

Using GIS in Sustainable Urban Design in Developing Countries (Gaza Strip, Palestine as a Case study)

Dr. Alaeddinne El Jamassi ⁽¹⁾
ajamassi@iugaza.edu

Dr. Farid S. Al-Qeeq ⁽²⁾
falqeeq@iugaza.edu

M. Mohammed El-Farra ⁽³⁾
mfarraa@iugaza.edu

Faculty of Engineering, IUGAZA

Abstract: Gaza Strip -Palestine is one of most needy regions to apply sustainability concepts and sustainable planning, owing to its critical narrow area of nearly 365 KM2. In addition, overpopulation and the increasing depletion of limited natural resources are of major concerns. Moreover, the conventional urban planning has failed to solve the ecological and economic problems, and even sometimes aggravates them.

This research aims to analyze one of the urban projects in Gaza Strip (Sheikh Zayed City), study their appropriateness and application of sustainability concepts by using the technology of Geographical Information Systems (GIS). In addition to recognize the most important criteria, fundamentals and standard indicators required for accomplishing the sustainable urban planning status of the Gaza Strip.

Keywords: GIS, Urban Design Strategies, Sustainability, Gaza Strip

استخدام نظم المعلومات الجغرافية في التخطيط العمراني المستدام في الدول

النامية (قطاع غزة - فلسطين حالة دراسية)

ملخص: قطاع غزة من أكثر المناطق احتياجاً لتطبيق مفاهيم الاستدامة نظراً للمساحة المحدودة لقطاع غزة (حوالي 365 كم²) ومحدودية الموارد الطبيعية في ظل الكثافات السكانية الهائلة، لذلك كان الحفاظ على هذه المصادر من أهم تحديات التنمية العمرانية المستقبلية. كذلك فإن التخطيط التقليدي السائد في قطاع غزة قد ساهم في تفاقم هذه الأوضاع ولم ينجح في حل المشاكل البيئية والاجتماعية والاقتصادية التي تواجه المناطق العمرانية. هذا البحث يهدف إلى تحليل مشروع مدينة الشيخ زايد في مدينة بيت لاهيا ودراسة مدى مطابقة الخصائص العمرانية لتلك المنطقة مع مفاهيم الاستدامة وذلك باستخدام نظم المعلومات الجغرافية، إلى جانب تحديد أهم المعايير التخطيطية لتفعيل مفاهيم الاستدامة في الواقع العمراني لقطاع غزة.

1) Introduction

1.1.Preface

With the development of man and the increasing growth of human communities, gab has increased between life requirements of human beings, ecology potentiality and the natural resources to fulfill these requirements.

(1) Professor Assistant, Faculty of Engineering, IUGAZA

(2) Professor Associate, Faculty of Engineering, IUGAZA

(3) Lecturer, Faculty of Engineering, IUGAZA

Hence, ideas relating sustainability and rebalance emerged, and concepts relevant to sustainable urban are planning, with its standard and accomplishment means.

Gaza Strip is one of most needy regions for the application of sustainability concepts and sustainable planning, owing to its critical narrow area of nearly 365 square kilometers. Added to this, is overpopulation and the increasing depletion of limited natural resources of the Strip.

Moreover, the conventional urban planning has failed to solve the ecological and economic problems, and even sometimes aggravates them.

1.2. Research problem

The research tries to shed light on these concepts, trying to set the corner stone for approaching a set of indicators of measuring the sustainable urban planning. Such indicators concern Gaza Strip where their application is standardized by technology of Geographical Information Systems, to serve as a curriculum of measuring the compatibility of any future project in the Strip, with sustainability concepts.

The significance of research is due to absence of any specialized study that lays foundation for the indicators of measuring the sustainable urban planning for Gaza Strip, hence, there is dire need to attain such goal.

