

Low-Cost, Low Environmental Impact Streetscape in Egyptian Informal Residential Areas.

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Abstract

Informal housing areas in Egypt are facing a lack of open spaces in the wake of increasing urban density. The utilization of available space is crucial for improving the environment and promoting social equality as we strive to create more resilient and healthy residential areas.

Streets in informal housing areas have a significant impact on public life, extending beyond just the flow of vehicles. Streets constitute a substantial part of the communal open space accessible to the community. Streetscape can greatly enhance streets in informal areas and have a significant impact on their development. Streetscape can encourage people to use outdoor spaces and increase their enjoyment, in addition to creating a welcoming, relaxed, and involved atmosphere for them.

On the other hand, Egypt has the opportunity to utilize waste materials and create a recycling system due to the large quantity of waste available. Reusing waste materials helps to decrease pollution and improve the quality of the environment, preventing waste from ending up in landfills, as well as providing significant financial benefits.

There is a mass of reclaimed materials being utilized in the creation of streetscape elements, such as wood, steel, plastic and rubber. This study explores the potential that would make the streetscape of informal housing areas more friendly to the environment by using recycled materials. The research finds a need to utilize waste recycling in streetscape which enhances the quality of life in informal housing areas in Egypt.

Keywords: Recycling- Informal Housing- Streetscape- Low-cost materials- low carbon.

Introduction

Most of streets in informal areas in Egypt lack good streetscape which negatively impacts the behavior of people and the appearance of these areas (Rehan, 2013). Street are a significant element of public space that incorporates various users with diverse interests (Ghandour, 2017).

Streetscape is in direct contact with people and the urban environment, making it an effective tool for communicating messages to the public and raising awareness about recycling benefits (Allameh & Heidari, 2020).

Considering environmental issues, global climate change, financial crisis, and public overconsumption, it is necessary to shift from traditional development strategies to adopting low-carbon, low-cost strategies in our communities. Recently, many countries have begun relying on recycled materials to improve their environmental impact and reduce energy consumption. Recycled materials save approximately 75% of energy compared to materials made from new resources, as well as reducing construction costs (Kamal, Atef, & Mostafa, 2022).

Carbon emissions are a major factor in climate change, which can have severe impacts on both the environment and humans. The issue is that a significant portion of emitted CO₂ remains in the atmosphere for extended periods of time, influencing the climate that future generations will experience (Moawad, 2021). The production of materials is a significant contributor to greenhouse gas emissions, increasing from 5 gigatons of CO₂-equivalent in 1995 to 11 gigatons in 2015. This accounts for 23% of global emissions, up from 15% in 1995. As shown in figure (1).

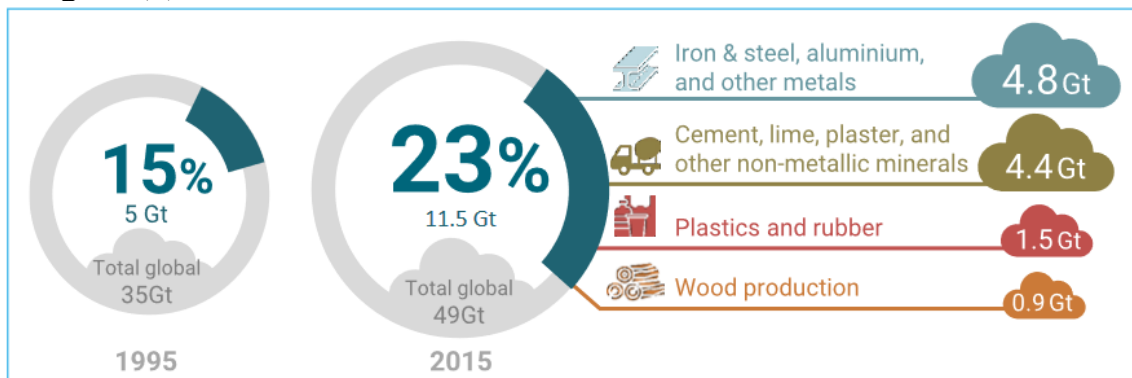


Figure.1. Emissions caused by material production as a share of total global emissions 1995 vs. 2015. (IRP, 2020)

Using recycled materials can result in urban context being more environmentally friendly, require less energy, and are more cost-effective compared to using native materials (Kamal, Atef, & Mostafa, 2022). Egypt's waste output is 16.2 million tons (Ismail, Ghalwash, & El Sebaie, 2022), thus recycling is an essential solution to address the issues of limited storage space and the decreasing availability of natural resources.

