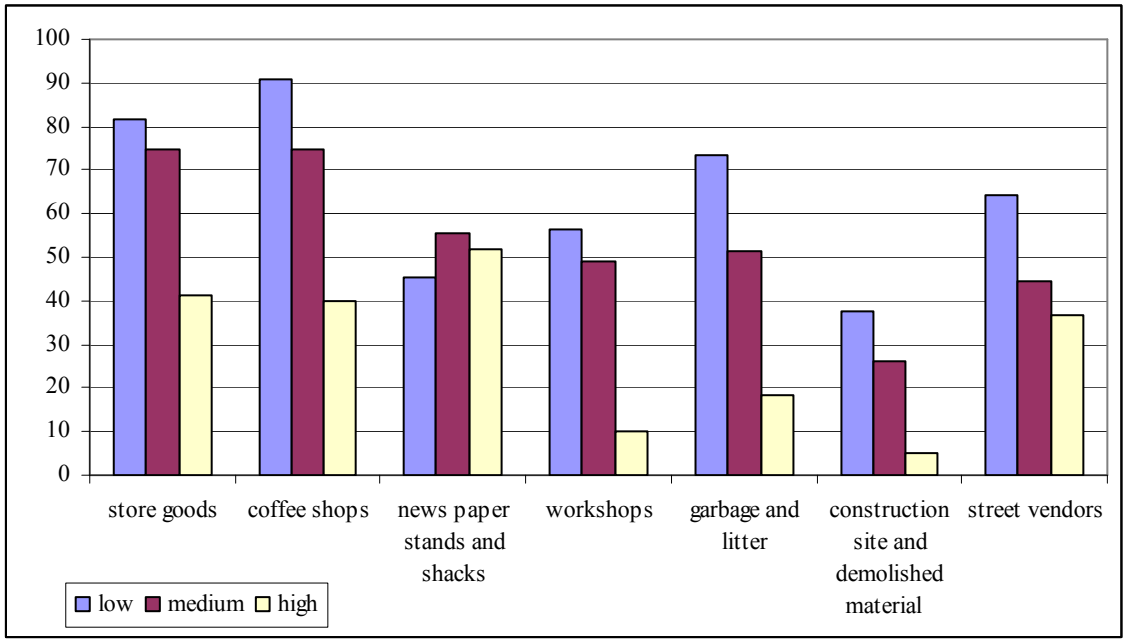
Figure 3 The width of the main street



Presence of obstructions on the main street was observed in all main streets in Cairo. However, these obstructions were more common in the low zones than the medium zones or high zones. About 90% of all main streets in the low zones had road obstructions, compared to 83% in the case of the medium zones and less than 71% in the case of the high zones.

The nature of these obstructions also varies by the type of zones. Figure 4 shows that main streets in the low zones are packed with all kinds of street obstructions. The least prevalent obstruction in these zones is construction site and demolished material which were found in only 37.5% of their streets.

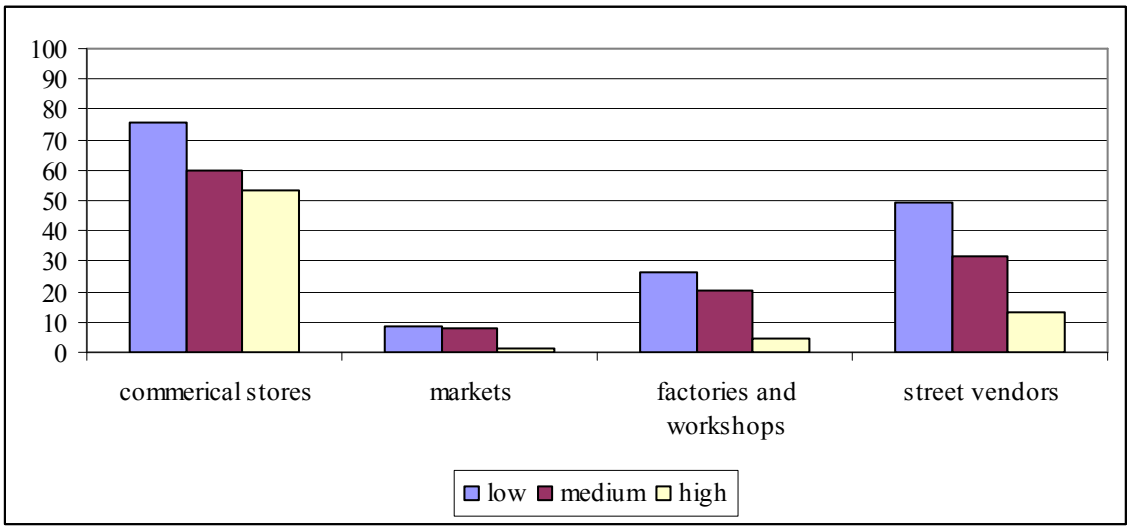
Figure 4 Types of main street obstruction by the type of the zones



