SJIF IMPACT FACTOR: 4.183 CRDEEPJournals
International Journal of Environmental Sciences Mikias Biazen Molla Vol. 4 No. 2 ISSN: 2277-1948
International Journal of Environmental Sciences Vol. 4 No. 2. 2015. Pp. 89-101

Review Paper

The Value of Urban Green Infrastructure and Its Environmental Response in Urban Ecosystem: A Literature Review

Mikias Biazen Molla
Hawassa University, Wondo Genet College of Forestry and Natural Resources,Department of Natural Resource and Environmental Studies, P. O. Box: 128, Shashemene, Ethiopia.

Abstract
The main objective of this review study is to explore and demonstrate the best socio-economic, and environmental benefit of green infrastructure technology from various literature documents, this will be helpful to the redevelopment or reestablishment of Green Infrastructure (GI) activity for developing countries especially for Africa. Currently, rapid growth of population and the high density cities in African are major environmental problems, due to inadequate planning and lack of attention; the GI resources (urban ecosystem) of African cities are also being rapidly depleted. Hence, this study has assessed different GI experiences which are found in developed countries for the sake of sharing information to developing countries (Africa). The study has also discovered how developed nations socially and economically benefited from GI, and assesses the response of GI to urban environment/ecosystem. Thus, as many studies confirmed that, GI has a multi-functional social, economic, cultural and environmental benefit which provide for urban and pre-urban dwellers. Therefore, this review document mainly focused on the multifunctional benefit of GI which has contributed to urban ecosystem. It includes; social benefit (health and wellbeing's, recreational and educational value); economic benefits (economic value, energy saving, and green job opportunities) and the environmental response/benefit of GI (includes biodiversity/ecological response, carbon reduction and sequestration, improving urban air quality and climate change and adaptation response). It also captures different scholar's view and opinions about the benefit and significance of GI to the entire communities. Finally the document attempts to bridge for further source of information and endeavors to indicate the existing research gaps about the issue.

Key Words: *Environment, Green Infrastructure, Social well-being, Sustainable Development*

Introduction

Today more than 50% of the world's population inhabits urban areas, making the urban environment the most common habitat for man, continuously the urban areas increase in the number of inhabitants as well as in size (Sandström, 2009). Cities are home to half the world's seven billion people. Current urbanization trends indicate that an additional three billion people will be living in cities by 2050, increasing the urban share of the world's population to two-thirds (Aromar, 2013).According to (Richard *et al*., 2013) and (Ahern, 2007), report human settlements are complex, evolving social-ecological systems which are dependent on the health of their associated natural environments for ongoing sustainability. Thus, planning for sustainable cities is a complex process addressing the fundamental areas of economic, environmental and socially equitable sustainability (Ahern, 2007 and Janet, 2007). Urban Green Infrastructure (GI) is an evolving concept to provide abiotic, biotic and cultural functions in support of sustainability (Ahern, 2007). GI is a new term, but it's not a new idea. It has roots in planning and conservation efforts that started a hundred and fifty years ago (Mark, 2000). It is emerged as an active term of reference in project development planning (Beauchamp *et al*., 2013).Hence, GI has become an important policy initiative in many cities internationally, and has been used to address a variety of environmental and social concerns to day (Kathleen, 2012).

Though, GI is an emerging planning and design concept that is principally structured by a hybrid hydrological/drainage network, complementing and linking relict green areas with built infrastructure that provides ecological functions (Benedict and McMahon, 2002 and Ahern, 2007). Currently, several studies confirmed that urban green spaces as a resource in improves the environmental quality of life, promoting public health and providing valuable ecosystem services, urban tourism, active and passive recreations to urban dwellers (Haq, 201; John, 2011 and Martin, *et al*., 2013). Therefore, GI needs to be an integrated concept, it should include both concepts in a single ideology, respecting ecology and mimicking nature (Beauchamp, *et al*., 2013).

Similarly, the current growth agenda may hopefully require the identification and targeting of land for new green infrastructures. But, along with finding political and economic mechanisms for land acquisition within and around growing urban environments, sound ecological decisions will need to be made at a landscape scale (Janet, 2007). Moreover, this literature review study proposes to explore, demonstrate and contribute the value of green infrastructure concept to promote the applicability of the green economy and technologies and meet the needs of incorporating green concepts in city infrastructure design. Therefore in this review document, the practical and quantified significance values of GI were illustrated to articulate the key ecological benefit of GI in urban ecosystem.

One of the main aims of this review is exploring different GI experiences which are found in developed countries and share that information to developing countries especially for Africa. Finally the document attempts to bridge to further source of information and endeavors to indicate the existing research gaps about the issues.

Overview of the Literature

Green infrastructure is an important part of any planning effort, and can be closely associated with integrated water management planning at the city or local scale (CLUVA, 2013). In urban areas where land is valuable and the challenges are greatest, the quality of green space is important and the aim should be to achieve areas of multi-functionality. A shift that is beginning to take place, but still needs further action, is to embed green infrastructure into spatial planning and view it as part of the wider infrastructure of urban areas (CIWEM, 2010). However, in most recent time, current trends suggested that Africa's rate of urbanization is two times faster than Latin America and Asia (UNCHS, 2007). Similarly, this urbanization trend appears not to have translated to proportionate economic growth and better welfare for the citizens (Kjellstrom *et al*., 2008).

Since the rapid rates of urbanization in most developing countries have led to massive housing shortages and qualitative deficiencies (Ozo, 1990). Conversely, the vegetation, water and open spaces within and around African cities are over exploited, due to unplanned and illegal sellers. Likewise, there is a witness African cities are loss a number of green resource and associated benefits through rapid development and inadequate planning (CLUVA, 2013). Studies showed that, majority of urban residents in West Africa are tenants with no interest of ownership, they find a room at a price they can afford (Okeyinka, 2014). Rakodi (1997) and (Okeyinka, 2014) confirmed that in many African countries access to land and house ownership is limited then the majority of the people become tenants and their life is mainly dependent on the surrounding natural resources. Adedeji *et.al.* (2010), agreed that, within the global context, Africa is generally assessed as a rural and the least urbanized continent with the antecedent high rate of slum development, crime, underdevelopment as well as overpopulation. Similarly, in sub Saharan Africa urban population continues to expand, but urban management system is very weak and most people are poor (Rakodi, 1997).