Using recycled materials in streetscape can have numerous benefits. Firstly, it helps reduce environmental impact by minimizing the need for new materials and thereby reducing emissions and conserving natural resources. Depending on the type of recycled materials used, greenhouse gas emissions can be significantly reduced between 47% and 98%. Secondly, using recycled materials can lead to cost savings ranging from 2% to 83%. Lastly, expanding the market for recycled materials can create more job opportunities, with the recycling sector generating more jobs compared to waste disposal (Groves, 2023).

The paper focuses on streetscapes because they cover very large areas of land in informal areas. Streetscape has the potential not only to improve the appearance and functionality of streets but also to promote sustainability by minimizing energy consumption by using recycled and durable materials (Dhaou, 2023).

This study investigates the potential of using recycling materials in streetscape for informal housing areas streets', aiming to explore innovative ways to materials. In addition to activate the role of low-cost, low environmental impact streetscape as an approach to provide a sustainable urban environment in informal housing areas in Egypt.

Materials and methods

The research aims to promote recycling materials as an effective solution in the streetscape elements, especially in informal residential areas as the upgrading proposals need to be more efficient economically and environmentally. As there is a need to develop new practices for the development of informal housing areas.

This study analyzes qualitative data by examining existing literature on the impact of using recycled materials, and the role of streetscape in upgrading informal housing areas. In addition to reviewing the upgrading efforts in the informal housing areas and discuss the potentials for enhance these interventions to be low cost and environmentally friendly.

The research deducts a proposed practices and urban interventions in informal housing areas' streetscape in the field to develop flexible concepts for the upgrading.

1- Informal housing streets conditions- classifications

Informal areas pose significant challenges to urbanization and are particularly vulnerable to the impacts of climate change. Upgrading interventions in these areas should be a top priority, with a particular focus on addressing the environmental impacts and ensuring sustainability in both the short and long term (Ghoneim, 2022).




One issue faced by authorities in developing cities is how to obtain and use resources to meet the high spending requirements caused by fast growth, while also supporting economic growth and employment. (Nixon, Chambers, Hadley, & Hart, 2015)

The lack of public spaces and small housing units, along with high density and overcrowding in informal housing areas, make the street crucial for people's quality of life (García-Villalba, 2014). Street-based upgrading are highly effective in driving the improvement of informal areas. The use of street-led approaches helps improve and enhance the development of streets. This in turn attracts businesses, encourages investment in housing and businesses, and fosters a sense of identity and belonging among residents. Implementing street-led approaches also allows for the creation of essential infrastructure and promotes a sense of security (Acioly, 2020).

Literature has shown that cities with well-planned streets and public spaces are both more enjoyable to live in and more efficient. Streets serve as the primary means of transportation and connection for individuals, allowing them to access their homes, conduct business, socialize, and interact with others. They also serve as the gateway for visitors to new communities, leaving a lasting impression (Fadda, Wahba, Kamel, & Kandil, 2019).

Streets in informal housing areas can be divided into 3 categories narrow streets, typical streets and main streets, as shown in table (1) (Tawfic, 2015).

Table.1. streets categories in informal housing areas. Source: (Tawfic, 2015) modified by author.

<p>Narrow Streets</p>	<p>these streets vary from 3 to 6 meters. 3-4 meters wide streets are typically used by pedestrians, bicycles, motorcycles, or tuktuks. Streets that are 4-6 meters wide only allow cars only in one direction.</p>	
<p>Typical Streets</p>	<p>Ranges between 6 -12 meters, due to the street conditions, sidewalks are often utilized as outdoor seating for cafes or as an expansion of garment stores or workshops.</p>	
<p>Main Streets</p>	<p>these streets vary from 12 to 22 meters width. All vehicles can access these streets. Some vendors choose to sell their products in busy markets located on main streets where there is a high volume of pedestrian traffic. shops often expand onto the sidewalks to create additional space for them.</p>	

According to street classification, walking is the most used form of transportation in informal areas. This is because the buildings are close together, and there are commercial pedestrian streets that connect directly to residential streets without any major roads for vehicles (Eldefrawi, 2013). Hence, Streetscape is used regularly by

a large number of people. It has the most direct interaction with people and the surrounding environment (Allameh & Heidari, 2020).

