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Identifying and Assessing the Critical Criteria for Material Selection in Storm Drainage Networks: A Stationary Analysis Approach

Ahmed Farouk Kineber [1,*], Saeed Reza Mohandes [2], Mohammed Magdy Hamed [3], Atul Kumar Singh [4] and Soha Elayoty [5]

1 Department of Civil Engineering, College of Engineering in Al-Kharj, Prince Sattam Bin Abdulaziz University, Al-Kharj 11942, Saudi Arabia
2 Department of Mechanical, Aerospace and Civil Engineering, School of Engineering, The University of Manchester, Manchester M13 9PL, UK
3 Construction and Building Engineering Department, College of Engineering and Technology, Arab Academy for Science, Technology and Maritime Transport (AASTMT), B 2401 Smart Village, Giza 12577, Egypt
4 Department of Civil Engineering, SRM Institute of Science and Technology, Chennai 600089, India
5 Faculty of Engineering, Cairo University, Giza 12613, Egypt
* Correspondence: a.farouk.kineber@gmail.com or a.kineber@psau.edu.sa

Abstract: Recent years have seen a rise in the frequency and severity of extreme rainstorm events, which have caused widespread damage and death in numerous cities. The manufacture and use of storm drainage materials result in numerous environmental concerns in the construction industry. Green materials for storm drainage networks are environmentally friendly compared to their traditional counterparts. Identifying and assessing sustainability criteria for green materials for storm drain networks has been challenging. This study aims to determine the critical criteria for selecting green materials for storm drainage networks using a stationary analysis approach. To this end, a questionnaire survey was administered to Egyptian storm engineers to assess their importance based on a selection criteria 29 green materials. From the results obtained, "Operation and maintenance cost" and "Use of local material" were seen to be the "stationary materials". The obtained findings in this research pave the way for the Egyptian storm industry towards becoming environmentally friendly, which will in turn improve the functioning mechanism of sewer networks.

Keywords: sustainability criteria; materials selection; importance index; Ginni's measure of dispersion

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1. Introduction

The building industry accounts for a sizable portion of total economic investment, and its link to economic growth has been thoroughly theorized. Various reports have stressed the importance of the building sector to national economies [1]. Peak flows and runoff volumes evacuated by drainage facilities are growing as a result of urbanisation processes and climate change [2,3]. Many areas lack access to basic infrastructure services despite the fact that they are widely acknowledged as crucial to economic growth, trade connection, social welfare, and public health. In order to achieve global growth objectives, an annual investment of between USD 836 billion and USD 1 trillion is required [4].

Draining surplus water from surfaces like roads, walkways, rooftops, and buildings is called "storm water drainage". Drainage wells, storm sewers, and storm drains are all terms for the same infrastructure used to collect and transport storm water. Storm water is the runoff that accumulates after it rains, snows, or sleets. While some of this water naturally percolates into the earth, if there isn't adequate drainage, standing water can cause structural damage and even harm to people. Projects involving storm drainage networks are among the most critical and challenging in the world. Governments have a particularly difficult time implementing storm drainage networks due to the expanding population in the recent era, which has increased the constructed area, which has increased the demand for establishing new storm drainage systems to serve new inhabited areas [5].

Recent years have seen a rise in the frequency and severity of extreme rainstorm events, which have caused widespread damage and death in numerous cities [6]. For example, serious flooding was produced by the largest daily rainfall quantity (312 mm) in Germany being recorded at the Zinnwald–Georgenfeld station on 12 August 2002 (Becker and Grunewald, 2003). Between May and July of 2007, England received 406 mm of rainfall (the previous record was 349 mm), but in 2009, a new rainfall record of 316 mm was established at Seathwaite in Borrowdale [7]. Over the previous 15 years, England has seen severe flooding due to extreme rainfall, leading to huge economic losses [8]. A number of Asian cities have also been hit by unprecedented rainfall. Extreme floods in Pakistan were triggered by a month of record rainfall in 2010. At least 79 individuals lost their lives and over 1.9 million were impacted when the greatest daily rainfall on record (460 mm) hit Beijing on July 2012 [9]. Even worse, there is mounting evidence that surcharging for use of drainage systems will become increasingly common [10].

Managing inundation risk is crucial in light of the growing threat of flooding [11]. An additional issue is that the hydraulic capacity of Urban Drainage Systems (UDS) are diminishing as a result of the ageing of their components [12]. As a result, operational shortages in UDS have been on the rise over the past few decades, leading to pollution, flooding, and human casualties [13]. As a result of the severe social, economic, and ecological consequences, water engineers have made it a top priority to improve UDS in order to reduce the frequency and severity of floods and pollution incidents [14]. Previous research by Zhu, et al. [15] shows that these floods can cause significant damage, especially in urban areas. There could be human and material casualties, as well as interruptions in the availability of essential services such as clean water and power [16]. Many municipalities have put off constructing storm drainage networks, despite their obvious benefits to the public and the environment, because of the prohibitive costs involved. As a result, numerous cities have been rendered useless and suffered tremendous economic losses, injuries, and deaths due to major rainfall occurrences [8]. Storm drainage networks are one of the most important projects for countries nowadays because of the great urban development and the increasing in the climate changes. These projects need a huge investment to be executed, especially piping these networks; thus, thinking about and to developing a new framework to be applied to these items to reduce cost while keeping the track of projects relating to and maintaining the safety of these items is vital. Consequently, there is a need to adopt sustainable adoption for storm drainage networks.