Rapid urbanization in East Africa (Ethiopia) poses several serious challenges for planning, city development, living conditions and a great challenge for urban ecosystem sustainability. To sustain their life a number of peoples try to solve their housing needs by getting land informally at the urban fringe. This result has become a problematic repercussion for proper land use and planned urban development (Bjørn, 2007). In Africa the rapid rate of urbanization has engendered several challenges and problems similar to situations in other parts of the world and most of the city are characterized by substandard and inadequate housing, slums, and lack of infrastructure, transportation problems, low productivity, poverty, crime and juvenile delinquency (Mabogunje, 2002).Urban development problems in Africa could be viewed from both socio-economic and environmental perspectives. Thus, the cities are especially vulnerable to frequent flooding, erosion and storm damage (Lawanson, 2006, and Youngquist, 2009). In addition to that, most urban people in Africa have very limited experience with green infrastructure development and underestimated in land use decisions, so they do not understand its significance or the potential it can bring to their city and towns (Youngquist, 2009).

Hence, the cumulative effect of the above mentioned urban problems has its own contribution to development of environmental sustainability and quality and quantity of GI. Usually, urban environmental problems are mostly due to developmental processes and are of local, regional and global effects (Adedeji *et al*, 2010). Thus, the integration of the Green Infrastructure approach can be smart and strategic and offer potential ways of effectively integrating biodiversity into spatial planning and sectoral considerations (SDC, 2010).However, with inadequate planning, the green infrastructure resource of African cities is being rapidly depleted and the communities has also miss the opportunity to maximize the benefits which is obtained from the existing green infrastructure resource (CLUVA, 2013).

Consequently, planning should avoid harm before the need of mitigation measures. At a policy level, planning and the planning system needs to incorporate green infrastructure and an ecosystem approach to ensure that benefits are optimized in the long term, especially in relation to climate change adaptation and biodiversity loss (CIWEM, 2010). Now it is the time of planners and decision makers to plan effectively for this infrastructure, in recognition of the essential role it plays in the sustainable and climate conscious development of all urban areas (www.cluva.eu).Green infrastructure should be recognized as providing a wide range of environmental and quality of life benefits and as a result, built into all regeneration and development schemes from the outset (Oulia *et al.*, 2009). Therefore, experience sharing, adopt the existing technologies and awareness needs to be raised about the importance of green infrastructure and ecosystem services, in order to link their protection with sustainable use and management of (CLUVA, 2013). Awareness creation of the multifunctional benefit of green infrastructure and in a multidisciplinary way stakeholder involvement is essential elements of successful urban sustainable planning system. These will have to be an assignment at all stages to build stable community structure and support sustainable development.

Socio-Economic Benefit of Urban Green Infrastructure

Social Benefits

In this section of the review assess the social benefit of green infrastructure and demonstrate the practical value of green infrastructure/space from the developed countries perspective. Therefore, this section includes; health and well-being; recreational and

educational value of green infrastructure. Various literatures confirmed that there are many potential social benefits that good quality, accessible green space and infrastructure can provide, but the most significant of these can be grouped into three broad categories: Improvements in levels of physical activity and health, promotion of psychological health and mental well-being and facilitation of social interaction, inclusion and community cohesion (Forest Research, 2010).

Health and Well-Being

Socially, benefits from urban greenery can accrue to urban communities through access to urban green spaces, healthy living and education. Many public green areas provide the local community and visitors with opportunities for physical recreation and relaxation, as well as for social interaction (Wodarczyk, 2007). According to *Forest Research*, there is a strong body of evidence which demonstrates the restorative value of green space showing that more passive forms of usage, or even just access to views of green space, can have a beneficial impact on mental well-being and cognitive function (Forest Research, 2010 and RICS, 2011). Studies found that, quality green spaces have positive benefits for people living in deprived urban communities (SDC, 2010). Similarly, access to green space is an important predictor of increased physical activity ("active living") and reduced risk of obesity (John, 2011). This was already found by Bayram *et al.* (2012), people who were exposed to natural environment, the level of stress decreased rapidly as compared to people who were exposed to non-environment.

Sustainable responses to climate change and economic difficulties can also help to solve social problems, such as fuel poverty and traffic congestion (SDC, 2010). Various research evidences, shows that they can have a beneficial impact on mental well-being and cognitive function. At their best, green spaces can also help facilitate social interaction, integration and the development of community cohesion (Forest Research, 2010). On the other hand, different case studies showed that reduced access to the natural environment can result in social isolation, obesity and chronic stress (Institute of Public Health, 2006). Clean waters are essential to the vibrancy and success of local businesses that depend on beachgoers and other recreational water users. However, a study conducted by USEPA found the contamination and loss of aquatic species and habitats from polluted stormwater runoff costs the commercial fish and shellfish industry up to $30 million every year (Water keeper Alliance, 2008).

Reducing polluted runoff that flows into rivers, streams, and coastal waters is a cost-effective strategy to ensure that these waters are safe for swimming, boating, and fishing (Banking on Green, 2012). In the study of John H. (2011), shows illness and death caused by eating contaminated seafood is estimated to cost local economies an average of $22 million per year from missed work days, medical expenses, and investigation of the contamination (John, 2011). Illnesses attributable to water contaminated by urban runoff can have a significant economic impact. Every year, up to 3.5 million people become sick from contact with water contaminated by sewage (Nelson *et al*., 2003 cited in Banking on Green, 2012). However, the existence of GI reduces the pollutants that enter our waters and can help to reduce the impact of these economic losses (Banking on Green, 2012).Studies suggest that 'Parks play a critical role in facilitating physical activity in minority communities'. It is confirmed that, people walking around parks have been shown to reduce stress across a broad spectrum of individuals (Cohen *et al*., 2007; Hartig *et al*., 2003).

