

MULTIFUNCTION GREEN INFRASTRUCTURE

Towards upgrading urban ecosystem in Cairo

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Abstract

Attention to green infrastructure and urban ecosystem is a result of needs for upgrading of ecological environment and social life of the city. Urban ecosystems are complicated and overlapping with other systems, such as economic, social and human activities that may cause conflict and negative/positive impact according to the nature of activity. Multifunction green infrastructure is an effective approach for enriching urban ecosystem. Green infrastructure leads to adaptation and even transformation of future and faces challenges such as climate change, food insecurity and limited resources .

Cairo ecosystem faces a lot of challenges that may affect the urban, cultural, heritage, economic and environmental aspects of one of the oldest capitals of the world. Biodiversity in Cairo is a key element could help in implementation of Multifunction green infrastructure strategy despite of all culture and awareness challenges .

The research methodology is divided into a theoretical review that discusses main concepts related to Green infrastructure such as: Landscape Sustainability, Ecosystem Services, Landscape Services, Multifunctional Landscape, Urban Green space, Green infrastructure and a field study conducted by the author upon which the action plan was based.

Key words

Multifunctional, Green infrastructure, Urban, Ecosystem

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1. Introduction

Urban communities have been crucially imperative in the advancement of humankind as centers of business, culture, and learning. Only over the last two centuries has mass urbanization occurred, and as recently as 2007, for the first time, the majority live in cities (ARUP, 2014). With this shift to urban living, cities are confronting greater economic, social, and environmental pressures.

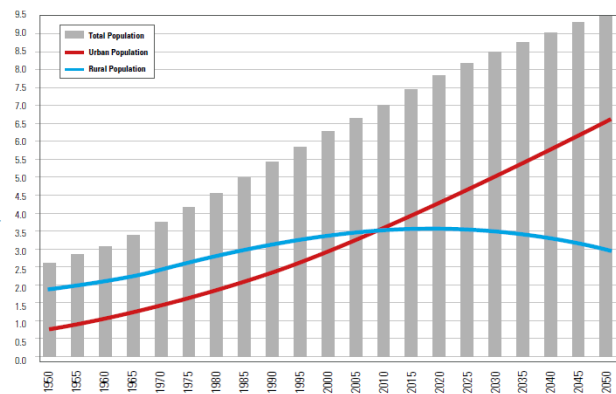


Fig.1: The rural and urban population of the world, 1950-2050, (ARUP,2014)

Cairo -like many other cities- face the same pressures of a scarcity of resources, climate change, pollution, environmental degradation, and dangers to human health. A lack of reaction to these issues will have dire results.

2. Green Infrastructure:

Nature can be used to offer different services for communities such as keeping them from flooding or extreme heat or helping to develop the quality of water, soil, and air. When nature used as an infrastructural system, it is termed "green infrastructure" (Benedict, 2006).

Green Infrastructure is a network that provides the mechanisms for facing climatic and urban challenges using nature (CNT, 2011). That proves the multifunctionality of green infrastructure.

Multifunction green infrastructure

Towards upgrading urban ecosystem in Cairo

Green infrastructure practices vary in scale from separate buildings, lots, and neighborhoods to entire cities and metro regions and the benefits range in scale accordingly (Foster et al, 2011). Green infrastructure includes parks, green pathways, spaces and public waterways, and less scale interventions like green facades and green roofs.



Fig.2 : Multilayered and integrated green infrastructure

Development of multifunctional green infrastructure can serve as an adaptive strategy to address unknown future conditions, including climate change, water scarcity, food insecurity, and limited economic resources. These conditions are expected to impact urban environments heavily, and certain vulnerable populations will be at extremely high risk of negative consequences to their health and well-being (Shonkoff et al. 2011; Lissner et al. 2012).

3. Benefits of green infrastructure:

Green infrastructure provides many services which have ecological, economic and social implications. It has a multitude of benefits

3.1. Water:

A lot of areas around the world suffer from water scarcity, and most of those areas are cities. Cities demand of effective approach for water management is increasing every day. Green infrastructure can play this role that it defends, restores, or imitates the natural water cycle.

Green infrastructure offers alternative solutions such as planting trees and reestablishing wetlands, instead of constructing a water treatment plant, picking water efficiency in place of building a water supply dam, and reestablishing floodplains rather than constructing levees.

