# Towards Mitigating Environmental Challenges in City Development: The Sustainable Landscape Architecture Approach

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**Abstract**
*Human developmental activities on the biophysical environment have precipitated a number of adverse impacts on the environment resulting to a number of environmental challenges. It is no secret that building construction and operations, urban growth and city development have enormous direct and indirect impact on the environment. These impacts are in terms of energy use, atmospheric emissions, use of raw materials, waste generation, water use and many other city degrading problems. The intergovernmental panel on climate change (2007) reports that carbon (IV) oxide equivalent of greenhouse gases in the atmosphere has already exceeded 400parts per million. This has been considered a critical point and already above the threshold that can potentially cause dangerous climate change. In the quest to curb these prevailing environmental problems, a conceptual developmental approach broadly referred to as sustainability was evolved. This is a mode of human development in which resource use aims to meeting human needs while ensuring the maintenance of natural systems and the environment both now and in the future. The issue of open spaces is very central in establishing the implications of landscape architecture on the environmental sustainability of the city development. This paper through the methods of conceptual analysis of literature and case study of some major open spaces in Lagos, Nigeria, reveals that Sustainable landscaping involves the consideration of ecological, social and economic aspects when implementing a plan. This paper outlines different environmental challenges and how sustainable establishment of natural and artificial landscape elements in open spaces can be used to mitigate the prevailing problems.*

***Key words:***
*City development, environment, landscaping, open spaces, natural system, and sustainability.*

## Introduction

Over the years, the development of cities has taken a pragmatic trend, a trend in which pressing city developmental issues (such as provision of basic amenities and infrastructures) are attended to. This trend has been most visible in developing countries. This is a city developmental approach characterized by carving out infrastructures and amenities out of open spaces, leaving surrounding left over spaces in a less environmentally friendly manner. The remaining undeveloped open spaces have led to the evolution of dumpsites, unkempt bushy areas that serve as mosquito breeding grounds, criminal hide outs, illegal slum structures and other degrading activities, consequently bringing about decay of the environments and cities. This pragmatic approach of city

development can be perceived as a high impact development practice, characterized by treatment of large open spaces with hardscapes, non-replacement of the damaged biotic environmental elements and a poor treatment of the general environment.

In order to mitigate these developmental problems, there is a need to approach city development in a low impact manner, through sustainable landscaping of open city spaces. Open spaces according to Fadamiro (1998) are landed areas not built upon, they range from purely natural landscapes to definitely cultural, artificial designed areas, from huge green areas to almost entirely enclosed small outdoor rooms. The surface properties and the amount of solar energy shaded, absorbed/reflected by these surfaces are major determinants of the tropical microclimatic condition of a particular area. Open spaces landscaping can be conceptualized as a sustainable synergistic approach of city development in which environmental friendliness, sustenance and conservation are fused with the processes of city development through open spaces.

These characteristic features of a high impact have precipitated several open spaces covered with hard landscape elements (which enhances increase in atmospheric temperature during sunny days) within developed cities, increased the amount of carbon (IV) oxide within the city envelope, through several city processes and reduced the oxygen (cooling atmospheric effect) due to decrease in plant biotic environmental elements within the city's open spaces. This has consequently resulted to greenhouse effect and climate change. According to Adeoye (2004) the various evidences of climatic change result from the effects of climate on animals, vegetation and land form, among others. All these effects are clear results of city development on open spaces if not sustainably approached.

**Materials and Method**

The various processes, procedures, methods and instrumentalities by which data are secured and examined for this research and ideal models proposed are highlighted as follows:

**Observation:** This involves making involves making direct clarification on existing situations in different open spaces, studies and notes taken of their merits and demerits.

**Literature Review:** Relevant text books, published and unpublished literature, lecture notes, project report, journals, magazine, the Internet and other literatures on sustainable landscaping, open spaces and city development were consulted.

**Case studies and Ocular presentation:** Pictorial documentation of the case studies was done to give firsthand information about the existing situations. It is a reliable source of information because it shows the phenomena in reality.

