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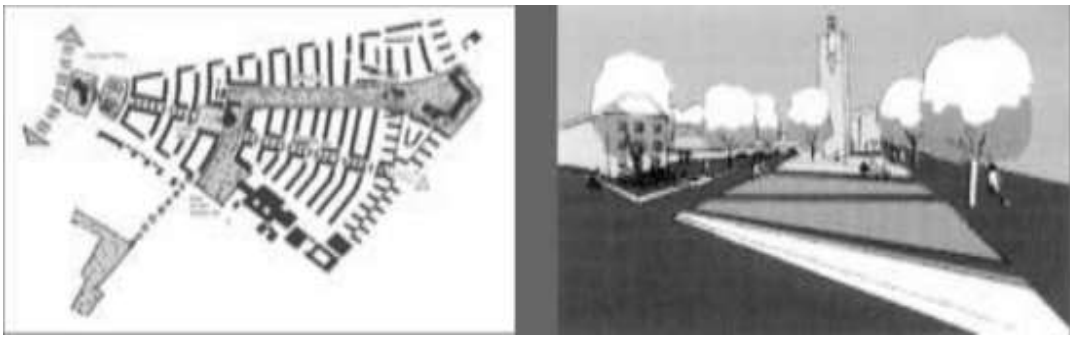

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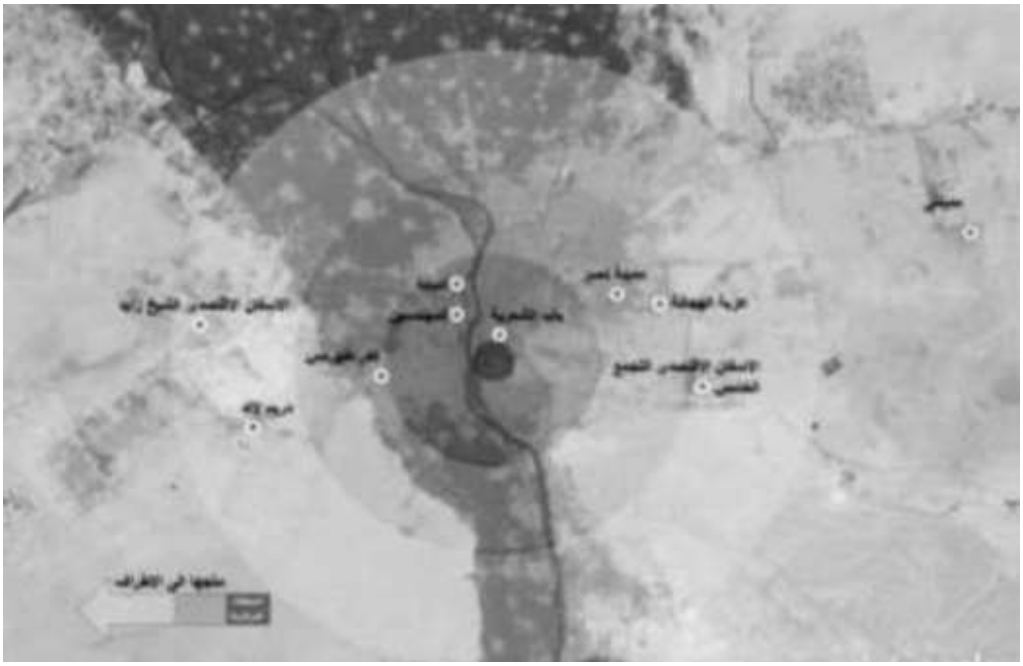

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Planning For An Eco-City To Sustainable Urban Environments
International Case Studies

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ABSTRACT

An eco-city is a city designed and built with a thorough consideration of environmental impacts. In eco-cities, inhabitants are dedicated to minimizing required inputs of energy, water, and food and to reducing waste outputs of heat and pollution. This paper examines how eco-city theory is applied in urban planning and design. The eco-city concept was introduced, international case studies on the eco-cities in developed countries were explored using case study methods to determine the application of eco-city concepts and theories, and a set of recommendations for converting Cairo, Egypt into an eco-city were formulated. Results showed that the eco-city concept can be effectively applied in combination with the characteristics specific to a locality. The study concludes that eco-city theory can be effectively applied in urban planning and design.

KEY WORDS: Eco-city, Green transportation, Renewable energy, Community participation, Cairo.

ملخص البحث

المدينة البيئية/ الايكولوجية هي المدينة التي صممت وبنيت مع الأخذ في الاعتبار الآثار البيئية. فهي تعتمد على التقليل إلى الحد الأدنى من المدخلات المطلوبة من الطاقة، والمياه، والغذاء، والحد من مخرجات النفايات من الحرارة والتلوث. من ذلك تركز هذه الورقة على كيفية تطبيق مفهوم المدينة الايكولوجية في التخطيط والتصميم العمراني. من خلال دراسة حالة لبعض التجارب العالمية التي طبقت هذا المفهوم، لتحديد كيفية تطبيق المفاهيم والنظريات المختلفة للمدن الايكولوجية على الواقع المصري. وخلصت الورقة إلى مجموعة من التوصيات لتحويل القاهرة إلى مدينة ايكولوجية. وأظهرت النتائج أن مفهوم المدينة البيئية يمكن تطبيقها بشكل فعال عند تكامل الخصائص المحددة لهذا الفكر. وتخلص الدراسة إلى أن نظرية المدينة الايكولوجية يمكن تطبيقها بفعالية في عمليات التخطيط والتصميم العمراني

1 INTRODUCTION

Rapid urbanization is arguably the most complex and important socio-economic phenomenon of the 21st century. It represents major and irreversible changes in production and consumption and in the manner by which people interact with nature. Only recently have cities and the urbanization process been viewed through the lens of sustainability, with the reduction of the ecological footprint of a city regarded as a positive contribution to sustainability. This research focuses on the eco-city concept and aims to facilitate the conversion of Cairo into an eco-city in terms of urban planning and design.

2 RESEARCH PROBLEM

The world is becoming increasingly urbanized, with more than half of the global population living in urban areas. The number of urban residents is expected to continue to grow, especially in developing countries. Such expansion will require a wide range of infrastructures, services,

housing and employment schemes, and land for development. Urban land expansion can threaten land supply, increase traffic volume and pressure on the environment, and result in massively unsustainable efforts for any city. These issues give rise to the urgent need to act on a number of indicators that have reached critical levels, notably greenhouse gas emissions, water pollution, and biodiversity. So that, cities are in need to apply the concept of eco-cities. Therefore, the paper aims to answer the following questions:

- What is the concept of an eco-city?
- How can cities initiate and accelerate their ecological transition under difficulties that confront the current context?
- How can cities contribute to the deployment of global and local solutions to these challenges?

3 RESEARCH OBJECTIVES

The main aim of this research is to pose recommendations regarding the conversion of Cairo city in Egypt from an unsustainable city into an eco-city, especially in terms of urban planning and design. To this end, the following objectives are considered:

- To build a viable future for humanity within a healthy environment;
- To promote sustainable living and zero carbon development;
- To involve conceptual thinking in environmental urban sustainability;
- To establish a livable and sustainable urban environment;
- To develop the visual image of Cairo by highlighting the importance of the eco-city concept.

4 RESEARCH METHODOLOGY

The study explores the eco-city concept from theoretical, analytical, and practical viewpoints for the purpose of sustainability. It seeks to identify the basic features of eco-cities. It also analyzes how the concepts presented in international case studies were developed and explores a practical approach to building sustainable cities. Finally, it uses the eco-city concept as basis in formulating a set of recommendations for developing the urban environment in Cairo.

5 THE ECO-CITY AS AN APPROACH TO SUSTAINABLE URBAN DEVELOPMENT

5.1 Definition of Eco-City

“An eco-city is an ecologically healthy city. It is a city built off the principles of living within the means of the environment. The ultimate goal of many eco-cities is to eliminate all carbon waste, to produce energy entirely through renewable sources, and to incorporate the environment into the city; however, eco-cities also have the intentions of stimulating economic growth, reducing poverty, organizing cities to have higher population densities, and therefore higher efficiency, and improving health” [1]. This “also means the city design is strongly informed by knowledge of ecology and its design principles” [2]. “Then we can say that an eco-city is an ideal

habitat with a benign ecological circulation in which technology and nature fully merge; human creativity and productivity reach a maximum level; the residents' health and environmental quality are well protected; and energy and materials are efficiently used" [3].

Finally, an eco-city is a city designed with consideration for environmental impacts and is inhabited by people dedicated to minimizing required inputs of energy, water, and food and waste outputs of heat, air pollution, and water pollution. "The eco-city is also known as eco-community, sustainable human community" [4].

5.2 Objectives of an Eco-City

Urban planning and design for eco-cities are driven by a number of objectives; to "promote urban transportation system reform that encourages the integration of efficient public transit systems and non-motorized modes (pedestrian and bike paths) and build strong capacity for sustainable urban planning and development through training programs" [5] and community participation.

Besides that, eco-cities aim to "support implementation of green buildings, green transportation, and zero waste plans. As well, help us clean our air, reduce our carbon footprint, lead toward a stable climate future and reduce emissions of greenhouse gases to achieve environmental sustainability. Moreover, eco-cities promote energy efficient through the use of renewable energy sources in urban design operations, enhance waste management to reduce consumption of natural resources, reduce the light pollution through the applications of solar lighting in urban design, maintain water quality standards and an above-average ratio of green space per capita and develop an urban ecosystem which is ecologically sound minimizing the negative impact of development on the environment" [6].

6 ANALYSIS (CASE STUDIES ON ECO-CITIES)

This section discusses some international case studies in which the eco-city concept was applied. The following cities are the most eco-cities in the world; (Vancouver-Masdar-Toronto-Curitiba- Freiburg-Stockholm-Frankfurt-Portland). The aim of this section is to determine the ecological considerations of each case.

