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ORIGINAL ARTICLE

Demographic influences on green infrastructure awareness among urban practitioners: evidence from Yemen

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Abstract
Green infrastructure (GI) is a term that focuses on achieving sustainable development across various dimensions, including social, economic, and environmental aspects. It serves as a platform to strike a balance between preserving the environment and developing urban areas, while also delivering environmental, social, and economic benefits to create a favorable environment for urban residents. However, many countries, particularly developing ones like Yemen, face challenges in planning and implementing GI effectively. As professionals play a key role in this process, it is essential to integrate GI elements into city planning and development. Understanding the level of awareness among professionals, including demographic information, is crucial. This study examines the awareness of GI concepts among practitioners based on factors such as gender, age, type of agency, experience, and education. Through data analysis of a primary survey conducted in Yemen, the study utilised descriptive statistics and ANOVA tests to identify significant relationships between these demographic factors and GI awareness. The results reveal that female practitioners have a higher level of awareness compared to male practitioners, with a statistically significant correlation. Additionally, education level significantly influences GI awareness, with postgraduate practitioners showing the highest awareness. However, age, type of agency, and experience do not demonstrate statistically significant differences in GI awareness. The study highlights the importance of targeted awareness initiatives, especially for less-educated practitioners, to enhance GI knowledge and implementation.

Keywords Green infrastructure · Awareness · Demographic factor · Sustainable development

1 Introduction

Nowadays, the issues related to the threats of climate change have demanded the appropriate tools to better manage the situations. Among others, the application of Green Infrastructure (GI) approach has been widely practiced in many countries globally as it is clearly evident beneficial to the environment, social and economic aspects of human life [1]. It is a platform to achieve a balance between environmental preservation and urban physical development, as well as to attain environmental, social, and economic benefits in order to provide a conducive environment for urban inhabitants. However, many countries suffer from weaknesses in planning and implementing GI, especially in developing countries, including Yemen. Currently, there is a lack of literature addressing this issue specifically in the context of Yemen. Compared to other regions, there is a noticeable gap in research on GI practice in Yemen. As a result, this paper focuses on the insights of local practitioners in Yemen who are navigating the challenges of implementing GI in the country. The absence of a defined legal framework for GI practice in Yemen has created ambiguity and a lack of clear guidance for its implementation.

Benedict and McMahon [2] said that GI is one of the most common terms in the twenty-first century. The concept of GI refers to the idea that maintaining the ecological system and incorporating biodiversity and ecological mechanisms into physical urban planning [3] and implementation can benefit

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human societies and also produces enormous environmental services [4]. Inclusive GI is based on coordinating society, the economy, and the environment in a new way to achieve sustainable development [5]. The broadness of GI definition is considered to be one of the obstacles that are making the GI term very difficult to be understood. So, this part reviews and summarises some of GI definitions in the literatures.

i. The linguistic definition of GI term consists of two words, the first word is 'green' because it is part of the nature and friendly to the environment. The second word is 'infrastructure' named for its role in providing essential services to both humans and nature.
ii. Davies et al. [6] said that "GI is the physical environment within and between our cities, towns and villages. It is a network of multi-functional open spaces, including formal parks, gardens, woodlands, green corridors, waterways, street trees and open countryside. It comprises all environmental resources, and thus a GI approach also contributes towards sustainable resource management".
iii. The European Commission (EC) gave a brief and distinctive definition to GI. They defined it as "a strategically planned network of natural and semi-natural areas, with associated environmental features designed and managed to deliver a wide range of ecosystem services (ES) [7].
iv. The key aspects of GI have several meanings, which sometimes suggest trees that bring ecological benefits to urban spaces and sometimes suggest engineering structures such as stormwater management and water treatment facilities. Moreover, Benedict and McMahon [8] and Williamson (2003) briefly defined GI as framework of land conservation and land development to provide the place's needs for living, working, and shopping (Table 1).
v. Barau [38] explained that GI is a system that is interconnected with other related systems, such as social and ecological systems, which primarily contribute to improving human health, economic growth, and overall well-being, as illustrated in Figure 1. The unified nature of these attributes creates a comprehensive GI system.

