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SUSTAINABLE LANDSCAPE REHABILITATION MODEL FOR SOLID WASTE LANDFILL AREAS: OLUSOSUN DUMPSITE

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ABSTRACT
This research analyzes current conditions of Olusosun landfill site in Ketu Municipality of Lagos, Nigeria and proposes a sustainable landscape rehabilitation model for the restoration of the damaged landscape and offers improving quality of life through environmental, social and economic developments. In other to achieve this, the primary testing instrument which was the questionnaires were polled towards public users and expert groups. This method is effective in proposing a sustainable landscape rehabilitation model that meets the demands of the public and regulated by experts of the built-environment. This research model ultimately provides solutions for basic environmental challenges such as flooding, land and air pollution around solid waste landfills, improves the landscape framework for the natural and built environment and restores depleted social and economic potentials for the near environment.

Keywords:
Sustainable Landscape Rehabilitation, Olusosun Landfill Site, Waste management.

INTRODUCTION

Over the years, solid waste landfills have been a critical environmental issue in Africa. Increase in population and human activities have contributed significantly to the degradation of landscapes due to the daily routine of waste generation and ineffective waste management schemes. Olusosun landfill site in lagos, Nigeria is the largest landfill site in Africa and one of the largest in the world. The 100-acre landfill is in an urban context surrounded by industrial, commercial and residential infrastructures. This resulted in an urban sprawl that causes communal interactions between public life and waste thereby creating indistinguishable components. This has also resulted in the depletion of vegetations on the site while being subject to floods and run-offs of waste matter into streets, sewers and residential areas during the raining seasons. The environmental conditions around slum communities regarding air, water and soil quality are at a decline while social interactions and connectivity amongst neighborhoods had regressed. This is because developers avoid such areas for community projects due to the environmental risk.

OBJECTIVE OF THE STUDY

The objective of the research is to analyze the current conditions of Olusosun landfill site and to propose a sustainable landscape rehabilitation model for restoring the damaged landscape in terms of the environmental quality, social cohesiveness and economic development. The objectives of the study are;

- To promote waste reduction, reusage and recycling efficiency in the municipality waste management process.
- To investigate the current physical conditions surrounding the landfill site and to propose a sustainable public green area that improves the quality of life and public health for the community.
- To propose a waste recycling building infrastructure that connects architecture and landscape design through integrating public activities with waste management functions.
- To regenerate social potentials amongst the neighborhoods within the territory.
- To promote productivity among local businesses within the territory.

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METHODOLOGY

The primary research instrument is the questionnaires and are done towards the user group and the expert group. Population size for the user group is limited to residents in Olusosun neighborhood which includes the slum communities, the business owners, factory workers and home owners. The expert group comprises of stakeholders in the urban and environment design sector in Nigeria which includes architects, landscape architects, waste management officers and urban planners. The sampling size for the expert group includes 60 professionals whereas the sampling size for the user group includes 100 people who engage regularly with the landfill site. The sampling technique used is the probability model adopting the random sampling method. The secondary instrument is the literature reviews and case studies of successful landfill rehabilitation from the world using journals, articles, books, etc. The data results are quantitively analyzed using the statistical package for social sciences (SPSS) in measuring frequencies of interaction with people's perception and future willing.

LITERATURE

Solid Waste Landfill Areas

Solid waste landfills are solid waste storage areas which includes the domestic wastes and industrial wastes. These areas often located in outskirts or shanty towns but are subject to urban sprawl over time.

Landfills are one of many sources of renewable resource especially in terms of power generation. Power generation from landfill gas is greatly utilized in the United States especially because these resources are used as commodities amounting up to about 95.6 million per annum.

The presence of landfill site contributes greatly to preventing spillage of waste or backlogs in streets, sewers, etc. They create a controlled environment where the negative impacts from wastes can be contained. They also act as economic assets in terms of recycling wastes for usable resource, increase in employment for the skilled and unskilled workers.

Landfills emit hazardous gases such as methane and carbon dioxide. During decomposition, Landfill produces two products; landfill gas and leachates. On the one hand, these landfill gas compositions are often responsible for some of the increased global temperatures and regressive air quality within such environment as the dwellers endure significant proportions of unpleasant odor. While on the other hand, the leachate formation endangers the aquifers and other water bodies such as rivers, lakes, etc. and degrading the soil quality of the landscape.

