Prospects, Barriers and Development Control Implications in the use of Green Roofs in Lagos State, Nigeria

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Abstract: Green roofs are gaining importance as "soft" engineering approach to urban environmental management and have been found to be beneficial in storm-water management, noise and thermal insulation, mitigation of the urban heat island effect, carbon sequestration and ultimately climate change mitigation. Lagos, a fast growing megacity is characterized by a rapidly growing population within a very limited land area. The resultant development pressure on land has given rise to dense urban fabric with associated loss of green cover especially within the inner city thereby eliciting suggestions for the adoption of green roofs. The present paper examined the prospects and the barriers to the adoption of green roofs as well as the attendant development control implications in Lagos, Nigeria. A combined quantitative and qualitative research strategy was adopted for the study. For quantitative data, pre-tested questionnaire was administered to 60 purposively selected built environment professionals in academics, consultancy and in government while qualitative data were obtained from interview of four key stakeholders. Secondary data were obtained from literature. Analysis of primary data was by the use of descriptive statistics and relative importance index while content analysis was used for the analysis of qualitative data. The study found that while opportunities for adoption of green roofs exist, they were not popular in the study area because of cost, technical challenges, poor knowledge as well as limitations imposed by the interpretation of planning laws. The paper proposed context-relevant application of green roofs as a complement to ongoing green infrastructure programme in the study area.

Keywords: barriers, development control, green roofs, Lagos megacity, sustainable development

1. Introduction

Rapid urbanization coupled with physical development pressure on land, increased physical density as well as ineffective urban governance structures combine to make many cities of developing countries rather unlivable. Lagos, the most populous city in Nigeria and one of the fastest growing mega cities in Africa is a typical example. With a population estimated by the Lagos Bureau of Statistics (2013) to be over 23million by the end of 2015 and accommodated within a highly limited land area in comparison to other cities in Nigeria, the pressure on land for development is real. The land challenge is also indicated by the vast areas of wetlands which are being depleted through uncontrolled reclamation for development purposes in spite of the difficulties associated with developing such lands. Such invasion of wetlands depletes the natural vegetative cover of the wetlands and renders them ineffective as natural sinks for storm-water, carbon and other chemical compounds. Evidence abound of land-use and land cover variations in Lagos indicating that the naturally available soft green infrastructure is vanishing at a fast rate (Okorie, 2012; Olaleye, Abiodun and Igbokwe, 2009; Adepoju, Millington and Tansey, 2006).

As a result, the administrative authorities of Lagos, in realization of the emerging megacity status and associated challenges, are driving a green agenda. This includes provision of soft green infrastructure such as parks and gardens, climate change advocacy programmes, sustainable environmental management policies, sustainable and low-energy/low-carbon building practices as well as the renewable energy initiatives (Ezema, 2013). A specific aspect of the green programme is the regulation through approval order of the minimum green coverage area for all types of developable plots of land in different parts of the city. Incidentally, the greening programme is being implemented alongside a densification programme aimed at accommodating more people in the already built up areas by increasing the prevailing density and encouraging mixed use development (Lagos State Government, 2006). Under the mixed use corridor for the Ikoyi-Victoria Island Model City Plan, building coverage is fixed at 30% while soft landscape (green space) is fixed at 30% with driveways and car parks taking up the remaining 40% (Lagos State Government, 2006). However, in built-up high density areas, providing green areas at ground level is difficult. As a result, more creative options for bringing the green benefits to this class of buildings such as the use of vertical greening systems (VGS) are being explored (Akinwolemiwa and Gwilliam, 2015). In this regard, green roofs are also proposed for adoption especially in redevelopment projects which are increasing in frequency due to income and ownership redistribution. This is expected to complement the densification programme, which in addition to increasing both physical and population densities as a way of maximizing access to existing infrastructure and discouraging sprawl, also has negative effect on available green-fields (Ezema and Oluwatayo, 2014).

This paper therefore examined the characteristics, advantages, opportunities and barriers to the adoption of green roofs as well as the associated development control implications in Lagos mega city. The development control implication of green roofs in the study area is necessitated by the additional architectural and structural design requirements. The study investigated the following: (i) level of awareness of green roofs by the selected built environment stakeholders, (ii) perceived advantages of green roofs, (iii) barriers that impede the widespread adoption of green roofs, (iv), measures to encourage increased use of green roofs, and (v) physical planning and development control implications of green roofs in the study area.