The importance of this research study can be summarized in the following two points:

- Lack of former studies specialized in the strategies of sustainable planning in Gaza Strip, so as to lay its bases and factors of its accomplishment. Subsequently, the rise of urgent need studies as such.
- Current status of Gaza Strip with its limited area and scarcity of resources amid the immense urban expansion and population growth. This necessitates the serious attempt to set standard indicators that reflect how far the implemented sustainable projects are applied regarding the present status, as well as future projects.

1.3. Research objectives:

- Recognize the most important criteria, fundamentals and standard indicators required for accomplishing the sustainable urban planning status of Gaza Strip.
- Conclude recommendations for sustainability, through studying the models of urban compounds around the world that applied the sustainability concepts.
- Analyze existing projects in Gaza Strip, study their appropriateness and application of sustainability concepts by using the technology of Geographical Information Systems (GIS).

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1.4.Gaza Strip: Planning status

Historical background

- Gaza Strip is the southern region of the Palestinian coast looking over the Mediterranean Sea. It is named after Gaza because it is the biggest city in the Strip. There are 1.5 million Palestinians living in the Strip.

- The population is distributed with relative density of approximately 26,000 citizens per one square kilometer in cities, and 55500 per one square kilometer in refugee camps.



Figure (1): Gaza Strip at the southern corner of the Palestinian coast.

2) Methodology

The research depends on the descriptive and analytical study as following:

- **Study of Universal standard indicators to achieve sustainable urban planning**
- **Weight of standard indicators:**
 - a) Defining the weight standard indicators realizes the sustainable urban planning in Gaza Strip
 - b) Questionnaire to determine the weight standard indicators of the sustainable urban planning in Gaza
- **Using Geographical Information Systems (GIS) as decision tool**
- Preparation of using the geographical information systems passes through four steps:
 - a) Firstly: Data collection, input and correction
 - b) Secondly: Data storage and retrieval
 - c) Third: Data Manipulation and Analysis Phase
 - d) Fourth: Data Display and Reporting Phase

- Using Geographic Information Systems in Measuring Sustainability Indicators (Shaikh Zayed City as Case study in the Gaza-Strip)

2.1. Study of universal standard indicators to achieve sustainable urban planning:

These indicators can be adapted to suit Gaza Strip status, by restudying them and adding new elements. The study will focus on the following five standard indicators:

- a) Indicator of measuring the movement of vehicles and pedestrians
(Movement Factor): [Kazimee, 2001]

Standard of movement by vehicles means the average of kilometers crossed by a vehicle of each living house during a day. When indicator of measuring the movement is calculated in a certain city, a maximum distance of 250 meters is adopted for the daily-crossed distance on foot, from the house to the daily activities.

- b) Indicators of measuring the purchasing power of inhabitants
(Affordability Factor): [Levine, 2004]

This indicator means the ability of citizens to purchase housing units at different parts of the city or district. Because of multi types of housing units and their varying prices, a general average is taken for the purchasing power.

- c) Indicator of measuring diversity of housing units:

This means definition of available housing units in a certain city, at the presence of citizens. [Teed, 2005].

- d) Indicator of measuring the confirmation of using the mixed land (Mixed land use factor): [Yan, 2006]

It means diversity of using the land in a city; for example, housing, agricultural, industrial, commercial, service, green surface areas.

- e) Indicator of measuring the biodiversity confirmation and green infrastructure (Biodiversity and Green Infra structure Factor): [Condon, 2003]

It is measured through the availability of general and private green surface areas, the existence of surfaces that allow penetration of water into soil; availability of tree coverage in the city to attract biodiversity, besides the existence of mechanisms for reserving the rain water, and recycling the leftovers... etc

2.2. Weight of standard indicators:

2.2.1 Defining the weight standard indicators realizes the sustainable urban planning in Gaza Strip

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The five universal standard indicators stated earlier, can be considered as the main fundamentals to define and standardize the extent of accomplishing the sustainable urban planning for any urban ecology.