To provide people with ecologically friendly constructions that make optimal use of water, electricity, resources, etc. is central to the concept of "sustainable adoption" [17]. Local and renewable materials are considered green materials. People often make unique materials in a specific region or area. The soil, rocks, and sand beneath our feet can be considered green materials. Buildings, objects, and spaces can also be constructed from grasses, straws, wood, and bamboo. The majority of renewable plant materials come from plants that proliferate. The use of a sustainable material also reduces a building's operational costs. Aside from making cities healthier for their residents, it also improves their productivity [18]. The overall picture painted by this description of environmentally friendly material is one that offers hope for a brighter future. Therefore, both emerging and industrialised nations are placing emphasis on green construction [19]. However, environmental, social, and economic variables are taken into consideration when selecting acceptable materials for sustainable storm drainage network projects [20]. These guidelines ensure that materials that are less taxing on the environment in terms of energy consumption and waste reduction are prioritised throughout the design phase of storm-related infrastructure project. Furthermore, economically viable storm drainage materials that are produced using as little energy as possible contribute to sustainability standards. When people live in these kinds of communities, they benefit socially and physically [21].

The evaluation procedure for choosing green construction materials and their long-term effectiveness is receiving increased attention from academics these days. High-performance, eco-friendly materials are available for use in storm drainage networks projects, lowering their overall environmental impact. All sustainability parameters must be considered, making the selection of storm drainage material networks significantly more difficult than with non-green materials [20]. Therefore, projects involving storm drainage networks need to use green materials selection criteria that take into account environmental, economic, and social factors. When choosing materials, it's important to take into account a wide variety of factors, some of which may be in conflict with one another. However, research on the criteria for selecting stationary green materials for storm drainage networks projects is lacking. This article aims to help close that gap by assessing the significance of green materials selection criteria for storm drainage networks projects in Egypt. Egypt's storm projects are analysed using a gap analysis between green adoption theory and practise. In addition, it uses a stationary analysis to show how several criteria for choosing eco-friendly materials are linked, allowing it to provide an optimal set of standards. The suggested research would give Egypt and other developing countries a benchmark against which to determine the best approach to adopting the green concept. This study aims to help executives and experts cut costs and boost quality by using environmentally friendly materials in their storm preparation and clean-up efforts. Following a brief overview of relevant prior studies, this paper details the methodology used to conduct the current study. Next, the paper's proposed findings are explored in the context of the relevant literature. Finally, the final section presents the most important findings and suggestions for the future.

2. Research Background

2.1. Nature of the Green Materials

Although the phrases "green building" and "sustainability" are commonly used interchangeably, they are not synonymous. Sustainable growth, a broad and far-reaching notion, underpins green building philosophy [22]. The Green Building (GB) idea refers to the effective design, construction, and maintenance of structures that consume raw resources such as electricity and freshwater and are beneficial to the environment [23]. Green buildings have improved living conditions for its residents by providing cleaner air and natural light, as well as increasing efficiency and lowering operating costs [24]. To qualify as a green building, our environments must be preserved, our energy consumption reduced, and our tenants' well-being improved [25].

Green buildings can be less expensive since they use less energy and require less maintenance, while staff are more comfortable and efficient. Finally, the reputation of a green building has been recognized or occupied. Investors are increasingly focusing on green building projects [26]. Many reasons contribute to the development of green, including environmental, economic, and social advantages. However, for current sustainability techniques to be integrated and synergistic, both a new construction and the retrofitting of an old structure are required. To alleviate and finally eliminate the environmental and human health consequences of new structures, a wide range of measures and processes are used. It also emphasizes the use of renewable energy sources such as sunshine through passive solar, solar, and photovoltaic technologies, and plants and trees through green roofs, rainwater utilization, and runoff reduction. Many alternative options, such as gravel or porous concrete or asphalt, are also utilized to boost groundwater supply. Green building requires the government and society to work together to coordinate their efforts [27].

At the close of the twentieth century, people became more aware of the environmental effects of technology and human progress. The city is becoming increasingly populated, resulting in a massive increase in buildings and skyscrapers and, as a result, an economic upturn, but with significant environmental effects [28]. People began to broaden their efforts to limit their impact on the environment, and buildings were identified as key contributors to global energy consumption, trash disposal, and green space degradation [29]. Green building practices are not a new phenomenon. Some were created using environmental design aspects in the late nineteenth and early twentieth century [30]. A unified green design movement did not emerge until the 1970s, when design and development were initially focused on environmental campaigners [29].

The building is a major consumer of natural resources and contributes significantly to greenhouse gases [31]. Because manmade greenhouse gas emissions are the primary cause of global warming and climate change, quick action is required to avert potentially disastrous consequences [32]. Buildings, in addition to consuming energy and material resources, can generate waste and possibly harmful air pollution [33].

2.2. Sustainability Criteria

Sustainability refers to enhancing the quality of life and allowing people to live in a healthy environment in order to enhance the natural, social, and economic position of current and future generations [20]. The term "sustainability" itself was coined at the Tampa conference on sustainable development. Sustainable management is a resource-efficient and environmentally conscious approach to creating a secure built environment [9]. High demand for both residential and commercial structures is a direct result of the growing urbanisation of several major cities [7]. To combat the rapid expansion of cities, a large amount of resources are required, but over time, this use depletes reserves [11].

