STORM-WATER CONTROL USING GREEN INFRASTRUCTURE TECHNIQUES

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ABSTRACT

In the last few years the notable increase in population and their environmental illiteracy has destroyed the worlds natural ecosystem; destruction is affecting all professions and sciences. The problem is global as well as local; Egypt and Ethiopia move closer to war over Nile river waters, also a lot of habitat disappears due to water pollution and the urbanization of coastal cities (such as Alexandria which struggles with storm water every winter because of ageing infrastructure) (Abdl Mawla, 2012). The problem calls for a more strategic and comprehensive approach to land conservation and the consideration of green infrastructure approach as a solution for the development of threatened regions.

Green infrastructure is an approach that maintains healthy waters, multiple environmental benefits and support sustainable communities (EPA,2012). Green infrastructure encompasses guidelines for water, energy, habitat, community and air values protection and restoration. This paper focuses on hydrological infrastructure as means for maximizing both the quality and quantity of storm water in coastal cities, *case study Alexandria (Egypt).* The paper methodology is to refer to case studies, publications, papers and books. It is expected that implementing a green infrastructure strategies in Alexandria will increase the water security and high quality of water, reduce the sewer overflow and support the natural habitats.

KEYWORDS: Hydrological, Overflow, Storm water management, Degradation of green areas.

INTRODUCTION

The loss of natural areas has reflection beyond the problems of water, air, energy, damage in communities and disappearance of rare species. That is why investing in green infrastructure makes economic sense, and be a strategic approach to land conservation that is critical to the success of smart growth initiatives. A green infrastructure will help reconnect existing natural areas and improve the overall ecological performance of the locality. Infrastructure is "*The substructure of underlying foundation on which the continuance and growth of a community or state depends*."(Wibsters dictionary). There are two types of infrastructure; as gray infrastructure and green infrastructure, Table (1).

The gray infrastructure designed as it is "the man made substructure that consist of engineered and built system that support community functions, such as highways, utilities, water and waste water systems, public buildings, culverts, and storm sewer systems"(Implementation manual, 2012).

Different references give different definitions to green infrastructure; (Benedict and McMahon, 2000) states that "*Green infrastructure means different things to different people depending on the context in which it is used"* For example, some people refer to trees in urban areas as green infrastructure because of the green benefits they provide, while others use green infrastructure to refer to engineered structure that are designed to be environmentally friendly.

While in the workshop held in Brussels in March 2009 "Towards green infrastructure for Europe" they defined it by many definitions, one of them that it is "*Planning/Strategic approaches that maintain ecological functions at the landscape scale in combination with multi-functional land uses*". Green infrastructure have five types which are; hydrological infrastructure, energy, air, habitat and communities. This paper targets about green infrastructure for storm water management purposes; "*A large scale and small scale storm water management approaches and technologies that infiltrate, evaporating spire, capture and reuse storm water to maintain or restore natural hydrologists*"(EPA,2012).

Problems arising from poor management of hydrological infrastructure "*increased volumes and rates of runoff discharges, reduced time needed for runoff to reach surface water, increased frequency and severity of flooding and reduce stream flow during prolonged of dry weather*"(Lagro Jr, 2011). Alexandria has a problem of rain water management that arise every winter, become roads comp-

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letely covered with runoff water which in turn lead to social problem such as traffic jams.

The hypothesis is could the principles of green infrastructure be applied to the city of Alexandria to improve its storm water management?

Smart growth is developed as "*development that is economically sound, environmentally friendly and supportive of community livability growth which enhances the quality of life*" (Benedict and McMahon, 2002). It is a solution to poor planning issues. Green infrastructure can help in finding the ideal places for development. Smart growth and green infrastructure are two sides of the same coin; Communities need to make better use of existing infrastructure and to support more walkable, mixed use communities. Also smart conservation promotes resource planning, protection, and management in a way that is; productive not reactive, systematic not haphazard, holistic not piecemeal, multi-jurisdictional not single jurisdictional, multifunctional not single purpose and multiple scales not single scale, (Benedict and McMahon, 2002).

PROBLEM DEFINITION

The human beings are the newest organism on earth. The industrial revolution happened in year 1750. During 350 years of industrial activity humanity polluted the earth CO2, which affected the eco system. Many green spaces are rapidly disappearing (For example; Alexandria lost 25% of its farmland after the 25 January revolution). (Abdel mawla, 2012). Second; fragmentation which is defined "the division of the farmland into a collection of scattering lots". "*Fragmentation increases edge habitat and the isolation between patches while reducing the number of natural plant and animal species*" (Benedict and McMahon, 2002). Third thing is the degradation of water resources. Alexandria also has a huge problem in water conservation due to bad habits of users, aging gray infrastructure that cannot cope with current over population and its stresses. Green infrastructure provides not only storm water management, but also flood mitigation, air quality management and more. The Final point is in the weakened ability of nature to respond to change.