Displacement of fauna is a very common phenomena when a land degradation occurs. Having landfill sites contributes massively to depleted health levels for surrounding settlements with diseases ranging from cancer to birthing illness and respiratory diseases. It also reduces the structural integrity of the site and makes it complex for any major construction project to take place.

The major objective of a landfill rehabilitation is to provide a safe living and healthy environment. The process initiated to achieve these outcomes is known as the safe closure or maintenance phase.

Landfill Engineering and Waste Recycling process

The characters of landfills are generally industrial or engineered. These characters consist of both the engineered layers and technological measures for managing methane gas and the leachates (Kurian, 2005). Quite a sufficient number of landfills globally produce wealth from the resources underneath the landfill. The capping and restoration process is based on the management of these sub-soil resources.

Figure 1 shows a landfill engineering layer diagram consisting of sub layers namely; the drainage layer, the gas ventilation layer, the impermeable plastic liner (geo-membrane layer), the soil blanket layer usually clay soil, the barrier protection layer which is used for covering the header pipes and the top soil layer which is usually organic in its nature.

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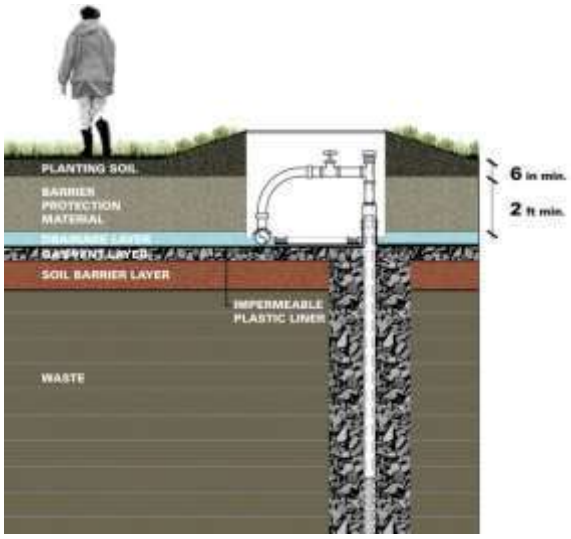


Figure 1: Landfill engineering layer. (Source: https://freshkillspark.org/)

Landfill Cover and Natural Landscape Restoration Process

The capping layer of the landfill is often recommended by landfill geotechnical engineers to be at least 60 cm of clay soil as the process of restoring the landscape structure begin to take form. Building soil in-situ is a method recommended by James Corner who is a renowned architect in charge of fresh-kills park. He recommended that instead of importing soils for landscapes with poor organic soil compositions, it would be sustainable to build the soils by planting crops of high organic quotient and ploughing them into the ground over time. Studies have confirmed that this model is successful in creating sufficient thickness of highly organic top soil.

Figure 2 shows a natural landscape restoration of Vall d'en Joan site which was a former landfill back in 1974. The topography of the site has a series of divots where seedlings and plantings can take root while also having pathways running along these divots.



Figure 2: Landscape restoration of the Vall d'en Joan landfill site. (Source: https://architizer.com/)

Vegetation Restoration process

Restoring vegetation is a common approach on damaged landscapes as they regenerate synergetic relationships between the depleted landscape and the natural environment (pang et al, 2020).
Often times, the artificial approach to restoring vegetation is implemented but this has proven to be an unsustainable method of having a long term multi-aged vegetation system. In addition, studies have suggested that installing organic wastes as capping layers contributes significantly to the fertility of the overlying top soil (Ashwood et al, 2018).

Public Life and Land use definition process

This is often the final process of a successful landscape rehabilitation. This process often involves the value and function of the place. The characters in building a place in a public landscape includes the settlement functions, monuments such as playgrounds and public recreation, transportation options and circulation and the built environment in general especially if such a park is located in an urban context. This process is in most cases heterogenous in perspectives and driven by politics, economy, demography, etc. (Wascher, 2004).