The 2030 Sustainable Development Goals (SDGs) aim to improve people's lives and the planet's ecosystem and economy by addressing some of the world's most intractable problems [21]. Sustainable cities and municipalities, with 17 aims and 169 objectives, are crucial SDGs for overcoming various difficult human concerns [22]. Companies in the construction industry around the world are making strides toward sustainability on a daily basis as a result of a growing awareness of the need to preserve natural resources, improve global health, and meet consumer demand for environmentally friendly building supplies. Environmentally responsible building practises are crucial because of the significant amount of carbon dioxide gas released due to the use of unsuitable building supplies and the energy used to heat and cool these structures [23]. In the face of climate change, the stability of these materials is compromised. The popularity of projects involving storm drainage networks would plummet if poor materials were chosen. It is important to receive community input on both the materials selected and the political risks taken into account. Additionally, by selecting appropriate materials, the economic link with the environment and community frequently indirectly lessens the environmental impact on society [9].

The design, growth, and longevity of the storm industry all depend heavily on the materials chosen [24]. Numerous studies have investigated the impact of material choice on sustainability [25]. Green material choices harken back to simpler times, when eco-friendly options were more widely available. However, the official green programme was launched in the midst of the energy crisis, and the idea of green building was widely discussed and disseminated in the 1960s and 1970s [27]. Ecological, health-promoting, recycled, or high-efficiency construction materials are green because they reduce negative impacts on the environment and human health across their full life cycles [28]. Green materials offer a wide range of options for construction, furnishing, energy generation, and other areas of infrastructure development. There has been a lot of study on choice of materials. Criteria for selecting environmentally friendly materials were arrived at after an exhaustive literature search. Previous research was used to identify the sustainable criteria selected as shown in Table 1.

Table 1. Sustainability criteria for green construction materials.

Code	Classification of the Environment	Impacts of Achievement on SDGs	Previous Research
C1	Recyclability and reusability potential	Community and city sustainability	[34–36]
C2	Material impact on indoor and outdoor air quality	A healthy and happy life	[37]
C3	Environmentally healthy interiors	A land-based lifestyle	[20]
C4	Eco-environmental form	Action on climate change	[38]
C5	Consumption of water	Sanitation and clean water	[20,34]
C6	A waste management system	A land-based lifestyle	[39,40]
C7	Acquisition of land	Consumption with responsibility	[34]
C8	Transportation and production activities	A clean and affordable energy source	[34,41]
C9	Natural resource consumption	Consumption with responsibility	[41]
C10	Efficiencies in energy	A clean, affordable energy source	[20]
C11	Cost of investment	Growth in the economy	[42]
C12	Maintenance and operation costs	Economic growth and decent work	[42,43]
C13	Construction materials' social costs	Growth in the economy	[34]
C14	Meeting the needs of stakeholders	Goal-oriented partnerships	[34,43]
C15	Risks associated with finance and economy	Poverty reduction	[42]
C16	Contribution to taxation (i.e., entry taxes on imported goods).	Growth in the economy	[20,39,44]
C17	A material's expected life span	Communities and cities that are sustainable	[43,45]
C18	Social and ecological acceptability	Underwater life	[38]
C19	Development and social benefits	Strong institutions and peace	[42]
C20	Adaptability and availability	Community and city sustainability	[46]
C21	Safety and health	Well-being and good health	[34,37]
C22	An aesthetic perspective	Goal-oriented partnerships	[34,47]
C23	Natural disasters and contamination of the environment resistance	Interventions in climate change	[20,37]
C24	Utilization of local resources	Producing and consuming responsibly	[20,48]
C25	Availability of labour	Inequalities reduced	[49]
C26	Resistant to fires	Well-being and good health	[37]
C27	Buildability (ease of construction)	Infrastructure and innovation in the industry	[45]
C28	Noise pollution isolation	Well-being and good health	[50]
C29	Integration with other materials and ease of Use	Infrastructure and innovation in the industry	[50]

3. Research Methods

The purpose of this research is to determine the stationary green material selection criteria for storm drainage network projects to increase the long-term viability of construction endeavours. The benefits of these criteria include lower total manufacturing costs and fewer negative effects on the environment [45]. To accomplish this, we conducted a questionnaire survey to establish the significance of the criteria for picking green materials and systematic literature research to identify the criteria for selecting green materials. Participants were drawn from Cairo and Giza, the two states in Egypt that are home to the majority of the country's development projects, for this study on the storm drainage industry [51]. The survey questionnaire had three primary parts, the first of which was designed to gather information about the participants' backgrounds and levels of familiarity with sustainable, environmentally friendly practises. Meanwhile, the next two sections were free-form questions for incorporating any criteria that the participants deem essential, including green parameters that influence sustainable storm construction. Participants used a Likert scale to rate each criterion based on their level of expertise and familiarity. The scale is a five-point scale "where 5 is very high, 4 high, 3 average, 2 low and no or very low". Numerous earlier research has employed this same five-point scale [52–59]. The significance of the green material selection was quantified using this scale. There were a total of 90 questionnaires sent out, and 49 of them were filled out completely. The return rate was 54.5%, which is deemed typical and indicates there is no problem with the questionnaire, according to [60,61]. Figure 1 illustrates the research framework of this study, which has been adopted from El-Kholy and Akal [62] and Al-Atesh, et al. [63].