6.1 Vancouver [7]

Vancouver is proof that a city can grow and still become an eco-city, as evidenced by its implementation of the greenest building code in North America. Vancouver addresses the challenge of green transportation by infusing investments into endeavors that encourage walking, cycling, and the construction of transit infrastructures instead of new roads. Neighborhoods are developed under renewable energy projects. Vancouver's Eco-city 2020 Action Plan is a strategy for staying on the leading edge of city sustainability, and its target is to reduce Vancouver's ecological footprint. The ecological considerations for urban planning and design in Vancouver are as follows:

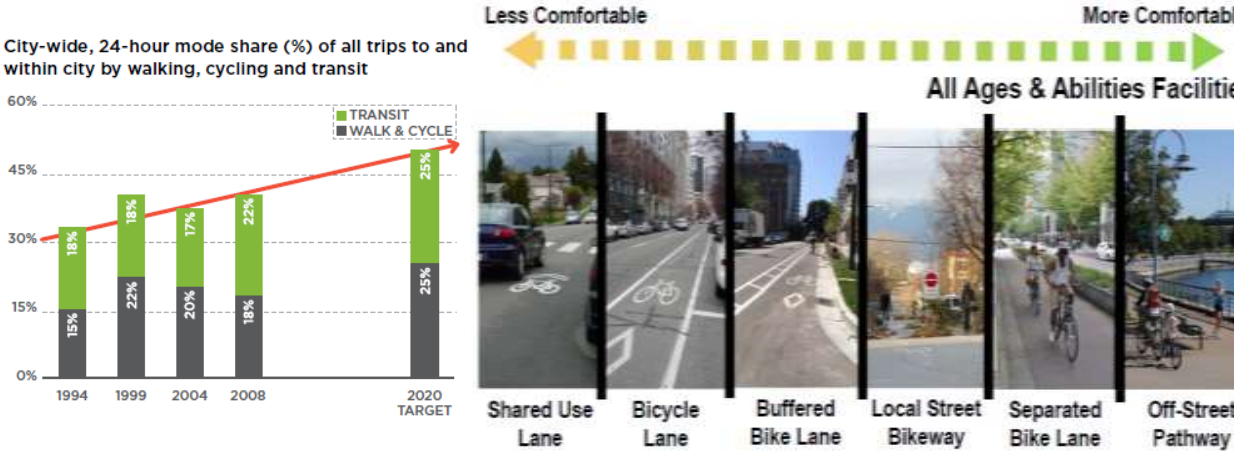
-*Community participation:* The city implemented the community participation concept. Many people contributed their time and ideas to the development of the Eco-city 2020 Action Plan. More than 35,000 people from around the world participated in the process online, specifically through social media, and in face-to-face workshops. More than 9,500 people, most of whom are residents of Vancouver, actively provided recommendations and feedback to help the city determine the best path for achieving the targets delineated in the action plan.

- *Green buildings*: Policy in Vancouver requires that all buildings constructed from 2020 onward be carbon neutral in operations. The city is leading the way in terms of green building design. Its next challenge is to improve the environmental performance of existing building stock by focusing on insulation, heating, and lighting system upgrades and on the use of energy-efficient appliances. All new building re-zoning schemes in Vancouver should comply with the construction industry's LEED.

- *Green transportation:* Green transportation includes transit, cycling, and walking. Support transportation and active transportation planning that are grounded on land use policies enable a city to satisfy mobility while improving pedestrian safety. Support technologies and infrastructure also reduce the environmental impact of vehicles. Vancouver needs to achieve green transportation targets in order to satisfy its 2020 goals for climate leadership, light footprint, and improved air quality. See figure 1.

- *Green spaces:* By 2020, all Vancouver residents should live within a five-minute walk to a park, greenway, or other green space. Green spaces benefit residents' physical and emotional health by reducing blood pressure and stress. These spaces also contribute to a sense of community by creating places for recreational activities, for children to play, and for neighbors to meet. The highest priority actions are as follows: (a) Four to six new mini-parks should be constructed by converting street rights-of-way into parks. These parks will be developed in consultation with the local community to determine their use as community gardens, plazas, or community yards. (b) New parks should be constructed in priority neighborhoods and (c) 15,000 new trees should be planted on city land.

Fig (1) The green transportation concept in Vancouver [7].



6.2 Masdar, Abu Dhabi [8]

Masdar city relies entirely on solar energy and other renewable energy sources to ensure a sustainable, zero-carbon, and zero-waste ecology. To achieve the city's goal of being one of the most sustainable cities in the world, every aspect of the city's urban planning, design, and architecture has been approached with sustainability in mind. In what follows, the applications of integrated photovoltaic technology in urban design are discussed.

-*Masdar Plaza:* The neighborhood of Masdar Plaza is characterized by distinct buildings. The plaza also has 54 automatically opening and closing sunshades with photovoltaic cells.

-*Masdar streets*: Streets are laid out at angles that optimize shading. The long and narrow angles cool prevailing winds and facilitate ventilation in the city (Fig. 2A).

-*Masdar, pedestrian friendly:* Street infrastructure for pedestrians enables the construction of buildings that are closer together, thereby providing considerable shading and cool streets.

-*Masdar, landscaping:* The planting areas in the Central Courtyard of the Masdar Institute are irrigated with recycled water (Fig. 2B), most water-based features are shaded to reduce water loss through evaporation, the air temperature in public spaces is reduced through the shading provided by buildings and through planting, to reduce water demand for irrigation, the plants and trees grown in Masdar are indigenous species and some waste wood is reused, whereas others are converted into mulch for use in landscaping around Masdar offices.

-*Masdar, sustainable materials:* The sustainable materials used for Masdar Institute buildings should be locally sourced. In selecting these materials, the city considers sustainability factors, such as recyclability, low embodied energy properties, and low-emission properties.

-*Masdar, landmarks:* The wind tower circulates wind to ventilate a public square at its base. The air is cooled by water sprays, wind cones provide natural ventilation and photovoltaic panels power buildings and provide shade that cool roofs (Fig. 2C).

-*Masdar, transport:* An electric light rail system for the city will reduce energy output and emit no carbon gases. Masdar will be using an automated system of electric vehicles and a public transport system that comprises electric buses, electric cars, and other clean-energy vehicles.

-*Masdar, energy management:* Masdar city is powered by renewable energy; The Solar Photovoltaic Farm provides clean energy to the Masdar Institute Campus. The photovoltaic array atop campus buildings helps provide 30% of the base electrical load of the campus. Raised above the laboratories and residential apartments, it also helps provide additional shading to the streets while reducing the amount of direct solar gain absorbed by the heavily insulated roofs.

-*Masdar, urban character:* The structure of the residential façades was influenced by the use of sand as aggregate for glass reinforced concrete, which provides the cladding its distinctive color

(Fig. 3). The marriage of traditional Arabic building practice and modern technologies satisfies demands for style, adaptability, and flexibility while maintaining a sustainable footprint.

Fig (2) Masdar city, Sustainable Development:
a) Streets in Masdar City [8]
b) Landscape in Masdar City [8]
c) Wind Tower in Masdar City [8]

Fig (3) Masdar city,
The form of the residential elevations [8]

6.3 Toronto [9]

Toronto is the highest rated eco-city in North America. Similar to the previously discussed cities, it seeks to transition into a low-carbon economy. To this end, it adhered to some criteria for eco-cities; it reduced energy consumption and reliance on carbon-based fuels, it manages stormwater from rain and snow fall and it supports green building design and construction. Besides that, its pedestrian infrastructure is intended to achieve sustainability at the streetscape level through the use of high-albedo surface materials for at least 50% of a site's nonroof hardscape and reducing the effects of urban heat islands. Moreover, it adheres to design guidelines for greening surface parking lots, it enhances ecology and the natural environment, it plants a minimum of one tree onsite for every 30 m^2 of a post-development area covered by soft landscaping and it constructs green roofs (eco-roofs).

6.4 Curitiba, Brazil [1]

The city of Curitiba, Brazil proactively addressed the challenges that confront the establishment of an eco-city with a master plan that outlines future integration among urban development, transportation, and public health. This plan was realized in modern Curitiba, which is defined by linear stretches of urban development surrounded by green spaces and low-density residential areas. The city was designed for the mobility of people, not the mobility of cars.

Curitiba maintains the lowest air pollution rates in Brazil and more than 300,000 trees in the city reduce natural flooding. Curitiba has maintained a consistent vision of the future and has

worked to attain this goal through careful urban planning that considers transportation while encouraging environmental and public health initiatives. In 2010, Curitiba was conferred the Globe Eco-City Award for its achievements and its understanding of sustainable city development – both regarding policy and implementation.

6.5 Freiburg, Germany [10]

Freiburg, Germany constructed itself as an eco-city by actively committing to its targets for energy, transportation, and its three pillars for sustainable development: energy saving, new technology, and renewable energy sources. One of the largest drivers of the city's success is citizen engagement; local power opposition led to the creation of a campaign for sustainable solutions to the energy needs of the city. A network of environmentalists and research organizations was established to advance the agenda for a sustainable city. In terms of ecology and economy, Freiburg has been extremely successful in conducting research on and marketing renewable energy. In addition to solar initiatives, improvements to the transportation systems of Freiburg have been made over the last four decades. The city is known for its huge pedestrian zone in the city center, where no cars are allowed. By 2030, the city resolves to cut carbon dioxide emissions by 40%, and by 2050, it aims to be a climate neutral environment. For these reasons, Freiburg is known as a green city. For more than 20 years, it has maintained public parks, guided by principles that encourage working harmoniously with nature. The city is also evaluated as a sustainable model district. All the houses are built for low energy consumption, and the entire district is designed to be car free (Fig. 4). Environmentally compatible modes of transport, as indicated in the traffic prevention strategy, are underpinned by the encouragement of transport modes that harmonize with urban life and the wider environment. These modes include walking, cycling, and the use of local public transport.

Fig (4) Freiburg,Solar power plant on the roof of the Badenova Stadium and Solar Settlement [9

6.6 Stockholm, Sweden [1]Stockholm in Sweden has been an environmentally focused city that is re-developing itself into an eco-city through efficient urban planning and resource use. Stockholm has established six environmental goals that fall under the umbrella called Vision 2030; these goals include the development of efficient transportation, the use of sustainable energy, the promotion of efficient land and water use, the implementation of waste treatment improvements, and the use of safe building and product materials. Beyond Vision 2030, Stockholm intends to be fossil fuel free by 2050.

In terms of urban planning, Stockholm currently requires the re-use of land before urban sprawl can continue. The Hammarby district of Stockholm has become twice as energy efficient as the rest of the city after an environmentally focused re-development. “Stockholm has pursued green development and optimization of urban systems. These efforts deemed Stockholm the European Green Capital for ‘leading the way towards environmentally friendly urban living’” [11]. “Stockholm is known for its extensive parks and green space, Sweden’s third-largest city is a model of sustainable urban development. With the goal of making the city an eco-city, several neighborhoods have already been transformed using innovative design and are planning to become more socially, environmentally, and economically responsive. The flat roofs on buildings are being converted into gently sloping roofs with integrated solar cells, to produced energy” [1].

6.7 Frankfurt

Frankfurt is home to the world’s highest skyscraper. “The Commerzbank Tower in Frankfurt is a symbolic and functional, green building. Though it has climate control, it uses a natural ventilation system for reducing energy consumption, something which makes it the world’s first ecological skyscraper”. “Its special construction feature, the facade has two shells for the air to freely circulate between them. Another special feature was added, the building is supplied entirely with green electricity, skyscraper’s gardens provide additional ecological touches, three each of them are situated in the east, south, and west of the building and offer ideal climatic conditions to the various plants” [12].