2. Literature Review

A green roof refers to living vegetation installed on a roof for a number of beneficial purposes. As continuous physical development characteristic of rapid urbanisation depletes natural green landscapes, interest in green roofs is growing especially in the world urban areas, which indicates that green roofs are urban phenomena. Green roofs are, however, not of recent origin as they have been used in the past in vernacular architecture which tended to emphasize architecture that is in harmony with the natural ecosystems. The development of buildings which are responsive to the natural ecosystem has been of interest to architects over the years. Distinguished American architect Frank Lloyd Wright strove to design buildings that were in harmony with nature in expression of the concept of organic architecture (Cruz, 2012). Even at the peak of the international style strand of modern architecture, one of its greatest exponents, Le Corbusier recognised the value of buildings being in harmony with nature. In the five points of a new architecture, Le Corbusier espoused the value of the roof garden as an attempt to recapture, at the roof level, the natural green landscape that has been displaced by the building (Corbusier, 1926). In fact, green roofs may have predated the cited examples above and could be traced back the hanging gardens of Babylon (Peck, 2002).

In modern times, green roof have been used extensively especially in Northern Europe and America with Germany regarded as a clear leader in the use of green roofs (Kohler, 2006). The leadership role of Germany in the use of green roofs has been linked to favourable government policy in the form of legislation, municipal grants and financial incentives for green roof adoption (Peck and Kuhn, 2003; Li and Yeung, 2014). Other European countries and cities have also adopted green roofs as part of new construction on flat roof buildings. The Swiss city of Basel is reputed to have the highest area of green roofs per capita in the world, a feat that was achieved through a combination of financial incentives and building regulation (Kazmierczak and Carter, 2010).

2.1 Green Infrastructure

Conceptually, green roofs are usually considered in the broader context of the low impact development strategies and more specifically within the context of green infrastructure. Green infrastructure (GI) has become, in recent times, an important word in the environmental management lexicon. In the context of this article, green infrastructure refers to “an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations” (Benedict and McMahon, 2002:12). It is believed to have emerged from two major precedents namely: linking of parks and other green spaces for the benefit of people, and the linking of natural areas for the benefit of biodiversity. From the foregoing, green infrastructure has a human component and a biodiversity component.

Green infrastructure is still an evolving concept and is therefore prone to a multiplicity of interpretations of which its link to environmental theory on one part and socio-economic policy on the other have been highlighted (Wright, 2011). However, irrespective of the theoretical bent of the interpretations, there is general consensus among scholars to the effect that natural environmental resources can be managed to deliver the desired benefits both to the environment and the inhabitants of the environment (Lennon, 2014).In this respect, it has been proposed as a climate change adaptation strategy (Matthews, Lo and Byrne, 2015). Green infrastructure is integrative as it seeks through design to link elements into a system that functions as a whole, rather than as separate, unrelated parts (United States Department of Agriculture, 2000).Inherent in the foregoing is the multi-functionality of green infrastructure (Science for Environment Policy, 2012). Hence, its function in promoting ecosystems services and societal well-being is the direction highlighted in this study. Green roofs constitute an important part of urban green infrastructure.

2.2 Structure and Types of Green Roofs

Typically, green roofs, also referred to as roof garden, vegetated roof, eco-roof and living roof (Voelz, 2006), have eight layers including the roof structure which is usually a deck. Other layers as shown in Figure 1 are waterproof membrane, root barrier, protection fabric, drainage layer, filter bed, a growing media and vegetation. Sometimes an insulation layer is added between the roof deck and the waterproof membrane.

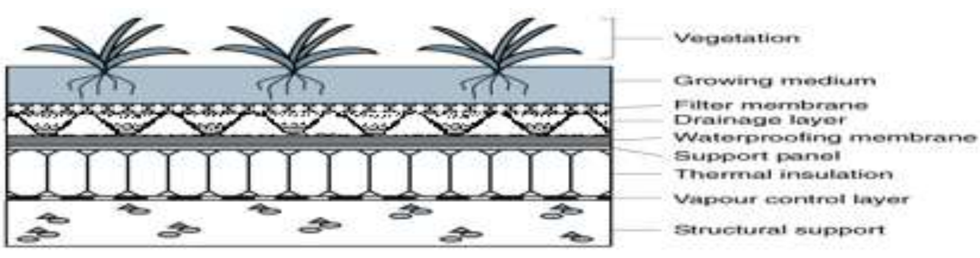

Figure 1: Typical Structure of Extensive Green Roof (Hui, 2006).