There are many projects that use green infrastructure for water management. For example, Bogotá, Columbia is seeking after upstream scene protection and rebuilding as a different option to more ordinary water treatment innovations. Ho Chi Minh City reestablished mangroves as opposed to building barriers with a specific end goal to shield shorelines from tempest harm. Furthermore, a compound office in Texas assembled a wetland as opposed to utilizing pro-found well infusion to treat wastewater.

Local Examples also exist, For instance, Suez Canal University in collaboration with Portsmouth English University has a successful experience for sewage biological treatment using reeds and papyrus plants. Experience idea depends on that there are some plants have the ability to absorb pollutants and convert some of the harmful nature to other useful. As well as the reduction of the number of bacteria so that it can raise the percentage of dissolved oxygen and convert toxic nitrogen to beneficial nitrogen and suitable for plant growth

Investments in green infrastructure can be less costly than those in gray infrastructure.



Fig.3. Green Infrastructure Can Be Less Expensive Than Gray Infrastructure
 Source: Kenny, 2006

Multifunction green infrastructure

Towards upgrading urban ecosystem in Cairo

New York City assessed two plans to deal with its temperate water streams. One was a green infrastructure approach for that highlighted stream buffer reclamation, green rooftops, and bio-swales, landscape components intended to expel sediment and contamination from surface overflow water. The other was a gray infrastructure approach involving tunnels and storm drains. The green infrastructure alternative offered a cost saving over \$1.5 billion.

3.2. Improve Air Quality:

Trees, plants and grass eliminate smoke, dust and other air pollutants. Greens absorb air pollutants (e.g. NO₂, SO₂, and O₃) and catch particulate matter. The cooling impact of vegetation diminishes smog creation. By decreasing energy usage, greens lower the air pollution created by electricity generation.

Plants lessen energy consumption, which improves air quality and decreases the amount of greenhouse gasses, as well as N₂O and CH₄, which sequentially reduces CO₂ levels.

3.3. Save Energy:

Buildings, in hot arid weather, which surrounded by green spaces consumes less energy for cooling because of shade evolved by trees and water that released into the atmosphere by trees resulting in cooler air temperatures. This shade reduces the air temperature in these regions. Trees decrease wind speeds. Wind speed, particularly in regions with cold winters, can have a huge impact on the energy needed for heating.

The green roof of The Academy of Sciences building reduced the requirements for heating and cooling by 35 percent. The cost saving of energy caused by the green rooftop on the Chicago City Hall is \$3,600 per year.

The (ASLA) created a green rooftop on the headquarters building. That about 32°F cooler than black roofs (ASLA, 2007)



Fig.4. Green roofs provide energy conservation, storm water management, and cultural benefits

Generally, green roofs -as a type of green infrastructure practices- provide a 15-25 percent saving in energy cost.

3.4. Mitigate urban heat island (UHI):

When urban regions develop, modifications occur in the landscape. Buildings, streets, and other infrastructure replace green spaces. This development creates urban heat islands. Urban areas are always warmer than rural surroundings (USEPA n.d.a).

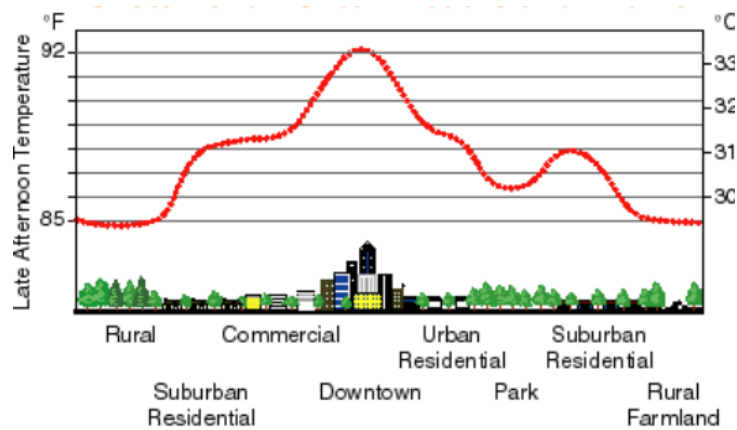


Fig.5. Sketch of an Urban Heat-Island Profile
Source: Lawrence Berkeley National Laboratory

Multifunction green infrastructure
Towards upgrading urban ecosystem in Cairo

Using Green Infrastructure applications in urban areas may help to lessen UHI by increasing vegetation, decrease ground conductivity and reduce ground-level ozone creation .