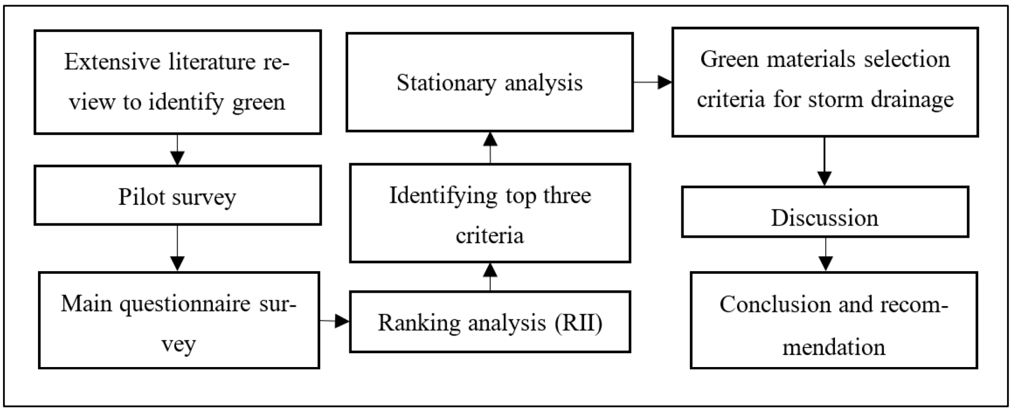

Figure 1. Research framework.

3.1. Relative Importance Index (RII)

Besides identifying the green material selection criteria, this study used a mean rating and a list of Relative Importance Index (*RII*) based variables to reveal the most important criteria that lead to sustainable storm drainage network construction in the Egyptian industry, in addition to identifying the green material selection criteria. As a widely employed method for ranking and evaluating variables [31–33], *RII* was first found by Salleh [64] as a statistical technique for prioritizing causes. Event frequency was evaluated using a 5-point Likert scale and *RII*, while intensity was evaluated using Equation (1) [65,66].

$$RII = \frac{\sum w}{A \times N} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5 \times N} \quad (1)$$

where w indicates the weighting given to each attribute by the participant, A is the maximum weight, and N is the total number of participants. Table 2 displays the statistical means, standard deviations, and *RII* values calculated from these inputs. The ranking derived from this computation was then used to compare the respondents' perceptions of the importance of the elements across the three groups they had formed (consultants, owners, and contractors). Therefore, the most important parameters that contribute to the creation of sustainable storm drainage networks in Egypt were identified through this study.

Table 2. Demographic characteristic frequency distribution.

Variable	Characteristics	(%)
Work experience (Years)	Less than five	17.7
	5–10	17
	11–15	26.3
	16–25	23.7
	More than 25	15.2
Current position	Director	5
	Senior Manager	10.3
	Manager	28
	Design Engineer	20.7
	Site Engineer	36
Educational level	Diploma	5
	Bachelor's degree	9.7
	M.Sc.	45.3
	Ph.D.	25.3
	Others	18.7
Organization function	Client	35
	Consultant	31.7
	Contractor	32.3
Awareness	Totally familiar	2.3
	Familiar	63.7
	Moderately familiar	17.7
	Not familiar	5.7

3.2. Stationary Analysis (Ginni's Mean)

This research followed the same methodology developed by Samuel and Ovie [67] to identify the long-term financial factors that contribute to the demise of Egyptian contracting organizations. This approach entails the following procedures:

(a) Determining the mean of dispersion of the *RII* numbers through the application of Ginni's mean difference measure of dispersion [68] as shown in Equation (2):

$$G.M = \frac{G}{M} \tag{2}$$

where $G.M$: the Ginni's mean difference measure of dispersion, G: the summation of the differences in the value of all possible pairs of variables, and M: the total number of differences, where N is the number of variables and

$$M = \frac{N(N-1)}{2} \tag{3}$$

(b) Developing weight for each *RII* number based on the calculated Ginni's mean difference measure of dispersion through the application of Equation (4):

$$Wi = G.M \times \frac{RIIi}{\mathrm{RII1}} \tag{4}$$

where Wi: the weight of each *RII* number, $RIIi$: the relative index number of any cause, and RII1: is the highest relative index number.

(c) Specifying the weighted geometric mean (*G.M. (w)*) of the *RII* numbers in order to represent the stationary central value and fit on the *RII* calibration to reflect the stationary, (see Equation (5)):

$$G:M.\,(w) = Antilog\frac{\sum \mathrm{w}.\log RII}{\sum \mathrm{w}} \quad (5)$$

where $\sum$w: is the sum of the weights assigned to the *RII* numbers.

4. Results

4.1. Characteristics and Demographic Features of Respondents

As indicated in Table 2, the authors categorised the participants in this study based on their years of work experience, current positions, degree of education, and organizational function. According to the current position findings, the "Site Engineer" had the highest frequency (36.0%), followed by the "Manager" (28.0%), and the director (5.0%) had the lowest frequency. The customer had the largest proportion (38.0%) in the organization function, followed by the client (35.0%). Table 3 further reveals that around 17.7% of respondents worked for 1 to 5 years. Respondents with 5 to 10 years of experience, 11 to 15 years of experience, and more than 25 years of experience were around (17.0%, 26.3%), and (15.2%), respectively. This shows that the participants in this study have prior expertise and can benefit from it.

Table 3. Relative rank.

High (H)	0.8 < RII < 1.0
High-Medium (H-M)	0.6 < RII < 0.8
Medium (M)	0.4 < RII < 0.6
Medium-Low (M-L)	0.2 < RII < 0.4
Low (L)	0.0 < RII < 0.2

This conclusion is similar to the finding of "awareness of sustainability component", in which 63.7% of respondents were "acquainted" or "completely familiar", and (2.3%) were "totally familiar". In general, respondents exhibited strong long-term awareness, with a knowledge level of (63.7%), somewhat higher than the (50%) average, indicating a sufficient degree of awareness among stakeholders.