Broadly, there are two main types of green roofs: extensive green roofs and intensive green roofs. The two types are differentiated by the depth of growing medium, type of plant, the cost of construction and maintenance of the green roof (Peck and Kuhn, 2003). Intensive green roofs have deep growing media (usually greater than 150mm thick) and present opportunities for wide variety of plants and vegetation. Intensive green roofs are more expensive to construct and maintain than extensive green roofs. Extensive green roofs, which are gradually replacing intensive green roofs are characterised by thinner (less than 150mm thick) and lighter growing media (Zhang, Shen, Tam and Lee, 2012). In addition, Hui (2006) identified a third type known as semi-intensive which falls between the intensive and extensive types. A pictorial comparison of the three green roof types according to the International Green Roof Association (IGRA) is presented in Figure 2.

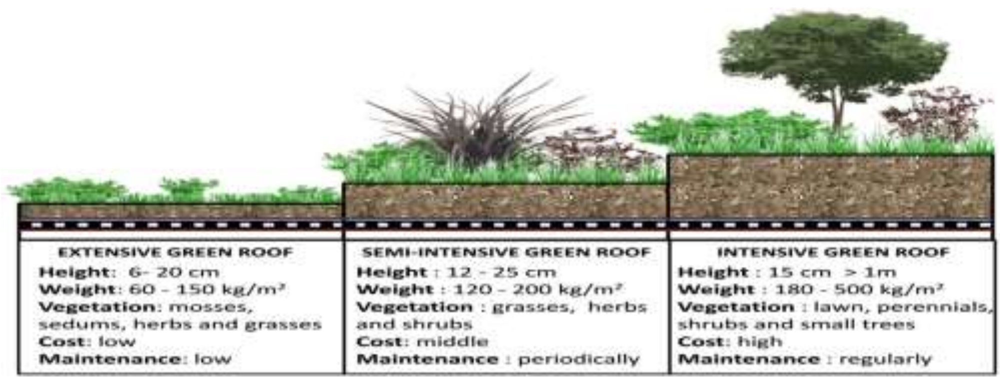

Figure 2: Types and Characteristics of Green Roofs (IGRA, 2008).

Renewed interest in green roofs has been associated with attempts to mitigate decline in the quality of the urban ecosystems as well as by the need for environmental sustainability. According to Bolund and Hunhammar (1999), urban ecosystems perform a number of functions including acting as a natural sink for carbon and other noxious emissions to the environment. With rapid urbanisation, the green component of urban ecosystems is depleting at a high rate. Green roofs are therefore seen as opportunity to bring back the lost green component of the urban ecosystem.

2.3 Functions and Benefits of Green Roofs

Green roofs have been shown to be beneficial in many ways (Nurmi, Votsis, Perrels and Lehvavirta, 2013). In more specific terms, green roofs help in the management of storm water by delaying run off from roof to the storm water drainage system thereby preventing the drains from overflowing. Delays of between 95minutes and four hours have been reported in the literature (Getter and Rowe, 2006). Also, green roofs have been shown to cool the interior and surrounding environment (Li and Yeung, 2014). At the urban scale, green roofs have been associated with mitigation of the urban heat island effect (Susca, Gaffin and Dell'Osso, 2011). Itprovides natural habitats for birds and other organisms thereby enhancing biodiversity in the urban environment (Fernandez-Canero and Gonzalez-Redondo, 2010). As a natural sink for nitrogen, lead and zinc and as a filter for particulate matter, green roofs reduce environmental pollution (Getter and Rowe, 2006). Roof membrane longevity as a result of reduced membrane temperature and protection from ultraviolet radiation is an acclaimed advantage of green roofs (Connelly and Liu, 2005). Temperature moderation is believed to increase the life span of roof membranes by reducing the stress associated with daily contraction and expansion of the roofing membrane materials (Getter and Rowe, 2006).The low temperature range between exterior and interior spaces ensure thermal comfort of the occupants thereby reducing the need for air conditioning and associated energy consumption. In an experimental study of thermal behaviour of green roofs in tropical Brazil, Cardoso and Vecchia (2013) confirmed that green roof had the lowest temperature range when compared with four other roof types. Green roofs have also been shown to increase sound transmission losses which makes them able to mitigate low frequency noise in buildings (Connelly and Hodgson, 2013).