Sustainable Approach to Landfill Rehabilitation

Sustainability can be defined as meeting the needs of the society by improving the current human conditions through environmentally friendly solutions, economically viable opportunities and societal equitable developments without necessarily compromising futuristic developments.
Basiago (1999) stated an example that proves the significance of the three components which are social, environmental and economic towards sustainable human developments. He said "if a person in a certain geography lacks a source of income (economic), he is most likely going to be disenfranchised (social) and if he is at this phase, he would most likely engage in activities and practices that may harm the environment such as cutting down trees to use as an alternative cooking source or as an alternative heating source during winter (environment)". This is most likely the system formulated by slum dwellers around solid waste landfill areas in most developing countries such as Nigeria. In this context, they attract like-minded people to such communities which leads to unhealthy environmental practices. At the same time, Basiago's theory proves that the restoration of damaged landscapes must consider these three components communally because human activities limited to these components can only be sustained by the components.

Revitalizing Landscape Identity (A Sense of Place)

The identity of a landscape is defined by its perceived uniqueness or originality of a place. The holistic character of a landscape is always rooted to place. Over the years, the evolution of landscapes has been so massive that their identities are often assessed from the vantage point of both natural which are the basic physical features such as landforms and geological formations and the cultural processes which are man-made features such as built-forms, circulations and land use functions (Worcestershire County Council, 2022). These landscape evolutions have often progressed to landfill sites located in an urban context where the natural features and the cultural processes are often indistinguishable. Olusosun landfill site is one of few places having such identities. In the event of a landscape rehabilitation, this place would have the potential of collaborating the natural and built environment as a system due to the existing relationship of the natural features and the human functions.
The collaboration of the two which are the natural environment and the built environment generally defines the identity of a landscape. These characters can create a sense of place for public users if the two components are in harmony with each other (Sunshine Coast Council, 2023).

CASE STUDY AREA: OLUSOSUN LANDFILL SITE.

Evolution of Olusosun Landfill Site

Olusosun landfill was the largest recipient of solid waste while housing up to about 4000 residents living and working within the territory. It was once a site that evolved from a laterite mining site to one of the world's largest landfill sites. However, over the years the process of urbanization and sprawling occurred that has resulted to the emergence of settlements and activities around the site. **Figure 3** shows the historical chronological relationship development of Olusosun landfill between the year 2000 to 2018.

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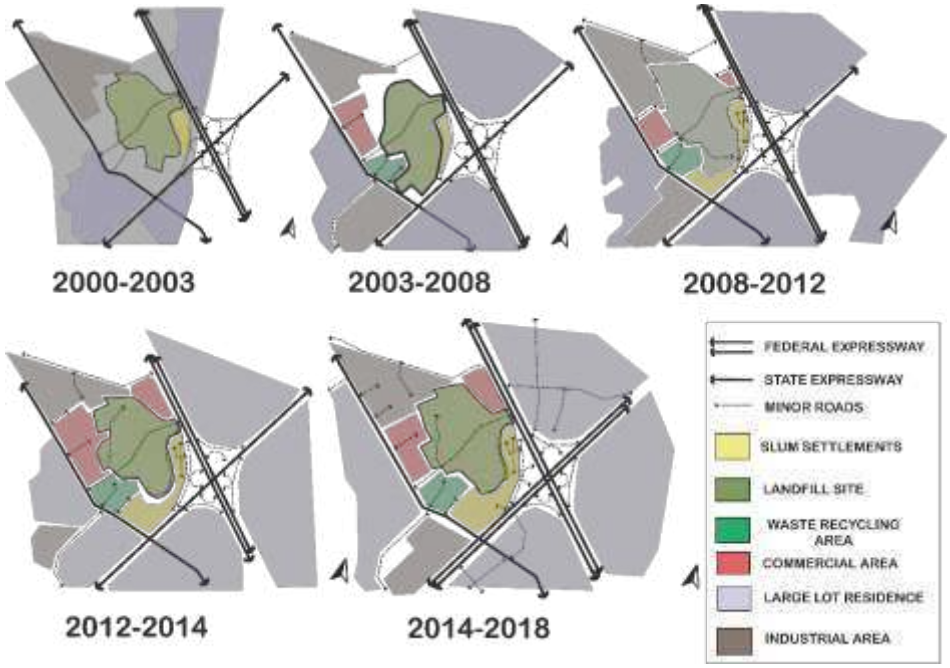


Figure 3. historical chronological relationship development of olusosun landfill (Source: author, 2023)

Site Location

The Olusosun landfill is located in the Ikeja municipality which is the north western part of Lagos state as shown in **figure 4**.