Green spaces also act as a filter to improve air quality, in this case vegetation has a great contribution to improve air quality through removing gas and dust related pollutants (Bolund *et al.*, 1999). Certainly, improvements in air quality due to vegetation have a positive impact on physical health with such obvious benefits as decrease in respiratory illnesses (Bayram *et al.,* 2012 and NICE, 2008). Various medical studies indicated that, peoples just being in, or viewing, green space for a few minutes reduces stress which is has been demonstrated with hospital patients and the general public (John, 2011). Thus, the connection between people and nature is significance and strong for everyday enjoyment, work productivity and general mental health (Haq, 2011). Similarly, a review of literature linking health and green infrastructure, observed that there were a number of epidemiological studies linking proximity of green space and levels of physical activity (Humpel *et al*., 2004; Pikora *et al*., 2003 cited in Forest Research, 2010).

Human contact with nature is recognized as valuable for our mental health (SDC, 2010). The positive effects increased with the length of stay and with the level of physical activity undertaken (Sun *et al*, 2003). A study illustrated by Frank (2003) found that students under exam stress had increased positive feelings and reduced fear and anger when they had a view of plants (Lovasi *et al*., 2007), he also found that more trees in urban neighborhoods correlate with a lower incidence of asthma. It was found that when plants were present in the interior space systolic blood pressure was reduced by one to four units, to which worker's productivity was also increased (Okunlola, 2013). At present, several studies have pointed to urban green spaces as a resource in promoting public health and providing valuable ecosystem services to urban dwellers (Martin *et al*., 2013).

Greater reductions in blood pressure were observed in subjects who had recently taken part in tasks demanding attention, when they were in a room with a view of trees compared with those in a room with no view (RICS, 2011). Lohr *et al.* (2007), has also demonstrated that plants in the workplace reduce stress levels. The health benefits of regular walking have been widely reported, for instance, Jones *et al*., (2009), confirmed that the benefits walking can contribute to reducing coronary heart disease and type 2diabetes. Similarly, blood pressure reductions, as well as reductions in anger and greater attention, were also found in those walking in a nature reserve compared with those walking in an urban setting (Hartig *et al*., 2003). Green infrastructure can also be used to encourage active travel, with integrated walking and cycling networks which promote cardiovascular health (Forest Research, 2010). People

who have better perceived access to green spaces have been reported to have greater physical activity (Coombes *et al*., 2010). The potential for green infrastructure to positively influence health needs to be balanced with other important factors, such as both the real and perceived personal safety of accessing and being in such areas (Jones *et al.*, 2009; Pretty *et al.*, 2005).

However, the links between green space and physical activity are not clear and different studies have found contradictory results (Jones *et al*., 2009). One studies demonstrated the concern that is sometimes raised about public open spaces is their potential to attract criminal activities such as drug dealers and other undesirable elements from outside the immediate community. This is because the public green spaces are often deserted at night, thus providing secluded and convenient venues for crime. (Thomas, 2013). Nevertheless, a study of public housing complexes in an inner city, found a correlation between lower crime rates and nearby vegetation (Kuo, 2001). Likewise, literature review conducted in Australia (Deakin University, 2008) showed that natural areas, such as parks, can reduce crime, foster psychological wellbeing, reduce stress, boost immunity, enhance productivity, and promote healing. In fact, the positive effects on human health, particularly in urban environments, cannot be over-stated. However, there is also evidence to suggest that the benefits of green space are unevenly distributed throughout society, and certain groups, such as those living in deprived areas, ethnic minorities, the elderly, women and people with disabilities do not experience the same levels of benefits as others (Weldon *et al*., 2007 and Fairburn *et al*., 2005). However, if the community has been involved in the planning and implementation of a green area, its presence could be increased as it takes over management and ownership of the green areas in their locality (Thomas, 2013). As a result, urban planning should ensure that the communities have adequate access to nature (ICLEI, 2012).

Recreational Value of Green Infrastructure

Green Infrastructure provides a high quality environmental setting attracting new businesses and which directly serve the tourism, recreation, leisure and health sectors (SDC, 2010). People satisfy most of their recreational needs within the locality where they live. Urban green spaces serve as a near resource for relaxation; provide emotional warmth (Bayram *et al.*, 2012). Studies conducted on UK found that, green corridors reaching into town centers from the surrounding countryside provide infrastructure for non-motorized transport and access to healthier environments (EFTEC, 2005). Similarly, studies in Mexico City, the centrally located Chapultepec Park draws up to three million visitors a week who enjoy a wide variety of activities (Haq, 2011). According to EFTEC, 2005) and John (2011), greening city centers also attracts new visitors, in turn supporting urban retail and tourism sectors and provide ideal surfaces for a variety of recreational and sports activity and high use activities including parks and playgrounds.

Many literatures illustrated the positive impacts on quality of life in urban areas from improved aesthetics, increased recreational space, and a connection to the natural environment (MMSD, 2012). One study found that office workers who can see nature from their desks report greater job satisfaction and lower rates of sickness than those who cannot see nature from their work areas (Niemelä, 2009). A study looking at the effect of nature on those living in poverty found that poor inner-city environments generate chronic mental fatigue through crowding, noise, together with the stresses of poverty and single parenting (SDC, 2010). Research results indicated that, nature has a rejuvenating quality in tackling mental fatigue and improves the ability of individuals to manage major life issues (Kuo, 2001 cited in SDC, 2010). Improved aesthetics values of cities have been shown to decrease stress and, when combined with transportation improvements that increase walking and biking, significant health benefits are realized (MMSD, 2012).Studies in the Northwest showed that, visitors are already worth £10.9bn per year and supporting 200,000 fulltime equivalent jobs and the rural economy element of this is worth around £770m a year. More than 8m visitors each year from outside the region visit the Northwest, while residents of the Northwest itself take 195m day trips to countryside areas within the region (NWDA, 2006).