The Egyptian government has implemented two main approaches to enhance the living conditions of informal areas residents. This includes creating a better physical environment as shown in figure (2), and establishing stronger legal regulations. As part of the second approach, they are utilizing in-situ upgrading, rehousing, or relocation to effectively address the issue of current informal areas (Maan , Shams , & Fouda, 2023).



Fig.2. unplanned areas development by urban development fund. Source: (UDF, nd).

There are numerous significant local projects and initiatives towards improving informal housing areas that could adopt a sustainable strategy by using recycled materials in different project stages and could be mainstreamed in Egypt. Wherever Egypt suffers from the existence of 273 informal areas (Abdelmelek, El Ghandour, Ibrahiem, Madi, & Nadeem, 2022) with non-environmental-friendly characteristics.

2- Streetscape elements

Streetscape refers to the space between buildings and the curb, which includes sidewalks, street trees, lighting, and site furnishings as shown in figure (3). (San

Francisco Planning & et al, 2020) Elements of streetscape that can designed by recycled materials are summarized as follows:

Table.2. Streetscape elements.

Streetscape elements	Street paving	Sidewalk
		Street corners
		Parking lots
		Curbs
	Street furniture	Trash receptacles
		Seating, Benches
		Bus Shelters
		Signage
		Planters
	Public art	
lighting		

Source: Author based on (Rehan, 2013) (Moussa & Gurguis, 2023) (San Francisco Planning, et al 2020)



Fig.3. Streetscape elements. Source: (San Francisco Planning, et al 2020).

There are five basic criteria involved in selecting and placing items of street furniture: function, sitting and layout, form and appearance, durability, and cost. (Yücel, 2013)

The selection of materials that are commonly used in streetscape such as wood, concrete, recycled plastic, and other materials, is dependent on many factors such as the need for furniture to withstand vandalism, the expected weather conditions, the frequency of use of the furniture, as well as the cost and ease of maintenance.

3- Recycled materials

Recycled materials are frequently used in streetscape design. Reusing waste materials helps reduce pollution and improve the environment. It has various advantages such as preventing waste from going to landfills and providing financial benefits. (Shao & Liu, 2016)

There are three levels of recycling: recycling without changing the physical and chemical structure, recycling by destroying the physical structure but not the chemical structure, and recycling by destroying both the physical and chemical structure. Examples include using old tires as fenders, melting and reprocessing metals, and breaking down plastic into its monomers (Ahmed & Aly, 2023).

Waste management involves different types of pollution including air, water, soil, and noise. Examples of this pollution include dust and fumes from storing waste, noise pollution and energy consumption during waste collection, and noise from machines during waste transfer and transport. To address this problem, recycling practices can be implemented to reduce the need for landfills and waste collection.

The study indicates the commonly used recycled materials in streetscape elements such as recycled plastics, glass, wood, steel and rubber.

3.1 plastic

Plastics are widely used in modern economies due to their durability, flexibility, and low cost. They have various beneficial properties such as resistance to corrosion, high strength-to-weight ratio, and thermal insulation. Egypt produces more than 16.2 million tons of plastic waste each year. (Kamal, Atef, & Mostafa, 2022).

Recycling plastic requires less energy than making new plastic because it can be melted and molded into new items without further processing. This helps reduce energy usage and greenhouse gas emissions by 37%.

Material	GHG From New Production (CO ₂ e/kg)	GHG From Producing Recycled Materials (CO ₂ e/kg)	Difference (%)
Plastic	2.1	1.3	37

Source: (Kilgore, 2024).

Recycled plastics are cheaper than new plastics (20-40% discount), making them a cost-effective option for plastic converters (Hesslink & Duuren, 2019). The price advantage of recycled plastics is even greater when the price of oil is high, which is expected to continue due to oil scarcity in the long term.

Street furniture can be made from recycled plastics because they come in many colors and are lightweight, making them great for movable furniture as shown in figure (4). However, a drawback is that they often have low UV resistance, causing them to fade when exposed to sunlight for long periods of time (Grabiec, Łacka, & Wiza, 2022).