2.4 Barriers to Green Roofs

Green roofs can be considered as innovations and as a result, challenges of innovation adoption also confront green roofs. According to Rogers (1995), the innovation adoption decision process is hinged on adequate knowledge of the innovation as well as attitude towards the innovation which may be dictated by factors such as cost. Hence, barriers would result from loop holes in the decision process. A number of barriers to green roof use in urban areas have been identified in literature. In a Hong Kong study, Tam, Zhang, Lee and Shen (2011), identified the four major barriers to be, in order of importance, (i) lack of promotion by government, (ii) lack of incentive by government, (iii) increase in maintenance cost, and (iv) lack of awareness. The above finding is corroborated by another study which attributed the high rate of green roof uptake in a country like Germany to favourable government policy and incentives (Liu and Yeung, 2014). The additional construction and maintenance costs of green roofs constitute another barrier. Closely related to the above is the increased structural load on the building as a result of increased weight of the roof (Alkhrdaji, 2012). The increased structural load becomes important in areas such as developing countries where the maintenance of appropriate construction standards is a big challenge. The additional cost of green roofs is of special importance to property developers given that the potential private benefits of green roofs are limited when compared to the public benefits. In cost-benefit terms, private benefits are mostly not high enough to induce private property developers to embark on the additional investments required by green roofs (Nurmi et al., 2013). As a result, incentives are considered necessary in view of the overriding public benefits of green roofs. The study area of Lagos is highly urbanised. According to a report by the United Nations on the ranking of the world urban agglomerations, Lagos was ranked 33rd in 1990, 19th in 2014 with a projected ranking of 9th in the year 2030 (UN, 2014). Urbanisation in Lagos, a fast growing megacity has given rise to a myriad of challenges especially with respect to sustainability at the urban scale. As a response to the challenge of urban sustainability in the study area, green infrastructure development is evolving with such initiatives the green Lagos programme which incorporates street tree planting, provision of public parks and gardens as well

as encouraging property owners to include green areas within residential areas. However, green roofs have not been comprehensively examined in the study area. In the study area, roof gardens in the form of potted plants, plants in free-standing containers and planters as well as vertical gardens do exist but they are not green roofs as described in this study. With the high percentage of built up area, opportunity for green roof abound.

2.5 Strategies for Green Roof Adoption

Modern green roofs are products of careful planning. A look at the countries and cities that have good record of green roof adoption indicates that deliberate policy integrated with incentives and planning regulations played central roles. In cities where green roofs have been used substantially, it had always been predicated on state policies which are most times supported by a number of incentives mostly financial. Such incentives include direct incentives like tax rebates, grants and access to special loans as well as indirect incentives like development fee reduction (Shepard, 2010; USEPA, 2010). There are also intangible incentives such as fast track development permit, density and zoning bonuses, utility rebates and recognition/awards (Shepard, 2010). The incentives are usually supported with robust building regulations such as compulsory inclusion of green roofs for some categories of buildings (Kazmierczak and Carter, 2010). The purposes had ranged from climate adaptation to energy reduction, urban heat island reduction, air quality and urban greening.

3. The Study Context

The study area is Lagos, the most urbanized city in Nigeria and one of the fastest growing mega cities in the world. Lagos, a coastal city covers a gross area of about 3,577 km2, a sizeable proportion of which was originally made up of wetlands, thus making it the smallest in terms of land area of all the states in the Federal Republic of Nigeria (Jeje, 2013). The official 2006 population census in Nigerian put the population of Lagos at just over 8 million people (NPC, 2007). However, more recent projections for the population of Lagos put it at over 23 million by the end of 2015 (Lagos State Government, 2013).Due to rapid urbanization, land vegetative cover cover is depleting at a fast rate. Adepoju et al (2006) found that within the period 1984 to 2002, built-up area in Lagos increased by 35.5% while forest and agricultural land decreased by 57.8%. Even in the peri-urban areas that hold more prospect for preservation of the vegetative cover, a study by Dekolo and Olayinka (2013) indicate that between 1990 and 2011, built-up area increased by 672% while forest and agricultural land depleted by 58%. From the foregoing, loss of vegetative cover in the study area is increasing rapidly. The rapid loss of vegetative cover necessitated the adoption of a green agenda in Lagos (Ezema, 2013). In addition, structures for managing development control in the area are ineffective and fraught with all kinds of challenges which include unwillingness to comply with planning regulations and weak enforcement structures (Aluko, 2011).