**Case Study Area (Lagos State, Nigeria)**

Lagos state is one of the coastal states in Nigeria and the most populous city in the country. It is also the fastest growing city in the world. The population of Lagos according to the Lagos State Government was 17.5million, but latest reports estimates the population at 21million, making Lagos the largest city in Africa.

The city of Lagos is divided into two geographical sectors, by the Lagos lagoon connected together by the mainland bridges;

- Lagos Mainland inhabits majorly the middle income developers, low income developers and the industrial developers.
- Lagos Island is characterized majorly by the central business district and the high income development.

These two geographical sectors of Lagos are characterized by several connecting road networks inform of ground road connections and overhead road connections (bridges and fly-overs). These numerous road networks has brought about numerous carved out open spaces inform of setbacks, cul-de-sacs, round-about, spaces underneath suspended land bridges and fly overs etc. Major open space areas on the mainland and island were visited, critical and analytical observations of characteristics and surface treatments done.

**Conceptual and Theoretical issues**

Sustainability is a conceptual idea traced back to the energy crisis and environmental pollution concerns in the 1970s (Mao *et al*., 2009). There are a number of motives to sustainable development; however modern sustainability initiatives call for an integrated and synergistic design to both new construction and in the renewal (rehabilitation and renovation) of existing structures (Ogunsote, 2012).

**Sustainability and Open Spaces Landscaping of Cities**

The role that is assigned to open spaces to play within the neighborhood structure, to achieve sustainability goals and objectives, is formulated in three key factors; space management, space function (circulation of people and permeability), and the role of objects within space (sustainable landscape). (Campbell, 2001; Ironside, 1999). The detailed study for these issues sets the sustainability checklist applied to open spaces. These details include:

**Space Management:**

This is a key factor to be taken into consideration. As in open space terms, sustainability is a function of the interrelationship between design and management. This includes (Campbell, 2001; Ironside, 1999):

- Encouraging sustainable lifestyles, for example by providing paths and cycle routes
- Making maximum use of existing features and assets
- Strengthening the sense of place
- Incorporating local or recycled materials
- Encouraging community participation and involvement
- Reducing inputs of non-renewable resources during construction and subsequent maintenance
- Eliminating or reducing the use of herbicides and resources that affect other ecosystems
- Encouraging habitat creation and native planting
- Managing resources carefully

**Space function (circulation of people and permeability):**
While most modern development planning uses the road network as the key structural element, a sustainable design takes the circulation of people on foot and bike and the effectiveness of public transport as starting points (Barton *et al*, 1996). However, creating neighborhoods where walking is the natural and pleasurable means of access between activities achieves much of sustainability goals and objectives (quality of life-health economics of communities, and community participation) (National Neighborhood Coalition, 2005). Moreover, it becomes a social activity in its own right. Thus the number of people on the streets and paths itself provides security. On the other hand, Smart Growth, New Urbanism and Neo-traditional Development trends highlight the importance of developing 'mixed land use' strategies to promote walking activities. They assert that "Communities can support walking and cycling if they are developed with meaningful destinations in close proximity to each other, such as shopping, school and employment". (National Neighborhood Coalition, 2005) These movements strive for well-designed communities that provide safe and abundant opportunities for routine physical activity. The objectives are to:

- Reduce the level of car reliance,
- Reduce the need to travel - with the social benefits of increasing transport choice for all groups in the population,
- Enhancing local security and community

**The Role of Objects within Space (Sustainable Landscape):** Landscaping elements are the basic constituent of any open space's structure. They have to be utilized to achieve sustainability goals at the micro level (Khalid Al-Hagla, 2008).
On the other hand, Ironside (1999) gives a detailed definition to sustainable residential greenspace as: "Greenspace fit for its purpose, responsive to evolving needs and changes over an extended period of time, not requiring an excessive input of resources." .This definition dictates that; for a Green space, as a division of open space- to be sustainable it should:

- meet the varied recreation and leisure needs of users and
- involve local communities