GREEN INFRASTRUCTURE VS. GREY INFRASTRUCTURE

It is clear that community's need both types of infrastructures and planners have to find ways of making the two types of infrastructure complement each other. The added value of green infrastructure arises from its multifunction use. (lucius, Dan and Caratas, 2011) Table 1.

Table 1- Comparison Between Green And Gray Infrastructure

	Gray Infrastructure	Green Infrastructure
Definition	Refers to the technical interconnected structures that support a society, such as roads, rail ways, water supply, sewers, power grids and telecommunications.	It is an interconnected network of green space that conserves ecosystem values and functions and provides associated benefits to society.
Cost	Gray infrastructure can provide service only after large investments.	Nature can provide services for free
Care	Does not necessary care for ecosystem.	Measures, such as habitat restoration and mainte-nance, also create jobs and fuel the economy, just as grey infrastructure do, but in a more sustainable manner.
(Elhalwagy. E, sustainable development of lakefronts, 2014).		

TYPES OF GREEN INFRASTRUCTURE

There are five types of green infrastructure; habitat, community, air, energy and water. Each one of them has its benefits and strategies to do it correctly. The Green Infrastructure is one of a number of innovative actions aimed at halting the erosion of biodiversity. The first appear of known organisms date from nearly 3.5 billion years ago. Approximately 1.8 million different species of animals and plants have been identified to date and some 15000 new species are described each year. A large number of them going too degraded. Biodiversity is a restoration of the natural environment, plants and animals. It provides many irreplaceable goods that people could not live without; oxygen, food, medicines and many row materials (Minland, 2010).

Green infrastructure has many benefits on community; social interaction benefits, inclusion and cohesion benefits. It helps to conserve the multifunctional use of the green space system and children, in order to gain from participation in green space terms, and can learn about the natural environment and develop skills through play. Around 65% of adults reported that the provision of nearby green spaces is important to them (Bureau, 2007).

Green infrastructure can provide climate change mitigation and adaptation through many things; it can help to reduce ambient heat and flooding in urban areas due to the cooling effect of trees, the implementation of sustainable urban drainage system (SUDS) in the right location plays a vital role in combating flooding, a higher percentage of green cover in urban areas reduces the air temperature, trees and other vegetations remove CO2 from the air, increasing environmental quality and quality of place encourages more people to travel sustainably through green spaces linkages, finally its linkages enable continued spaces diver-sity (HM Government, 2009).

Green infrastructure can save energy through many things; urban heat island, energy use, climate change and Water/Energy Nexus (EPA, 2012).

There are a lot of water types; drinking water, ground water, lakes, oceans, beaches, rivers and streams, storm water, waste water, water sheds and wetlands. All of these resources need to be treating and protected. The research focused on hydrological infrastructure design and application in Alexandria (Egypt).

THE HYDROLOGICAL INFRASTRUCTURE

Much of infrastructure is needed to replacement or repair, the community needs resilient and affordable solutions that meet many objectives at once. Green infrastructure is one solution. The bad use of humans to nature makes many alterations to the natural environment which can affect the movement of water through the hydrological cycle and alter its composition, Fig. (1).

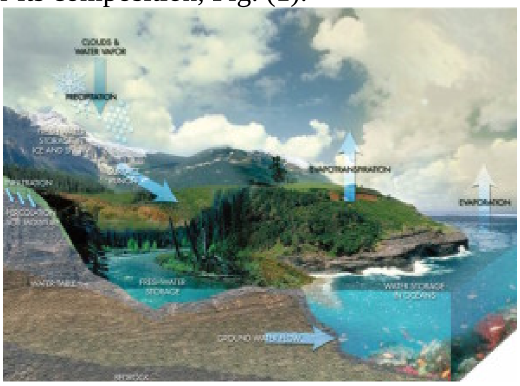

Fig. 1- The Hydrologic Cycle, Showing How Water Circulates Over, Under, And Above The Earth's Surface (Image Courtesy NASA, 2012)

That leads the scientist, geological and architects to face the approach of green infrastructure which requires integrated strategies for managing water, waste water, energy and solid materials systems. There are many problems happens because of the damage of hydrological infrastructure; storm water, runoff water, sea level rise and more. Once rain water hits the ground, it is considered storm water. The quality of storm water varies depending on where it falls. Storm water can be treated by using porous pavement, structured soil and swales. On the other hand the runoff can be increase by the increases on impervious area which make the infiltration decrease. Removal of natural vegetation reduces foliar interception of precipitation, whilst the use of impermeable materials in urban construction decreases ground infiltration of Precipitaion, giving an overall reduction in evapotranspiration, Fig.)2).