Figure 4. Location map of olusosun landfill site Lagos, Nigeria. (Source: Author, 2023)

Land use analysis

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The site is surrounded with various enclaves of mixed used functions even though some of these functions have slum character. The site is bisected by a major connecting road between a minor highway and a major high way. there are also minor connecting roads between the surrounding settlements. There is limited mobility between communities due to ineffective transportation infrastructures. The transit networks do not support walkability and pedestrian sustainability. The existing streetscapes are lacking bike lanes and have ineffective side-walks as most of the side-walks are occupied by the roadside retailers.

Whilst the existing vegetations are massively depleted due to the presence of the landfill within the territory, the vegetation which are on the outskirts of the landfill only covers up to 35 percent of the site. The nature of the vegetation within the territory are grasslands and were conserved due to the format of the excavation at the early stages of the site. Others outside of the territory are small pockets of parks and gardens around the expressway intersections as shown in **figure 5**.



Figure 5. Land use analysis mapping of olusosun solid waste landfill site, Ketu Municipality (Source: author, 2022)

Socio-cultural analysis

The most common populace residing in the neighborhood are the retailers, landfill site scavengers, factory workers and the business owners. The community engagements and interactions within the neighborhood is non-existent due to the negative conditions and perception of residents towards the landscape. The territory accommodates up to about 1000 homes whilst having a population of up to about 5 million people within a 10 km radius. Assessing the perception of the community toward the condition of the community would require the knowledge of people's attitude towards the site, the factors influencing their attitude and their expectations from a possible rehabilitation process.

DISCUSSIONS

Based on findings from the study analysis, it is indicated that the quality of air around dwellers living close to the dumpsite are massively depleted. This as shown in **figure 6** indicates that residents of the slum community endure very bad quality of air than those residing in the mass hosing areas.

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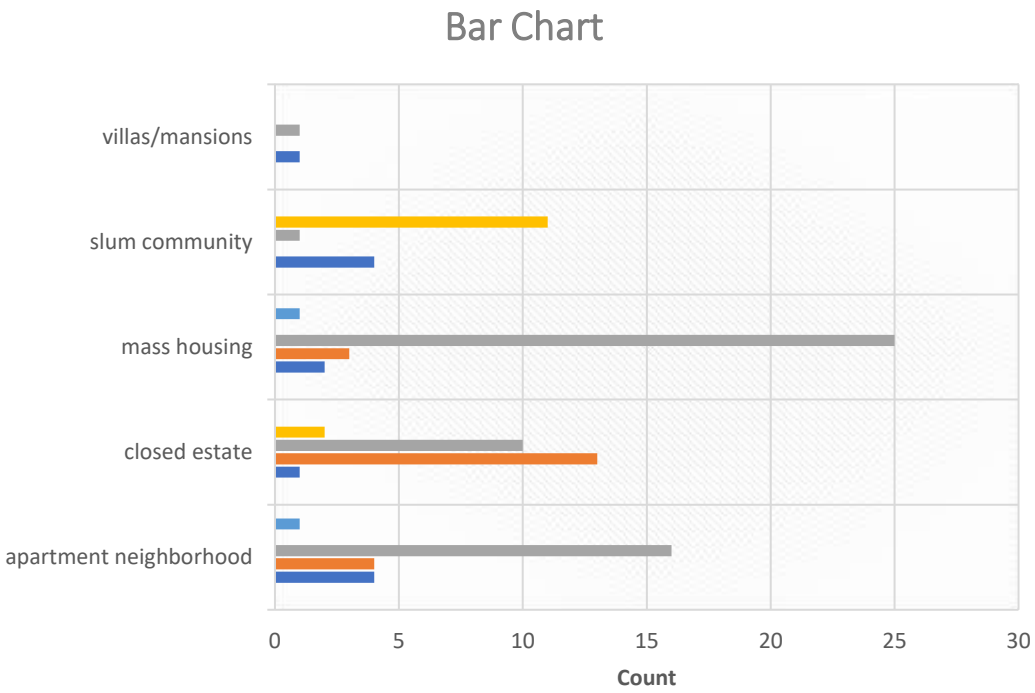


Figure 6: cross tabulation between residential type and the quality of air around them (author).