6.8 Portland, Oregon, USA

Portland is the first US city to enact a comprehensive plan for reducing CO2 emissions and has aggressively advanced green building initiatives. It also runs a comprehensive system of light rails, buses, and bike lanes to help keep cars off the roads and boasts of 92,000 acres of green space. “The goal is to move toward zero. Traffic-related fatalities “make walking and cycling safe, convenient, comfortable, and fun, and pedestrian improvements through development (street trees-wider sidewalks-bike signals- pedestrian friendly buildings)” [13].

“One of Portland’s flagship projects for green building is the Oregon Sustainability Center (OSC) in 2013; the center was “the greenest high-rise ever built,” going beyond the design qualifications for LEED certification. The OSC was planned to fulfill the requirements of the Living Building Challenge: As a “net-zero” building, it was carbon-neutral, produce as much energy as it used and recycle wastewater onsite. The project is cooperating extensively with the Oregon University System—the seven state universities—and will act as a laboratory for testing green design ideas. Portland also remains on the sharp end of eco-friendly transportation models. The city has over 315 miles of developed bikeways; as of 2010, Portland had the highest percentage of bike commuters in the country” [14].

7 CRITERIA FOR BUILDING ECO-CITIES

On the basis of the examined international case studies, the most important criteria for moving toward becoming an eco-city were identified. These criteria are listed in the following.

7.1 Economic Criteria

The economic criteria can be satisfied through "resource conservation by maximizing efficiency of water and energy resources, constructing a waste management system that can recycle waste and reuse it and creating a zero-waste system, decreasing material consumption and increasing awareness of environmental and sustainability issues. Over that, the movement away from carbon-producing energy sources to more renewable energy sources, such as wind, water and solar power, and public transportation system that makes the priority methods of transportation as follows possible: walking first, then cycling, and then public transportation" [12].

"Eco-cities look to design buildings with natural ventilation systems; eco-cities reduce the need for air conditioning, thus, drastically decreasing commercial and residential energy use" [1].

7.2 Environmental Criteria

"Eco-cities employ vertical landscaping, as methods of decreasing the environmental impact of land use. Additionally, vertical landscaping lower urban temperatures and help prevent the heat island effect allows for rainfall collection" [1] and "conserve energy through energy-efficient landscaping" [15]. This approach includes the following measures: "planting trees for the purpose of providing shade, which reduces cooling costs; green roofs that cool buildings with extra thermal mass and evapotranspiration; reducing the heat island effect with high albedo paving, shade, and minimizing paved areas; site lighting with full cut off fixtures and high efficiency fixtures" [15]. Furthermore, eco-cities look to employ renewable energy sources, such as wind turbines and solar panels, to reduce emissions.

7.3 Social Criteria

An eco-city should be designed with lively spaces where people can see and be seen by other people. The image of the city and its attractiveness to visitors depend, to a large extent, on its street and open space life. A social eco-system must achieve distributional equity and adequately provide social services. "Urban developments in order to be socially sustainable should create a harmonious living environment, reduces social inequality, townscape design, preservation of local characteristics and improves quality of life in general" [16].

7.4 Urban Criteria

At the urban level, eco-city criteria aim at restoring ecological continuity through the application of the factors discussed in the previous sections, aside from focusing on the ecological trends in building and urban environment design. These trends include the promotion of energy efficiency in buildings, building re-use, reduced water use, and access to

public spaces and community walkability, in addition to the "preservation of local characteristics and heritage items" [17].

Moreover, an "eco-city can achieve sustainable transportation through the use of renewable resources, minimizing consumption of non-renewable resources, reusing and recycling its components, reducing carbon emissions on all transport modes" [18], and optimizing the use of electric vehicles, completed streets, and sustainable transportation infrastructure.

An eco-city can achieve water efficiency through the application of water-sensitive urban design, which pertains to "a land planning and engineering design approach which integrates the urban water cycle, including stormwater, groundwater and wastewater management and water supply, into urban design to minimize environmental degradation and improve aesthetic" [15].

8 CASE (PRACTICAL) STUDY ON CAIRO, EGYPT

First, this section documents the most important problems that confront the urban environment in Cairo. These problems impede the transition of the city into an eco-city. Second, it presents the set of future recommendations that were formulated on the basis of the sustainability framework for establishing a more ecological urban environment in Cairo.

Objective: This section discusses the promotion of sustainability and attractive solutions that contribute to the transition of Cairo into an eco-city.

8.1 Documentation Of The Problems Confronting Cairo's Urban Environment

Cairo is experiencing problems that prevent its transition into an eco-city.

8.1.1 Urban Problems

Fig (5) Traffic congestion in Cairo

(Ref.:19)

Cairo is a historical city; it is an ancient urban region and a center for culture and civilization. The city currently suffers from numerous urban and environmental problems, such as deteriorating urban design and physical character, high population density due to rapid urbanization, environmental pollution from old vehicles, traffic congestion

Caused by poor transport distribution, and an unsustainable urban transportation infrastructure. The unsustainable streetscape operation equally contributes to the degradation of Cairo's urban environment (Figs. 5). This degradation is caused by congestion, especially in the downtown area, and by the unexpected overlap in the envisioned political, commercial, and administrative uses of urban spaces.

8.1.2 Economic Problems

Cairo suffers from many of the economic problems. These problems are manifested in the some aspects such as; Lighting in most of the streets is energy inefficient, the “sky glow” produced by the over-illumination of urban areas negatively affects energy consumption, unsustainable materials are used for streetscape operations and photovoltaic applications in urban design and wind turbines or solar panels are lacking.

Besides, Cairo lacks waste management initiatives. “In 2002, international waste management companies started operations in Egypt, particularly Cairo, Alexandria and Giza governorates. However after ten years of participation in solid waste management in Cairo, their performance has been dismal. In 2009 Egyptian government acknowledged that solid waste management has deteriorated alarmingly after the entry of foreign companies”.

Over that, slums abound in scattered areas, buildings are in bad condition, and very narrow streets are constructed. Many areas cannot be provided with efficient infrastructure

(Waste management/disposal, water supply, electricity) (Fig. 6).

Fig (6) Urban image degradation in Cairo

Informal settlements in Cairo

Non-reflective the historical and cultural context

(Ref. : Google Earth)

Waste management

8.1.3 Social Problems

Cairo lacks urban parks that should preferably be situated in the heart of the city to connect all urban spaces. This deficiency impedes accessibility, prevents the construction of lively spaces, and negatively affects the health of the residents. Most urban spaces are constructed without consideration for the principle of liveliness and most pedestrian sidewalks and vehicle lanes are inadequately separated, and no seating elements are provided in transportation stops.

Besides, community participation is not a component of urban design development processes. And the construction of buildings that do not conform to sustainability principles disregards the architectural character of a place, thereby negatively affecting the city’s identity and sense of place and culture. The city is characterized by deficient social equity, which is due to the poor distribution of urban open spaces, especially child-oriented spaces.

8.1.4 Environmental Level

Cairo suffers from many environmental problems, but the primary challenge that confronts the city revolves around ecological problems. Cairo is heavily polluted by emissions from car exhausts, inefficiently managed garbage disposal, and agricultural waste burning. Additional problems include stormwater planters play an important role in sustainable urban design because these minimize stormwater runoff, yet the city does not employ such tools. The River Nile is polluted with large quantities of industrial, agricultural, and domestic wastewater and the heat island effect increases because of the shortage in green roofs in most buildings. This increase, in turn, negatively affects the air quality and image of the city.

9 RECOMMENDATIONS FOR CONVERSION OF CAIRO CITY IN EGYPT INTO AN ECO-CITY

Reducing the Cairo's ecological footprint is essential to sustainability.

9.1 Urbanization Recommendations

At the level of urban problems, many methods can be applied. The cultural heritage of the region in terms of historical urban classification (which includes phases of growth, street network hierarchy and design, texture of building lots, land-use patterns) should be respected. A balanced residential, employment, and educational uses should be also organized. Walkable urbanism should be promoted through measures such as the construction of walkable streets and accessible open spaces.

In case of Egypt, for example, pathways should be designed as public spaces with highly sustainable streetscapes. Public events should also be geared toward promoting sustainability (e.g., activities that encourage walking/cycling and social control initiatives). Also, priority should be given to the public transport and mixed-use areas should be promoted. Additionally, land use should be characterized by a balance of residential, business, and production purposes (mixed used urban environment). This concept also refers for establishing a combination of facilities, such as public spaces to which green areas are integrated.

9.2 Economic Recommendations

The fact that the next generation of economy will be a "green solar economy" that depends on the maximization of renewable energy applications should be taken in account. Thus, the priority should be accorded to sustainable modes of transport (pedestrian lanes, cycling, public transport). The low energy consumption should be promoted through the adoption of renewable energy and water consumption should be minimized through the construction of rain gardens. Environmental-friendly and renewable materials should be maximized and the maintenance needs for such measures and material recycling should be reduced.

In case of Egypt, The use of green roofs, which improve energy efficiency, should be sustained. As it reduce the amount of energy needed to moderate building temperature. Lighting efficiency can be enhanced using passive solar applications and design not only in building

design but also in urban design. The recycling of resources within the city systems and the minimization of waste outputs (to protect the environment) should be incorporated through a national program and project depending on the national Egyptian labor capacities. A new set of policies that help sporting new green small industries will be needed.

9.3 Environmental Recommendations

Air pollution emissions as the main element affected the environment should be minimized through several actions. For example, sustainable transportation, the adoption of green roofs should be promoted as they will improve the aesthetic aspects of air quality, reduce the amount of stormwater runoff, minimize the urban heat island effect, and improve air quality in general. The consumption of energy and natural resources should be reduced. Thus, the energy efficiency of buildings and urban components should be optimized.

In case of Egypt, clean air quality should be improved by reducing traffic emissions, which forms a great part of the problem of air pollution and " heat island effect" in Cairo. Such reduction can be achieved by an integrated system of public sustainable transport to reduce adverse environmental health impacts, and establishing open and green spaces, such as public parks or planting greenery in streets and squares. People should be aware of environmental policies of waste management to reduce the consumption of natural resources. In addition, attention should focus on sustainable landscaping throughout the city to reduce wastage of water and electricity.

9.4 Social Recommendations

Generally, Community engagement should be supported and social live should be redesigned within urban development projects. The amount of parks, open and green spaces and recreational facilities should be increased to facilitate social contact. The accessibility, beauty, safety, and cleanliness of public spaces should be enhanced. Streets and urban spaces should be designed as lively spaces where people can participate social designed activities. In this real, the new policy of aiming at creating new open space and parks through the existing urban context of the greater Cairo such as "Embaba Airport Park" should be sustained.

The vision for eco-cities can become a reality only through implementation. On this basis, a necessary requirement is to apply the following policies, as seen in Table 1.