4.2. Consistency of the Collected Data

After collecting questionnaires from 50 participants, we used Cronbach's alpha coefficient to validate our findings across the two areas of 28 material selection criteria. Over the cut-off value of 0.70, the Cronbach's alpha was 0.811 [69]. Therefore, it was determined that the acquired questionnaire data met the criteria for internal consistency and was reliable and valid for analysis.

4.3. Relative Importance Index (RII)

The primary motivation for the storm drainage industry to embrace eco-friendly materials is to improve efficiency and effectiveness, which in turn lowers project costs and increases the project's long-term viability. Furthermore, numerous actions that have greatly boosted construction's success have been documented in the literature. The decision by building professionals to use environmentally friendly materials is influenced by these actions. As a result of this study, we now know the 29 essential criteria for using eco-friendly building materials.

The RII Method was applied to the data gathered from the questionnaires and entered into the SPSS program (Important Relative Index). This study used the approach to quantify the significance of factors that influence the use of environmentally preferable materials. The RII ranges from 0 to 1, where 0 is not included. The more significant an RII number is, the more weight that criterion should be given, and vice versa. In accordance with the recommendations made by Yap, et al. [70], the transformation matrix is an evaluation of RII that takes into account both the original importance and the importance generated through RII, which are as follows:

Table 4 and Figure 2 show the results of the Relative Importance Index (RII) of the green material's criteria, along with the accompanying rating and their level of importance. The ranking analysis verified that all criteria were assigned "High" relevance levels, with the exception of activity VM.IP2, which was assigned a "High-Medium" value level. On the other hand, the five factors with the greatest RII of 0.85 or above among all participants were the same.

Table 4. Relative Importance of green materiel selection criteria in the storm drainage networks projects.

Criteria	RII	Importance Level	S.D.	Rank
C1	0.829	H	0.816	4
C2	0.812	H	0.899	10
C3	0.816	H	0.672	5
C4	0.735	H-M	0.922	27
C5	0.816	H	0.862	7
C6	0.837	H	0.782	1
C7	0.727	H-M	1.014	28
C8	0.743	H-M	0.890	26
C9	0.833	H	0.921	3
C10	0.808	H	0.865	11
C11	0.784	H-M	0.838	18
C12	0.788	H-M	0.922	16
C13	0.776	H-M	0.927	21
C14	0.763	H-M	0.905	23
C15	0.776	H-M	0.881	20
C16	0.698	H-M	1.139	29
C17	0.812	H	0.876	9
C18	0.780	H-M	1.005	19
C19	0.800	H	0.935	14
C20	0.751	H-M	1.071	25
C21	0.837	H	0.928	2
C22	0.816	H	0.838	6
C23	0.812	H	0.801	8
C24	0.796	H-M	0.968	15
C25	0.788	H-M	1.008	17
C26	0.767	H-M	0.965	22
C27	0.759	H-M	1.000	24
C28	0.808	H	0.912	12
C29	0.804	H	0.946	13

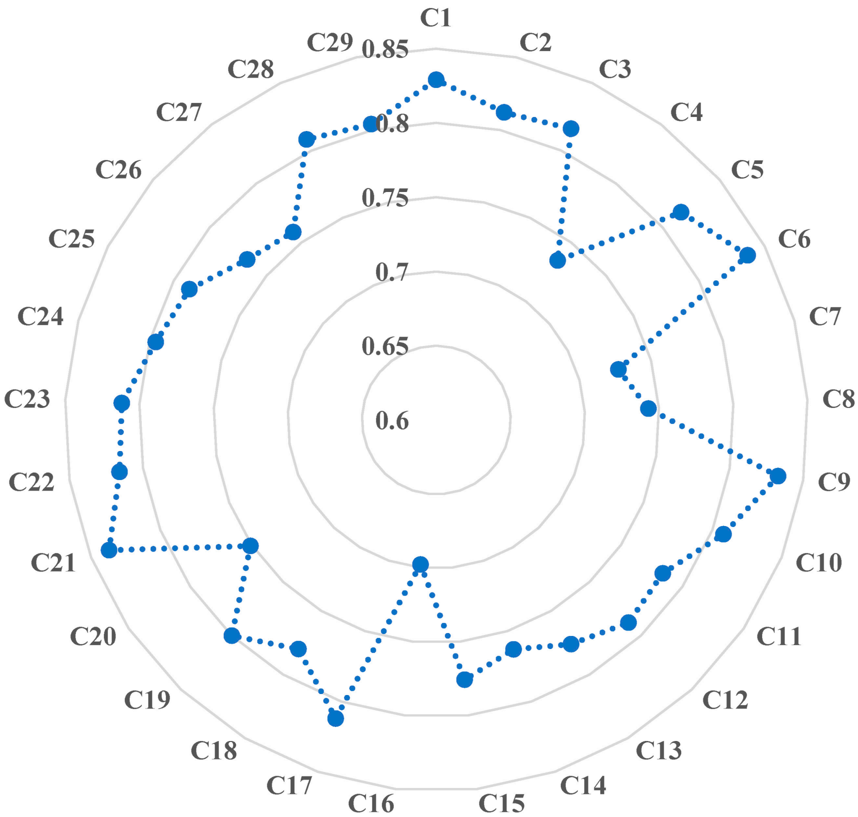

Figure 2. RII levels for green materiel selection criteria in the storm drainage networks projects.