Fig.4. using recycled plastic in benches and planters. Source: (Goplastic, 2023); (Fábregas, 2023)

3.2 Crushed Glass

Glass waste is around 5% of the total solid waste produced in Egypt. Recycled glass reduces the energy required for glass production by 25-32% (Abdallah, 2009). In addition, using recycled glass can decrease air pollution by 20% and water pollution by 50% (Kamal, Atef, & Mostafa, 2022).

Material	GHG From New Production (CO ₂ e/kg)	GHG From Producing Recycled Materials (CO ₂ e/kg)	Difference (%)
Glass	0.9	0.5	41

Source: (Kilgore, 2024).

Recycled crushed glass can be used instead of sand for sanding concrete, asphalt, and other paving. It can also be used as a substitute for aggregate in fill materials, as shown in figure (5). Additionally, it can be used as an ingredient in tiles and similar products (Shao & Liu, 2016).

Glass beads made from recycled glass are used in road marking paint to improve visibility during nighttime and wet conditions. These beads work by reflecting vehicle lights in the paint (Government of Western Australia, 2022).



Fig.5. using recycled crushed glass in paving. Source: (Landscape Architect, n.d) (RockPave | Melbourne, n.d).

3.3 Construction and demolition waste (CDW)

In Egypt, 40% of construction materials are being wasted, amounting to 16% of the overall cost of building (Daoud, Othman, Ebohon , & Bayyati, 2021). In recent years, there has been a shift towards using construction and demolition waste (CDW) as a replacement for natural aggregates, rather than sending it to landfills. This is seen as crucial for sustaining the environment, reducing negative impacts, and increasing the economic value of recycling (Silva, Silva, Delgado, Azevedo, & Pereira, 2022).

Construction projects in Egypt generate approximately 50 million tons of waste annually (Beshara, 2023). Recycling can lead to the development of new industries, prevent the issues caused by dumping waste, lower energy usage and greenhouse gas emissions, and improve environmental cleanliness. CDW primarily consists of materials such as concrete, metals, wood, gypsum board, glass, and asphalt. Which can be utilized in various ways, such as paving roads (Beshara, 2023).

Using recycled aggregates from construction and demolition waste (CDW) in sub-bases, and foundations for roads can help increase recycling rates and create a market for recycled materials. This is a sustainable solution for reducing the

energy-intensive use of non-renewable resources in pavement construction (Reis , Quattrone , Ambrós, Cazacliu, & Sampaio, 2021).

Using CDW instead of natural aggregates can significantly reduce CO2 emissions in the manufacturing process by 65%. This suggests that incorporating CDW can help address environmental issues and promote a circular economy (Contreras-Llanes, Gázquez, & Romero, 2023). CDW can be used in road infrastructure. Examples include kerbs, footpaths, roads and pavements as shown in figure (6) (Groves, 2023).

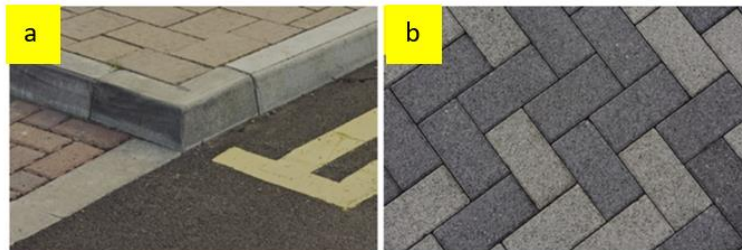


Fig.6. Applications of recycled concrete in streets. Source: (Groves, 2023)

3.4 wood

Recycled wood from demolished buildings and other structures, has been widely utilized in construction, and manufacturing various products. Recycled wood has minimal environmental impact and effectively reduces waste and energy usage (Shao & Liu, 2016). Recycling wood has significantly less environmental impact up to 29% and is more cost-effective with 32% lower costs (Jahan, Zhang, Bhuiyan, & Navaratnam, 2022). Utilizing recycled wood, particularly from doors, windows, and structural timber, is clearly advantageous as it helps conserve energy and resources (Shao & Liu, 2016).