4. Research Methods

This research is an exploratory study. It incorporates both quantitative and qualitative research strategies. Given the low prevalence of green roofs in the study area, the exploratory study targeted only built environment practitioners who are more likely to know the intricacies involved in green roofs. Hence, a sample of 54 built environment practitioners in such professional areas as architecture, engineering, quantity surveying, estate management, building technology, and town planning was purposively selected for the survey. The sample was evenly distributed between professionals in academia, private practice and in government employment. The practitioners were known to be involved in built environment research, management and practice within the study area. The data collection instrument used is the questionnaire which was divided into five parts namely: (i) background information of respondent, (ii) level of awareness of green roofs, (iii) advantages of green roofs, (iv) barriers to the use of green roofs, and (v) measures to improve the uptake of green roofs. In parts (iii), (iv) and (v) of the questionnaire, respondents were required to rate the advantages, barriers and recommendations on a 5 point Likert scale with '1' for strongly disagree; '2' for disagree; '3' for neutral; '4' for agree; and '5' for strongly agree. Descriptive statistics and relative importance index (RII) were used to analyse questionnaire responses.

The relative importance index was calculated as follows:

Relative Importance Index (RII) = $\frac{\sum w}{AN}$, $(0 \leq \text{RII} \leq 1)$

Where w is the sum of individual scores; A is the possible highest score and N is the total number of responses. For result interpretation the RII value closest to the value 1.00 is selected as the highest ranked.

For the interview aspect of the research, the Lagos State Ministry of Physical Planning and Urban Development (MPP&UD), the Lagos State Parks and Gardens Agency (LASPARK), and two property development companies were targeted. The two companies were: Lagos State Development and Property Corporation, a government-owned company and UAC Properties PLC, a publicly quoted company. Senior personnel such as departmental heads were chosen to represent each of the organisations. Both companies are strong players in the Lagos property market with the former being a dominant player in the low and medium income segment while the latter is a dominant player in the medium and high income segment. Content analysis was used for analysing the interview responses.

5. Findings and Discussion

The findings of the study and the associated discussion of findings are presented below under the following sub-headings: background information of respondents, awareness of green roofs, benefits of green roofs, barriers to the adoption of green roofs, and recommendations on how to improve green roof adoption in the study area.

5.1 Background Information

Out of the 60 practitioners surveyed, 46 representing 85% responded. As shown in Table 1, 9 architects, 9 engineers, 8 quantity surveyors, 8 builders, 6 estate surveyors and 6 town planners responded and returned the questionnaire. Similarly, out of the 46 that responded, 18 (39%) were in private practice, 16 (34%) were in teaching/research while 12 (26%) were in government employment. In terms of experience, about 70% of the respondents had a minimum of 11 years post-qualification experience, indicating that those surveyed were well experienced built environment practitioners.

5.2 Awareness of Green Roofs

When asked to rate their familiarity with green roofs, the responses according to Table 1, showed that 36 (78%) were very familiar with green roofs, 7 (15%) were somewhat familiar while 3(7%) were slightly familiar, indicating that all the respondents had some knowledge of green roofs. However, none of the respondents had been involved in any green roof project which indicates that most of what the respondents know about green roofs was obtained from secondary sources. Pilot and experimental green roofs for research and advocacy purposes can help deepen the experience of built environment professionals regarding green roofs.

Table 1: Background Information of Respondents

Category	**Frequency**
Type of Practitioner	
Architects	9 (19.6%)
Engineers	9 (19.6%)
Quantity Surveyors	8 (17.4%)
Builders	8 (17.4%)
Estate Surveyors	6 (13.0%)
Town Planners	6 (13.0%)
Experience of Practitioners	
0 – 5 years	4 (8.7%)
6 – 10 years	10 (21.7%)
11 – 15 years	18 (39.1%)
16 – 20 years	12 (26.1%)
21 – Above years	2 (4.3%)
Type of Practice	
Private Practice	18 (39%)
Teaching / Research	16 (35%)
Government employed	12 (26%)
Familiarity with Green Roofs	
Very Familiar	36 (78%)
Somewhat Familiar	7 (15%)
Slightly Familiar	3 (7%)
Not Familiar	0 (0%)