The importance of each indicator differs according to the nature and circumstances of the district that is subject to standard. As for Gaza Strip, a mechanism has to be followed, through which the weight of each standard indicator is defined, in accordance with Gaza Strip's priorities and needs.

2.2.2 Questionnaire to determine the weight standard indicators of the sustainable urban planning in Gaza Strip [Elfarrar, 2010]

The researchers sees the way of taking a questionnaire random sample, in order to conclude the weight of each indicator; hence, apply it later to a case study in Gaza Strip. A questionnaire for public opinion survey was carried out about the indicators to define their weight in order to be used by the geographical information systems later on. The questionnaire included a range of required principles and fundamentals to achieve sustainable urban planning, and to be helpful in judging the extent of its success.

Sample choosing: The orientation of the Department of Statistics at the IUG directed researchers to the work of a random sample of total number of 400 copies a questionnaire of the population of the sector with an emphasis on focus groups and is in the universities primary in the sector such as the Islamic University and Al Azhar university and Al-Aqsa University and Palestine University, and the Community College and the College of Science and Technology, as well as government institutions working in the field of planning and municipalities such as the Ministry of Local Government and the Municipality of Khan Yunis, and some communities such as Alqalaa Towers and Al fukhary UN housing, and towers of Sheikh Zayed City .. Etc.. This is in addition to the work of 10 copies that have been mobilized from experts in the field of urban planning, depending on the theory or technique of Delphi questionnaires.

These principles that were defined were included within each of the standard indicators according to their arrangement in the questionnaire clauses. The aim was to determine the most important matter according to the sample support. It was observed that the stated support rate took into account the graduality of agreement, regarding the exclusive agreement, the agreement to a certain extent, as well as the absolute disagreement.

Result of the questionnaire analysis was as follows table (2):

Standard indicator	No. of principles	Supporting	Opposing	Support rate
Vehicles & pedestrians movement	13	11	2	79.7%
Purchasing power of buying a housing unit	3	3	0	100%
Diversity of housing units	4	3	1	75.4%
Mixed land use achieved	5	4	1	67%
Achievement of biodiversity & green infrastructure	8	8	0	90.2%

Table (2): shows support rate for standard indicators stated in the questionnaire, through these principles;

According to the table (2), the five standard indicators can be arranged relative to their weight, as follows:

Standard indicator	Weight coefficient
Standard purchasing power	0.25
Standard bio diversity & green infrastructure	0.22
Standard movement	0.19
Standard diversity of housing unit	0.18
Standard use of mixed land	0.16

Table (3): Shows weight factor for each of the standard indicators stated in the questionnaire;

2.3.Using Geographical Information Systems (GIS) as decision tool:
[ESRI, 2009]

A Geographic Information System (GIS) is a collection of computerized maps and databases that are linked together for the purpose of storing,

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retrieving, managing and analyzing information. [ESRI, 2009]. Also, GIS is defined as an information system to input, retrieve, process, analyze and visualize geographically referenced data or geospatial data in order to support decision making for planning and management of natural resources and environment, [ESRI, 2009]

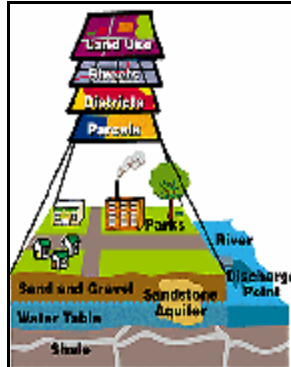


Fig. 2: Conceptual model of GIS (ESRI, 2009)

2.3.1 Preparation of using the geographical information systems passes through four steps: [Yaakup, 2005]

Firstly: Data collection, input and correction

This is the basic step in setting up any geographical information system. It is represented in the collection and entry of information with their different shapes.

Secondly: Data storage and retrieval

This step includes the storage of geographical information from its different sources (maps, digital and descriptive data with different patterns points, polylines, polygons, and Attribute data). They are connected with each other, in order to retrieve them easily, in the form of class or classes when needed.