Table (1) The objectives of convert Cairo to an eco-city

policies of eco-cities	Eco-city criteria								
		Improve Air Quality	Improve Energy Efficiency	Promote Lively Spaces	Reduce Heat Island Effects	Reduce Light Pollution	Improve Water Quality/ Efficiency	Strengthen identity& Sense of Place	Economic Efficiency
	renewable energy applications		■						■
	renewable & reused materials		■		■				■
	Solar lighting		■			■			■
	green spaces & parks	■		■	■			■	

	green roofs								
	sustainable transport								
	sustainable Landscaping								
	waste management								
	Respect the cultural heritage								
	mixed use								
	Sustainable streetscape								
	Continuous Planting Strips								
	Bicycle Lanes								

Ref.: The author.

10 CONCLUSION

In recent years, cities all over the world have developed construction systems that incorporate the idea of creating urban environments that are more ecological and livable. The strategies adopted place considerable emphasis on achieving harmony between humans and nature as urban planning and design are carried out. The eco-city concept indicates that planning for sustainability translates to ecology-based community planning with the aim of conserving global resources.

This study developed a framework for moving toward a more ecological Cairo through the analysis of some international case studies that applied the eco-city concept. This paper has presented future recommendations that are specific to the Egyptian context; the recommendations revolve primarily around promoting sustainable transportation, providing attractive and livable public and green spaces, integrating cultural heritages to create varied surroundings, enhancing sustainable structures that contribute to the health, safety, and wellbeing of inhabitants, using renewable energy sources, and promoting community engagement.

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Redefining The Egypt Megalopolis

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ABSTRACT

Egypt has one of the most populous regions in the world. It's the Nile delta. This region has a lot of urban areas that ranges between metropolitan areas and small villages. In 1998, Tarek Abullatta concluded the possibility of the emergence of a megalopolis in Nile delta. This area extends between the two metropolitan areas of Greater Cairo and Alexandria. Meanwhile, new urban development plans and infrastructure projects were adopted and many of it had been executed. A great focus was given to developing the new cities especially those located near to the metropolises. In addition many projects of developing regional roads and increasing its capacities were progressed. Accompanied with continuing population growth at high rates, all this have resulted in urban sprawl that creating intertwined network of socio-economic relations between many adjacent human settlements in the region. This paper examines the existence of megapolitan area in Nile Delta region. It utilizes statistical tools to investigate the composition, boundaries and main characteristics of this agglomeration. It depends on data of 2006 national census. Finally, new boundaries that differ than what was previously proposed were settled.

ملخص البحث:

يعد إقليم دلتا النيل في جمهورية مصر العربية واحداً من أكثر المناطق تركزاً بالسكان والأنشطة في العالم. يضم هذا الإقليم مجموعة كبيرة من التجمعات العمرانية التي تتراوح ما بين القرى الصغيرة والمناطق المتروبوليتانية. في العقد الأخير من القرن العشرين، أظهرت بعض الدراسات احتمالية تكون تجمع عمراني ميجابوليتاني ضخم في الإقليم. وفقاً لهذه الدراسات يمتد هذا التجمع ما بين منطقتين متروبوليتانيتين هما القاهرة الكبرى والإسكندرية. ومن الجدير بالذكر، أنه منذ ذلك الحين تشهد جمهورية مصر العربية صياغة العديد من خطط واستراتيجيات التنمية العمرانية ومشروعات البنية الأساسية وتم تنفيذ مجموعة كبيرة منها بالفعل. كما شهدت هذه الفترة اهتماماً ملحوظاً بتنمية المدن الجديدة لاسيما في جوار القاهرة الكبرى والإسكندرية. ولقد تزامن مع ذلك أيضاً تنفيذ مشروعات لتطوير العديد من محاور الطرق الإقليمية وزيادة طاقاتها الاستيعابية. كل ما سبق بالإضافة إلى استمرار النمو السكاني بمعدلات مطردة أدى إلى ظهور امتدادات للتجمعات العمرانية في الإقليم في اتجاهات متعددة حتى كادت أن تلتحم كتلها العمرانية مع بعضها البعض. الأمر الذي ترتب عليه تكون شبكة علاقات اقتصادية واجتماعية شديدة التداخل والتعقيد بين سكان هذه التجمعات. يتناول هذا البحث دراسة تكون تجمع عمراني ميجابوليتاني في إقليم الدلتا بجمهورية مصر العربية وذلك من خلال توظيف وسائل التحليل الإحصائي المتطورة في استكشاف توفر الخصائص والسمات العمرانية والسكانية والاقتصادية للميجالوبوليس في الأقسام الإدارية بالإقليم. اعتمد التحليل على البيانات الإحصائية لأحدث تعداد سكاني رسمي في الجمهورية وهو تعداد عام ٢٠٠٦

1 INTRODUCTION

The Egypt megalopolis has been discussed in a limited number of researches. Actually, research work is much more theoretical without neither concrete numerical evidence nor comprehensive geographic analysis. In addition, rapid urban growth accompanied by multiple urban development plans and infrastructure projects have resulted in continuous urban sprawl and socio-economic changes in communities and this will affect the future of urban life.

The importance of studying the emerging of megapolitan area in the Nile Delta mainly comes from the context of this phenomenon. As the Nile Delta is the most important and largest agriculture zone in Egypt and the unplanned and uncontrolled growth of such huge urban agglomeration will threatened the sustainability of agriculture economy due to the negative effects on agriculture land, water canals and agriculture labor force. This may resulted in a national disaster.

This paper mainly targets to numerically investigate the emergence of megapolitan area in Egypt. If this achieved, then it will search for its composition, boundaries, structure and socio-economic characteristics. To achieve the previously mentioned goals, the paper depends on statistical analysis to find out the potential zones that have the characteristics of megapolitan areas. A set of variables were determined according to the characteristics and conditions of megalopolises. After gathering the required data for the study area cases, a data matrix had been created. Then two statistical analyses were applied. Factor analysis was used to investigate the effect of selected variables and cluster analysis was used to classify the study area cases into homogenous groups. The resulted groups were spatially represented on map in order to investigate the geography of candidates of megalopolis. If these candidates form a continuous chain of neighboring urban settlements, a megapolitan area will be existed. A discussion and analysis of results were progressed to determine the boundaries of the megalopolis and its main socio-economic characteristics.

2 LITERATURE REVIEW OF MEGALOPOLIS

2.1 Megapolitan Area Definition

Megalopolis (or megapolitan area) is a unique urbanization trend. It's an agglomeration of large number of urban settlements and suburban areas.

"…. very large polynuclear urbanized systems endowed with enough continuity and internal interconnections for each of them to be considered a system in itself."[i]

"….. a special urban organizational form after sophisticated interactions and integration with economic, social, cultural and political elements of urbanization processes."[ii]

"….. greater urbanized area developed by the gradual merging of many metropolises and cities into one urban system. Its population is calculated in the tens of millions" [iii]

Megapolitan area is created due to the continuous growth of both population and area of adjacent metropolises, cities, towns and suburbs. This is resulted in a huge urban system. That could be considered as a new functional region that is powerful and distinguished than other surrounding regions[iv]. Megapolitan area is considered to be a development hinge on the

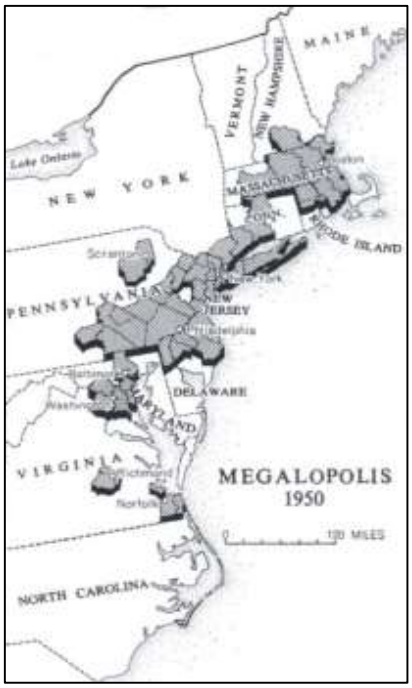
national and maybe on the international ones. It is the new form of urbanization in the twentieth century. It is a large region that its metropolitan areas have expanded so that it becomes mutually adjacent[v].

2.2 History of Megapolitan Area

The term megalopolis was used for the first time by Jean Gottmann (French Geography researcher[vi] who lived in USA) in 1957 through an article that was published in the Journal economic geography[vii]. This term was coined to describe a continuous stretch of urban and suburban areas for 600 miles approximately that extends between Boston and Washington with 30 million inhabitants[viii]. As a result, a new way of thinking about large-scale urbanization was introduced[ix]. **Error! Reference source not found.** illustrates the original map of the then newly emerged megalopolis as presented in Gottmann's original research.

In addition, Doxiadis in 1960s predicted the rise of interconnected broad urban complexes due to the continuous growth of urban settlements[x]. Until 1970s, only five megapolitan areas were examined around the world. These areas are the Great Lakes megalopolis in USA, the Tokaido megalopolis in Japan, the megalopolis of UK, the megalopolis of northwestern Europe and the China mainland megalopolis[xi].

Figure (1) **map of the first megapolitan area in the world, the Boswash megalopolis**



2.3 Main Characteristics

Megapolitan areas have many characteristics that determine its uniqueness. These characteristics are:

- High concentration rates of population in the settlements of the agglomeration. This results in high population densities than other surrounded areas. Jean Gottmann estimated this density to exceed 250 persons/km^2 on the average[xii].
- Abundance and Closeness of human settlements in the agglomeration. This entails more proximity between the components of the megapolitan area and resulted in intertwined network of social and economic relationships.
- Diversity in sizes, land uses and specializations of the settlements that existed in the agglomeration. A variety of landscapes of megapolitan areas is existed that makes the observers doubt the unity of its components[xiii].
- A magnet region, so that it is attracting people from all over the nation[xiv].