To encourage professionals to use environmentally friendly products, these guidelines emphasize certain green construction standards. The construction sector also benefits greatly from a variety of other activities. Table 3 summarizes the 29 criteria that were given a RII score and standard deviation for this study. The results show a large RII and a large standard deviation, indicating that the respondents' perceptions are very agreeable and significantly different from one another. Green material selection criteria are seen as a driver of creativity in the construction sector. Therefore, it is important for businesses to learn how to execute the criteria for selecting green materials in their projects.

4.4. Stationary Green Materials Selection Criteria for Storm Drainage Networks

In order to calculate Ginni's coefficient of mean difference, we need to know the RII number for each criterion, which can be found using Equation (4) and Table 3. The Ginni's coefficient of mean difference (G.M) can be calculated by adding up the differences between the values of all feasible pairs of independent variables. Differences between all pairs of RII numbers are displayed clearly in Table 3. Table 3 shows that the total number of value differences between all conceivable pairs of variables is 406, and that the sum of these differences, G, is 16.012. Ginni's coefficient of mean difference (G.M) is 0.039 when calculated using Equation (5). Additionally, as indicated in Table 4, the weighted geometric mean G.M. (w) is 0.789 because $\sum$w = 1.07 and $\sum$w. Log RII = −0.1107. This RII value coincides with the RII numbers for C24, C12, and C25, as stated in Table 5. Accordingly, these criteria are considered the stationary criteria for green material selection in storm drainage networks in Egypt (Table 6).

Table 5. Differences of all possible pairs of RII number.

Rank	Criterion	RII	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	C6	0.837	0.139														
2	C21	0.837	0.110	0.139													
3	C9	0.833	0.102	0.110	0.135												
4	C1	0.829	0.094	0.102	0.106	0.131											
5	C3	0.816	0.086	0.094	0.098	0.102	0.118										
6	C22	0.816	0.078	0.086	0.09	0.094	0.089	0.118									
7	C5	0.816	0.074	0.078	0.082	0.086	0.081	0.089	0.118								
8	C23	0.812	0.070	0.074	0.074	0.078	0.073	0.081	0.089	0.114							
9	C17	0.812	0.061	0.070	0.070	0.070	0.065	0.073	0.081	0.085	0.114						
10	C2	0.812	0.061	0.061	0.066	0.066	0.057	0.065	0.073	0.077	0.085	0.114					
11	C10	0.808	0.057	0.061	0.057	0.062	0.053	0.057	0.065	0.069	0.077	0.085	0.110				
12	C28	0.808	0.053	0.057	0.057	0.053	0.049	0.053	0.057	0.061	0.069	0.077	0.081	0.110			
13	C29	0.804	0.049	0.053	0.053	0.053	0.040	0.049	0.053	0.053	0.061	0.069	0.073	0.081	0.106		
14	C14	0.800	0.049	0.049	0.049	0.049	0.040	0.040	0.049	0.049	0.053	0.061	0.065	0.073	0.077	0.102	
15	C24	0.796	0.041	0.049	0.045	0.045	0.036	0.040	0.040	0.045	0.049	0.053	0.057	0.065	0.069	0.073	0.098
16	C12	0.788	0.037	0.041	0.045	0.041	0.032	0.036	0.040	0.036	0.045	0.049	0.049	0.057	0.061	0.065	0.069
17	C25	0.788	0.033	0.037	0.037	0.041	0.028	0.032	0.036	0.036	0.036	0.045	0.045	0.049	0.053	0.057	0.061
18	C11	0.784	0.029	0.033	0.033	0.033	0.028	0.028	0.032	0.032	0.036	0.036	0.041	0.045	0.045	0.049	0.053
19	C18	0.780	0.029	0.029	0.029	0.029	0.020	0.028	0.028	0.028	0.032	0.036	0.032	0.041	0.041	0.041	0.045
20	C15	0.776	0.025	0.029	0.025	0.025	0.016	0.02	0.028	0.024	0.028	0.032	0.032	0.032	0.037	0.037	0.037
21	C13	0.776	0.025	0.025	0.025	0.021	0.012	0.016	0.02	0.024	0.024	0.028	0.028	0.032	0.028	0.033	0.033
22	C26	0.767	0.025	0.025	0.021	0.021	0.008	0.012	0.016	0.016	0.024	0.024	0.024	0.028	0.028	0.024	0.029
23	C14	0.763	0.021	0.025	0.021	0.017	0.008	0.008	0.012	0.012	0.016	0.024	0.020	0.024	0.024	0.024	0.020
24	C27	0.759	0.021	0.021	0.021	0.017	0.004	0.008	0.008	0.008	0.012	0.016	0.020	0.020	0.020	0.020	0.020
25	C20	0.751	0.021	0.021	0.017	0.017	0.004	0.004	0.008	0.004	0.008	0.012	0.012	0.020	0.016	0.016	0.016
26	C8	0.743	0.008	0.021	0.017	0.013	0.004	0.004	0.004	0.004	0.004	0.008	0.008	0.012	0.016	0.012	0.012
27	C4	0.735	0.004	0.008	0.017	0.013	0	0.004	0.004	0	0.004	0.004	0.004	0.008	0.008	0.012	0.008
28	C7	0.727	0	0.004	0.004	0.013	0	0	0.004	0	0	0.004	0	0.004	0.004	0.004	0.008
29	C16	0.698	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum			1.402	1.402	1.294	1.19	0.865	0.865	0.865	0.777	0.777	0.777	0.701	0.701	0.633	0.569	0.509
Rank	**Criterion**	**RII**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**Sum**	
1	C6	0.837														0.139	
2	C21	0.837														0.249	
3	C9	0.833														0.347	
4	C1	0.829														0.433	
5	C3	0.816														0.498	
6	C22	0.816														0.555	
7	C5	0.816														0.608	
8	C23	0.812														0.653	
9	C17	0.812														0.689	
10	C2	0.812														0.725	
11	C10	0.808														0.753	
12	C28	0.808														0.777	
13	C29	0.804														0.793	
14	C14	0.800														0.805	