According to "CDC recommendations for improving health through transportation policy," several green infrastructure strategies, such as porous pavement and bio-retention, can be placed along roadways and help form complete streets roadways that are planned, designed, and operated to enable safe, attractive, and efficient access and travel for all users (Centers for Disease Control, 2010). Well-maintained parks promote community engagement and civic pride, attract and connect individuals of all ages and ethnic backgrounds who share a vision for the betterment of their surroundings **(**Okunlola, 2013). Attractive settings add to the value of the land and property (SDC, 2010). Urban housing developments that are adjacent to natural amenities such as woodland, parks, waterways and the coastline are more attractive to buyers and this is often reflected in market prices (UCD, 2008). Similarly, some other benefits like providing recreational opportunities, rendering aesthetic enjoyments, enhancing social ties and playing a role in developing a community identity have been attributed to green spaces (Yang *et al.*, 2005). It has also been demonstrated that social benefits of green spaces in dense urban areas go as far as helping people cope with poverty and life difficulties (Kuo, 2001). As well as a resource for learning, green spaces can also be used to develop understanding of healthy, active lifestyles which are a component of physical education **(**Okunlola, 2013). Many public green areas provide the local community and visitors with opportunities for physical recreation and relaxation, as well as for social interaction (Wodarczyk, 2007).

Educational Value of Green infrastructure

Green infrastructure has also been used as a valuable education resource, and has the potential to improve educational achievement, eventually helping to create a better qualified and more highly skilled workforce, and to bring higher salaries and more valuable business investment into the region (GLA, 2003). It also offers learning and employment opportunities through events, educational

outreach and jobs as rangers and green space managers (Richard *et al*., 2013). Various case studies illustrated that, the educational value of green infrastructure can be achieved through both formal education, e.g. field trips with school, and informal education, e.g. through visits with friends and family (Okunlola, 2013). But, in order to derive the maximum benefits from outdoor learning and play, the green space should offer a variety of vegetation types and topographies, as well as the ability to interact with the environment (Niemelä *et al*., 2009).

Lifelong learning skills can also be enhanced by engagement with green infrastructure. The fostering of greater respect of green infrastructure among adults can also assist in reducing management costs through reduction in litter, fly tipping and other inappropriate uses (Okunlola, 2013). Studies in UK found that, the importance of outdoor learning is recognized in the UK National Curriculum where the need for fieldwork and data-recording skills, as well as the ability to discover information about the local environment, are required from as early as primary education (The Countryside Agency, 2005; Natural England, 2010). Green infrastructure provides a valuable, local resource for local schools and parents to use to teach children about sustainable development, conservation, environmental change, places, plants, animal and natural and man-made processes, all of which are taught as part of the National Curriculum in UK (Okunlola, 2013). Therefore, green infrastructure is an instrument which can be used to demonstrate and know peoples especially youngsters about their entire environment.

Economic Benefits of Green Infrastructure

Investment in Green Infrastructure can encourage and attract high value industry, entrepreneurs and skilled workers to a region through the creation of high quality, environmentally friendly living and working environments, value adding to local economies (ECOTEC, 2008). Green Infrastructure investment provides for the generation of new recreation and leisure opportunities and also stimulating economic activity within agriculture, forestry, and public services (EFTEC, 2005). Studies in North West show that, investments in green space have been used to improve a region's image, helping to attract and retain high value industries, new business start-ups, entrepreneurs and workers (NENW, 2008). In order to given that, good quality green infrastructure can have positive impacts on environment and society, it follows that it can also positively contribute to economic performance (RICS, 2011). A studies conducted by Michigan State University found that, as components of green infrastructure, natural and environmental resources provide a wide array of amenity services benefits to society (LPI, 2008.

In order to assess local or regional economy, studies showed on the value of green infrastructure in offering local economic opportunities, this becomes particularly relevant to communities and regions in transition from "old" to "new" economies and also determine population and income growth (Deller, et al., 2001;LPI, 2008). Nelson *et al.* (2003) also found that and generate direct and indirect economic impacts through visitor spending in the local economy. Thus, local economic regeneration is strongly related to increased quality of place, recreation and leisure, and tourism (Martin *et al*., 2013). According to forest research studies economic regeneration involves increasing employment, encouraging business growth and investment, and tackling economic disadvantage (Forest Research, 2010).

Countries when developing the green economy there is also related opportunities; they can create new jobs, limit the environmental impact of towns and cities, and reduce the costs of running them (SDC, 2010). Similarly, in poor urban areas, where food purchasing makes up a large part of a household's income, they produce from urban agriculture can be used for home consumption and as an effective way of supplementing income, thus contributing towards poverty reduction (Thomas, 2013). On the other hand, green infrastructure can provide less expensive, and more cost-effective, approaches to managing runoff municipalities may benefit from lower capital costs (Banking on Green, 2012). USEPA recently released case studies about green infrastructure benefits, the study estimates that capital cost savings ranged from 15 to 80% when green infrastructure was used, with a few exceptions in which costs were higher than conventional stormwater management costs (LID, 2007).

Studies conducted on North West America showed that, green infrastructure technologies can reduce flood water surface elevations, which means that property values, due to reduced flooding, could increase by as much as 5% and avoided costs in downstream culvert replacement and upgrades could equal over $3 million and decrease flood losses by amounts ranging between $9,000 per acre of floodplain for the 100-year event to $21,000 for the 2-year event (Johnston *et al*, 2006; Medina *et al.*, 2011). Various literatures illustrates that this type of flood control is cost-effective for small flood events, and also provide measurable flood control benefits for larger, less frequent events (Banking on Green, 2012). Still, indicators are very strong that green spaces and landscaping increase property values and financial re-turns for land developers, of between 5% and 15% depending on the type of Project (Haq, 2011).This can assist in urban regeneration and renewal; improve the attractiveness of locations for business investments; create community enterprises; and generate new employment opportunities (Wodarczyk, 2007).