The impact of the streets obstructions also differ for the three zones in particular for the extreme case where the obstruction restrict the flow of both traffic and pedestrian. In the case of the low zones, this occurred in more than 49% of their main streets, whereas the corresponding percentages for the medium and high zones were 32% and 13%, respectively.

Main economic activities on the main streets also vary among the three types of zones. Figure 5 shows that main streets in the low zones experience a multiplicity of economic activities with the commercial stores the most common economic activities followed by street vendors. It also shows that there is a gradient in these economic activities over the three types of zones. They are very common in the low zones, followed by the medium zones and the high zones.

Figure 5 Economic activities on the main streets by the zones types



Side streets

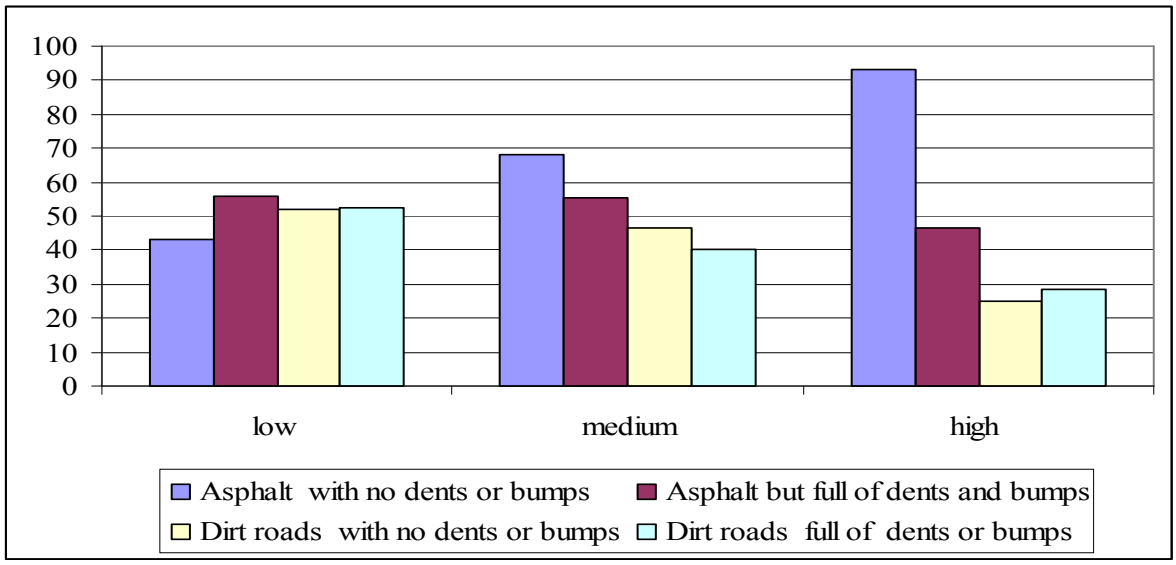
Similar to the situation of the main streets, there was no significant difference among the three types of zones in the presence of the large number of side streets. However, there was some variation in the characteristics of these side streets by the type of the zones. While about two thirds of the high zones had names for all their side streets, only in one fourth of the low zones all side streets had names. Furthermore, low zones where characterized with the presence of large number of narrow roads and alleys in particular dead end ones compared to both medium and high zones. While 41% of the low zones had large number of narrow roads and alleys and 24% had dead end alleys, the corresponding percentages were significantly smaller in the other two types of zones (14% and 10%, respectively).

Another indication about the nature of these side streets, researchers were asked to describe the width of these streets. Table 7 shows that side streets that allows for smooth flow of the traffic in both ways were found in all three types of zones, although only 45% of the low zones have them, whereas they were found in 81% of the medium zones and 75% of the high zones. At the other extreme, side streets that were not wide enough to allow for proper ventilation among the building were found in 41% of the low zones compared to 22% in the case of medium zones and 18% for the high zones.