**Sustainable Open Spaces Landscaping in Developing Cities**
Sustainable landscaping begins with an appropriate design that must be functional, cost-efficient, visually pleasing, environmentally friendly and maintainable. It pays close attention to the preservation of limited and costly resources, reducing waste and preventing air, water and soil pollution. Also, compost, fertilization, pest control measures that avoid or minimize the use of chemicals, integrated pest management using the right plant in the right place, appropriate use of turf, irrigation efficiency and or water-wise gardening are all components of sustainable landscaping. A sustainable environment is the one in which all plants, animals and other forms of life are able to exist in an ecosystem without any exterior aid or interference (Sustainable Landscape Designs, 2010).

Sustainable landscaping includes a diversity of practices that have developed in response to environmental issues.Sustainable landscaping can be achieved by the adoption of the following:

- Reduction of storm water run-off through the use of bio-wastes, rain gardens and green roof sand walls (Rowe *et al*, 2006).
- Reduction of water use in landscapes through design of water-wise garden techniques (sometimes known as xeriscaping (Krizner, 2008).
- Bio-filtering of wastes through constructed wetlands (Carver, 2008).
- Landscape irrigation using water from showers and sinks, known as gray water
- (Melby, and Cathcart, 2002).
- Integrated Pest Management techniques for pest control.
- Creating and enhancing wildlife habitat in urban environments.
- Permeable paving materials to reduce storm-water run-off and allow rain water to infiltrate into the ground and replenish groundwater (Kerkhoff, 2006).
- Recycling of products, such as glass, rubber from tires and other materials to create landscape products such as paving stones, mulch and other materials.
- Soil management techniques, including composting kitchen and yard wasts, to maintain and enhance healthy soil that supports a diversity of soil life.

**Approaches to Sustainable Open Spaces Landscaping in cities**

Approaches to sustainable open spaces landscaping can be broadly termed as low impact development approach or Green Infrastructure. It capitalizes on the integration of infrastructure, architecture, and landscape in order to create a balanced, hydrologically functional and sustainable environment. Sustainable landscaping means that ecological, social and economic aspects are considered when implementing a plan. (Sarah and Danahinders, 2007). Open spaces landscaping can be perceived in two ways;

- Active open spaces Landscaping
- Passive open spaces landscaping

**Active Open Spaces Landscaping**

This is an open spaces landscaping approach whereby open spaces are functionally treated employing natural plant landscape elements. Plants materials form the green spaces of urban areas which play a vital role in urban biodiversity, contribution to sheltering, shading, water protection and decrease in local air temperatures (Tyrvainen, 1999).

Active open spaces landscaping involves two natural landscape design approaches. The first involves fusing traditional and naturally existing landscape elements in the city developmental process. While the second involves introducing majorly natural and soft landscape elements on to open spaces to enhance its natural capabilities. Active open spaces landscaping types include:

**Lawn:** A lawn is an open space planted with grasses or (rarely) other durable plants, which are maintained at a short height and used for aesthetic and recreational purposes. Lawns are of different types (depending on the type of plant used), this include; grass lawns, sedge lawns, herb lawns, wild flower lawns and ground cover lawns (Ripmeester, 2009). Lawns are subject to weed and pest infestations which require control.

***Rain Garden*:** This is a man-made depression in the ground that is used as a landscape tool to improve water quality, reduce flooding and enhance environmental quality. The rain garden forms a bio retention area by collecting water runoff and storing it, permitting it is filtered and slowly absorbed by the soil. Rain gardens helps recharge groundwater sources, helps protect communities from flooding and drainage over flow and provides a valuable wildlife habitat (Center for Neighborhood Technology, 2013)

***Shrubbery*:** This is an open space of cultivated shrubs. A shrub is distinguished from a tree by its multiple stems and shorter height, usually less than 6m tall. Plants of many species may grow either into shrubs or trees, depending on their growing conditions (Wikipedia, 2013a). Shrubs in common garden practice are generally broad-leaved plants, though some smaller conifers are also shrubby in structure. Species that grow into a shrubby habitat may be both deciduous or evergreen enhancing environmental outlook and sustenance.