That should happen beside many strategies; water conservation and use reduction, conjunctive use, water recycling and improvements to infrastructure. There are many problems happened depend on human behavior which cause the degradation of hydrological infrastructure. It could be seen in many things such as; agricultural pollution, urban groundwater pollution and industrial pollution. The agricultural pollution happens because of the use of chemicals in lands. The dispersed nature of sources of pollutants is a core challenge facing both monitoring and control of groundwater pollution related to agriculture. Unlike industry or municipal sewage systems, agricultural pollutants are dispersed over large land areas. While return flows in drainage canals can be monitored, it is difficult to determine the extent of pollutants through soils and into the groundwater.

The other type of pollution is the ground water pollution which happens because of the direct leakage of wastewater to groundwater and the human damage in the soil structure. The last thing is the industrial pollution; industrial activities have polluted large areas. The industrial units drain effluents containing cadmium, zinc, mercury, chromium and other pollutants into the water elements and polluted ground water with its wastes.

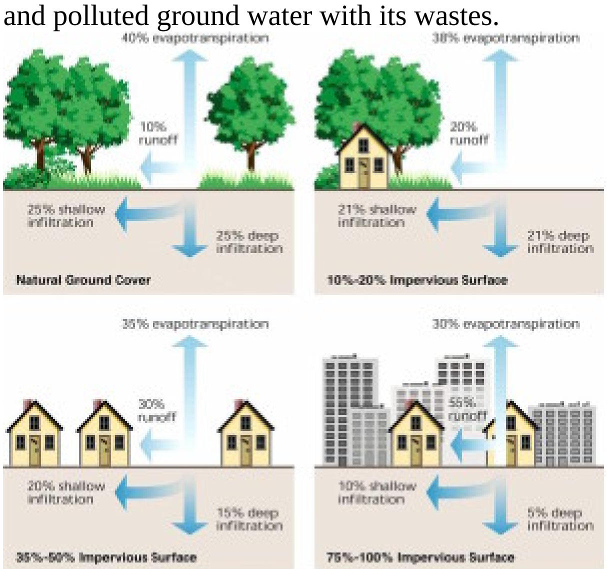

Fig. 2- Relationship Between Impervious Cover And Surface Runoff. Increased Impervious Cover Increases The Risk Of Flooding And Water Quality Degradation; As Little As 10% Impervious Cover In A Watershed Can Result In Stream Degradation (Image From FISRWG, 1998).

RESTORATION OF HYDROLOGICAL INFRASTRUCTURE

There are many techniques of hydrological infrastructure; green roof, down spout disconnection, rain barrel, permeable pavement, vegetated swale, rain gardens, infiltration trench, and urban fortes and restored wetlands. Each one of them has its benefit. Some of the techniques achieved all restoration benefits while others achieved only few. The benefits are; slower rate of runoff, infiltration, retention, detention, water quality control and reduced CSO frequency, Table (2).

Table 2- The different types of ways which can help in restore the hydrological infrastructure and the benefit of each

Green infrastructure technique	*Slower rate of runoff*	*infiltration*	*retention*	*Detention*	*Water quality control*	*Reduced CSO frequency*
Green roof	*		*	*	*	*
Down spout disconnection	*	*				
Rain barrel			*			*
Permeable pavement	*	*			*	*
Vegetated swale	*	*		*	*	*
Rain garden	*	*	*	*	*	*
Infiltration trench		*			*	*
Urban fortes	*		*		*	*
Restored wetlands	*	*	*	*	*	*
(Elhalwagy.E, sustainable development of lakefronts, 2014)						

Kansas City's sewer systems are aging. Each year, combined sewer overflows discharge 6.5 billion gallons of untreated effluent, and sanitary sewer overflows discharge another 100 million gallons. During large storms, systems can become overwhelmed by excess water, causing flow volume overflow. (EPA, 2010). The Metro Green Plan outlines the following goals; Preserve and protect stream corridors throughout the metropolitan area, Link people to outdoor resources close to where they live, work and play, Link Metro Green corridors to road bike and pedestrian routes creating interconnected alternative transport network.