Another study in California, showed that the city's 24,000 public street trees provided US$1.2 million annually in net environmental and property value benefits (Maco *et al*., 2003). It was also shown that the benefit cost ratio was US$3.81 for every US$1.00 spent on tree planting and management. Economic performance of an area, be it at the town, city or regional scale, is related to the condition of physical, social and cultural infrastructure (RICS, 2011)

Economic benefit increased city tax revenue from the development has resulted in an estimated increase of ecological, recreational, and aesthetic resource site value (MMSD, 2012). Studies showed that, in Michigan skiers and snowboarders spent $146 million on trips to ski areas through 2.2 million skier visits, generating $63.7 million in ski revenue; $41.3 million in visit expenditures; and $41.4 million in tourism related spending. This created $54 million in direct personal income and 3,900 jobs (Sun *et al.*, 2001). Similarly, Pictured Rocks National Lakeshore in Michigan hosted 421,000 recreational visits in 2001, spending $14.8 million. The total estimated economic impact of visitor spending was $12 million in sales, $4.6 million in personal income, $7.4 million in direct value-added and 426 jobs (Nelson *et al*., 2003). Although several plans were evaluated, ultimately the green infrastructure based solution was chosen because it saved $1 million, a 45% reduction compared to the conventional stormwater management option. (Banking on Green, 2012). At the local level, the economic impact of green infrastructure-based activities was also substantial. For instance, in 2002, total tourism spending in Washtenaw County was estimated at $352 million. The direct economic impact of this spending was $111 million in wages and about 5,700 jobs (Nelson *et al*., 2003).

Parks has also makes substantial contributions to the community's economy for example Golf is growing in popularity, and appealing to a broad range of people **(**Okunlola, 2013). Urban public park can help in increasing the property value the real estate market consistently demonstrate that many people are willing to pay a higher amount for a property located close to parks or open space areas than for homes that does not offer this facility (Love,et.al,1999 cited in Okunlola, 2013). A park basically becomes one of a city's landmarks and attraction making it a prime marketing tool to attract tourists, conventions and business. **(**Okunlola, 2013 and MMSD, 2012). Although direct economic evidence about the provision of these benefits is limited, what little exists suggests that green infrastructure provision and green space initiatives are a cost-effective method of achieving them. The improvement of existing and creation of new green infrastructure should be prioritized, especially in areas of greatest need (Forest Research, 2010).

Green Infrastructure for Energy Saving

Energy is the base of today's economy; communities around the world are seeking ways to reduce energy consumption and spending (Banking on Green, 2012). Vegetation has a great contribution in order to reduce the energy costs of cooling buildings has been increasingly recognized as a cost effective reason for increasing green space and tree planting in temperate climate cities (Bayram *et al*., 2012). Studies show that, green roofs, street trees, and increased urban green spaces have the effect of making individual buildings more energy efficient by reducing heating and cooling demands (Banking on Green, 2012). Heisler (1986), analyzed the amount of costs of which is reduced by green infrastructure show that, cooling cost reductions of 20-50%, and heating cost reductions of 10-15% for residential allotments with trees. Similarly, a study in Chicago has shown that increasing tree cover in the city by 10% may reduce the total energy for heating and cooling by 5 to 10% (Haq, 2011). The City of Chicago was an early pioneer in the green roof movement, installing a green roof on its half of the City buildings that is estimated to yield an annual building-level energy savings of $3,600 (Banking on Green, 2012).

Some studies confirmed that, an 11,000 square foot green roof surface would save roughly $400 per year in heating costs and $250 per year in cooling costs for a total of $650 in savings per year (Obendorfer, et.al, 2007). One recent study showed that, savings of $650 in annual heating and cooling costs associated with a typical, commercial-sized green roof (Foster *et al*., 2012). The green roof at O'Hare covers nearly 175,000 square feet, captures close to two million gallons of stormwater annually, and will save the company an estimated $35,000 in energy costs per year (Obendorfer *et al.*, 2007). Likewise, at a nominal 5.4 cents/kWh, recharge from green infrastructure could save the City of Los Angeles $23,112,000 annually.

One study found that adoption of widespread green infrastructure practices could save over 1.2 million megawatt-hours of electricity per year in California. These energy savings represent enough electricity to power more than 102,000 single-family homes for one full year (Garrison *et al*., 2009). Implementing green infrastructure practices for runoff prevention and management can also help municipalities to reduce current and projected expenses, while providing additional resiliency in the face of increasingly expensive energy supplies (Banking on Green, 2012). Case studies in the city of Los Angeles indicated that, increased use of green infrastructure throughout Los Angeles County could recharge groundwater supplies that would save the city from the costs of importing up to 152,500 acre-feet of water every year by 2030. This would save the city up to 428,000 MWH in energy costs, equivalent to the electricity use of between 20,000 and 64,800 households (Chau, 2012).

Plants improve air circulation, provide shade, this cooling effect contribute to lower air temperatures, for example; a study conducted on Turkey indicated that, a park of 1. 2 km by 1. 0 km can produce an air temperature between the park and the surrounding city that is detectable up to 4 km away (Bayram *et al.*, 2012). Correspondingly, property value areas of the city with enough greenery are aesthetically pleasing and attractive to both residents and investors. This variability combined with inconsistent energy costs makes it difficult to calculate global energy benefits of green infrastructure. However local and regional examples indicate that considerable savings are possible through green infrastructure development (Banking on Green, 2012).