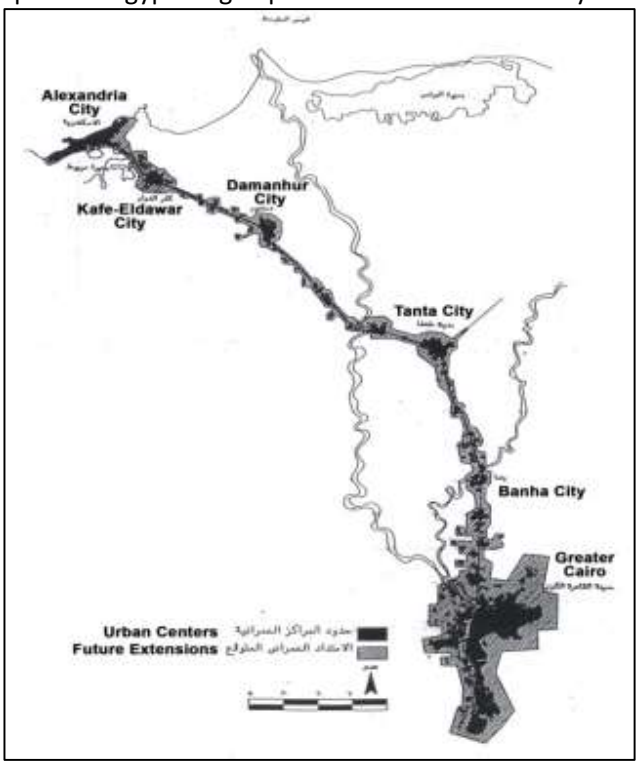
2.4 Main Conditions

Specific conditions have to be achieved in order to list urban agglomeration as a megapolitan area. The first condition is the concentration of inhabitants in agglomeration settlements that exceeds 25 million inhabitants[xv]. It's worth mentioning that some previous studies determined this number as 10 million, but this led to consider sole large cities (mega cities) as megalopolises and this is a mistake. Another condition is that the megapolitan area should combine at least two metropolitan areas[xvi]. These metropolitan areas should have national and international functions. Third condition is the existence of regional transport corridors that extends along the agglomeration. These corridors are considered as a backbone of the region that enables the mobility of users and goods between the parts of the region[xvii].

3 THE RISE OF EGYPT MEGAPOLITAN AREA

In 1990s, the notion of the emergence of Egyptian megapolitan area appeared in some researches. In 1994, as a result of both settlements proximity and high growth rates in settlements population and area, it was concluded that a megapolitan area may emerge either along Cairo-Alexandria agriculture road or at least between Cairo and Tanta cities[xviii]. In 1998, a proposal of megapolitan area that extends along 217 kilometer between Cairo and Alexandria was introduced[xix]. According to this proposal, the population of this newly emerged megalopolis may reach the threshold of 25 million inhabitants with gross population density that exceeds 250 persons/feddan. Figure (2 presents the map of this megapolitan area.

Figure (2) map of the Egypt megalopolis of 1990s addressed by Tarek Abul-atta.



4 URBAN DEVELOPMENT TRENDS IN EGYPT IN LATE 20TH CENTURY

Egypt has witnessed major urban development actions starting from the last decade of the twentieth century. These actions mainly focused on developing both the new cities and transport infrastructure.

4.1 New Cities Development

The new cities program is one of the most important urban development plans in Egypt and especially in Greater Cairo region. In the last decade of the twentieth century, many plans were settled to extend some of these cities such as 6th October, 10th Ramadan and New-Cairo. This is resulted in doubling the target population which will lead to increasing the region population and economic activities consecutively. Figure (3 illustrates the evolution of the masterplan of Greater Cairo in from 1982 to 1997[xx].

Figure (3) Maps show the evolution of Greater Cairo from 1982 (left) and 1997 (right)

4.2 Infrastructure Projects

Some important developments were progressed to the roads network in the Nile Delta. Establishing the ring road around Greater Cairo facilitates the connectivity between the region settlements. This is resulted in notable urban sprawl in the rural areas near to the region. In addition, a group of important projects have been executed on the regional roads network in Delta such as the following:

1) Expanding Banha-Mansura road to dual carriage way.
2) Establishing bridges on some important intersections on Cairo-Alexandria agriculture road.
3) Developing the entrances of regional cities.

All these developments have been resulted in enhancing the quality of life and offering better opportunities of housing, services and economic activities. This generates more relations between the settlements of the region. So that, it's important to investigate the current status of the Egyptian megalopolis that was previously defined in the nineties of the 20th century.

5 STATISTICAL INVESTIGATION OF EGYPT MEGAPOLITAN AREA

5.1 Study Area

The study area covers the Nile delta region. This region is the most populous one in Egypt. Out of the twenty seven governorates of Egypt, the study area includes a group of fourteen ones. According to 2006 national census of Egypt, the region population is 50.1 million inhabitants which constitute 69.6% of total Egypt population[xxi]. On the other hand, the region total area is 62670 km^2 [xxii] which represents only 6.2% of total Egypt area. Table (1 presents a list of study area governorates.

Table (1) List of study area governorates

#	Governorate name	#	Governorate name	#	Governorate name
1	Cairo	2	Giza	3	Alexandria
4	Qalubia	5	Munufia	6	Dakahlia
7	Beheira	8	Gharbia	9	Sharqia
10	Kafr Asheikh	11	Damietta	12	Suez
13	Port Said	14	Ismailiah		

According to the administrative division system of Egypt, each governorate is divided into two levels of administrative divisions. The first level is urban and rural divisions where urban divisions called (QESM) and rural ones called (MARKAZ). The second level divides each division either urban or rural into local areas. Urban local area is called (Shyakhah) and the rural one is called (Wehda Mahalya)[xxiii]. The fourteen governorates of the study area are divided into 234 divisions. Table (2 presents the administrative divisions of the study area[xxiv].

Table (2) Administrative divisions of the study area

#	Gov. name	Urban divisions	Rural divisions	#	Gov. name	Urban divisions	Rural divisions
1	Cairo	45	0	**2**	Giza	14	8
3	Alexandria	17	0	**4**	Qalubia	8	7
5	Dakahlia	5	17	**6**	Sharqia	8	15
7	Gharbia	4	8	**8**	Munufia	3	9
9	Damietta	4	5	**10**	Beheira	3	15
11	Kafr-Sheikh	4	10	**12**	Suez	5	0
13	Port Said	11	0	**14**	Ismailiah	4	5

It deserves to mention that adjacent urban divisions are combined in one city. So the final number of case studies is 151 urban places. Figure (4) presents a map of the study area.

Figure (4) Map of the study area of statistical analysis

5.2 Selected Variables

Variables have been selected to cover the main conditions and characteristics of megapolitan areas as stated by Gottmann and mentioned previously in this paper. A data matrix table of seven variables for all cases has been assembled. Following is a brief description of each variable.

Urban Population: it's the number of people who live in urban areas. It's more indicative than population only as it focuses on the urban dwellers. The data of this variable is dated back to 2006. This variable is measured by inhabitants.

Population Density: it's the number of people who live in one square kilometer. The data of population is gathered from the national census of Egypt in 2006 and the data of divisions' areas is calculated by the researcher from maps issued by the central agency for public mobilization and statistics (CAPMAS) and Egyptian survey authority (ESA). This variable is calculated by persons/km^2.

Both previous variables indicate the condition of high concentration of inhabitants in the settlements that compose the megapolitan area.

Share of regional Traffic volume: this variable indicates the regional traffic between the settlements on dual carriageway roads. The study area has four main dual roads[xxv]. These roads are:

- Cairo-Alexandria agriculture road.
- Cairo Ismailiah desert road.
- Tanta-Damietta road
- Benha-Mansura road.

It deserves to mention that there are many other roads within the study area but its capacity is limited. The traffic volume data is gathered from fixed counting stations that is operated and

managed by the general authority for roads and bridges (one of the agencies of the ministry of transport). The data of traffic volume is dated back to 2011. The share of each division of regional traffic is a percentage of the total traffic volume for the road that its influence zone intersected with the division. The influence zone is determined as 10 kilometers width from each side. This variable indicates the intertwined web of relationships between the settlements.

Percentage of division area that located within train station catchment area: it's the area of the division that is served by train station located on dual railway. The radius of the catchment area is 10 kilometers. The data of this variable is measured by the researcher from digital maps created and issued by the central agency for public mobilization and statistics (CAPMAS) and the general authority for roads and bridges.

No. of Train Station users: it's the number of users who traveled through train station (either departure or arrival). This includes all train stations in the study area regardless of the type of the railway (dual or single way). The data of this variable is derived from a technical study of railways network in Egypt that dated back to 2004[xxvi]. The variable is calculated by number of users.

It deserves to mention that the three previous variables indicate the strength of the intertwined network of socio-economic relations between the communities.

No. of workers: it's the actual number of people aged more than 15 years who are actually working in one of the economic sectors. The data of this variable is dated back to 2006 and is measured by number of workers. This variable indicates the concentration of economic activities in the settlements.

No. of internal migrants to division: it's the number of people who internally migrated to administrative division mainly for the purposes of work or study. The data of this variable is dated back to 2006 and is measured by number of persons. This variable indicates the existing of comparative advantages (such as job opportunities) in the division that encourage people to migrate from their home land. So it indicates the regional importance of the division as a center of development.

Table (3) summarizes the seven selected variables and its main information.

Table (3) list of variables used in the statistical analysis

Variable code	Variable name	Measuring unit	Date	Characteristic			
				Population	High pop. Density	Intertwined web of relationships	Important regional centers
V1	Urban Population	Inhabitants	2006	○			
V2	Population Density	Persons/km^2	2006		○		
V3	Share of Traffic volume on	Vehicles	2011			○	

	dual carriageway roads				
V4	Percentage of division area that located within train station catchment area	%	2006	○	
V5	No. of Train Station users	Users	2004	○	
V6	No. of workers	Workers	2006		○
V7	No. of internal migrants to division	migrants	2006		○

5.3 Stage1: Factor Analysis

Factor analysis is an important statistical tool that is used in the field of urban planning. It mainly targets to examine the existence of common variance between variables that are related to certain phenomenon. It could be used as a reduction tool of large amounts of data. It converts a number of variables into a smaller number of components which each of them could be considered as a composite variable[xxvii]. In this research, this analytical tool will be used to investigate the selected variables of megapolitan areas. Factor analysis has many outputs. The most important ones are both the component loadings and the component scores. After processing the analysis through SPSS software, the first output of component loadings shows that one of the selected variables is weak and doesn't correlated with the other variables. This variable is V2 (population density). As a result, a second run of the analysis is processed and the outputs are more positive than the first round. Two principal components with an eigenvalue over one are extracted. Approximately, these two components account for 80% of the total variance. Table (4 presents the details of these components. Table (5 presents the loadings of each component after the second run.

Table (4) Total Variance Explained

Component	Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	3.582	59.703	59.703
2	1.245	20.746	80.449

Table (5) Component Matrix

Variable Code	Variable name	Components	
		1	2
V1	Urban Population	.962	
V3	Share of Traffic volume on dual carriageway roads		.745
V4	% of division area that located within train station catchment area		.744
V5	No. of Train Station users	.753	
V6	No. of workers	.954	
V7	No. of internal migrants to division	.897	

According to table 9, only six variables out of the selected seven ones have been proven to be strongly correlated and sharing common behavior. Four of them are grouped in one component and the other two are grouped in another one. The second output of the factor analysis is the factor scores. A calculated value for both components is settled for each case. These scores will be used in the cluster analysis.