Third: Data Manipulation and Analysis Phase

It is represented in the change of pattern, level of the data, removal of the entry mistakes, data updating and making some calculating processes such as specification of the areas or spaces and determination of the buffers and fields of the elements.

Fourth: Data Display and Reporting Phase

The mission of this phase is represented in the display of all or some of the original data in a database in different patterns such as the compound maps, tables and manipulated data and the display of the modified data, graphics, pictures, videos and reports, in addition to the specification of the features, dimensions and calculating the spaces, areas and the spatial analysis where they are displayed on the screen, printer or on laser disk.

2.3.2. Using Geographic Information Systems in Measuring Sustainability Indicators (Shaikh Zayed City as Case study in the Gaza-Strip):

2.3.2.1 A General Background of Shaikh Zayed City [Elfarra, 2010]

Shaikh Zayed City project is located within the east borders of Bait Lahia town. Its total area is 527 donums (One hectare= 10 Donums=10000m²) and it contains 3700 dwelling units. The general planning of the project is based on the network system. The city was selected to be the case study of this paper because of its planning which took in consideration some of the sustainable urban planning basic principles. This makes the city the perfect case study to be measured by the indicators mentioned in the paper.

Components of the Sheikh Zayed:

70 Housing Buildings – 82 Towers - 9 schools - Municipality Building - police station – gymnasium - civil defense station – Mall - commercial buildings consisting of two floors (shops and offices, supermarket, post office , cultural centre, library and theatre) - a bank branch - health centre - Mosque and Qura'n Learning Centre - a public garden.



Figure (3): A sight view of a Street in the City ending with the mosque as a sight feature distinguish for the city

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Figure (4): The general plan of the city showing the services buildings, towers, buildings and future expansion.

Source: Ministry of Public Works and Housing, Gaza Governorates, 2010

2.3.2.2. Sheikh Zayed City and the Measuring Indicators [Elfarrar, 2010]

For calculating the measuring indicators the complete implementation and future city plan should be dealt in order to assess it by using the GIS (Geographic Information Systems). Therefore a certain mechanism should be put for measuring including the following:

- Taking all the components of the city plan as elements and layers by using ArcGIS 9.3 Software.
- Definition of layers and their definition in the ARCGIS 9.3 in accordance with the suitable coordinate system for Gaza-Palestine so that the results may be correct and true.
- Specification of the layers and data required for calculations and measuring. For example, specification of the areas for each layer and each building and specifications of levels of the income, water permeable materials and others.
- Carrying out the required analyses for calculations including the spatial, and attribute analyses in accordance with the weight coefficient of each indicator as shown in table (3).
- Display of results and conclusions.

First: Measurement of the movement of vehicles and Pedestrians indicator:

To measure the movement indicator it was focused on knowing the housing buildings connected with the daily activities services (mosque – school-clinic-public garden – commercial center – office buildings) located in the project and which are only 250 meters from the dwelling units.

By using the GIS (geographic information systems) it was possible to identify the services available in the Sheikh Zayed city within Buffers zone of 250 meters radius circles which each circle covers the conception of the sustainable urban planning. Then, the ArcGIS 9.3 were used to determine the number and places of the housing units covered with services . Then the specifications of the various circles intersection areas to specify the dwelling buildings which are completely covered by all the daily services, and then determine their percentage to the whole housing buildings to determine the scopes of achievements of the movement indicator and the scope of achieving justice in the distribution.

The following table (4) shows the housing buildings (Buildings and Towers) in terms of the number and the percentage of them covered by the primary services in the project and they elicit the percentage of the coverage of all the buildings with the daily services in the city.