Figure 6 also examined the condition of the side streets' pavement. About 93% of the high zones had Asphalt Street with no dents of bumps compared to less than 43% in the low

zones. Dirt roads full with dents and bumps were found in more than (52%) of the low zones compared to 29% in the case of the high zones.

Figure 6 **The condition of the street pavement by the type of the zone**



Working and good condition light poles on side streets were only found in 60% of the low zones, whereas the corresponding percentage in the medium and high zones were 63% and 76%, respectively. While only one out every three low zones had side streets where no light poles were found, this were only observed in one out of ten street in the high zones.

Table 7 Main attributes of the side streets by the three types of zones.

Characteristics of Side Streets and Roads			
All side streets have names	26.0	43.5	63.3
Presence of large number of narrow roads and alleys	41.0	23.4	14.3
Presence of large number of dead end narrow roads and alleys	24.4	14.9	10.7
Width of the side street			
Wide enough to allow for the smooth flow of traffic	44.9	80.9	75.0
Wide enough to allow for one way traffic flow only	75.6	63.8	64.3
Not wide enough to allow for any type of traffic flow	66.7	40.4	28.3
Not wide enough to allow for proper ventilation for buildings on its sides	41.0	21.7	17.9
The condition of the light poles in the side street			
Presence of working and good conditions	59.0	63.8	75.9
There is no light poles on the street	32.1	17.0	10.3

Building conditions

Figure 7 shows the configuration of the building in the three types of zones. It reveals that multiple story buildings are the most prevalent type in all zones and were found in more than 97% of all types of zones. However, single story building, tents and shacks and graveyard used for housing were also found in all three types albeit more common in the case of the low zones.

Figure 7 Buildings configurations by the type of the zones.

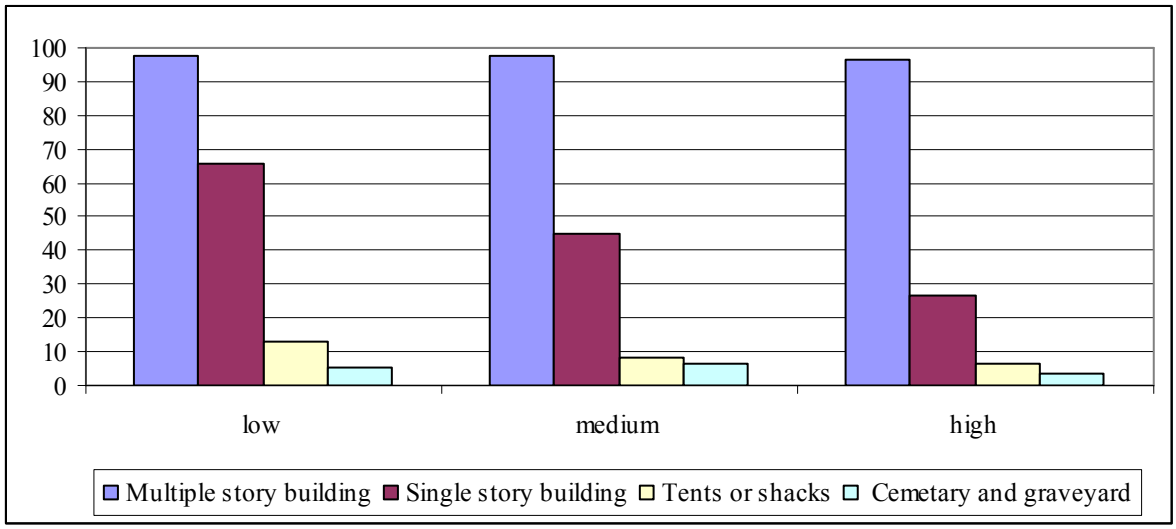
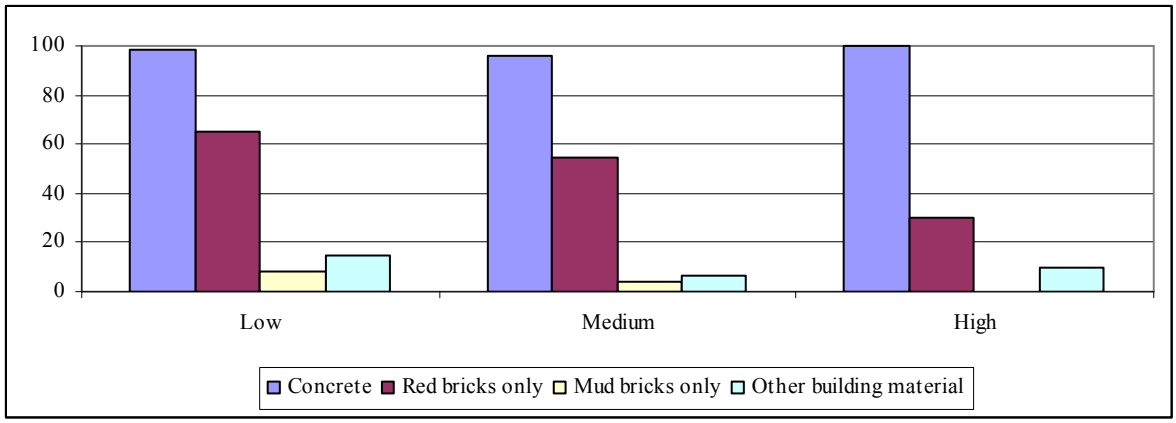