5.4 Stage2: Cluster Analysis

Cluster analysis is an exploratory statistical tool that is used to organize observed data into meaningful taxonomies, groups or clusters[xxviii]. It identifies the similarities between cases and classifies them into groups. In this research, cluster analysis helps in determining which cases have the potential to be parts of the megapolitan area of Egypt according to the previously calculated components scores. This analysis will be processed through SPSS software twice. In the first time, the suitable number of distinctive clusters will be determined. Then, in the second time, cases will be classified into the previously assigned number of clusters. Table (6 presents the re-formed agglomeration table that was the main output of the first run of cluster analysis.

Table (6) Re-formed agglomeration table

No. of clusters	Agglomeration last step	Coefficients this step	change
10	7.201	6.098	1.10
9	9.745	7.201	2.54
8	12.337	9.745	2.59
7	15.746	12.337	3.41
6	20.722	15.746	4.98
5	37.786	20.722	17.06
4	57.625	37.786	19.84
3	173.387	57.625	115.76
2	300.000	173.387	126.61

A clear demarcation point seems to be here.

The second run of cluster analysis targets to classify the 151 cases into three groups. It's worth mentioning that, there is no ranking in this classification. Table (7 summarizes the clustering output.

Table (7) distribution of cluster cases in the study area

#	Cluster	Number of cases	% of study area
1	One	3	2%
2	Two	91	60%
3	Three	57	38%

According to table (7), 60% of cases are clustered in group 2 and 38% of it in group 3. For more clarification, a third round of cluster analysis will be processed but this time for the cases of group 2 only. This is resulted in dividing cluster two into two distinctive clusters. Table (8 presents the final clustering of the 151 cases into four groups.

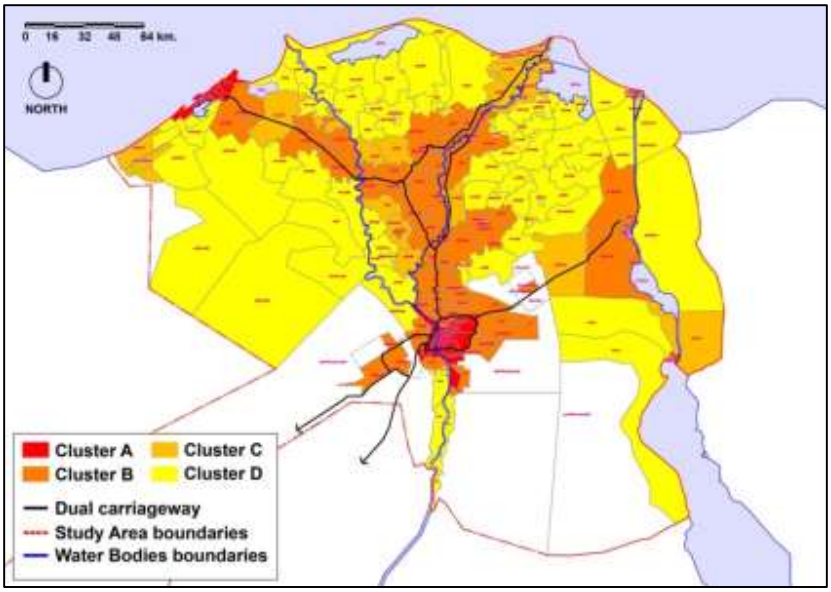
Table (8) list of the four resulted clusters

#	Cluster	Number of cases	% of study area	Cities	Urban division	Rural division
1	A	3	2%	3	0	0
2	B	22	15%	3	4	15
3	C	69	45%	1	19	49
4	D	57	38%	9	16	32

5.5 Stage3: Spatial Representation of Clusters (Mapping)

In this stage, the results of cluster analysis process will be spatially represented in order to investigate the geographies of the four clusters. Applying a color code for each cluster, presents the spatial distribution of these clusters.

Figure (5) Spatial distribution of the resulted four clusters



The four clusters could be classified as follows:

Cluster A: includes only three units. These units are the cities of Cairo, Giza and Alexandria. Of course these three cities are considered to be the most important urban centers in the nation. Together, Cairo and Giza constitute the major part of political and economic capital of Egypt. They have important role internationally and regionally. On the other hand, Alexandria city is

considered to be the main marine gate of Egypt. Its harbor is one of the most important ones in the Mediterranean basin.

Cluster B: is composed of 22 units, which is considered a limited number of cases compared to clusters C and D. it has a group of urban and rural divisions that are geographically scattered in the study area. On the other hand, the locations of most of these units are adjacent or close to cluster D units. Examples of divisions of this cluster are Burj-Alarab new city which is close to Alexandria and Meet-Ghamr division which occupies a location that mediates the distance between Banha and Mansoura cities.

Cluster C: has the larger number of cases. It includes 69 urban and rural units. These units are isolated from the important transport corridors (such as dual railways and dual carriage roads). Around 70% of the included cases are rural divisions.

Cluster D: it has 57 units where 25 of them are urban units. This cluster contains important regional cities such as Shubra-Elkheima, Tanta, Banha and Elmansoura. Actually, Shubra-Elkheima city is the third component of Greater Cairo. Other cities are considered as important regional economic and social centers in Delta. In addition, this cluster includes the new satellite cities around Greater Cairo such as 6th October, New-Cairo and 10th Ramdan cities. It deserves to mention that these new cities gain great developmental attention from both governmental and private sectors. Many urban development plans are focusing on these new cities. Also, the proximity to the nation capital creates high potential of development in these cities. Today, these cities are of the most important internal migration destination. Furthermore, the rural divisions (such as Tukh, Damanhour and Zefta) that are grouped in this cluster have relative regional economic importance. All these divisions have good regional connectivity through both regional roads and railways. This resulted in making these divisions as gateways to the surrounded rural areas.

Table (9) presents selected socio-economic characteristics of each cluster

Table (9) selected socio-economic characteristics of the four selected clusters

Cluster	A	B	C	D
Number of cases	3	22	69	57
% of study area	2%	15%	45%	38%
Cities	3	3	1	9
Urban division	0	4	19	16
Rural division	0	15	49	32
Population (Mil.)	14.3	4.4	15.1	16.9
Urban Population (Mil.)	14.1	1.0	4.2	6.2
% Urban population	99	23	28	37
Area (km^2)	828	4654	57676	9349
Gross Population Density (persons/km^2)	17,300	951	261	1,807
Internal Migration (Mil.)	1.7	0.2	0.8	1.6
Workers (Mil.)	4.1	1.3	4.2	4.6
% of workers in Agriculture Sectors	1.2	29.7	39.7	18.1
% of workers in ICT Sector	2.1	0.4	0.4	0.9
% of workers in Industry Sector	16.5	15.3	10.4	16.9
% of workers in Services Sector	75.7	54.2	48.9	63.2
% of unclassified workers	4.6	0.3	0.6	0.9

% of High Education	15.7	6.0	5.1	7.9
% of Intermediate Education	26.2	23.7	21.2	24.7

6 ANALYSING THE POTENTIALS OF CREATING MEGAPOLITAN AREA

The statistical analysis resulted in classifying the study area into four distinctive clusters. Both clusters A and D have the highest values of urban population, gross population density, internal migration to its settlements, workers in both industry and services sectors and high education levels. In addition, the components of these clusters are adjacently located on main transport corridors. The divisions of these two clusters are the most candidates to form a megapolitan area.

From the spatial representation of the results of the statistical analysis of the study area, it's obvious that most of megalopolis candidates divisions are concentrated along Cairo-Alexandria transport corridor that encompassed both the agriculture road and the dual railway. It creates a chain of highly urbanized and populous divisions that extend between Greater Cairo and Alexandria metropolises. Only one division that belongs to cluster B is existed (markaz Abu-hommus), but its effect doesn't weaken the chain because of its limited length along the corridor and the strength of the surroundings. This chain could be considered as the backbone of the megalopolis. It's worth mentioning that this chain is very similar to the megalopolis that identified by Tarek Abul-atta in 1998.

Figure **(6**) presents the geography of the megalopolis backbone while Table (10) presents a list of the divisions that are sharing in the composition of the megalopolis backbone.