Total of the housing units covered from the 3688 units	The percentage of the housing towers covered (%)	The percentage of coverage Of the 5 flours building (%)	The no. of housing towers covered by the scope of service	The no. of housing buildings of 5 flours covered by the scope of service	Total no. of housing towers 2988 Apartment	The total no. of housing building 5 flours 700 Apartments	Services
1238	28	58	23	41	83	70	Mosque
3688	100	100	83	70			Schools
1380	30	68	25	48			Commercial
1818	46	64	38	45			Garden
1036	25	40	21	28			Courts
1418	34	58	28	41			Cultural
2536	61	100	51	70			Administrative
384	8	34	4	24			Health
1218	28	56	23	39			Bank
1635	Average number of the housing units						


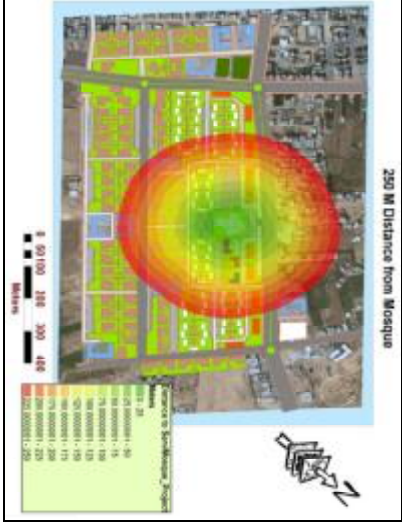

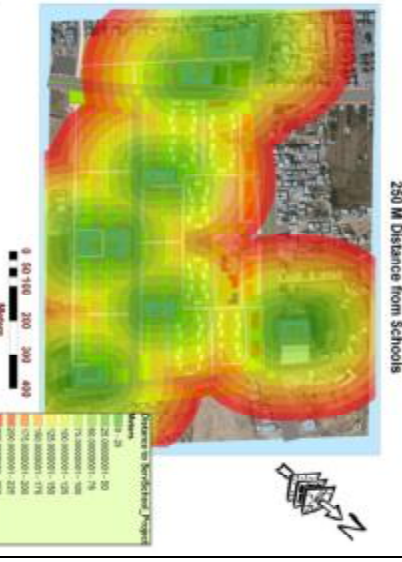
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covered by the primary services		
40%	64.2%	The percentage of the kind of each housing building according to the scope of service
56%		The total percentage of the buildings covered by the primary services

Table (4): shows the housing units in terms of the number and percentage of them which are covered by the primary services in the project and then the scope of achievements of the movement measuring indicator.

Table (4) and Figures (6-7-8-9-10) show some remarks as following:

- It is possible to reach the mosque from about one third of the housing units established in the projects after walking a distance not to exceed 250meters.
- The schools according to the previous distribution shown in the maps cover all the housing units and the distance walked does not exceed 250 meters from any housing unit to the school.
- The commercial services and the bank cover one third of the housing units in the project and within a service area of 250 meters while the cultural services and the public garden cover about one half of the housing units in the project within the same area of service .
- The health services are located at end of the project and do not cover the housing properly against which is required from it.
- The total percentage of the housing buildings covered by the primary services in the project is 56%. by calculating the number of housing units covered by the primary services, they were about 1635 housing units. This percentage shows that the major part of the inhabitants is not provided with the primary services, and this can be attributed to the fact that some of the services are located at the end of the project.
- It is noticed that the distribution of the services in the city aimed at achieving justice to some extent, though it failed in some of the important services. It is necessary to point out here that the services were centered in the city plan besides the housing buildings (Which have less housing units) and accordingly they were far from the towers which have more housing units) and which caused a decrease in the number of the covered units as it is shown clearly in the analysis and the previous table. This interprets the low percentage and number of the covered units.