The city had "10,000 Rain Gardens" initiative in 2005 to encourage residents to voluntarily install rain gardens on their property as a means of reducing storm water runoff, Figure (3).

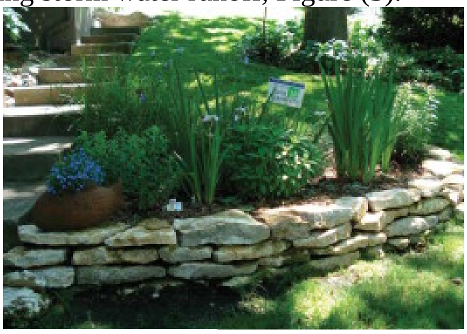

Fig. 3-: Rain Gardens. (NRDC Organization, 2012)

The highlights from a storm water perspective include, adoption of stream buffers (minimum 100-foot measured from stream edge); a goal to plant 120,000 trees in streetscapes and parks; including green infrastructure practices into city planning and development processes; and an Economic Development and Incentives Policy promoting preservation and enhancement of green infrastructure as tools for economic development. Measures were added under CSO overflow control plan. There are different techniques used; Green roofs, rain barrels/cisterns, permeable pavement, rain gardens, infiltration trenches or vaults, vegetated swales, street trees, stream buffers and downspout disconnections (NRDC organization, 2012).

Kansas City built the basic sewer infrastructure over 150 years ago. The overall sanitary sewer system is comprised of both combined and separate sewer systems totaling 58 square miles of combined sewers. A separate sanitary sewer system collects sewage and a relatively small percentage of inflow-storm water and infiltration - ground water which gets into the sewers through cracks- and is not designed to overflow unless a storm occurs which exceeds the sanitary sewer design capacity (John Franklin, 2009), Fig. (4).

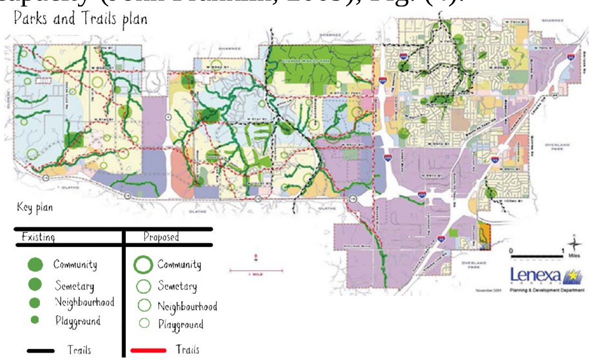

Fig. 4- The Existing And Proposed Green Areas With Its Different Types And Trails. (John Franklin, 2009)

CASE STUDY: Alexandria, Egypt, Abu Kier District

Alexandria is considered by the locals divided into seven zones, Abu kir district is one of them, (Fig.5)

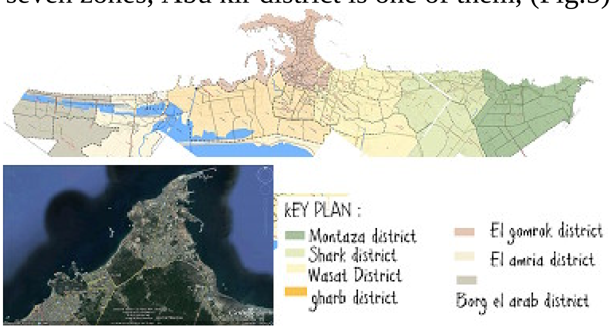

Fig. 5- Alexandria Districts And Zoom In El Montaza District. (Google Earth And Edited By The Researcher, 2019)

It is linked by the others mainly by el Montazza Bridge. However many attraction zones are located in Abu Kir which causes a large flow of residents from other districts to Abu Kir. Some of those nodes are health facilities, governmental offices and a college of engineering and technology. Leading to block of road network and traffic congestion is a reoccurring issue for locals. That causes water settlement on non-porous street with insufficient drainage system. So the roads to and from Abu Kir are usually completely blocked due to wet weather condition. The case study focuses on three main points which the problem can be clearly seen in it; El-Montaza bridge area, the degraded farmlands along the road and El-Ma'mora sea line, Fig. (6).

Fig. 6- The Three Nodes Which Discussed In The Case Study. (Google Earth And Edited By The Researcher, 2019)

El- Montaza Bridge is the main link between Abu kir and the rest of Alexandria districts. There is traffic problem at the zone of the bridge during dry periods because the street narrows down to only two lanes around a 90 degree bend, Figure 7.