Due to the pollution challenge as a result of the presence of solid waste on the landscape, experts mostly proposed a small-scale waste to energy plant as shown in **table 1** to mitigate the backlog of wastes and solve the country's electricity deficit. This is suitable in preventing pollution by extracting all hazardous gases from the landfill on the one hand, and recycling these gases as renewable resource for domestic and commercial puposes on the other hand.

Table 1: mean ranking index of expert proposal a waste management landscape character (author, 2023).

WASTE MANAGEMENT LANDSCAPE CHARACTER	Mean Item Score	Ranking Index
A small-scale waste to energy plant for providing an independent source of electricity for the green infrastructure and the surrounding neighborhood	**2.30**	**1**
A biodegradation facility system for composting would be efficient for reducing the traffic of domestic waste transported to the site.	**2.22**	**2**
A waste incineration facility would be efficient in reducing the traffic of electronic wastes transported to the site from the factories.	**1.62**	**3**

In the same context, the quality of air around the landfill is significant If the site would undergo a successful rehabilitation process. Therefore, experts suggested as shown in **figure 7** that the built environment which comprising of buildings and its infrastructures has a bit of biophilic properties where nature and architecture are indistinguishable. This may be significant also in mitigating climate challenges and preventing pollution especially around the waste recycling areas.

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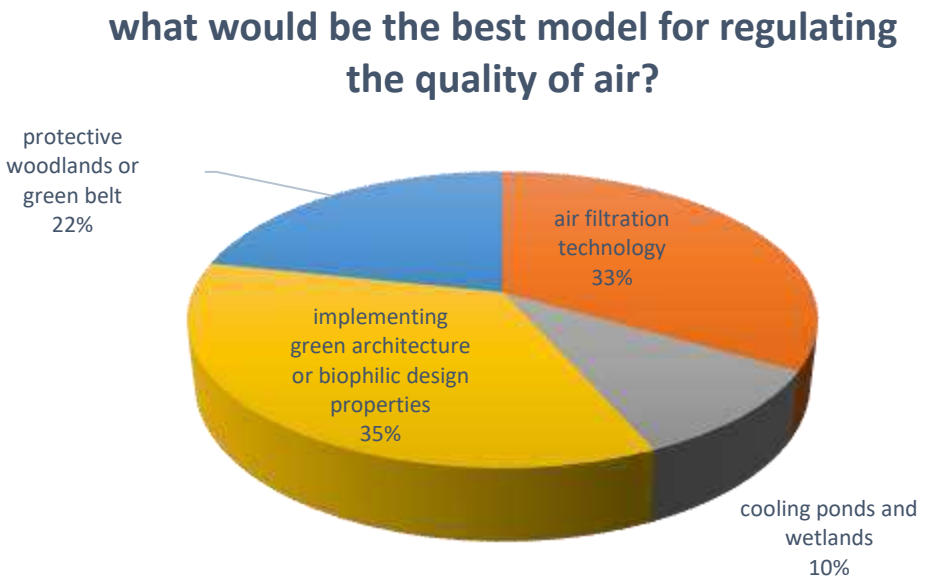


Figure 7: proposed model for regulating the quality of air in the landscape (author, 2023).

The successful design of a landscape is incomplete without the cultural and human made functions. In this context, user scale of preference regarding the socio-cultural functions is highlighted as shown in **table 2.** It indicates that community squares and monument were mostly preferred by the public. Other functions in the descending order of hierarchy includes, sports complexes, playgrounds and shopping centers.

Table 2: mean ranking index of user preference of the open recreation landscape character (author, 2023).

OPEN SPACES AND RECREATIONAL AMENITIES	Mean Item Score	Ranking Index
Community square and monument as urban aesthetic elements.	**4.20**	**1**
sport complexes.	**4.12**	**2**
Playgrounds for each age groups and amusement parks.	**3.98**	**3**
Shopping streetscapes and streetscape furnitures (streetscape is how the buildings, gardens, paths and road work in harmony to define the character or feeling of a street).	**3.93**	**4**
Recreational areas for relieving stress such as picnic zones and etc.	**3.93**	**4**
Secluded resting areas within the landscape	**3.71**	**5**
Shaded side-walks throughout the landscape.	**3.68**	**6**
Large tree canopies throughout the landscape.	**3.47**	**7**
Thematic gardens (for therapeutic purposes such as aromatic garden, color garden etc.)	**3.16**	**8**
Mobile sitting equipments.	**2.89**	**9**
Pet scaping (landscaping for pets)	**2.27**	**10**

These public recreation infrastructures are often built to the general health and safety standards especially because of the recent COVID19 pandemic impact on social interactions. In this context, most experts proposed public open areas that are designed to satisfy the post-COVID19 universal design standards as shown in **figure 8** whether they are public squares or linear parks.