Different reviews have assessed that greens within building sites lower temperatures by around 5°F comparing with outside non-green space. At bigger scales, variety between non-green downtown areas and vegetated areas has been as high as 9°F.

3.5. Enhance community livability:

There are diverse ways in which increasing the use of green infrastructure can upgrade neighborhood quality of life, such as increase of the aesthetic value, reduction of noise pollution, recreation, and community cohesion.

3.5.1 Aesthetics:

Greenery has a significant impact on the aesthetic value of urban areas. There is a strong relationship between the property value and urban green spaces which reflect the positive effect of green infrastructure applications on aesthetics. Different reviews have concluded that property values rise when an urban neighborhood has more greenery. For instance, a study stated a growth in property value of 2–10 % for properties with new street trees (Wachter 2004; Wachter and Wong 2008.)

3.5.2. Decrease noise pollution:

Green infrastructure systems have one more benefit of decreasing noise pollution. There are many sources of noise pollution in urban areas. The noise level sometimes exceeds the level at which noise becomes a health risk .

Studies measured the sound transmission loss of green roofs as compared to conventional roofs and found that transmission loss increased 5–13 decibels in low- and mid- frequency ranges, and 2–8 decibels in the high frequency range (Connelly and Hodgson 2008)

3.5.3. Recreation:

Green infrastructure can increase recreational opportunities (such as walking, jogging on sidewalks, bench sitting or picnicking) when increased green areas within a community .

3.5.4. Community cohesion:

Green infrastructure practices can promote the livability of communities through its impact on ‘community cohesion.’

A study discovered that; Exposure to green areas lessens mental exhaustion and the feelings of irritability that accompany it. Even small areas of greenery can help residents to have safer, less violent domestic atmospheres (Kuo and Sullivan 2001b). Another study found a link between more vegetation and the usage of outdoor spaces for social activities, concluding that urban greening can foster contacts that form social resources (Sullivan, et al. 2004). A further study found a significant relationship between more greenery and less crime (Kuo and Sullivan 2001a.)

3.6. Food production

While urban populations increase and the expenses related to rural food production and delivery continue to grow, urban agricultural practices are being counted to address concerns associated with food security and cost (Argenti 2000 .)

Urban areas are currently providing about 15 percent of the world's food supply (AFSIC 2010). Green infrastructure applications can present more opportunities for urban agriculture and urban foraging .

Multifunction green infrastructure

Towards upgrading urban ecosystem in Cairo

Urban agriculture can offer many advantages to urban areas, such as recreational, educational opportunities for youth, economic development, and increased habitat within the urban ecosystem .

Local food production via green infrastructure offers a variety of valuable community benefits.

3.7. Habitat improvement:

Various vegetated green infrastructure practices can enhance habitat for a wide diversity of flora and fauna. Ecological economists identify two features of habitat which are preconditions for the provision of a full array of ecosystem services. First, habitat is living space for both resident and migrating species. Second, habitat grants nurseries for species which live their adult lives elsewhere.

3.8. Public education

Green infrastructure gives a good chance to develop community awareness and knowledge about the value of sustainable water resources management. Community participation in tree planting affords a valuable educational opportunity for residents to become more informed about green infrastructure benefits.

Educating and informing the general public about the efficient use of water resources is a helpful service that can create support for better water management decisions in the future.