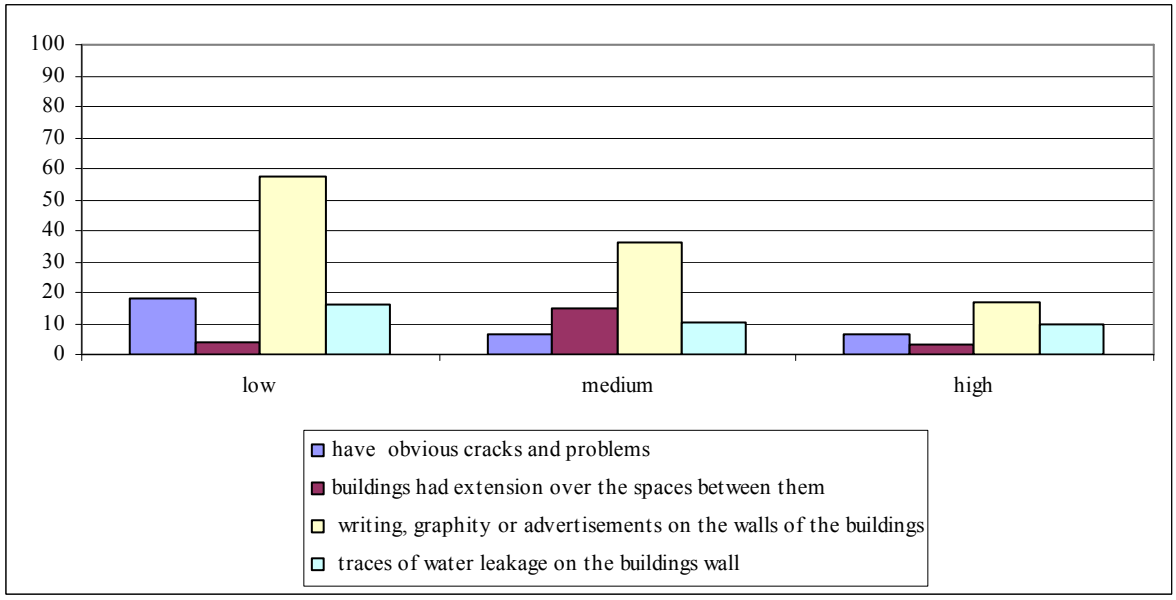
Figure 8 shows that the materials used in these building vary by the zone type. Concrete was the most commonly used building material followed by red bricks without any use of concrete. Mud bricks were observed in 8% of the low zones and 4% in the medium zones. Other building material such as wood and tin sheets were observed in all three types of zones although they were observed in more low zones than the other two types.