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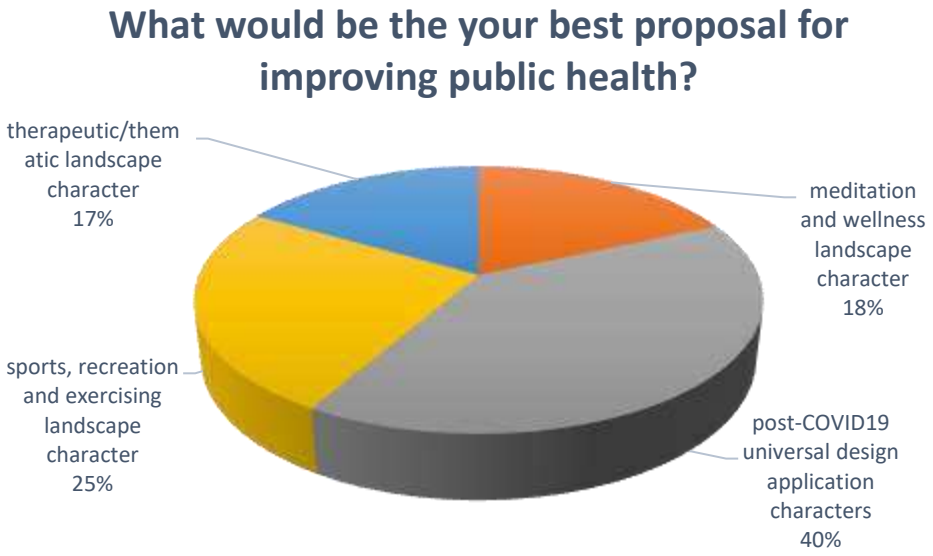


Figure 8: proposed public health and safety model for public recreation (author, 2023).

Studies have indicated that public participation in programs or initiatives are often achievable if they are integrated into public spaces. The waste reduction, reusage and recycling initiative is an important aspect in this study. Public participation in the initiative of a greener environment is a major identity in the rehabilitation model. In this context, the public's psychology was tested and it indicated as shown in **figure 9** that majority of the public are extremely willing to adhere to the waste management initiatives if they are primary beneficiaries of the renewable resource gotten from them.

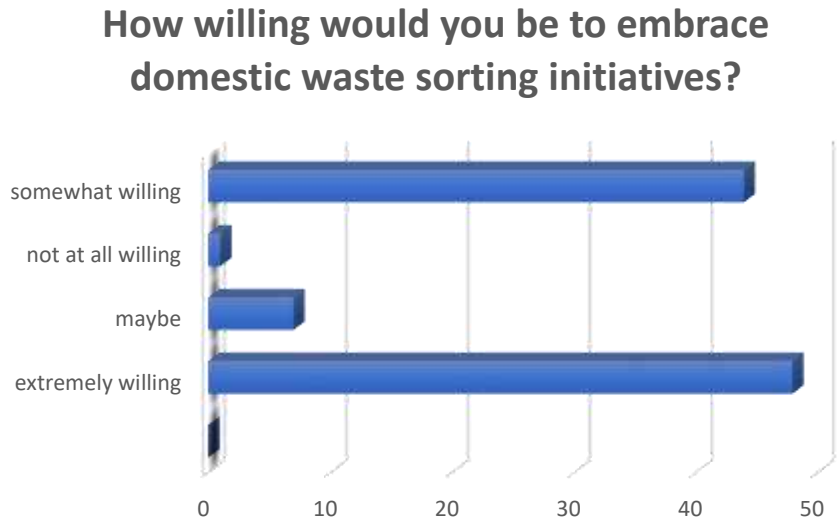


Figure 9: trends of user group willingness to participate in waste management (author, 2023).