Figure (6) The geography of the proposed megalopolis backbone

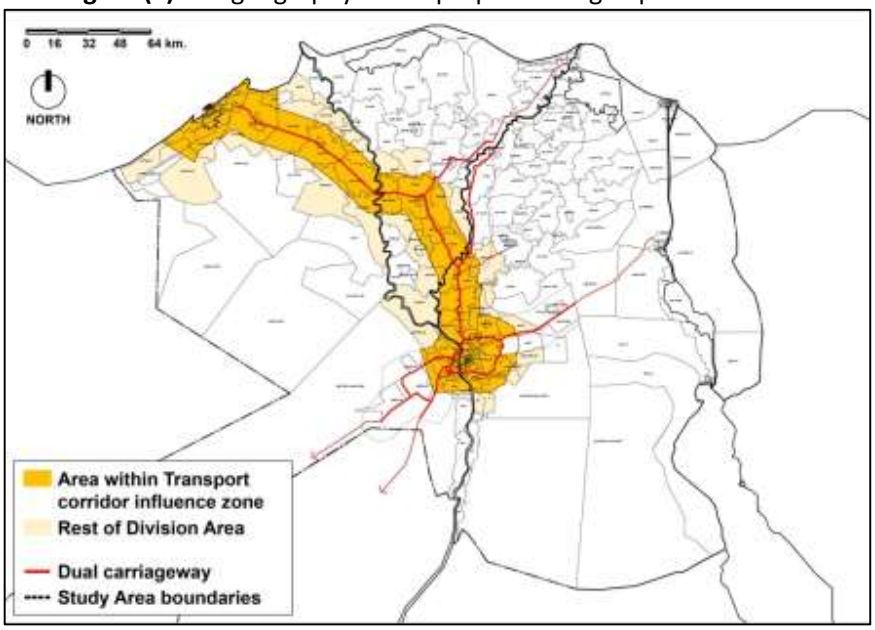


Table (10) List of nominated divisions of the megalopolis backbone

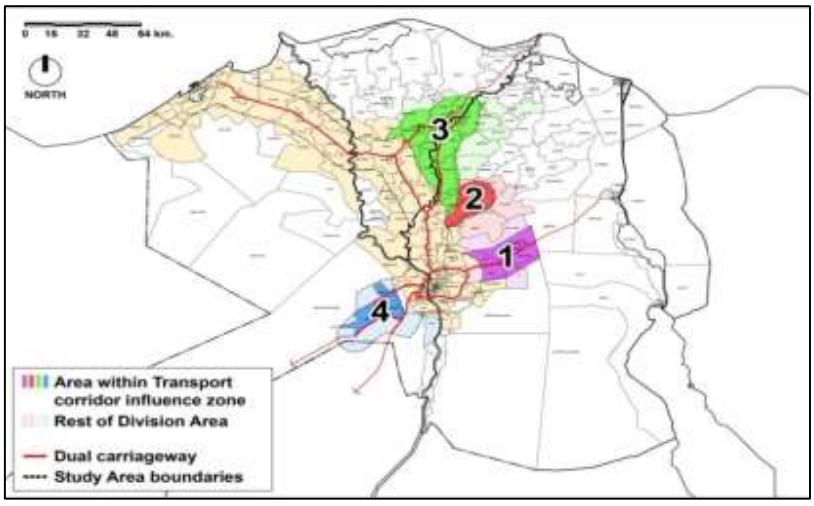
#	Gov.	Division	Area (sq.km.)	Area within backbone boundaries	2006 POP. (in millions)
1	القاهرة	مدينة القاهرة	449.7	100.0	7.580
2	الإسكندرية	مدينة الإسكندرية	239.1	100.0	3.537
3	الأسكندرية	قسم العامرية	347.6	35.3	.174
4	الجيزة	قسم ١٥ مايو	69.4	100.0	.091
5	الجيزة	قسم التبين	24.8	100.0	.069
6	الجيزة	مركز الجيزة	65.3	85.8	.207
7	الجيزة	مركز امبابه	19.7	7.2	.028
8	الجيزة	مركز أوسيم	72.3	99.8	.275
9	القليوبية	قسم الخصوص	9.2	100.0	.291
10	القليوبية	مدينة شبرا الخيمة	40.7	100.0	1.026
11	القليوبية	قسم بنها	10.5	100.0	.158
12	القليوبية	قسم قليوب	20.1	100.0	.107
13	القليوبية	قسم قها	10.8	100.0	.036
14	القليوبية	مركز الخانكة	103.7	74.9	.327
15	القليوبية	مركز القناطر الخيرية	125.2	96.3	.369
16	القليوبية	مركز بنها	186.2	93.7	.352
17	القليوبية	مركز شبين القناطر	84.2	70.7	.299
18	القليوبية	مركز طوخ	187.2	94.9	.434
19	القليوبية	مركز قليوب	79.8	100.0	.366
20	القليوبية	مركز كفر شكر	36.4	56.6	.084
#	Gov.	Division	Area (sq.km.)	Area within backbone boundaries	2006 POP. (in millions)
21	الغربية	مدينة طنطا	22.1	100.0	.423
22	الغربية	مركز السنطة	168.7	79.0	.293
23	الغربية	مركز زفتى	38.9	18.8	.084
24	الغربية	مركز طنطا	299.2	98.4	.530
25	الغربية	مركز قطور	22.4	9.5	.027
26	الغربية	مركز كفر الزيات	185.1	96.5	.366
27	المنوفية	قسم شبين الكوم	25.0	100.0	.177
28	المنوفية	مركز أشمون	1.9	0.7	.004
29	المنوفية	مركز الباجور	31.6	17.9	.055
30	المنوفية	مركز بركة السبع	119.7	100.0	.239
31	المنوفية	مركز تلا	52.3	28.7	.086
32	المنوفية	مركز شبين الكوم	52.2	27.6	.097
33	المنوفية	مركز قويسنا	225.6	99.4	.380
34	البحيرة	قسم دمنهور	16.8	100.0	.244
35	البحيرة	قسم كفر الدوار	31.8	100.0	.263
36	البحيرة	مركز أبو حمص	357.1	64.8	.266
37	البحيرة	مركز إتياى البارود	293.0	99.6	.377
38	البحيرة	مركز الدلنجات	82.0	15.1	.046
39	البحيرة	مركز الرحمانية	23.8	21.3	.028

40 البحيرة	مركز المحمودية	8.9	5.5	.012
41 البحيرة	مركز دمنهور	320.3	83.2	.368
42 البحيرة	مركز شبرا خيت	89.2	53.7	.122
43 البحيرة	مركز كفر الدوار	405.5	73.8	.386
44 البحيرة	مركز كوم حمادة	105.6	26.8	.106
45 الشرقية	مركز منيا القمح	45.2	16.9	.097
46 الغربية	مركز بسيون	31.6	19.8	.048
47 الجيزة	مركز كرداسة	84.0	100.0	.511
48 الأسكندرية	قسم برج العرب	5.8	2.0	.001
49 البحيرة	مركز ادكو	14.7	8.3	.013
50 الجيزة	قسم الحوامدية	1.3	4.8	.007
51 حلوان	مدينة القاهرة الجديدة	286.5	100.0	.122
52 القليوبية	قسم العبور	173.7	100.0	.044
53 الجيزة	مدينة الجيزة	139.5	100.0	3.212
Total Backbone		**5942.9**		**24.842**
Gross population density: 4180 inhabitants/sq.km.				

In addition, four cross extensions may be included in the megalopolis. These extensions are:

1) Extension 1 that starts from Greater Cairo to 10th Ramadan city to the east and along the Cairo-Ismailiah desert road.
2) Extension 2 that starts from Banha to Zakazik city to the east.
3) Extension 3 that starts from both Banha and Tanta cities to Mansura city to the east and along Banha-Mansura dual carriage way and Tanta-Mansura dual carriage way respectively.
4) Extension 4 that starts from Greater Cairo to 6th of October City to the west along both 26th July corridor and Wahat regional road.Figure (7 illustrates the four extensions in relation to the backbone.

Figure (7) The geography of the megalopolis four extensions



In the following part, the four extensions will be analyzed to determine the final composition of the Egypt megalopolis in the 21st century.

6.1 Extension 1:

This zone extends along Cairo-Ismailiah desert road which is a 106 kilometers dual carriage way. The extension length is only 45 kilometer. It has many new satellite cities that are located to the east of the capital such as 10th of Ramadan, Shuruk, and Badr cities. 10th Ramdan city has target population that exceeds two million inhabitants[xxix]. Table (11 presents a list of the divisions that are sharing in creating the megalopolis extension 1.

Table (11) List of nominated divisions of the megalopolis Extension 1

#	Gov.	Division	Area (sq.km.)	Area Shared in Extension	2006 POP. (in millions)
1	الجيزة	قسم الشروق	176.5	100.0	.023
2	الجيزة	قسم مدينة بدر	162.5	100.0	.017
3	الشرقية	مدينة العاشر من رمضان	45.5	100.0	.126
Total Backbone			**384.6**		**.166**
Gross population density: 431.6 inhabitants/sq.km.					

It deserves to mention that there are four other divisions on the Cairo-Ismailiah road that are classified as cluster D which means that they have the main characteristics of megapolitan areas. These divisions are Ismailiah city, Ismailiah, Kantara and Fayed divisions. But there is a vast desert area that separated between 10th Ramadan city which is considered the end of extension 1 and these four divisions. So, they are excluded from the megalopolis. Maybe later, future urban sprawl between 10th Ramadan and Ismailiah cities leads to include these divisions in the megalopolis.

6.2 Extension 2:

Banha-Zakazik extension is the shortest one. It extends for only 37 kilometers but along second grade regional road. The city itself is an important urban center for the rural surrounding. Only one city is existed at the middle of this extension. It's Menia-Elkamh city. This extension composed of four divisions. These divisions are classified as cluster D, so they have the same characteristics of other divisions that compose most of the backbone. Table (12 presents a list of the divisions that are sharing in creating the megalopolis extension 2.

Table (12) List of nominated divisions of the megalopolis Extension 2

#	Gov.	Division	Area (sq.km.)	Area Shared in Extension	2006 POP. (in millions)
1	الشرقية	مركز منيا القمح	140.9	52.7	.302
2	الشرقية	مركز مشتول السوق	6.8	10.5	.017
3	الشرقية	قسم القنايات	9.5	100.0	.043
4	الشرقية	مدينة الزقازيق	14.4	100.0	.303
5	الشرقية	مركز الزقازيق	243.5	72.1	.471
6	الشرقية	مركز ههيا	29.3	24.3	.050

7	الشرقية	مركز أبو حماد	3.4	1.3	.004
8	الشرقية	مركز بلبيس	5.8	1.6	.010
Total Extension2			453.7		1.199
Gross population density: 2642.7 inhabitants/sq.km.					

6.3 Extension 3:

This extension is more important than the previous ones as it extends along two important dual carriage ways, Banha-Mansura (76 kilometers) and Tanta-Mansura (58 kilometers) roads. It has the shape of a triangle where its base is part of the megalopolis backbone and the Mansura city is located at the head point. Actually, this half million inhabitants city is one of the important cities in Delta and is considered as an important urban center for the northeastern part of delta. This extension includes 12 divisions, 10 of which are classified as cluster D and the other 2 are classified as cluster B. Table (13 presents a list of the divisions that are sharing in creating the megalopolis extension 3.

Table (13) List of nominated divisions of the megalopolis Extension 3

#	Gov.	Division	Area (sq.km.)	Area Shared in Extension	2006 POP. (in millions)
1	القليوبية	مركز كفر شكر	27.9	43.4	.064
2	الغربية	مركز السنطة	44.9	21.0	.078
3	الغربية	مركز زفتى	168.7	81.2	.362
4	الغربية	مركز طنطا	4.8	1.6	.009
5	الغربية	مركز قطور	46.6	19.9	.055
6	الشرقية	مركز منيا القمح	74.8	27.9	.160
7	الشرقية	مركز الزقازيق	22.7	6.7	.044
8	الشرقية	مركز ديرب نجم	19.5	8.7	.031
9	الدقهلية	مدينة المنصورة	35.1	100.0	.439
10	الدقهلية	قسم ميت غمر	4.6	100.0	.117
11	الدقهلية	مركز أجا	248.8	97.7	.393
12	الدقهلية	مركز السنبلاوين	18.5	6.8	.031
13	الدقهلية	مركز المنصورة	187.1	62.3	.281
14	الدقهلية	مركز تمى الأمديد	.3	0.2	.000
15	الدقهلية	مركز طلخا	128.6	84.0	.257
16	الدقهلية	مركز ميت غمر	212.3	99.7	.516
17	الدقهلية	مركز نبروه	109.4	69.9	.153
18	الغربية	مدينة المحلة الكبرى	20.4	100.0	.443
19	الغربية	مركز المحلة الكبرى	305.7	66.8	.394
20	الغربية	مركز سمنود	133.3	100.0	.298
21	الدقهلية	مركز محلة دمنة	6.8	2.4	.001
Total Extension3			1820.9		4.126

Gross population density: 2265.9 inhabitants/sq.km.

6.4 Extension 4:

It's the only extension that spreads to the west of the backbone. It's composed of only two units. They are two satellite cities, 6th October and Sheikh-Zayed. It's worth mentioning that the target population of 6th October city is 1.5 million inhabitants approximately[xxx].

Table (14 presents a list of the divisions that are sharing in creating the megalopolis extension 4.