Source: Authors' Fieldwork (2015)

5.3 Benefits of Green Roofs

Eight green roof pluses were listed and the respondents were asked to rate the benefits in order of importance on a 5point scale. The result is presented in Table 2. Accordingly, the ability of green roofs to provide thermally comfortable indoor environment was rated the most important while the ability of green roofs to prolong the life span of roof membrane was rated least. The most important benefits were found to be: indoor comfort, air quality improvement, aesthetics, urban heat island reduction, and improved biodiversity. The storm water management and roof membrane longevity benefits received the lowest ratings. While it could be inferred from observation that green plants enhance visual amenity, create habitats for birds, and play a moderating role on the micro environment in terms of air quality and cooling effect, its role in managing storm water and improving roof membrane longevity is not easily discernible. Such can only be proved or disproved through research on green roofs which is not yet well established in the study area.

With particular reference to research in green roofs, it is important to understand the multi-disciplinary nature of green roofs as practitioners in the fields of general agriculture, horticulture, environmental science, environmental biology and soil science can complement the work of core built environment practitioners in advancing the frontiers of research in green roofs.

Table 2: Ranking of Green Roof Benefits

s/n	Green Roof Benefits	rongly Disagree	Disagree	Neutral	Agree	Strongly Agree	RII	Ranking
1	Reduces Urban Heat Island Effect	0	0	4	28	14	0.843	4
2	Improves Air Quality	0	0	9	17	20	0.848	2
3	Provides Indoor Comfort	0	0	6	18	22	0.870	1
4	Helps to manage storm water	0	10	12	10	8	0.591	7
5	Encourages Biodiversity	0	3	15	16	12	0.761	5
6	Improves aesthetics	0	0	10	16	20	0.844	3
7	Reduces air and noise pollution	1	5	10	18	12	0.752	6
8	Increases life span of roof membrane	15	10	5	10	6	0.522	8

Source: Authors' Fieldwork (2015).

5.4 Barriers to Green Roof Use

Six factors considered as constraints to green roof adoption in the study area were rated by the respondents and the result is shown in Table 3.From the analysis, all the listed barriers were rated very high. However, the barriers that most negatively affect the adoption of green roofs in the study area were found to be: cost of construction, cost of maintenance, absence of government regulation, and low knowledge and technical capacity. In the study area, construction cost is usually high and any item that would add to the cost of construction without necessarily contributing directly to the use of the building is usually discarded. Green roofs may therefore be seen as unnecessary additions to the basic components of a functional building.

The above is corroborated by the property development companies interviewed who preferred the cheaper option of providing green area at the ground level. In addition, green roofs are mostly placed on reinforced concrete roofs which have the capacity to withstand the envisaged additional load. Reinforced concrete roofs are comparatively more expensive than non-concrete roofs. While properly sloped non-concrete roofs within the study area are easy to maintain, green roofs require frequent maintenance. Similarly, no specific government planning regulation on green roofs was found in the study area. According to an official of MPP&UD interviewed, a reinforced concrete flat roof is usually interpreted to mean that an additional floor may be added later. This is because instances of increasing the height of an existing building abound in the study area. In many cases, such modifications do not follow the statutory procedures and have often resulted in serious building failures and outright collapse in some cases.

Table 3: Ranking of Barriers to Green Roof Use

s/n	Green Roof Barriers	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	RII	Ranking
1	Increased Construction Cost	0	0	3	10	33	0.930	1
2	Increased maintenance cost	0	0	4	9	33	0.926	2
3	Absence of government regulation	0	0	3	12	31	0.922	3
4	Lack of government incentives	0	0	3	13	30	0.917	4
5	Increase in structural load of building	0	0	6	12	28	0.896	7
6	Challenge of installation on existing roofs	0	0	4	15	27	0.900	6
7	Low knowledge and technical capacity	0	0	3	16	27	0.904	5

Authors' Fieldwork (2015)

5.5 Measures to encourage Green Roof Adoption

Five strategies aimed at improving the use of green roofs in the study area were ranked by the respondents. Government incentives with an RII score of 0.848 was ranked highest and was closely followed by government policy with a score of 0.835. The third strategy in order of importance with an RII score of 0.813 was encouraging research and development. The result underscores the important role of government in driving the adoption of green roofs. Also of particular importance is the role of research and development which not only has the potential of improving the knowledge base but also reducing the installation cost of green roofs. Incidentally, the use of modular green roof panels which holds a lot of prospects for built-up areas did not rank highly as a strategy for green roof adoption. This can be explained by the high ranking of research and development which may be able to identify other more efficient strategies of encouraging green roof adoption in built-up areas. Similarly, public education and enlightenment ranked least apparently because public education without the requisite government intervention may not achieve the desired result.