***Topiary*:** This is a horticultural practice of training live perennial plants by clipping the foliage and twigs of trees, shrubs and subshrubs to develop and maintain clearly defined shapes. (Coombs *et al*, 2001). The plants used are evergreen, mostly woody, have small leaves or needles, and have compact and/ columnar growth habits. The hedge is a simple form of topiary used to create boundaries, walls or screens (Center for Neighborhood Technology 2013).

***Urban forestry and tree boxes within dense infrastructural areas*:** This is a careful management of urban forests, which are tree populations in urban settings for the purpose of improving the urban environment (Wikipedia, 2013b). An urban forest is a collection of trees that grow within a city, town or a suburb. In a wider sense, it may include any kind of woody plant vegetation growing in and around human settlements (McPherson, 2006). In a narrower sense (also called forest park) it describes areas whose ecosystems are inherited from wilderness leftovers or remnants. Trees serves as wind breaks, reduce residential heating, air pollution and unlike sewers and built infrastructures, trees appreciate in value and require less maintenance as they age (Center for Neighborhood Technology, 2013).

***Artificial water Bodies:*** Open spaces can also serve as platforms for creation of artificial water bodies. A water body is a significant accumulation of water usually covering the earth or another planet (Wikipedia, 2013c). Bodies of water created by man such as manmade lakes, pools, reservoirs and other large accumulation of water are all referred to as artificial water bodies. These man made water bodies are usually incorporated into the city system to enhance multiple environmental functions.

***Wet lands*:** Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all the year round or for varying periods of time during the year including growing season. In addition to capturing and slowing water flow velocity and improving water quality, wetlands provide valuable wildlife habitat and recreational opportunities (Center for Neighborhood Technology, 2013).

***Swales*:** A swale is a low tract of land, especially one that is moist or marshy. The term can refer to a natural landscape feature or human created one. Artificial swales are often designed to manage water runoff, filter pollutants and increase rainwater infiltration. The swale concept has also been popularized as a rain water harvesting and soil conservation strategy (United States Environmental Protection Agency, 1999).

***Porous paving*:** Also referred to as permeable paving is a range of sustainable materials and techniques for permeable pavements with a base and sub base that allow the movement of storm water through the surface (Wikipedia, 2013d). Although some porous paving materials appear nearly indistinguishable from nonporous materials, their environmental effects are qualitatively different. Porous paving materials include pervious concrete, porous asphalt and paving stones, all allowing percolation and infiltration of storm water into the soil below. Porous paving helps in reducing flood tendencies of cities, recharges ground water quality and eliminates the need for detention basins (Center for Neighborhood Technology, 2013).

***Native Landscaping*:** this is also referred to as natural landscaping/native gardening is the use of native plants, including trees, shrubs, groundcover and grasses which are indigenous to that particular geographic area. Native landscaping attracts a variety of birds, butterflies and other supporting agents of biodiversity. Once established native plants do not need fertilizers, herbicides, and pesticides or watering, thus benefiting the environment and reducing maintenance cost (Center for Neighborhood Technology, 2013).

**Passive Open Spaces Landscaping**

Passive open spaces is conceptualized as a form of vertical or elevated for of landscaping, whereby the elements used for active open spaces landscaping are taken above the natural ground level onto plat forms on infrastructural developments to enhance environmental sustainability. One of the major problems of green open spaces landscaping in densely populated major cities is the issue of absence of such free spaces. This is because practically all spaces have been developed using hardscapes brought about by the building and transportation fabric. The concept involves creation of large flat accessible spaces in buildings in densely populated city sectors. Such areas includes roof tops, terraces etc. This approach can also be employed in areas having rough and steep topographies. Open spaces landscape elements used in achieving this include, sand, grasses, groundcover, water, hedges, flowers and other shallow rooted plants. Some forms of shrubs can also be used, depending on the design of the structure. In some cases, an artificial grass (AstroTurf) is used to create a psychological natural landscape effect on users, increasing comfort.