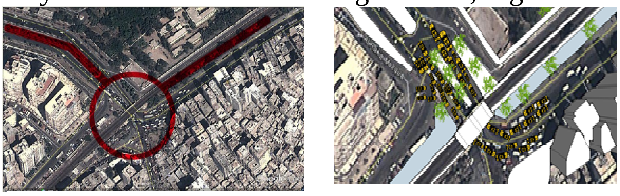

Fig.7- El-Montaza Bridge Area. (Google Earth And Edited By The Researcher, 2019)

In the rainy days this problem is magnified by storm water submerging the road, Appendix (1) Recently along Malek Hanafy street the road which lead to Abu Kir, there are a lot of degradation of farmlands. People start to remove farmlands and build their buildings instead of it. That causes a huge problem, these farmlands helps in absorb the over flow of storm water. Now it can't do that because of its degradation, Figure 8.

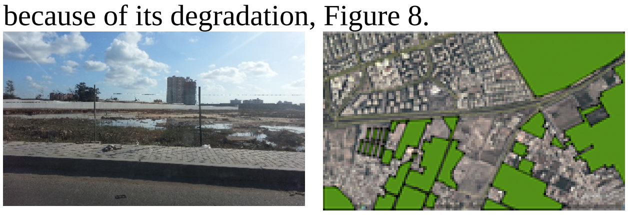

Fig.8- The Degradation Of Farmlands. (Google Earth And Edited By The Researcher, 2019)

The shore line of el Ma'mora beach has a small area of wetland buffer which is the sand area then pavement walk way area which are around 20m. The ideal amount of wetland buffer in shore lines is from 20 to 50 feet. (Costal.Gov, 2013). However the pavement area not pours pavement, Figure 9.

Fig, 9-El-Ma'mora. (Google Earth And Edited By The Researcher, 2019)

The proposal will discuss each problem by solving it by using different techniques of green infrastructure.

EL-MONTAZA BRIDGE AREA

Green infrastructure is one solution for the problem. First making swales instead of the normal walk ways and roads islands. That leads the storm water to swales so it decreases the storm water amount. However it helps to grow the native plants which can help the biodiversity also. Second the porous pavements which can help in absorb the storm water and collect it in underground tanks to reuse it again in irrigate the green areas, Figure 10.

Fig. 10- The Proposed Swales And Rain Gardens (Google Earth And Edited By The Researcher, 2019)

THE FARMLAND DEGRADATION

The solution of it is to replant those farmlands to help the environment, Figure 11. It will allow storm water to seek into the ground as it would in natural setting. This approach has a potential to restore groundwater recharge rates. But also has a potential to introduce pollution into the subsurface.

Fig. 11- The Proposed Farmlands. (Google Earth And Edited By The Researcher, 2019)

THE WETLAND BUFFER ZONE

To solve the problem the proposal replaced the small amount of wetland buffer with an average amount of it –green area- to gain the benefits of the wetland buffer which are; Forms a protective barrier from runoff, provide feeding and breeding habitat of birds and it absorbs the overflow of storm water, Figure 12.

Fig. 12- The Proposed Wetland Buffer. (Google Earth And Edited By The Researcher, 2019)

DISCUSSIONS

The proposal suggests three uses of green infrastructure strategies to solve the problems. First separate the sewage system, second rainwater management control in the site through swales and pours pavements, third will be through the restoration of farmlands and the restoration of wetland buffer.

CONCLUSIONS

Green infrastructure approach must be start in Alexandria, it will help the city to control the overflow of storm water and give it a lot of benefits. It will help in support municipal water supplies, reduce infrastructure costs, reduce energy and greenhouse gas emission, increases water security, improves flood control, reduces sewer overflow and offers community benefits. That can help the city to be safe from the every winter over flow storm water. Which happened according to the over flow sewage system. This approach can lead the city to the net-zero water which makes all water demands are met with harvested rainwater and reuse water. Waste water and storm water can be managed on site. However it can save a huge amount of water in several techniques.

APPENDEX (1)

Date: I8 January 2013

Time: 11:00 AM to 12:30 PM.

Key Plan

1

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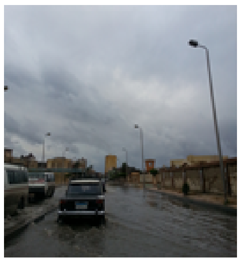

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