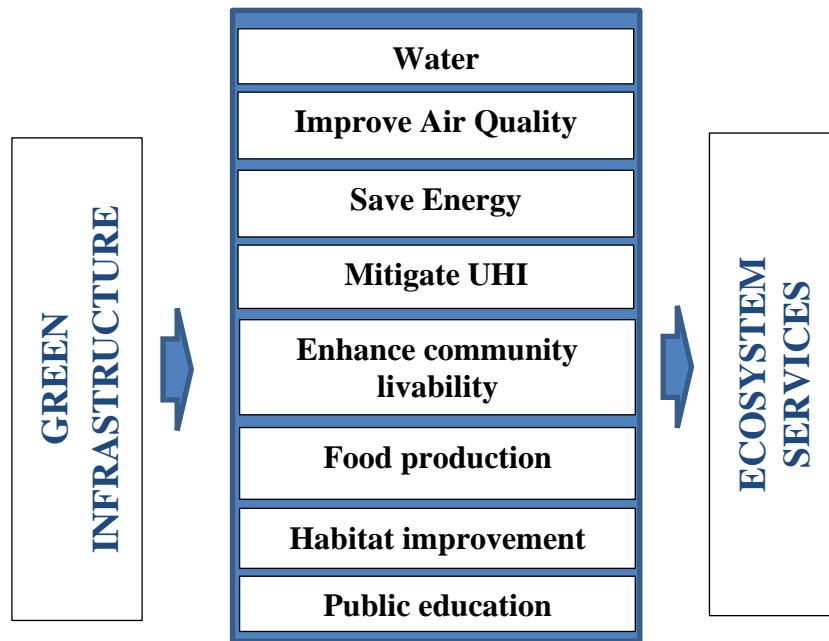


Fig.6. There is a clear link between green infrastructure and health of the ecosystem and the ability to deliver ecosystem services.

4. Case Study - CAIRO:

Cairo has been a dominant political, cultural, commercial and religious capital throughout history in Egypt (Abbas M. el Zafarany 2011). Cairo is a part of The Greater Cairo region, in addition to being one of the largest cities in the world. , like many other main cities of devolving countries, it's facing the same Environmental, Economical and Urban pressures (Ahmed Khaled 2014). Cairo Cannot be neglected as the main part of Greater Cairo when dealing with planning or infrastructure province of Greater Cairo. It must be addressed through a range of urban and environmental indicators to determine the beginning of any development plan. The region consists of the Governorate of Cairo, Giza, Benha in addition to new cities surrounding (El Sherouk - New Cairo - Obour - Badr – 6 October).

Multifunction green infrastructure

Towards upgrading urban ecosystem in Cairo

According to published reports, Greater Cairo suffers from a range of environmental problems, including air pollution, high noise ratio (EEAA2008), drainage systems problems, and the problem of drinking water in addition to high population density and road accidents.

The research will focus on the problems affecting one of the new cities, New Cairo, to develop a methodology and visualization methods as a solution.

4.1. Focus - NEW CAIRO:

New Cairo City is considered as an exceptional experience between Egyptian new cities. The emergence of the city and growing from Separated urban communities in 90's to be the biggest new city in Egypt in 2016, as a part of Greater Cairo. It is located in the north-east of Greater Cairo; Bordered from North by Cairo –Suez highway, Katamia–Sokhna highway from the south, Cairo ring road from the west and eastern desert from the east. It covered 70580 acres and divided into groups of communities (neighborhoods) the biggest is the Fifth district, in addition to a range of real estate investment cities such as (Al Rehab – Madinaty).

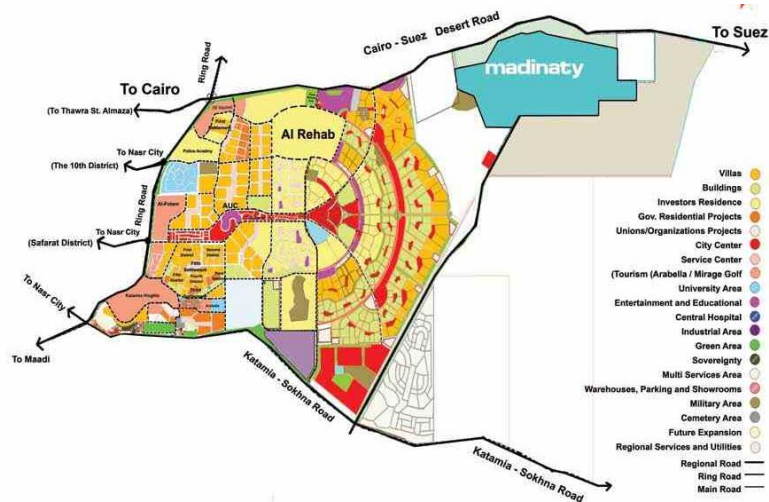


Fig.7. New Cairo Master plan

City master plan shows the variety of planning concept according to real estate project or beginning of Avenue. The population of New Cairo is 1.3 Million people in 2012 (CAMPAS2016), Expected population will increase to 6 million at 2027 (New Cairo 2016). Residential areas representing 61.6% from City land use, 25.5% services and 1.7% Industrial use.

4.2. City infrastructure between reality and future:

4.2.1. Water:

The city is receiving water from water purification station in Al Obor City, 550,000 m³ /day. The city water station will be established by a capacity of 3million m³/day. Only 50% of the targeted water network was implemented, in addition to the main source of water from other stations (Al Obor City and Maadi) .