Table 5. *Cont.*

Rank	Criterion	RII	16	17	18	19	20	21	22	23	24	25	26	27	28	Sum
15	C24	0.796														0.805
16	C12	0.788	0.090													0.793
17	C25	0.788	0.061	0.090												0.777
18	C11	0.784	0.053	0.061	0.086											0.753
19	C18	0.780	0.045	0.053	0.057	0.082										0.725
20	C15	0.776	0.037	0.045	0.049	0.053	0.078									0.689
21	C13	0.776	0.029	0.037	0.041	0.045	0.049	0.078								0.653
22	C26	0.767	0.025	0.029	0.033	0.037	0.041	0.049	0.069							0.608
23	C14	0.763	0.021	0.025	0.025	0.029	0.033	0.041	0.040	0.065						0.555
24	C27	0.759	0.012	0.021	0.021	0.021	0.025	0.033	0.032	0.036	0.061					0.498
25	C20	0.751	0.012	0.012	0.017	0.017	0.017	0.025	0.024	0.028	0.032	0.053				0.433
26	C8	0.743	0.008	0.012	0.008	0.013	0.013	0.017	0.016	0.02	0.024	0.024	0.045			0.347
27	C4	0.735	0.004	0.008	0.008	0.004	0.009	0.013	0.008	0.012	0.016	0.016	0.016	0.037		0.249
28	C7	0.727	0	0.004	0.004	0.004	0	0.009	0.004	0.004	0.008	0.008	0.008	0.008	0.029	0.139
29	C16	0.698	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum			0.397	0.397	0.349	0.305	0.265	0.265	0.193	0.165	0.141	0.101	0.069	0.045	0.029	16.012

Table 6. Calculations of the weighted geometric mean.

Criterion	RII	Wi	Log RII	Wi. Log RII
C6	0.837	0.0394	−0.0773	−0.0030
C21	0.837	0.0394	−0.0773	−0.0030
C9	0.833	0.0392	−0.0794	−0.0031
C1	0.829	0.0391	−0.0814	−0.0032
C3	0.816	0.0384	−0.0883	−0.0034
C22	0.816	0.0384	−0.0883	−0.0034
C5	0.816	0.0384	−0.0883	−0.0034
C23	0.812	0.0383	−0.0904	−0.0035
C17	0.812	0.0383	−0.0904	−0.0035
C2	0.812	0.0383	−0.0904	−0.0035
C10	0.808	0.0381	−0.0926	−0.0035
C28	0.808	0.0381	−0.0926	−0.0035
C29	0.804	0.0379	−0.0947	−0.0036
C14	0.8	0.0377	−0.0969	−0.0037
C24	0.796	0.0375	−0.0991	−0.0037
C12	0.788	0.0371	−0.1035	−0.0038
C25	0.788	0.0371	−0.1035	−0.0038
C11	0.784	0.0369	−0.1057	−0.0039
C18	0.78	0.0368	−0.1079	−0.0040
C15	0.776	0.0366	−0.1101	−0.0040
C13	0.776	0.0366	−0.1101	−0.0040
C26	0.767	0.0361	−0.1152	−0.0042

Table 6. *Cont.*

Criterion	RII	Wi	Log RII	Wi. Log RII
C14	0.763	0.036	−0.1175	−0.0042
C27	0.759	0.0358	−0.1198	−0.0043
C20	0.751	0.0354	−0.1244	−0.0044
C8	0.743	0.035	−0.129	−0.0045
C4	0.735	0.0346	−0.1337	−0.0046
C7	0.727	0.0343	−0.1385	−0.0047
C16	0.698	0.0329	−0.1561	−0.0051
Sum		1.0777		−0.1107

5. Discussion

5.1. Sustainability Criteria for Green Storm Drainage Materials

Using the data gathered from the respondents and indices formulas explained earlier and as shown in Table 4, the five most important criteria for selection the green material for storm drainage networks projects in Egypt are: recycling and reuse possibilities, effects of air quality content, embodied energy within a material, land acquisition, and social advantage and growth.

Besides being one of the largest materials consumers, the building industry is also a significant polluter. The consideration of the technical, environmental, and economic feasibility of alternative systems is of the utmost importance in ensuring integrated environmental production, reuse, and recycling. Sustainable development and life cycle assessment are incorporated into integrated environmental management. Construction waste can be salvaged, reused, and recycled in many ways to reduce waste and increase profits. The need to save money in the processes through reduced resource and utility costs is an integral part of sustainable development as a tool for continual improvement [71]. Currently, little guidance is available regarding air quality and green stormwater streets; this is the first communication offering suggestions and advice [72]. Street width and height ratios, trees and their location, and prevailing winds can influence pollutant concentrations within a street and along sidewalks. By utilizing vegetation in stormwater control measures, particulate matter concentration can be reduced; however, the vegetation must be carefully selected and placed within green streets to make this happen [73].