Table (14) **List of nominated divisions of the megalopolis Extension 4**

#	Gov.	Division	Area (sq.km.)	Area Shared in Extension	2006 POP. (in millions)
1	الجيزة	قسم الشيخ زايد	52.0	100.0	.029
2	الجيزة	مدينة السادس من أكتوبر	345.2	100.0	.154
Total Backbone			397.2		.184
Gross population density: 463.2 inhabitants/sq.km.					

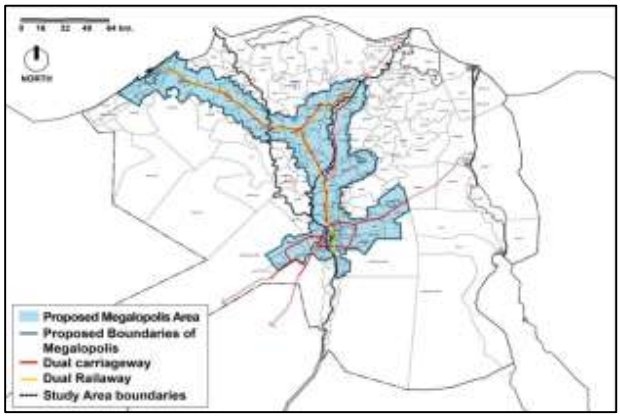
7 DEFINING THE EGYPT MEGALOPOLIS

According to the previous analysis, the Egyptian megalopolis extended between Greater Cairo and Alexandria metropolises with four cross extensions. Three out of which are extending from Cairo, Banha and Tanta to the east and the fourth one extends from Cairo to the west. Following is a description of the proposed megalopolis.

7.1 Geographies of Megalopolis

After determining the nominated divisions to compose the megapolitan area, it's time to identify its boundaries. The boundaries of the second level of administrative divisions (local areas) will be used. To achieve this, a new layer is added to the map of the megalopolis. Guided by the 10 km width of the transport corridor influence zone, the final proposed boundaries are the best fitting between both lines of the influence zone and of local area boundaries. Figure (8 presents the final proposed boundaries of the megapolitan area according to the second level of administrative divisions.

Figure (8) Proposed boundaries of 2014 Egypt megalopolis



7.2 Urban Composition

The agglomeration has 35 urban centers that are located along major transport corridors. The largest center is Cairo city with population 7.6 million inhabitants and the smallest one is Badr city with 17 thousand inhabitants. These centers offer essential services and job opportunities to the surroundings. The distance between these centers ranges between 8 and 35 kilometers. Many rural settlements occupy lands between and around them.

Table (15 presents a list of urban centers and presents a map of these centers

Figure (9) urban centers in the 2014 Egypt megalopolis

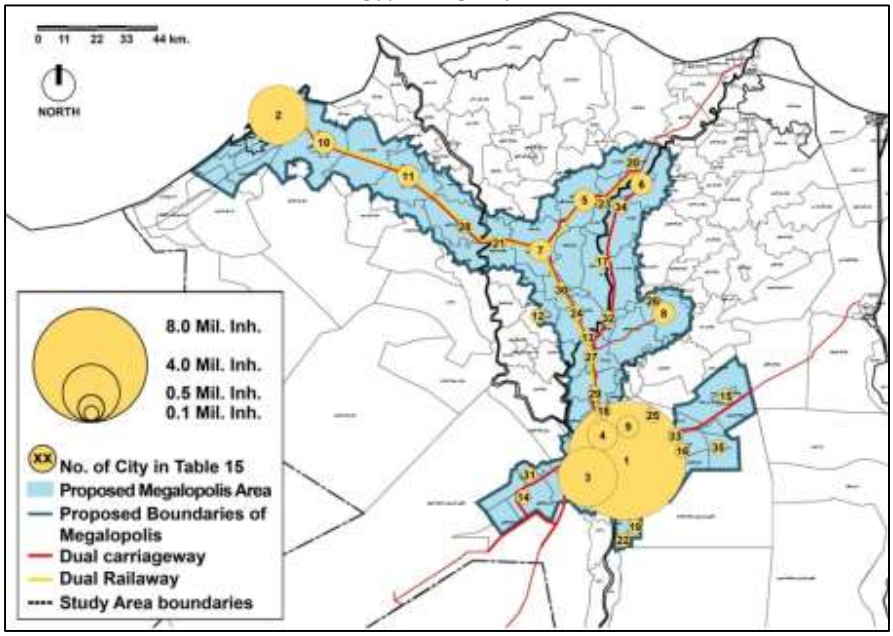


Table (15) List of urban centers included in the proposed Egypt megalopolis

#	Urban Center	Governorate	2006 Pop.	Megalopolis Sector
1	مدينة القاهرة	القاهرة	7,580,381	Backbone
2	مدينة الإسكندرية	الإسكندرية	3,536,655	Backbone
3	مدينة الجيزة	الجيزة	3,211,977	Backbone
4	مدينة شبرا الخيمة	القليوبية	1,025,569	Backbone
5	مدينة المحلة الكبرى	الغربية	442,958	Extension 3
6	مدينة المنصورة	الدقهلية	439,348	Extension 3
7	مدينة طنطا	الغربية	422,854	Backbone
8	مدينة الزقازيق	الشرقية	302,840	Extension 2
9	قسم الخصوص	القليوبية	291,242	Backbone
10	قسم كفر الدوار	البحيرة	262,751	Backbone
11	قسم دمنهور	البحيرة	244,043	Backbone
12	قسم شبين الكوم	المنوفية	177,112	Backbone
13	قسم بنها	القليوبية	157,701	Backbone
14	مدينة السادس من أكتوبر	الجيزة	154,093	Extension 4

#	Urban Center	Governorate	2006 Pop.	Megalopolis Sector
15	مدينة العاشر من رمضان	الشرقية	125,920	Extension 1
16	مدينة القاهرة الجديدة	القاهرة	122,339	Backbone
17	قسم ميت غمر	الدقهلية	116,593	Extension 3
18	قسم قليوب	القليوبية	107,303	Backbone
19	قسم ١٥ مايو	الجيزة	90,740	Backbone
20	مدينة طلخا	الدقهلية	78,121	Extension 3
21	مدينة كفر الزيات	الغربية	71,103	Backbone
22	قسم التبين	الجيزة	68,897	Backbone
23	مدينة سمنود	الدقهلية	57,144	Extension 3
24	مدينة قويسنا	المنوفية	44,611	Backbone
25	قسم العبور	القليوبية	43,600	Backbone
26	قسم القنايات	الشرقية	42,563	Extension 2
27	مدينة طوخ	القليوبية	41,554	Backbone
28	مدينة إيتاي البارود	البحيرة	40,505	Backbone
#	Urban Center	Governorate	2006 Pop.	Megalopolis Sector
29	قسم قها	القليوبية	35,655	Backbone
30	مدينة بركة السبع	المنوفية	33,615	Backbone
31	قسم الشيخ زايد	الجيزة	29,422	Extension 4
32	مدينة كفر شكر	القليوبية	23,390	Extension 3
33	قسم الشروق	القاهرة	22,570	Extension 1
34	مدينة اجا	الدقهلية	17,425	Extension 3
35	قسم مدينة بدر	القاهرة	17,158	Extension 1

7.3 Morphology of Megalopolis

The structure of the emerged megapolitan area is composed of a group of intersected urban corridors (chains of close urban settlements). These corridors are created along regional roads and railways. The main corridor is the backbone that extends between Greater Cairo and Alexandria metropolises. The other five corridors are hinged at three spots (Greater Cairo, Benha and Tanta) to create the rest of the agglomeration. Figure 10 presents the morphology of the megalopolis.

Figure (9) the morphology of the 2014 Egypt megalopolis

7.4 Demography and Socio-Economic Characteristics

The total population of the current megalopolis is 30.5 million inhabitants. The gross nominated area of the agglomeration is 8999.2 km^2. This means that 42% of Egypt population occupies less than 1% of nation area and 11.4% of the populated area. This is resulted in high gross population density which is 3389 persons/ km^2. Actually this density significantly exceeds the threshold of 250 persons/km^2 that was determined previously by Jean Gottman. The megalopolis has 8.5 million workers which constitute 43% of the nation workers. In addition, it is considered to be the most important magnet in the nation as 62% of all internal migration that happened in Egypt targeted one of the megalopolis settlements. Finally, Table (16 summarizes the main socio-economic charactersitics of the redefined Egypt megalopolis.

Table (16) socio-economic characteristics of the five main components of the Egypt megalopolis

Characteristic	Backbone	Extension 1	Extension 2	Extension 3	Extension 4	ALL MEGAL-OPOLIS	% of Nation
Area within Transport Corridor shed (km^2)	5942.9	384.6	453.7	1820.9	397.2	8999.3	1
Population (million inhabitants)	24.842	0.166	1.199	4.126	0.184	30.517	42
Gross Population Density (persons/km^2)	4180	431.6	2642.7	2265.9	463.2	3391.0	4664
No. of Internal Migrants (in millions)	2.61	0.1	0.04	0.09	0.13	2.97	62
No. of shared divisions	53	3	8	21	2	87	24
No. of Urban Centers	16	3	2	3	2	26	28
Dual carriage way Length (km.)	279.6	45.3	31.2	125.4	27.5	509	14
Dual Railway Length (km.)	221.6	0	44.1	53.1	0	318.8	22
No. of Workers (in millions)	6.99	0.05	0.31	1.12	0.06	8.53	43
No. of workers in Agriculture Sector	609620	464	55321	232209	553	898167	17
No. of workers in Industry Sector	1163131	26307	42199	176178	14630	1422445	59
No. of workers in Services Sector	4944597	26366	209464	708925	42499	5931851	50
No. of workers in Telecom Sector	116270	410	2186	5405	1916	126187	72
No. of High Education Graduates	2986142	20930	124338	348451	35321	3515182	64
No. of Medium Education Graduates	6267676	51559	290843	1053636	55239	7718953	47

8 CONCLUSION

Statistical analysis of the satudy area proved the emergence of a megapolitan area that is located in Nile Delta. This megalopolis extends between both Greater Cairo and Alexandria metropolitan areas with four extensions that started from Greater Cairo, Benha and Tanta. It is composed of a group of intersected urban corriodrs. The resulted agglomeration is larger in area and differ in form than what is concluded in previous researches that dated back to the last decade of the twentieth century. According to 2006 national census, the population of this agglomeration reaches 30.5 million inhabitants with gross populaiton density 3389 persons/km^2. 43% of Egyptian workers are concentrated in the settlements of this megalopolis. Future extensions may take place on the directions of both Ismailiah and Damietta cities as a result of economic and geographic potentials. Due to its critial location within the main agricultre zone of the nation and the huge concentration of people and activities, it is important to pay great attention to such highly urbanized agglomeration in the next years. The uncontrolled and unplanned continous groth may threaten the Nile delta and even the whole Nation. In addition, the intertwined web of social and economic relastionships requires more research work to help in the governance of this huge agglomeration and sustainable management of its components.

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