4.2.2. Sewage:

Projects are divided into Sewage treatment plants with capacity 560,000m³/day present; the first phase of sewage stations in planning reach 1.5 million m³/day. One Treatment station of sewage will be used to irrigate the green belt of West Ring Road with capacity of 8000m³/day. The Sewerage network that was implemented is about 49.3% of target .

Next tables 1 and 2 clarify the gap between planning and implementation process when compared to the growth of the city and the population needs.

It is clear from the field study that in spite of the presence of City Authority and it's right of management and coordination, but the presence of the central' plans of the bodies responsible for infrastructure and lack of association in line with the city's growth and development in harmony with the administration and urban design system.

Multifunction green infrastructure
Towards upgrading urban ecosystem in Cairo

| station process | Sewage | | Water | | Electricity | |
|--------------------|--------------------|---------------|--------------------|---------------|--------------------|---------------|
| | Number of stations | % from target | Number of stations | % from target | Number of stations | % from target |
| Constructed | 3 | 15% | 1 | 14% | 4 | 36% |
| Under construction | 3 | 15% | 1 | 86% | — | — |
| Designed | 2 | 10% | — | — | 2 | 31% |
| Under Design | 5 | 60% | — | — | 3 | 33% |
| Total | 13 | 100% | 2 | 100% | 9 | 100% |

Table (1) shows list of stations building process.

| | Sewerage network | Water network | Electricity network | Road network | Telecommunication network |
|--------------------|------------------|---------------|---------------------|--------------|---------------------------|
| Constructed | 49.3% | 50% | 60% | 56.1% | 32% |
| Under construction | 21% | 20% | 15% | 15.3% | 16.3% |
| Under Design | 30% | 30% | 35% | 28.6% | 51.1% |

Table (2) presents infrastructure network Implementation process according to City plans.

4.2. Discussion:

4.2.1. Infrastructure between green and gray

Despite of the recently emerged planning Egyptian new cities, most of these plans are based on the same traditional methods of urban planning and gray infrastructure perspective. This research highlights the possibility of restoring the plans which have not been implemented to turn them from gray to green infrastructure plans. The previous section of the research discussed the unique benefits of green infrastructure and the current status of the city's infrastructure. It being by research clarifies a set of associated planning, design and operational concepts of green infrastructure issues.

4.2.2. Administration issue: Planning infrastructure is an integrated process that depends on the integration between all environmental systems and networks in the city in addition to the activities and uses that affect or affected by various environmental systems. Therefore

plans should be linked to the concept of comprehensive goals of the city. All process must be under the local administration of the city, according to a new regime of Egyptian cities to face the conflict between the authorities and bodies. International experiences in green infrastructure, explain the importance of the local administration in the planning and design process as well as the participation of stakeholders (Danielle Sinnett, Nicholas Smith and Sarah Burgess 2015.).

Despite New Cairo having management tools and jurisdictions over the city, the local authorities do follow the central government authorities' plans .when it covers to managing infrastructure plans. The role of city authorities minimized to coordinate between different bodies, leading to inconsistent and sometimes failure in planning, management and execution. In planning every authority puts its own agenda from different perspectives. for example the city water supply is not enough , so it takes the rest of supply from Obor city .which could cause supply problems in future, if water needs increases either in Obor City or New Cairo City . Many other examples could be discussed in future researches.

4.2.3. Economical issue: Many politicians and local administrations even planners believe that the cost of green infrastructure is greater than the cost of gray infrastructure. In fact, the cost which must be calculated in the cost of construction of these projects in addition to the large operating costs in some projects, such as sewage in addition to the cost of environmental damage (Michael R. Bloomberg, and others 2015).

For the Egyptian case or the case of Greater Cairo, the cost of improving air quality (world bank 2016) and reducing noise in addition to the economic benefits of tree planting forests in desert areas (EEAA2015). The processing of new soil for agriculture and plug in some types of wood must be added to the original cost (Josh Foster, Ashley Lowe and Steve Winkelman 2011). That is evident in Minis-

Multifunction green infrastructure

Towards upgrading urban ecosystem in Cairo

try of Environment affairs and ministry of Agriculture reports In addition to the reports about wood industries from Ministry of Trading. Many other economic benefits can be added and not mentioned here.

4.2.4. Environmental Issue: Some ideologies introduce the welfare and environmental issue as a luxury issue, although it is a crucial factor to achieve a reasonable degree of quality of life.