Whilst incentivizing the public towards participating in waste management is a significant aspect of the model, improving the public's participation through activities and programs can increase education and awareness in this area. Integration public activities such as hiking, biking, jogging and exploring with waste management functions is one area that may bring a bit of complexity to the landscape identity. This theory was tested with the expert groups about the interface of public functions and spaces with the waste management functions. Most experts however,

suggested as shown in **figure 10** that the interfacing of the public open areas that includes biking paths, sitting areas and other recreational active spaces with the waste recycling building as a singular physical unit would be effective in improving participation and awareness through experiential learning.
In addition, the user group popular demands regarding circulation and transportation include driveways rather than the popular demands of biking trails or pathways. This also increased the demands for transportation infrastructures such as car parks and public bus terminals. At the same time, the user group demanded structures within the built environment that would perform cultural functions such as religious activities, commerce, food and drink, etc.
In the context of security, the user group most popular demand was a secluded gathering area using plantation corridors such as plant exhibition areas and shaded pathways as connective components between spaces. The expert group went further to suggest commercial areas along the borders to provide an active entrance into the landscape and a sense of security.

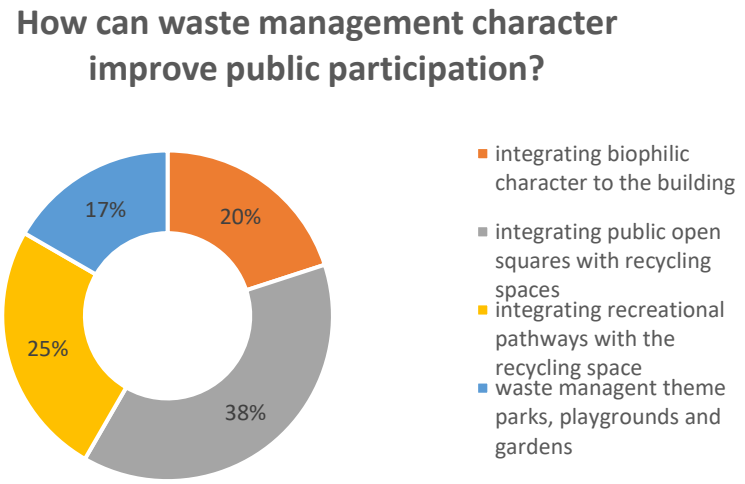


Figure 10: expert suggestions on improving public participation with waste management (author, 2023).

Furthermore, improving participation and social cohesion between neighborhood is one of the pillars of this study as the proposed rehabilitation is set out to renew or restructure the psychology of public open space users. In this context, the public reluctance to engage in public open spaces or gathering was tested. The reason behind the reluctance of public participation by most respondents was the fact that social media was present.
In this context, proposal opinions were being tested from the expert group. Most experts as shown in **figure 11** proposed integrating ICT technology into the landscape such as accessible WiFi connections, charging areas, etc. they believe that if the landscape is technologically active, it would prompt the public to be more active in engaging these outdoor spaces.

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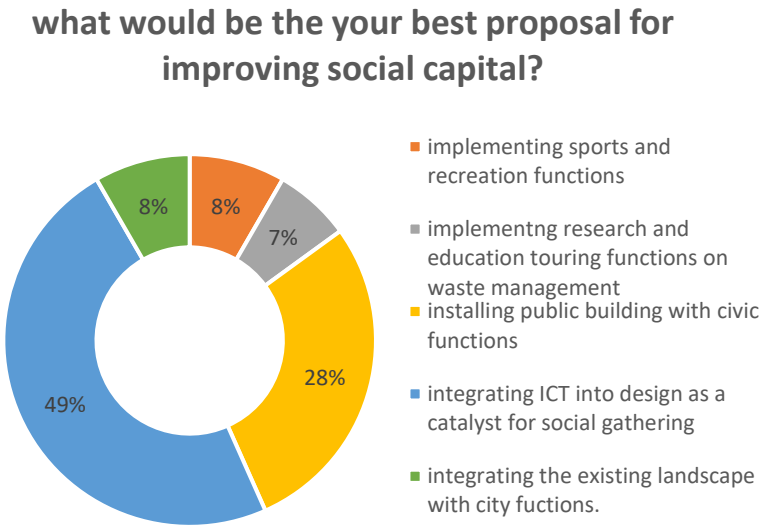


Figure 11: expert proposal for improving social cohesion (author, 2023).