**Green Roofs**

This is also referred to as living roof. It is a roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a water proofing membrane. Container gardens on roofs, where plants are maintained in pots, are not generally considered to be true green roof, although are still being debated (Vandermeulon *et al*, 2011). Depending on rain water intensity and green roof soil depths, run off can be absorbed between 15-90% thereby considerably reducing runoff and potential pollutants from traditional impervious roofing (Center for Neighborhood Technology, 2013).

**Green terraces**

A terrace is an architectural term used primarily to describe an external flat area in either landscape (such as a park or garden) or protruding from a building (Davis and Jokiniem 2008). The term also often applies to a raised area in front of a building or structure, which is usually reached by a grand staircase and surrounded by balustrade. A terrace may be supported by an embankment or a solid foundation, either natural or man-made. Terraces may also be platforms, supported by columns but without the space below filled in. terraces are always open to the sky, but may not be paved. Container gardens on terraces, where plants are maintained in pots and beds are generally considered as green terraces

**Plate 1: Aerial view of the Casa En Huatulco, Mexico, showing passive open spaces landscaping through its elevated suspended pool, green terraces at different levels and its green roof.**
*Source: New coastal houses, 2001*

**Results and Discussion**

The mitigation of environmental challenges in city development through open spaces landscaping was approached at different levels. According to Hoyt sector model, cities can be broken into sectors. These sectors include: the central business district, the factories/industrial areas, low class residential area, middle class residential area and the high class residential area (Hoyt, 1939). This structure was observed moving through the city of Lagos.

A sector is peculiar to its own socio-economic and environmental features and characteristics, though they are all related to form the city system. Consequently open spaces landscape mitigation measures were structured according to these sectors.

**Central Business District Open Spaces Landscaping Mitigation Approach**

This is the most developed sector of the city of Lagos with a high concentration of multi-story buildings and skyscrapers and organized transport circulation network.

- Green designs were introduced along road networks, trees and green paths were used to design open spaces along edges of roads. Trees such as various palm tree species was used since their roots go deep into the ground and do not spread close to the surface causing undulations on road surfaces. Native ground covers and grasses were also used for green paths since they become resistant to several environmental issues once established.

- Transformation of large open spaces such as round-about, spaces underneath land bridges, fly-overs and cul-de-sacs into lawns whose monotony was broken at different points using flower beds, interlocking foot paths, trees and shrubs and hedges around their boundaries.
- Porous paving were used in some areas which enhanced peculation of storm water through these porous paving. This consequently reduced vulnerability of these areas to flooding issues.

**Low Income Residential Open Spaces Landscaping Mitigation Approach**

The low income residential sector of the city is majorly characterized by residential story buildings, low cost housing units, inhabiting large number of individuals. This area is also characterized by large parking areas for these story buildings and majorly densely populated (Hoyt, 1939).Open spaces landscape mitigation for this sector includes:

The design of large open spaces was incorporated into this area, a park which had various sustainable open spaces landscaping elements such as trees, shrubs, hedges, flowers, grasses and groundcovers.

Green networks along road networks was introduced in this area, through introduction of trees, shrubs, hedges and grass ground covers on opens spaces formed .

Most of large open spaces found within social amenities in this sector were sustainably treated. This involves a functional introduction of trees, shrubs, hedges, flowers and lawns onto open spaces present in hospitals, churches, schools, malls and other social amenities present in this sector. This approach improved security within sector through proper treatments of bushy areas, improves health of inhabitants through reduction of various forms of pollution and environmental treatments through functional installation of natural landscape elements and creates an aesthetically organized sector.

**Middle and High income Residential Open Spaces Landscaping Mitigation Approach**

These sectors are also characterized majorly by residential structures but in low density organized into individual plots and linked together by a well-planned road network. Open spaces landscaping approach for this sector include:

Sustainable open spaces landscaping and planning of setbacks of buildings from roads and adjoining structures through the use of majorly natural landscape elements such as deciduous trees and shrubs, hedges, flowers, ground covers and lawns.