Green Job Opportunities

A green oriented infrastructure has an economic stimulus options that would have an immediate impact on job creation. For instance, the Apollo Alliance estimates that every $1 million invested in the US in energy efficiency projects creates 21.5 new jobs, as compared to only 11.5 jobs for new natural gas generation (DB advisors, 2008). On the other hand, green infrastructure has a potential to restoration, maintenance habitats, balance ecosystem services, and also create jobs and fuel the economy at different level. Investments in green infrastructure provide jobs as well as business opportunities and help to build partnerships (SURF, 2011). Studies on Milwaukee Metropolitan Sewerage District (MMSD) show that, on average, there will be 160 new construction jobs per year for constructing and maintaining new facilities. Once the new facilities are constructed, there will be over 500 green operations and maintenance jobs (MMSD, 2012). Globally, the UK Prime Minister has estimated that up to 25 million new "green" jobs could be created by 2050 with appropriate supportive policy in place, an estimation in-line with President-elect Obama's plan to create 5 million new "green" jobs in the US (DB Advisors, 2008).

Similarly, the research highlights green infrastructure's role in economic prosperity and stability, with a direct gross value added (GVA) from the environment calculated at £2.6bn, supporting 109,000 jobs in environmental and related fields (Environment Agency, 2006). One study indicated that in 2000, Michigan had 89 million "travel party nights" with $8.8 billion in tourism spending, creating 209,000 jobs; $4.3 billion in personal income; and $6.9 billion in value added, according to the report this represented 2% of the state economy and 4% of total jobs (Stynes, 2003). Likewise, business parks has also generated more than £4.5m in capital receipts and created more than 2,800 jobs (Richard *et al.,* 2013 and LPI, 2008).

On the other hand according to Environment Agency (2006), the Northwest's environment has supports 109,000 jobs and is worth up to £2.6bn in Gross Value Added (GVA) to the region. Similarly, a $10 billion investment in water efficiency projects at would produce a total economic output of $25–28 billion and create 150,000 to 220,000 jobs (Banking on Green, 2012). According to the Cambridge shire report there is expected to accommodate a significant amount of strategic growth over the next twenty years, equating to at least 73,000 new homes, 50,000 new jobs and over £ 4 billion worth of new infrastructure in the period to 2021 (Cambridge Horizons, 2010).

Green Infrastructure Response to Environment

Biodiversity/Ecological Response

Ecologically, green spaces are significant for nature conservation as they provide habitats for a wide range of flora and fauna (Thomas, 2013). Urban green spaces provide to cities with ecosystem benefits ranging from maintenance of biodiversity to the regulation of urban climate (Bayram *et al*., 2012). This may include both the preservation and protection of rare and vulnerable species, and the provision of a valuable educational resource (Sinnett, 2006). A studies conducted on Turkey indicate that, green spaces do many functions as protection center for reproduction of species and conservation of plants, soil and water quality (Bayram *et al.,* 2012). In the study of Haq (2011), in green spaces that feature has good connectivity and act as wildlife corridors or function as urban forests, can maintain viable populations of species that would otherwise disappear from built environments.

Ecological benefits of urban green infrastructure are largely related to the provision of habitat (Forest Research, 2010). Studies showed that, the very presence of plants in a city improves the visual appearance of the urban environment, contributes towards climate change prevention, creates lower densities of development and reduces levels of activity in an area (Thomas, 2013). There is big variation comparing with rural areas, in solar input, rainfall pattern and temperature is usual in urban areas, hence solar radiation, air temperature, wind speed and relative humidity vary significantly due to the built environment in cities (Bayram *et al*., 2012). In UK Neighborhoods, Cities and Regions Analysis Division (NCRA) analysis indicated that, the ecosystem is finely tuned with plant and animal species highly interdependent on each other for survival. Thus, urban green spaces provide valuable habitats for animals and plants but species can respond strongly to environmental change (NCRA, 2007). Similarly, urban green space offers a unique landscape that supports a diversity of flora and fauna and provides urban citizens with direct access to nature and all its benefits (ICLEI, 2012).

Studies carried out on London illustrated that, green infrastructure/spaces are increasingly being recognized for their ecological significance (Harrison *et al*., 2002). On the other hand, green Infrastructure has good opportunities to reconnects habitats which had been separated by development creating physical space for natural processes to take place (SDC, 2010). This helps to supply the linkage of the urban and rural areas. They provide visual relief, seasonal change and link with natural world (Bayram *et al.*, 2012). Whereas, a functional network of green spaces is important for the maintenance of ecological aspects of sustainable urban landscape, with greenways and use of plant species adapted to the local condition with low maintenance cost, self-sufficient and sustainable (Haq, 2011). A literature review which is conducted on Nigeria demonstrated the combination of mowed turf, trees and natural areas provides a diverse environment for people and wildlife, and preserving these green spaces improves the environmental quality of the entire community **(**Okunlola, 2013).

Carbon Reduction and Sequestration

Green roofs, bio-retention/rain gardens, and trees provide carbon reduction benefits by sequestering CO2 from the air as they grow (MMSD, 2013). Similarly, vegetation intercepts airborne particulate matter (PM10), reducing concentrations in air, thereby improving air quality. This reduces the amount of PM10 exposure to humans and, in turn, reduces the incidence of respiratory illness (Forest Research, 2010). Recent researches show that, GI/spaces purify and trap more that 12 million tons of dust, soil and other particulate matter. This is particularly important in urban areas due to the high incidence of asthma and other breathing disorders (John, 2011). Various studies explored the links between urban tree cover and air quality (Escobedo *et al.,* 2009). On the other hand, the results of the 3-year Chicago Urban Forest Climate Project estimated that the trees removed 6145 tons of air pollutants (valued at $9.2 million), and sequestered 155 000 tons of carbon per year, in addition to providing energy savings for residential heating and cooling that, in turn, reduce carbon emissions from power stations (Martin, 2013 and MMSD, 2013).