Environmental challenges in New Cairo became of paramount importance that affects the Egyptian capital conditions. By observing the available green infrastructure potentials, particularly in the light of establishing a new city, the environmental concerns may turn into a motivation for the city future even more it could be an economic attractive element for investors and the residents who want to get out of Cairo to the new communities. This may also lead to ease the load on the old city and its crumbling infrastructure.

By using green infrastructure methodology will increase air quality, reducing noise, planting tree forests and safe using of wastewater. It is environmental solutions as a comprehensive system. That need re-structure and training of the local administration, legislation of new policies and the most important of all is the real well and determination to change reality.

4.3. Application levels:

Green infrastructure solutions vary according to application scale, starting from the regional scale reaching to the housing unit scale. This study will focus on city level.

4.3.1. City Level:

New Cairo City existing plans and future plans are showing the gap between plans and real needs in both aspects, quantitative and Qualitative aspects. For instance, the Wastewater treatment station was built for irrigation usage treats 1.6% of the amount of drainage wa-

ter. It's used for irrigating the green belt near Cairo ring road. While Egypt suffers from water scarcity, the majority of green areas in the city are irrigated by city drinking water. Despite starting in implementation of drip irrigation network using treated waste water, this network represents only 0.05% from target.(Melissa G. Kramer2014).

5. Action Plan framework

In this part, the research presents a framework of a solution according to the available data. It could be developed by stakeholders in future plans. This framework depends on theoretical study, field study and some of stakeholders suggestions (New Cairo inhabitants, Academics, City Administration, Media, Real estate companies). This frame focuses on three main themes (Administration theme, Environmental-Economic theme, Socio-Economic theme)

Field study methodology: The research team adopted a variety of field monitoring methods to determine the current status of the city infrastructure as well as main problems. The field study has been divided into; a survey of the publication of scientific research, official reports and some newspapers articles which clarify the problems and the situation of the study area, In addition to monitoring and photographing of the current situation, interviews with city employees and residents. The research took the stake holders recommendations into consideration in the development plan.

5.1. Administration framework:

The concept of framework depends on the development of administration system of the city that leads to the achievement of sustainable development objectives, in addition to using green infrastructure as a catalyst. The system improvement process is classified to two

Multifunction green infrastructure

Towards upgrading urban ecosystem in Cairo

parts: the first part is related to city administration structure, legislate a set of laws and regulations that realizes decentralization of the urban administration and adding sub departments under the city authority and establishing new departments such as, urban observatory which responsible for data gathering and analysis using new techniques and providing technical support for decision-makers. The second part is dealing with the rehabilitation and training of workers in urban administration and sections associated with infrastructure projects and urban management.

5.1.1. City hall: specialized with supervising design, planning and construction infrastructure projects, in addition to its comprehensive vision of city sustainable transactions. Since that Egyptian government system are centralized and through it the central government control all the projects and its planning, Legislators must develop a set of laws lead to decentralization in urban planning and management. International experience and successful projects proved that transactions from gray to green infrastructures are more successful and effective in decentralized systems, New York and Barcelona are good examples. This transaction process is dynamic process that must have dynamic management to deal with.

5.1.2. Urban Observatory: Although there were urban Observatories under the Ministry of Housing, But their role is limited that they don't have intervention ability. In green infrastructure perspective, there must be an urban observatory following all changes and transactions, make reports and give advices for local authorities and other stakeholders.

5.1.3. Technical teams: Importance of technical staff with understanding of green infrastructure themes is basic need for this transaction. Training these teams before implementation processes is priority. Because urban management teams in local governments became old bureaucratic structure, only work theoretically and with slow

rhythm. Changing from traditional management vision to new era need a lot of development for human recourses.

5.2. Environmental - Economic framework:

According to sewage water map, the distribution of sewage stations near the desert allows the modification of the network pipe lines to create more forests that depend on treated wastewater for irrigation.