Figure 8 Building material used by type of zones



Information on the conditions of the buildings in the three types of zones was gathered. Figure 9 shows that buildings that have obvious cracks and problems were more found in the low zones than the other two types of zones. Almost 18% of the low zones had buildings in bad conditions, whereas these buildings were found only in 6% of both medium and high zones. Writing, graphite and have advertisements on the walls of the building was also more common in the low zones (58%) followed by the medium zones (36%)and least common in the high zones (18%). Figure 9 also shows that more than 16% of the low zones had buildings were traces of water leakage can be observed on the buildings wall, whereas the same condition was only found in 10% of both the medium and high zones

Figure 9 The conditions of the buildings walls by the type of zones

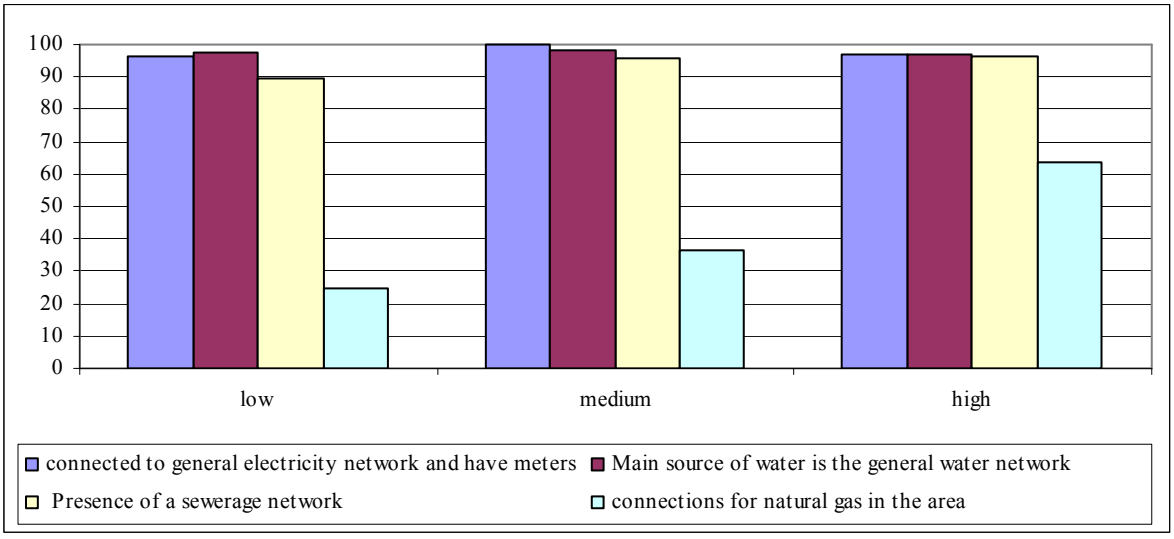


Accessibility to environmental services

One of the main features of the slum areas around the world is their inaccessibility to main environmental services such as electricity, clean drinking water and connection to the sewerage system or network. These services have been the core of the upgrading efforts in most of the countries and in also Egypt. Figure 10 shows that there are no substantial differences in the three types of zones in their accessibility to these services. On the contrary, all zones achieved almost universal coverage for these services. Two problems can be stressed in this figure. The first is that the reported percentages are percentages reflecting accessibility to these service for"most of the dwelling in the zone" and not for "all dwellings in the zone." The second problem is that these figures are reported for the presence of connections rather than the quality of the service which can reveal a total different picture on these services. Hence, we can not judge these services through this figure only.

However, Figure 10 also shows that access to natural gas was more common in the high zones where more that 63% of these zones are having natural gas connections. This percentage is about 36% in the case of the medium zones and 25% in the case of the low zones.