Through both carbon sequestration and avoided emissions, widespread green infrastructure will reduce CO2 by a total of 73,000 tons per year (MMSD, 2013). This mass is equivalent to removing the emissions of 14,000 vehicles, based on annual vehicle emission rates from USEPA (USEIA, 2010a). Studies on Australian found that vegetation could limit CO2 fluxes to the atmosphere, caused by urban traffic (Coutts *et al*., 2007). Because the filtering capacity of vegetation is closely linked to leaf area, trees with larger canopies can provide the most benefits (Trees and Design Action Group, 2008). A study in Santiago, found that urban forestry may be effective in improving air quality, particularly in terms of removing atmospheric particulates (PM10) (Wodarczyk, 2007; Escobedo *et al.,* 2009). Other environmental services provided by trees, which can be given a monetary market value, include carbon sequestration and air pollution mitigation (Martin, 2013).

The natural functions of urban trees are known to remove atmospheric pollutants, oxygenate the air, and absorb carbon dioxide through photosynthesis (Nowak *et al.,* 2006). The net present value of carbon storage of woodlands has been estimated in different part of UK; this varies from £601 million in the North West to £2,684 million in the South East, £114 million in the East Midlands to £492 million in the South West, (ECOTEC, 2008). The projected net present value of investment in planting and care of trees in Chicago indicates that the long-term benefits of trees are more than twice their costs (Nowak, 1995). Although the evidence clearly suggests that properly maintained green space is a net benefit in the effort to sequester carbon from the atmosphere, further study is required to determine precisely how the significant net carbon sequestration benefit of green infrastructure to the environment and the revere benefits such offsetting factors as fuel expense in maintaining green space, fertilizer and pesticide use, energy for water costs, etc. (John, 2011).

Improving Urban Air Quality

Green infrastructure can have a positive impact on air quality. Vegetation is capable of removing ammonia (NH3), carbon dioxide (CO2), oxides of nitrogen (NOx), ozone (O3), particulate matter (PM; dust) and sulphur dioxide (SO2) from the air (Nowak *et al*., 2006 and Powe *et al.,* 2004). The ability of trees to intercept pollution varies between species, throughout the age of the tree, and with the planting design (Martin, 2013). A case study carried out in West Midlands on urban forest reported that some species of tree have a greater potential to improve air quality (O3, NO2, HNO3, NO and PAN) while others could have a detrimental impact (Nowakn *et al*., 2006).

Urban areas contain the most particulate matter, due to an abundance of motorized vehicles. Thus, well maintained turf grass shields the soil and traps the particles which prevent harmful pollutants such as sulfur dioxide, ozone, hydrogen fluoride, and peroxylacetyl nitrate from being carried into the atmosphere (Almeida, 2006). Nowak (1995), analyzed the environmental impact of air pollution, according to him air pollution is a major environmental problem in most cities across the world. Major pollutants in urban areas are carbon monoxide (CO), nitrogen oxides (NOx), ozone (O3), volatile organic compounds (VOCs), sulphur dioxides (SO2) and particulate matter (Nowak, 2006). While, a recognized ecosystem service which is provided by urban trees and vegetation is mainly improve air quality in cities and towns (Martin, 2013). This can have positive impacts in terms of climate change mitigation (CO2) and human health (PM, SO2 and O3) (RICS, 2011). Increasing green space through green infrastructure practices like green roofs can improve air quality, particularly in urban areas, because the trees and plants that are critical components of these technologies are able to remove common air pollutants like nitrogen dioxide, ozone, sulfur dioxide, and some particulate matter (Obendorfer *et al*., 2007).

A recent study used a suite of models to predict the impacts of a 10 x 10 km area of the proposed East London Green Grid on particulate pollution (Tiwary *et al*., 2014). This estimated that 25 per cent tree cover (20 per cent broadleaf, 5 per cent conifer) on the green spaces could result in 90 tons of particulate matter being removed from the air each year, corresponding to the avoidance of two deaths and two hospital admissions per year (RICS, 2011). The City of Chicago estimated the economic benefits of greening 10% of the city's rooftops with green roofs could remove 17,400 Mg of nitrogen dioxide every year which would result in avoided public health costs of $29.2 million to $111 million annually (Clark *et al*., 2009). The natural functions of vegetation can directly and indirectly improve air quality, different studies show that gaseous pollutants are absorbed by leaves and either metabolized or transferred to the soil by decay of leaf litter, which may be particularly important in streets with high traffic volumes (Nowak, 1995 and Milly, 2012).

A study on City of Portland, on green roofs showed that each square foot of green roof removed 0.04 pounds of dust and particulate matter out of the air. Their analysis found that one 40,000 square foot green roof would remove 1,600 pounds of particulate matter from the air every year and would yield $3,024 annually in avoided healthcare costs (Gill *et al.,* 2007). Studies on urban Ecosystem Analysis of Washington, DC confirmed that tree cover in the city not only saved $4.7 billion in avoided stormwater storage costs, but also created $49.8 million in annual air quality savings by removing20 million pounds of pollutants from the air every year (Urban Ecosystem Analysis for the Washington, DC Metropolitan Region, 2002). Therefore, the use of urban green space offers significant potential in moderating the increase in summer temperatures expected with climate change (Gill *et al.,* 2007). Species selection and location play an important role in the use of vegetation to improve the air quality, but this needs to be balanced against other factors, based on the objectives for the green infrastructure. Species selection also impacts on biodiversity, aesthetic appeal, perception of security and accessibility (RICS, 2011).

Climate Change and Adaptation Response

Green infrastructure can also play an important role in reducing some of the impacts of climate change in our urban environments (RICS, 2011). It supporting the adaptation of people who live in towns and cities to a changing climate, depending on location, type and extent, green infrastructure provides shade, cooling and wind interception and an insulation role in the winter (Forest Research, 2010). Trees, in particular, have been identified as a key element of urban climate change adaptation strategies (Greater London Authority, 2008), without which the cities of the future are likely to become very inhospitable places (Trees and Design Action Group, 2008).The scientific evidence showing that the earth's climate is changing is well established, as is the fact that much of this is due to man-made greenhouse gas emissions (IPCC, 2007).