Fig.7. Waste container built into a seat. Source: (Grabiec, Łacka, & Wiza, 2022)

3.5 Steel

Steel is 100% recyclable, allowing it to be reused and made into the same high-quality material repeatedly. It is also easily recovered using magnetic separation (Association, n.d). Using recycled steel instead of new steel significantly decreases air pollution by 86%, reduces water usage by 40%, and minimizes water pollution by 76%. (Quintè, 2023).

Material	GHG From New Production (CO ₂ e/kg)	GHG From Producing Recycled Materials (CO ₂ e/kg)	Difference (%)
Steel	2.4	0.3	87

Source: (Kilgore, 2024).

Steel street furniture is known for its minimal maintenance needs. It is simple to clean and does not often need to be repaired or replaced. This is especially beneficial in public areas where maintenance can be costly and time-consuming. Stainless steel furniture can be easily wiped clean, and any scratches or harm can be effortlessly polished away (Lifestyle, 2023). Types of Steel Street Furniture (Benches, Bollards, Waste bins, Signage, and Planters) as shown in figure (8).



Fig.8. Applications of recycled steel (planters, trash pin) in streets. Source: (ATECH, n.d)

3.6 Tires and rubber

Egypt produces around 20 million tires each year, but only 10% of these tires are recycled (General Authority for Investments and Free Zones, 2021).

Using tires frames instead of furniture like tables, chairs and planters, particularly in gardens, can be visually appealing when decorated and colored to match the overall decor. Nevertheless, there are other options available. There is more practical option is to dismantle the tire structure to obtain its raw materials (BAYRAKTAR, ÇGTOĞLU, & ABO AISHA, 2019).

There are many creative ways to reuse tires, such as using them as playground cover. Also, rubber pavers are a practical and attractive option for paving in areas where comfort and grip are important, regardless of the weather conditions as shown in figure (9). They can be used in various applications such as playgrounds, walkways, gardens, and patios to prevent slipping. (Bulei, Todor, Heput, & Kiss, 2018).



Fig.9. Application showcases of rubber (Rubber pavers). Source: (Bulei, Todor, Heput, & Kiss, 2018)

This is how recycling solid materials can be used to create sustainable streetscapes, leading to the discovery of innovative materials and their applications.

4. Recycled Streetscape Applications in Unplanned Residential Areas in Egypt

According to the urban development fund (UDF), the implementation of upgrading projects in unplanned areas has been conducted by paving, lighting, some projects are still in progress. In Giza as an example, paving and development of 26 vital streets from the King Faisal Street in Bulaq Al Dakrur neighbourhood with a total length of about 6 km at a cost of about 8.5 million pounds has been completed as shown in figure (10) (Elaosboa, 2022).



Fig.10. Development of local streets in unplanned areas in Giza. Source: (Akhbarelyom, 2022) (Akhbarelyom, 2021).

These local projects that aim to improve unplanned housing areas, could benefit from using recycled materials throughout their streetscape development in order to create a sustainable strategy, as shown in figure (11).