It is apparent from the above discussion that natural environment is the key element related to GI in order to blend with the built environment. Thus, the future planning and development should incorporate its inclusion in the plan-making so that the GI system is complete. Literature demonstrates that planning and designing the concept of GI face many benefits and challenges along its process of implementation. Accordingly, the pressure on GI practice is increasing due to unprecedented urban growth and other related urban problems [1]. Consequently, there is a positive correlation between GI and environmental conditions as demonstrated by Hein et al. [9] and Tzoulas et al. [10], in which such

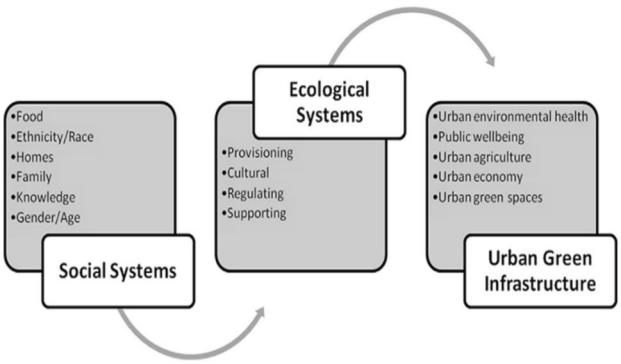

Fig. 1 Systems that supports the concept of green infrastructure. Source: [38]

Table 1 Comparison between definitions and targets of green infrastructure. Source: (Benedict 2002, Williamson, 2003)

The definition	Targets
Benedict and McMahon [2] GI is an interconnected network of green space that conserve the natural ecosystem values and functions and provide associated benefits to human population. GI is the ecological framework needed for environment social and economic sustainably	To conserve the natural ecosystem values and functions and provide associated benefits to human population
Williamson (2003) The nature life support system that includes interconnection network of protected land and water which support native species maintain nature ecological process sustain air and water resource and contribute to the health and quality of life	To support native species, maintain nature ecological process sustain air and water resource and contribute to the health and quality of life

network should concurrently aim at enlightening environmental condition, human health and quality of life [1, 11]).

Regardless of that differences between the definitions of GI that mentioned above, Davies et al. [6] said that GI term has got common ground, which includes:

i. GI means either natural green areas or man-made green areas that are designed in urban or rural areas;
ii. GI links green areas with each other at all levels; and
iii. GI can provide multiple benefits to environmental, social and economic sectors.

In this context, the green areas primarily indicate the presence of vegetation, typically found in parks, gardens, fields, or green belts. It is crucial to differentiate between green building, which is related to sustainable design or eco-friendly building, and GI, which is associated with planning science. Similarly, it is important to avoid the confusion between green area and GI. Green area is nice if it co-exists in urban area, but the GI is necessary to be implemented in urban area, especially in cites that develop rapidly. Furthermore, GI works in conjunction with development and plans while other approaches work separately [8]. In the practice of GI, it can include a wide range of features and practices, from small-scale projects to citywide networks, aimed at improving sustainability and resilience which is very timely to combat the threat of climate change. Thus, according to Janiszek and Krzysztofik [12] and Nakamura [13], GI is regarded as an effective tool for urban adaptation as solution to counter the impacts of the incoming pressures of global climate change in relation to sustainable development goals.

2 Literature reviews

2.1 Key terms related to GI

Natural-based solutions (NBS) are a key term related to GI. It is a strategy that refers to a set of measures that rely on natural elements and are designed to address the challenges our environment is facing nowadays (Van Den [14]). The term was introduced as a tool to deal with climate change, energy sustainability, food and water security as well as to social and economic development (Table 2).

Meanwhile, Werner and Zahner [39] defined urban biodiversity (UB) as the variety of animals and plants that inhabit a city's settlement. According to Muller [16], UB is the variety and richness of living organism (plants, birds, insects, and mammals) which is found within human settlement and on its edge. There is a strong relationships between urban biodiversity and urban ecosystem service, biodiversity attributes (habitat, species abundance, species richness) support many of the processes that form the basis of ecosystem services [17].