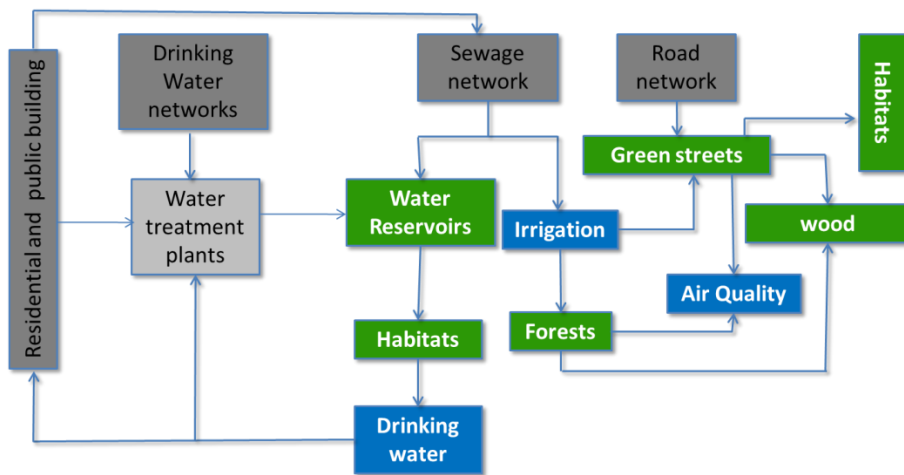


Fig.8 Environmental framework chart (Reference: Author)

5.2.1. Agricultural irrigation network

Establishing Agricultural irrigation network that depends on treated sewage water could serve to irrigate green areas of the city. This leads to increasing the economic outcome and decreasing carbon dioxide emissions increasing the habitats life as an environmental impact.

5.2.2. Wood Forest

Establishing forest in east part in city in desert these forests also function as protection barrier against dust and sands coming from the desert to the city. Investment in the production of urban forests

can cover a large part of the operating expenses of these stations (Habitaturba, Medi Ambient 2013).

5.2.3. Ground water reservoirs:

Considering the amount of sewage coming from residential and office units, The surplus in the water for irrigation and drainage It can be used and re-directed to the desert part of the work of the ground storage tanks and lakes . In addition to the exploitation of water and increase environmental habitats it has economic return in the agricultural exploitation and fish farming. There are local and international experiences of pioneer in this field, and the best example of this experience of Wadi Rayan, Fayoum

5.2.4. Industrial zone:

Converting an existing industrial zone to environmentally friendly zone is a complicated process but setting up a successful new one only depends on planning and management. Despite the poor selection of the industrial zone and the advanced industries zone location in the city (review city plans) we must deal with the current situation as high priority because there is another factor in the equation which is, companies and the industrial land owners.

One of the most important factors that must be included in the action plan is planning a green belt around the industrial zone and introducing clean industries that depend on clean energy. Also establishing a monitoring system by the city hall to monitor factories activates and its impact on the city.

5.2.5. Green ways:

Turning high ways into green ways for protecting the city core from climatic changes, dust and pollution, then using wood for economic

value outcomes and transforming the ring road into a green way. Beijing city second ring road case study is good example (Jun Yang, Zhou Jinxing 2007)

5.2.6. Energy

Using solar energy in new Cairo city is considered to be one of the most efficient and promising development strategies because all contributing factors are easily provided except for the well and planning and the management system that facilitate this process.



Fig.9. Proposal for environmental action plan

5.3. Socio-Economic theme

Improve the quality of life in the city will lead to the lifting of real estate value of the city, In addition to raising the economic factors of

Multifunction green infrastructure

Towards upgrading urban ecosystem in Cairo

the population and the development of new professions. Infrastructure development will lead to the lifting of buildings efficient and sustainable living in the city.

6. Results and Recommendation:

Study has explained the importance of green infrastructure. It may be one of the major economic and environmental engines in new cities, In light of the concept of sustainable development.

It has been directing the light into the gap between the urban reality in the new city of Cairo and the infrastructure, which could lead to deep problems in the near future if it is not remedied.

This study emphasizes the need for Egyptian researchers and planners in addition to the Egyptian government to develop a strategy for green infrastructure, according to the Egyptian reality. This strategy can lead to a real plan linked to the needs of the people and cities and share the implementation with all stakeholders

The local administration is capable of developing integrated systems and linking them to the city. Therefore it should be given more powers in planning and implementation to local governments and departments.

Green infrastructure integrated system can raise the quality of life in the cities of Egypt, and investment to achieve economic returns over the long term as well as environmental and urban returns.

The shift from gray infrastructure to green infrastructure could be applied in different stages of the city life. But it is preferred to be applied at the beginning of the founding of cities infrastructure, therefore still allows time to amend the New Cairo plans to align with modern concepts of sustainable development.

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Towards upgrading urban ecosystem in Cairo

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