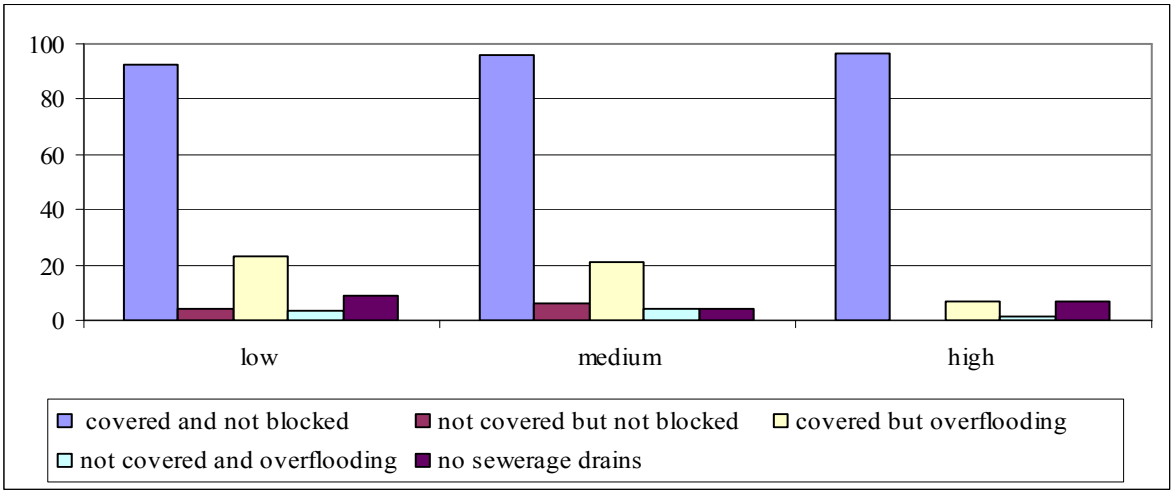
Figure 10 Accessibility to environmental service by the type of zones



Over flooding sewerage drains are one of the most environmental problems commonly faced by the deprived areas. Figure 11 shows that although covered and unblocked sewerage drains were found in all zones in Cairo, covered but over-flooding sewerage drains were found in 23% of the low zones and 21% of the medium zones whereas only 7% of the high

zones had similar sewerage drains. Having no sewerage drains was more common in the low zones (9%) compared to the high zones (7%) and medium zones (4%).

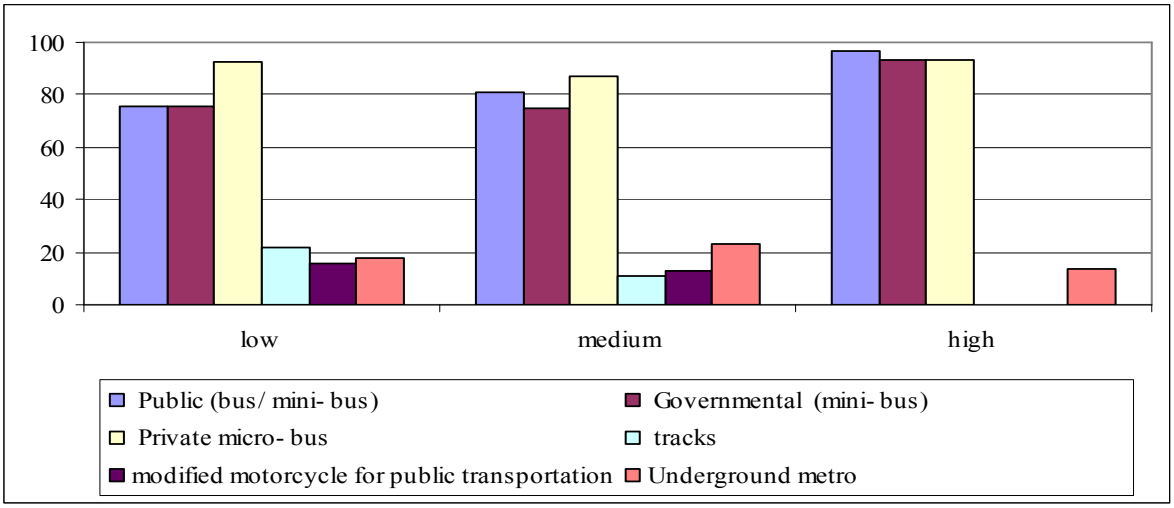
Figure 11 **The condition of the side street pavement by the type of the zone**



Means of transportation serving the zones

Figure 12 shows that public and governmental transportation are common in all types of zones, albeit less available in both low zones and medium zones where less than 90% of these zones are served by these means compared to at least 93% of the high zones. Other means of transportations such as private micro buses, modified track, or modified motorcycles has been used to compensate for the lack of the public and governmental means of transportation. Modified tracks and motorcycle were found in 22% and 15% of the low zones. It should be noted that these two locally manufactured means of transportation are not recognized by the government due to issues related to their safety and the majority of them are working without a licenses.

Figure 12 Means of transportations serving the area by the type of the zone.