Government intervention can also be in the form of advocacy for green roofs. Advocacy in this regard may take the form of adopting green roofs for the entire roof or part thereof of public building. By adopting this strategy government is showing leadership by example.

Table 4: Measures to encourage green roof adoption

s/no		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	RII	Ranking
1	Educating the public	2	4	15	13	12	0.726	5
2	Encouraging research and development	1	3	10	10	22	0.813	3
3	Government policy on green roofs	0	2	11	10	23	0.835	2
4	Government incentives for green roofs	0	2	9	11	24	0.848	1
5	Use of modular green roof panels	3	5	15	10	15	0.752	4

Source: Authors' Fieldwork (2015).

5.6 Development Control Implications of Green Roofs

According to operative laws in the study area, responsibility for physical planning regulation of which development control is an important part of, falls on the Ministry of Physical Planning and Urban Development. The ministry exercises development control function through the various agencies such as: Lagos State Planning Permit Authority (LASPPA), Lagos State Urban Renewal Agency (LASURA) and Lagos State Building Control Agency (LASBCA).The basic document is the Urban and Regional Planning and Development Law 2010(Lagos State Government, 2010) and approval orders and regulations made pursuant to the stipulations of the law. Under the extant law and regulations, there is no clear provision on green roofs in buildings. There are however regulations on the minimum green area per developable plot. Based on interview with an official of the MPP&UD, the minimum green area coverage per plot in high density residential areas is 10%. However, in the mixed use development corridor of the Ikoyi and Victoria Island Model City Plan, the proportion of green areas relative to the plot size is considerably higher (Lagos State Government, 2006). This is in line with the greening programme being implemented by the administrative authorities of Lagos.

It is important that government should be at the forefront of driving green roof adoption as a necessary complement to the green agenda in the study area. This can be done through appropriate legislation, regulations and institutionalized incentives. Incentives may include monetary incentives such as property tax rebates, reduced planning approval processing fees and access to special grants for green roof development. Incentives could also be non-financial such as accelerated planning approval and density bonuses. Density bonus is particularly important in a city like Lagos where available land for property development is scarce and continually dwindling. In order for the development control function to be used for the advantage of green roofs, planning laws and regulations should accommodate some flexibility in their interpretations.

5.7 Green Roof Prospects

One of the most frequent violations of planning laws especially in residential areas is inadequate air space around and between buildings (Aluko, 2011). The MPP&UD staff interviewed confirmed that the most frequent violations are building without government approval, changing the design after approval and building with inadequate air space around the buildings. Given the tendency of property developers to exceed recommended and built-up ratios thereby decreasing opportunity for ground level green areas, the interview respondents agree that the prospect for green roofs in the study area is high. It provides an opportunity to provide green areas above the ground level thus making the ground level available for other uses.

6. Conclusion

Green roofs are desirable in the study area because of the obvious environmental advantages derivable. Such advantages as found in the study include improved indoor comfort, better air quality, improved aesthetics, reduction of urban heat island effect and improved biodiversity. A number of barriers beset the widespread use of green roofs in the study area which include increased construction and maintenance costs, absence of government regulation, lack of appropriate government incentive, and low level of knowledge and technical expertise. In order to encourage the adoption of green roofs in the study area, the study found that strategies such as appropriate government policy, government-driven incentives and encouraging research and development in green roofs should be deployed.

In all, given the public benefits of green roofs, government through regulations and incentives should be at the forefront of promoting the adoption of green roofs. In this respect, it can be made mandatory for new government buildings in urban areas to incorporate in their designs, an extensive green roof at the least. In addition, commercial buildings with gross floor area in excess of a given benchmark should also incorporate a given minimum green roof area. Other property owners can be encouraged to incorporate green roofs in their buildings through appropriate incentives from government. Given the pressure on land for development in the study area, incentives such as density and floor area bonuses should be considered. Very importantly, in a built-up city like Lagos, the modular green roof panels may be the appropriate way to go for existing buildings.

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