The functional application of xeriscaping landscaping elements such as sharp sand and granite on circulation areas within plots, creating a durable surface for movement and also enhancing underground water movement within plots.

Subsistence garden introduction was observed in some areas, through orchards and other small scale/household planting of edible plants (vegetables, cassava, yam, etc) within setbacks (open spaces around buildings) within plots.

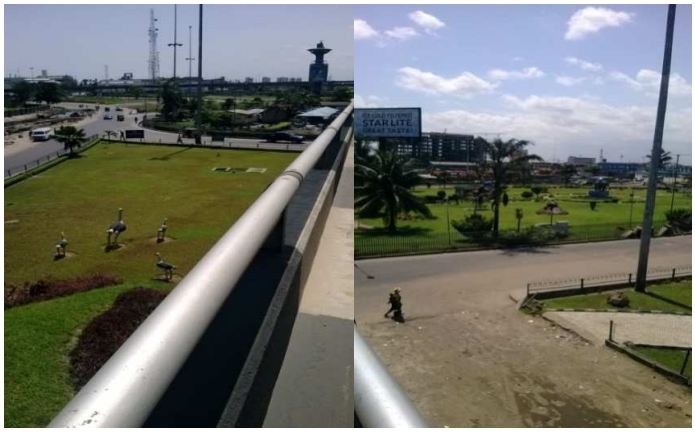

**Plate 2 and Plate 3:view showing transformation of large open spaces such as round-about,, fly-overs and cul-de-sacs into lawns whose monotony was broken at different points using flower beds, interlocking foot paths, trees and shrubs and hedges around their boundaries, in an open space at costain, Lagos, Nigeria**
*Source: case study field work 2014*

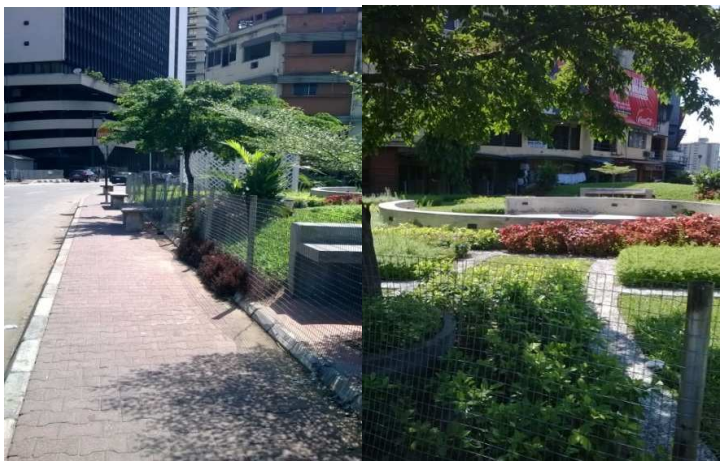

**Plate 4: view showing Green designs for road networks, trees and green paths were used to design open spaces along edges of roads. Tree species used whose roots go deep into the ground and do not spread close to the surface causing undulations on road surfaces, Broad street, Lagos island Lagos, Nigeria**
*Source: case study field work 2014*