Construction materials and products are evaluated based on their embodied energy. Embedded energy is low in sustainable materials and products. A locally sourced material with relatively low embodied energy is relatively unprocessed and locally sourced. Embodied energy is the estimate of all the energy that goes into manufacturing the materials that go into building materials. Materials are mined, manufactured, transported, and serviced, all requiring energy [74]. Storm drainage is another essential part of a land development project that ensures stormwater runoff from the proposed construction is adequately drained. A stormwater drainage system collects stormwater runoff during a rain event and conveys it through a portion of land to either discharge the water to a stormwater management system or take it away from the site. Storm drainage systems, also called rain gutters and sewer pipes, allow stormwater to be safely conveyed from one place to another [75]. Traditional piped water drainage systems are supplemented in urban streets by green infrastructure. Water enters the piped system and is captured and absorbed by vegetation, soil, and natural processes. Stormwater can be absorbed and filtered by green infrastructure, thus reducing flooding and water pollution. Having storm drains in the driveway and yard encourages the water to flow away from home instead of building up and flowing into it as it would if it did not have them. It does not go to a water treatment plant when it runs into a storm drain. Keeping the garden's soil moist reduces soil erosion with drainage systems; especially near large bodies of water, continuous, heavy rains can lead to flash floods [76].

5.2. Stationary Green Materials Selection Criteria

With 0.789 as a weighted geometric mean of the RII numbers of the selecting green material criteria considered in the study, the results suggest that the stationary green material selection in storm projects in Egypt is "Operation and maintenance cost, and Use of local material". This paper's findings proved that green materials are more cost-effective and longer lasting than conventional alternatives. Investors and owners benefit from green materials with lower costs over their buildings' lifetimes. A significant barrier to implementing this stormwater management approach in the US is the funding and valuation of green materials. Capital costs can be reduced, and long-term operations and maintenance (O&M) can be planned more effectively. Providing accurate cost information for green materials is essential for long-term operations and maintenance. Increasingly, information about the cost of green materials over their lifetimes as they mature is coming to light. Green materials' actual costs can be revealed by analysing this data in new ways.

Materials made from locally available resources, such as wood, stone, and sand, are considered local materials. Using local materials can contribute to a project's sustainability quotient and result in some points being awarded. For materials to qualify as local materials, they must be within a certain distance of their source [37]. According to LEED, the most commonly used standard, local materials are defined in MR Credit 5 as: "Building materials or products that were harvested, harvested, or recovered within 500 miles of the project site, as well as manufactured within that distance, for a minimum of 10% or 20% of the total value of the materials" [42].

6. Conclusions and Recommendations

In many industrialized and emerging countries, supplying excellent building structures and completing large-scale projects for storm drainage networks has been extremely difficult. To help remedy this problem, we need to implement new criteria for selecting green materials for storm drainage systems. Consequently, this is the study's primary focus. From the available research, we have derived a total of 29 criteria for evaluating green materials. An RII has been used to rank these criteria, and the top criteria have been selected and identified. Furthermore, the stationary green material selection criteria for storm drainage network projects have been explored. This study contributes to the body of knowledge on the subject by offering vital inputs that will help researchers better grasp the green criteria for selecting materials, and sets solid groundwork for future studies on the topic. Based on the findings of this study, it is recommended that businesses push for the use of environmentally friendly materials and provide opportunities for experts to hone their sustainable implementation abilities. Training and seminars can help participants learn the theory behind a topic, while hands-on experience with the technology itself can help them learn the details. Using a quantitative research strategy, the study uncovered 29 criteria for evaluating the storm drainage network projects in Cairo and Giza, Egypt. The results should help the Egyptian storm industry become more environmentally friendly. Moreover, since the scope of this study is to determine the stationary materials in storm drainage networks, future research could be undertaken on the utilization of cost-benefit analysis for the installation of the proposed materials, and accordingly, the obtained results can be compared against those of this research.

7. Implications

The research has numerous theoretical and practical applications for use in both academia and industry. To a large extent, the stagnation of Egypt's storm drainage project delivery can be attributed to the fact that they are still being carried out using the same methods that were used before, as well as to a general reluctance to accept innovation. In order to make these adjustments, stakeholders will need to be open to embracing innovative alternative ideologies, particularly those that have an effect on the actual delivery of the project. The study's finding that the green material selection criteria have not been used in Egypt's storm drainage sector supports the importance of doing so. Stakeholders need to be made aware of the importance of implementing fresh concepts through seminars and lectures if projects are to be successful. This alleviates the client's concerns and clears up their misconceptions regarding the rising cost of sustain bale green material. This study's findings will help business owners and managers identify and remove the most significant obstacles impeding the implementation of green practices related to material choice. Experts in the field of storm drainage should be taught the principles, ideas, and methods outlined in environmentally friendly processes.

In addition, organizations in Egypt with a stake in storm water management should provide regular green training seminars for their members and factor those seminars into their continuous assessments of employee growth and development. The government's role in delivering public projects and establishing and enforcing policies and regulations across a wide range of industries is likewise substantial. As a result, the government is working to pass laws and regulations that would increase the use of green solutions in the country's storm drainage industry. Company-wide green initiatives are not feasible in the storm drainage industry. In a similar vein, training staff need direction from above. It is not enough to simply create policies; proper implementation methods must be provided to guarantee that they are followed.

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