Green Infrastructure alleviates the impacts of climate change, such as flooding and the heat-island effect and provides effective eco-system services that are expensive and difficult to replace with man-made solutions (SDC, 2010). Urban areas have warmer air and surface temperatures compared with non-urban areas. Buildings, roads and paved surfaces store heat during the day which is then released in the evening and night resulting in increased temperatures (RICS, 2011). The urban heat island effect can be reduced by increasing albedo (the reflection of incoming radiation away from a surface) or by increasing vegetation cover with sufficient soil moisture for evapotranspiration (Obendorfer *et al*., 2007).

Incorporating green infrastructure (GI) into the urban built-space is gaining popularity as a cost-effective and long term measure for mitigating climate change impacts associated with proliferating grey infrastructure globally (CABE, 2010 and Schäffler *et al*., 2013). Over the next century, climate change scenarios project extremes of precipitation and temperature, increased storm frequency and intensity and sea-level rise (Milly, 2012). Green spaces around homes can reduce air conditioning costs, potentially saving $6.3 billion (USGA, 2007).

Modeling studies indicate that, despite the projected effects of climate change, addition of 10% green space in high density urban areas will allow cities to maintain current summer temperature levels for the next 70 years (John, 2011). Green infrastructure can help communities become more resilient to the likely impacts of climate change (Milly *et al.,* 2012). A study in Greater Manchester showed that increasing urban green cover, in high-density areas could decrease expected maximum surface temperature in the 2080s by approximately 2.5° C (Gill *et al.,* 2007). The use of urban green space offers significant potential in moderating the increase in summer temperatures expected with climate change (John, 2011). Particularly in urban areas, where evaporative cooling and shading provided by green infrastructure can ensure that towns and cities continue to be attractive and comfortable places to live, work, visit and invest (SURF, 2011).

Conclusion and the Way Forward

A growing literature recommends that while green infrastructure developments activities are necessary, that alone is unlikely to be sufficient as green economy and technology policies implementation. Because, the multifunctional (social, economic, cultural and environmental) benefit of GI are unlikely distributed every country on the world, thus every country takes part to intensify, and maximize the benefit of GI development. However, developed countries have already established ground and go far to exploit benefits obtained from each GI activity. While, developing country especially, African countries have remained very huge assignment to get the optimum benefit from GI.

Studies showed that, in many African nations, the general attitude in green space planning is, often articulated exclusively through spontaneous action and direct intervention to a persistent/visible problem, no long-term plan; it is only centered on the short-term effects that are set against limited time frames. As a result, this has contributed to frequent erosion and flooding, urban waste management problems, urban pollution, and increment of urban heat island effects in most African cities and towns. However, few African countries have been given little attention to urban green space/infrastructure development like Nigeria, South Africa, Egypt, and Ethiopia.

The development of urban green infrastructure activity is demonstrated through conservation of existing green belts in cites/towns, planting multipurpose tree, landscaping design, exercising urban agriculture, establishment of public and private parks and gardens, all

these component of GI has a great contribution to stabilize and regulate the cities/ towns weather condition and preserve urban ecosystem services. Various scholars in developed country confirmed that, green infrastructure practices can be less expensive and more cost-effective than traditional infrastructure approaches and increase energy efficiency and reduce energy costs, improve air quality, mitigate climate change and flooding impact, improve public health, cerate job of opportunities, and keeping the quality of city life and attract visitors.

Thus, in this paper an attempt has been made to review the potential benefit of green infrastructure to urban ecosystem, and existing opportunities that could help to address the redevelopment of GI and promote/ share profitable and sustainable practices for developing countries. This paper can also contribute and demonstrated developed countries experience and share to those countries that has not been reached the optimum benefit with GI development. This paper has revealed that there is an abundant benefit on the development of green infrastructure, there is also a wealth of knowledge of a range of measures that can help the development and establishment of GI activities to meet the objective of green economy strategies at worldwide. Therefore, the paper has suggested some of the following point to implement and obtain the desired benefits from GI developments;

- Applying a comprehensive urban green infrastructure is an important approach to mitigate urban heat island happened during the urbanization, construction, and development process. Various research results shows that the ambient temperature in urban areas is usually several degrees higher than that of their surrounding suburban and rural areas. Current trends suggested that Africa's rate of urbanization is two times faster than Latin America and Asia. Thus, different case studies shows that green roof is one of the best technologies to reduce energy for heating and cooling and minimize urban heat island effect as a whole, but it is not common in African countries, therefore, policies and strategies will be formulated to adopt from other developed nations and implement it on the ground.
- In Africa there are so many unemployed urban peoples, in different part of the continent. On the other hand, investments in green infrastructure provide jobs as well as business opportunities and help to build partnerships in different institution and stakeholders. Studies showed that, globally up to 25 million new green jobs will be generated by 2050 with appropriate supportive policy in place. Therefore, GI investment has a great contribution to create new economy and job of opportunities to the lower community members. Moreover, leaders and politician in Africa has to be considered this new dimension of development opportunities to create stable cities and town's environment and improve sustainable development.
- In Africa most of the cities and towns are affected by frequent flood and erosion, pollution, uncontrolled waste management system, high polluted runoff that flows into lakes, rivers, streams, and coastal waters. Stormwater management is an increasing concern due to climate change and water supply and contamination of water sources is also another concern resulting from pollution. This can cause for illness and death of people's which are lived around rivers, lakes, oceans, seas. Moreover, ecosystem conservation and GI implementation has a great potential to conserve the surrounding environment and protect water bodies from polluted runoff and wastes. Therefore, African cities/towns leaders should be invested their time and money to tackle the effect of flood and runoff on urban dwellers. Research evidence shows that GI has a beneficial impact on mental well-being and cognitive function and it helps to create and promote healthy and recreational environment for the urban community and has better influence on various patient treatments.

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