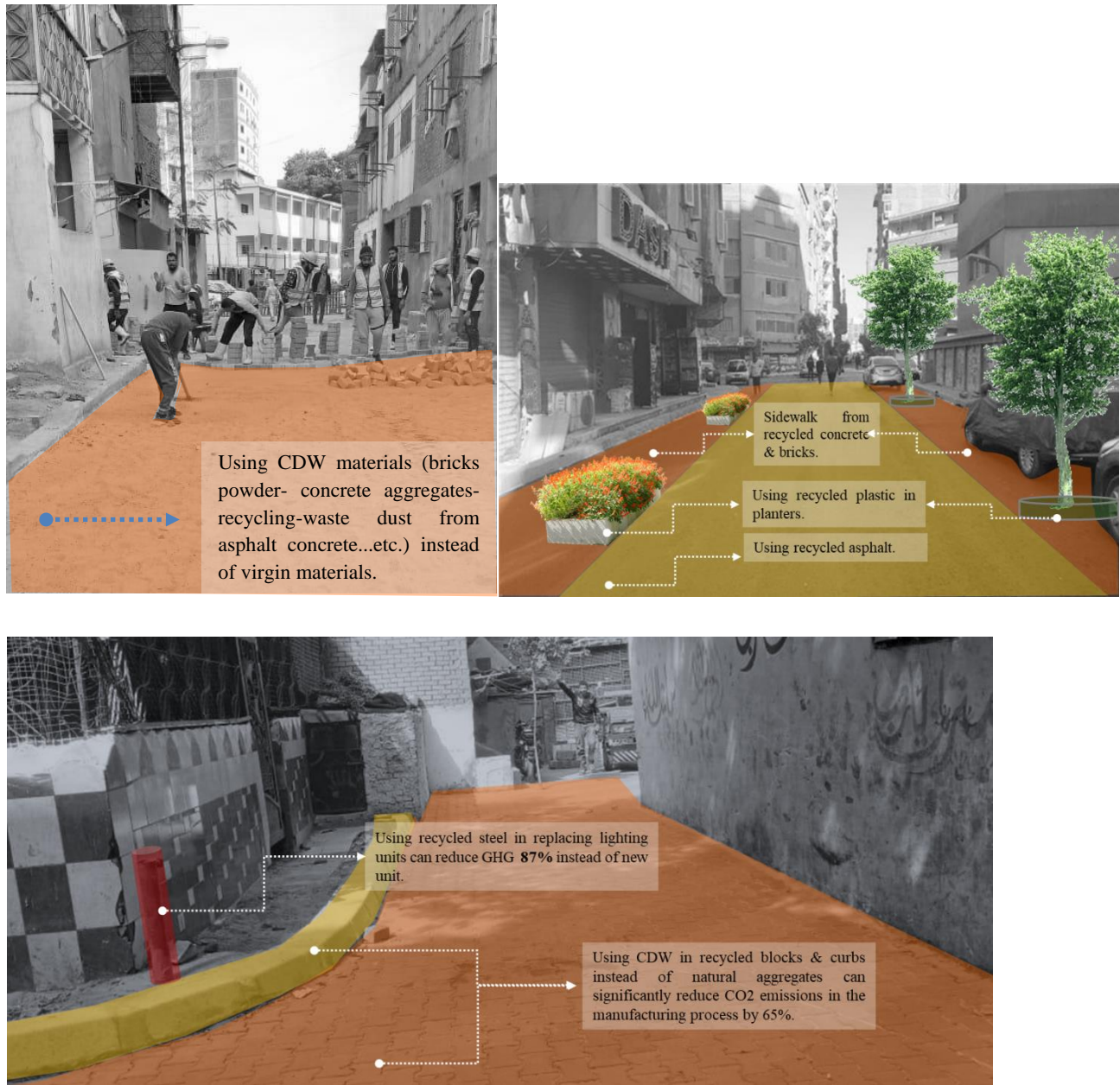


Fig.10. Development proposal of local streets in unplanned areas in Giza. Source: Author.

4. Results & Discussion

The research suggests using recycled waste in streetscape development in informal residential areas to improve the quality of life. Since it is challenging to create more open spaces, the focus is on enhancing streets using recycled materials.

There is great potential in using recycled materials in streetscape, as shown in table (3), Different types of recycled materials, including plastics, glass, steel, wood, concrete, and rubber, are examined. The study proposes recycling options for waste materials in streetscape design, with the goal of transforming them from a financial and environmental burden into a valuable resource for improving informal housing areas.

Egypt Vision 2030 aims to improve the quality of life in informal areas by focusing on economic, social, and environmental aspects, in line with the Sustainable Development Goals. So, Egyptian government needs to adopt a series of facilities that will help the environment, beginning with the recycling of waste materials.

Table.3. proposed recycled materials for informal housing areas' streetscape elements.

			Recycled materials					
			glass	Plastic	wood	CDW	steel	rubber
Streetscape elements	Street paving	Sidewalk						
		Street corners						
		Parking lots						
		Curbs						
	Street furniture	Trash receptacles						
		Seating, Benches						
		Bus Shelters						
		Signage						
		Planters						
	Public art							
	lighting							

Recommendations

Based on the results of this study, it is recommended to adopt recycling strategy to solve more than problem in Egypt as follows: (1) waste-efficient practices based on their impact on the reduction of both the environmental pollution and total upgrading project cost. (2) innovation streetscape design approach in informal housing areas which lack an adequate streetscape design by using recycled waste materials

Creating a waste management plan is crucial in order to comprehend the characteristics of waste and determine the most effective way to handle it for maximum utilization.

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