 <p style="text-align: center;">Residential Buildings Covered by Mosque</p>	 <p style="text-align: center;">250 M Distance from Mosque</p>
<p>Figure 7: Residential building covered by mosque</p>	<p>Figure 6: Buffer Zone of 250 meters for Mosque</p>
 <p style="text-align: center;">Residential Buildings Covered by Schools</p>	 <p style="text-align: center;">250 M Distance from Schools</p>
<p>Figure9: Residential building covered by school</p>	<p>Figure 8: Buffer Zone of 250 meters for Schools</p>

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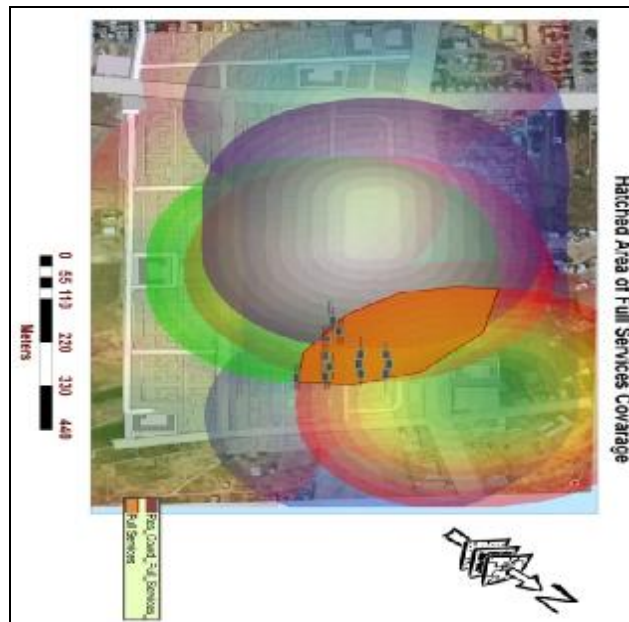


Figure 10: Area Building Covered by all services
Second: Measurement of the Achievement of the Mixed Usage of the Land indicator:



Figure 11: Aerial Photo rectified by coordinate system with required data

This indicator can be measured by studying the areas allocated for each activity, service or usage of the land of the project. Then they should be analyzed and results elicited represented in the percentage of each usage. Then they will be compared to the percentage of the usage of the land in

some the international studies to know the scope of identification and accord between them.

The following table shows the percentage and area of each usage of the land of the project:

Percentage	Area (M2)	land use
18,03	111654,3	Main streets
7,41	45882,29	Inside streets
15,14	93764,08	Pedestrian streets
5,40	33433,32	Parking lots
0,62	3811,87	Health Service
0,11	666,43	Bank
0,11	711,3	Qura'n learning house
0,09	583,73	Civil defense
0,09	583,73	Police station
0,20	1268,05	Cultural Service
0,57	3510,63	Public Garden
0,60	3719,07	Mosque
0,43	2643,57	Bus station
1,37	8466,26	Administrative buildings
0,72	4461,73	Commercial Center
7,70	47700	Schools
0,87	5357,7	Courts
5,52	34200	Housing towers
3,60	22325	Housing buildings
4,15	25700	Paved areas
27,27	168853,85	Landscapes
100,00	619296,93	Total

Table (5) shows the areas and the percentages of the land use in Sheikh Zayed City

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Table (6) shows the percentages of the land usage in Sheikh Zayed City comparing it with the usage percentage of Gong Tan City in China and Masdar city in UAE.

Percentage of proximity achievement	Average of DTC and Masdar	Percentage			Land Usage
		Sheikh Zayed City Gaza	Masdar City UAE	Dong Tan City - China	
96.3%	41.5%	40%	38%	45%	For housing and residence open spaces
40.7%	27%	11%	30%	24%	Work and search
64.2%	31.5%	49%	32%	31%	Services marketing and roads
67%	The total percentage of the achievement of the land usage indicator				

Table (6) Comparison among the percentage of the land usage in Dong Tan city, Masdar and Sheikh Zayed Cities.

According to the previous tables (5; 6); some remarks can be deduced as following:

The land usage percentages were divided in an unfamiliar manner (housing-services-landscapes – roads) because the percentages are connected with the two study cases shown in the table and because their percentage are not available in a minute manner which allows precise comparison .