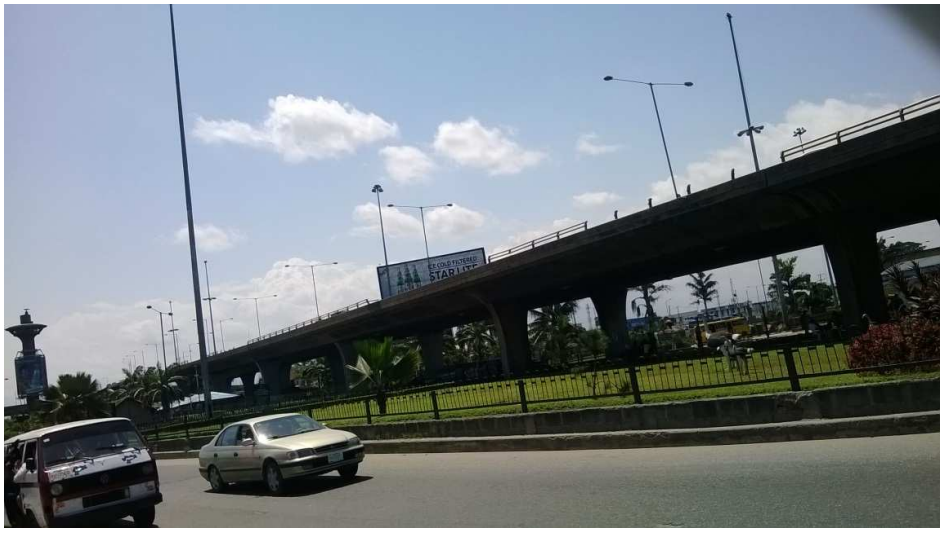

**Plate 5: View showing open space underneath land bridge transformed into place through design, management and introduction of natural and artificial objects (landscape elements) onto the space transforming it into a place of recreation in an open space at costain, Lagos, Nigeria**
*Source: case study field work 2014*

**Industrial Sector Open Spaces Landscaping Mitigation Approach**
This is the production sector of the city development, consisting of industries and industry related structures such as a warehouses, truck parks, etc. This is usually situated at the outskirts of most cities and a major of environmental degradation as a result of its production processes and wastes.

There were a number of issues arising from this aspect, because some industries were situated within the city of Lagos thereby making it difficult to employ certain open spaces treatments peculiar to the industrial sector such as the urban forestry open space approach.

**Recommendations**
**Material Driven Open Spaces Landscaping Mitigation Approach**
More efforts should be made in Incorporation of green networks along road networks in this area, through introduction of trees, shrubs, hedges and grass ground covers on opens spaces formed and associated with these networks.

Incorporation of green terraces and balconies in the design and construction of buildings within sectors to through passive open spaces landscaping, consequently enhancing sustainability with individual plots.

Use of porous paving for walkways and road networks within sectors and also incorporation of swales along strategic paths to enhance underground water drainage, thereby reducing flooding.

Introduction of tree boxes accommodating trees and shrubs within large parking and walkway areas within sectors. This creates shades and consequently dampens the effect of heat islands from these hardscape areas.

Incorporation of green roofs, roof gardens and green terraces into the designs of structures within sectors, especially in structures used for accommodation and relaxation within this sector, such as hotels and guest houses. This green approach reasonable replaces plant life area occupied by structures, hence reestablishing a sustainable link and natural system with all parts of the city.

For the industrial area, in addition to the open spaces mitigation measures employed for the other sectors in treating their hardscape areas, urban forestry is a major approach since dense tree population brings about improved pollution absorption and balances natural system.

The introduction of more of these open spaces elements will positively enhance the micro climatic condition of the central business district, reduces flooding issues through enhancement of underground water movement, reduction of air and noise pollution through absorption of pollutants by plant life and generally improving aesthetics and outlook of this sector.

**Societal Driven Open Spaces Landscaping Mitigation Approach**

This open spaces mitigation approach is conceptualized as the development and management of open spaces by the government and inhabitants of cities in the course of its development. These approaches include:

Sustainable environmental policies, good governance and enhanced urban development, Green enlightenment, Poverty reduction and economic empowerment International collaborations for sustainable city development.

**Conclusion**

City development is an inevitable process that constantly precipitates environmental issues majorly through replacements of natural landscapes with manmade structures, creating left over spaces around these manmade developments. This paper has presented these spaces as open spaces and how sustainable landscaping of these spaces can be used to cushion the environmental and climatic issues brought about by man's continuous pragmatic effort to meet his needs through city development.

In conclusion, with a functional and sustainable application of these open spaces mitigation approaches, properly managed by human empowerment and enlightenment schemes driven by government and other agencies, low impact developed cities would emerge. Hence producing a safer, secured, healthier, balanced and stable relationship between man, infrastructure (city development) and environment (natural/eco system).

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