Finally, the economic viability of the model was tested as expert opinions on the landscape potential on improving local business growth within the territory were measured. In this context, most experts recommended integrating the existing landscape identity with the urban or city functions. This was supported by the user group demands for basic urban furniture such as sitting equipment, ATMs, transportation infrastructures such as car parking areas, public bus terminals, etc. as these are significant in effective business service delivery. This could strengthen the fabric of the city where on the one hand, the landscape rehabilitation model heals the fractures of the built environment through natural and living landscape characters, while on the other hand the landscape in its entirety acts as an extension of the city fabric rather than just an auxiliary urban character.

CONCLUSION AND RECOMMENDATION

In the context of landscape design, the observations and analysis were significant in proposing a sustainable landscape rehabilitation model for Olusosun landfill site by amplifying the basic needs of the public and foresights of the expert. In this process, the model is structured on two fundamental layers namely; the natural environment and built environment. The natural environment consists of the landfill engineering, the water management, the topography and vegetation. The built environment consists of the cultural or man-made layers such as the buildings, the circulation, the land use and new socio-cultural amenities to be built on the landscape over time.

In the context of the natural environment design, it is proposed that the built environment within the landscape be integrated with the natural environment especially in the waste recycling section of the landscape. This phenomenon helps to improve the learning process about waste and enhances the interests of the public in participating in waste management. This is mostly expressed by expert suggestions to having public recreation interfacing with the built characters in the waste management section of the landscape. This phenomenon results in the improvement of air quality by implementing a natural biophilic character to the buildings as experts have suggested. In this context, the natural environment which includes the grasslands, plantation areas and other features such as artificial wetlands or cooling ponds would create a synergetic relationship between the built environment and the natural environment while solving basic environmental challenges such as air quality and flood control. In addition, security is a fundamental requirement for outdoor design and it is proposed that plantation areas act as corridors connecting spaces as well as providing a sense of security along the boundaries of the landscape.

Furthermore, the built environment consisting of the man-made layers and new amenities to be built over time is what defines a place on the landscape for the public. The primary preferences for civic activities and public functions are the squares and monuments, sports facilities and playgrounds for all ages. It is necessary that these facilities are built in line with public health and safety regulatory standards. In this context, experts have suggested that these spaces

follow post-COVID19 pandemic universal design regulatory standards. This is important because such spaces attract massive pedestrian activities and may be subject to health risks if not from the previous pandemic, maybe from future ones. Since the psychology of the general public towards social engagement is through the social medium networks and spaces as analyzed in the study, it is imperative that the approach to attracting the public to the public green areas is through a technologically driven narrative. This was supported by the experts and therefore recommended that technology in terms of digital and internet infrastructures are integrated into the landscape. The public squares or play areas are recommended for this activity. Besides the space being a buffer or a connective layer between the surrounding settlements, it can also become a place where people gather to connect physically and digitally. However, the design of commercial areas would adopt a different approach in this context. This is because psychological expert believe that pedestrian active outdoor entrances create a sense of security and discourages criminal activities. Furthermore, building the commercial layer at the boundaries of the landscape as suggested by experts would not only provide a sense of security, but also create a sense of continuity between the existing landscape and the city fabric.

In the context of connectivity and transportation, the basic options for mobility are the bike paths and the walking paths. However, due to the demands of the user group for public transportation system and infrastructures, it is recommended that a major streetscape connecting the existing landscape and the surrounding city fabric be built. This is supported by expert who believe this is important in promoting productivity among local businesses within the territory. The streetscape may consist of the bike lanes, side-walks, vegetation layer, parallel parking, a light rail lane and a two-way roadway. This is proposed to be built in the minor connector road linking the two highways parallel to the site.

Finally, this study provides alternative solution for rehabilitating damaged landscapes such as Olusosun landfill site by using the fundamental social, economic and environment measurements. This is significant in reducing pollution, mitigating climate challenges and restoring land use potentials within the landscape. Even though, the study provides adequate solutions for rehabilitating solid waste landfill sites, there is one field that is significant for future research. This includes discovering a sustainable approach to restore slum settlements on landfill sites.

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