Availability of public services

Researchers were asked to investigate the presence of the following public service list in the three types of zones. Table 8 shows the results regarding the availability of these services. It reveals that the availability of these services vary by the type of service and the zones' type. However, the average number of services is similar across the three types of zones where an average of 10-11 services are available in these zones. (these services needs more work).

Table 8 Availability of public services by type of zones

	Low	Medium	High
1-Governmental Telephone station	15.4	14.9	23.3
2- Private Telephone Station	93.6	91.5	83.3
3- Telephone Booth	82.1	89.4	93.3
4- Shops that provide telephone use for the public	88.5	91.5	66.7
5- Post Office	35.1	27.7	23.3
6- Bank	12.8	27.7	40.0
7- Fire Station	11.5	12.8	23.3
8- Police Station	19.2	34.0	26.7
9-Youth Center	14.1	19.2	6.7
10- Public Arena	12.8	6.4	0.0
11- Gym	32.1	21.3	20.0
12- Coffee Shop/ Cafeteria	94.9	85.1	73.3
13- Cyber Cafe	69.2	68.1	56.7
14- Bakery (Foreign)	82.1	68.1	36.7
15- Local Bakery	78.2	55.3	33.3
16. Prayer House (Mosque/ Church)	96.2	93.6	.90.0
17- Church or Mosque that provides educational services	43.6	34.0	20.0
18- Ceremonial Centers	46.2	42.6	26.7
19- Orphanage	24.4	27.7	16.7

20- Nursing Home	5.1	14.9	6.7
21- Public Library	7.7	8.5	16.7
22- Public Garden	20.5	48.9	33.3
23- Botagas Tube Storage Station	7.7	6.4	3.3
24- Gas Station	24.4	34.0	53.3
25- Cinema or Theater	6.4	17.0	36.7
26- Non Governmental Organization or Charitable	68.0	61.7	40.0
27- Cleaning Company	15.4	19.2	16.7
28- governmental supermarket	25.6	27.7	13.3
29- Children's Library	3.9	10.9	6.7
30- Sports or Social Club	11.5	23.4	30.0
31- Peoples Assembly representatives' office	7.7	6.4	0.0
32- Head Quarter of a political party	15.4	12.8	20.0
Average number of services	11.7	11.8	10.3
Std dev	0.50	0.71	0.78

Exposure to environmental risks

Researchers were asked to investigate the presence of list of 19 environmental risks in the zones visited. Table 9 shows the prevalence of these risks by the type of the zones. A skim over the values in the table discloses the higher prevalence of these environmental risks in the low zones area, followed by the medium zone. This result is confirmed by the average of a simple summative scale of these risks. While low zones experience an average of eight environmental risks, medium zones experience 7 of them on average, whereas only 4 risks on average can be found in the high zones.

Table 9 Environmental risks by the type of the zones

	low	Medium	High
Close to industrial area	27.6	27.7	13.3
Has bad odors, gas leakage, and smoke	45.5	29.8	16.7
Has stagnated water around the dwellings	20.8	25.5	6.7
Has solid waste (human or animal)	62.3	36.2	33.3
Has high voltage towers	10.5	27.7	10.0
Has cellular transceiver stations	36.4	51.1	13.3
Close to a garbage dump	46.8	25.5	13.3
Suffer from sewerage over-flooding	20.8	21.3	10.3
Close to a sanitation dump	5.2	6.4	3.5
Has a large number of workshop and shops that disturb the residents activities and rest	80.5	73.9	43.3
Has incomplete buildings	74.0	55.3	56.7
Has buildings that are iron fenced or spike fenced	31.6	44.7	26.7
Has piles of dirt and rubbish	71.4	66.0	33.3
Has garbage scattered around	81.8	70.2	43.3

Has covered or uncovered sewerage outlets	20.8	12.8	6.7
Has stray animals (cat/ dogs)	77.9	70.2	50.0
Has gathering places of homeless children and road venders	16.9	17.0	23.3
Has places for drug dealing	29.9	10.6	16.7
Has corrupt places (poker/ drug abuse)	27.3	12.8	16.7
Average Number of environmental risks	7.8	6.8	4.1
Std dev	0.40	0.53	0.70

Conclusion (needs more work)

The current study is mainly concerned with developing a methodology that is capable of identifying small geographic areas that can be defined as slums or deprived areas using minimum requirement of geographical information systems. It comes in response to the global concern for the living conditions of the slum dwellers.