There is almost 96% among the three cities shows that the land allocated by sheikh Zayed for work and search is little in comparison of what was expected to be allocated according to the two other cities (Dong Tan city, Masdar city). This affects other criteria pertaining to sustainability such as the need for more movement between the job site and the residence place and this contradicts the principles of sustainability which endeavors to reduce the movement, effort and time spent in them through a approximation of the work sites to the housing and residence places.

Sheikh Zayed city achieved more progress in terms of services, marketing, roads and landscapes than the two international models though this was at the expense of the allocation of the places for work and search. In general the city achieved 67% of the indicator of the mixed land usage.

Sheikh Zayed city achieved more progress in terms of services, marketing, roads and landscapes than the two international models (see table though this was at the expense of the allocation of the places for work and search .In general the city achieved 67% of the indicator of the mixed land usage.

As the same analysis, it is possible to arrange all indicators (Measuring of the Purchasing Power to Buy a Housing Unit; Measurement of Variety in the Housing Units; Measurement of the Vital Variety and Green Infrastructure Indicator)

3) Results and Recommendations:

3.1 Results:

- a. The Gaza-Strip is a small and limited geographic area which is suffering from many problems, the most of which is the high population density and the limited land and natural resources available .Therefore there is a real need to reconsider the ways of developing and planning the civic environment in it to maintain the natural environment and its ability to give and renew its self on a continued basis.
- b. The sustainability and urban planning conceptions are considered the best ways, methodologies and strategies which may be adopted to preserve the Gaza Strip in a manner that preserves the rights of the coming generations.
- c. The study focused on five of indicators which are vehicles and pedestrian movement measurement indicator, purchasing power measurement indicator to buy housing units, mixed land usage measurement indicator and the green infrastructure and vital variety measurement indicator. These five measurement indicators are considered foundations and broad lines which can be followed to achieve a sustainable urban planning.
- d. The weight of each of the five indicators mentioned previously through the questionnaire with the study which concluded by determining a certain weight for each measurement indicator according to the view of the sample.
- e. The sample of the questionnaire is a random sample selected from several academic institutions and also Government institutions like the Ministry of Public works and Housing, the Ministry of Local Government.
- f. The questionnaire determined the weight of each measurement indicator as the result of the questionnaire showed that the measurement indicator connected with determining the purchasing power of the inhabitants to buy housing units was the most important of the five indicators at all. Equal to it in importance green infrastructure and vital variety

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measurement indicator followed by the vehicles and pedestrians movement measurement indicators then the mixed land usage indicator. The indicator which was less important was the variety in the housing units measurement indicators.

- g. The Geographic Information Systems technology became a tool decision which cannot be ignored in all fields of life and may be used in the field of sustainable urban planning.
- h. The plan of Sheikh Zayed City Project was analyzed as a case study of a housing project carried out inside the Gaza-Strip. The analysis concluded that the project is a good example on which the measurement indicators can be applied by using the technologies of the GIS geographic information systems as it meets the requirements of many of these indicators taking into consideration that the project is carried out as a modern planning method which can be adopted and improve it to be a reference for any future planning project that can be carried out in the Gaza-Strip.
- i. The current study was limited to five indicators that have been tackled from various perspectives. Therefore, they can be studied and developed later. Issues that can be examined are, for example, the relations between planning and the social, cultural, and physical dimensions and the impacts of having the social centre in the middle of the neighborhood...etc in addition to linking green areas with residential units in the project.

3.2 Recommendations:

- a. The need to adopt the principles of the sustainable urban planning as a way out and solution of the severe problems facing the Gaza-Strip and trying to find a solution which accords with it in a way that preserves the rights of the coming generations to live in dignity in the future .
- b. The need to benefit from the international experiments in the field of sustainable urban planning to build on the experience of others in a manner that may serve the Gaza strip.
- c. The latest technology available such as GIS must be exploited, for it provides accurate and advanced analyses saving cost and time.
- d. Future Studies can attempt to find other indicators than the five mentioned in this study, such as indicators for the use of renewable energy, indicators of the negative zero impact on the environment.

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