There are some factors that influence positively on biodiversity such as planning, designing and managing of the built environment. On the other hand there are some other factors that influence negatively on biodiversity such as population density, road density and increase of air temperature [16]. One of the most threatening processes for biodiversity is rapid urban development, especially in the twentieth century.

Due to these reasons the increase of life requirements, limited sources of earth, imbalance between the nature and urban area and the loss of biodiversity, the term ecosystem is of increasing significance in the field of the management of technology and innovation as stated by Tsujimoto et al. [18]. Urban ecosystem service (UES) is a process to enable the nature (components and types of nature) to sustain human life and meet its requirements [19]. UES is defined as the direct and indirect goods provided by the ecosystem that aim to maintain and enhance human well-being [20, 21]. It provides material benefits and non-material benefits. Hanah and Comín [22] stated that the evaluation of UES was used to support the values of GI in relation to sustainable development initiatives. In terms of material benefits, it provides food, clean water, disease prevention, and soil protection. While in non-material benefits, it provides entertainment and aesthetics places. Figure 2 illustrates that the services of UES are divided into four main services, which are supporting services, providing services, organising services and cultural services. The supporting services provided by the UES approach interact with biodiversity within the same land use. Culture and provision services provided by the UES approach interact with society and the economic system, while regulation services provided by the UES approach interact with the environmental system.

Table 2 NBS definitions according to IUCN and European commission. Source: (Van Den [14])

IUCN Definition	European Commission Definition
Action to protect, sustainably manage and restore nature or modified ecosystem that address societal challenges effectively and adaptively, simultaneously providing human wellbeing and biodiversity benefits IUCN (2016)	Nature-based solutions (NBS) are actions which are inspired by, supported by, or copied from nature", and that are designed to address range of environmental challenges in an efficient and adaptable manner, while at the same time providing economic, social, and environmental benefits (European [15])

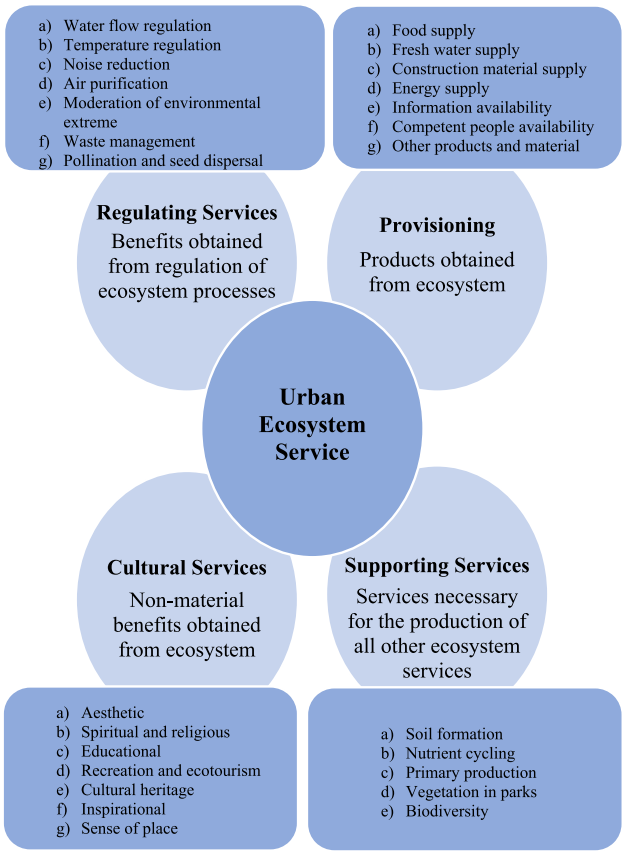

Fig. 2 Categorisation of ecosystem services. Source: [41]

On the other hand, UES has three main components which are capacity, flow and demand. Firstly, the capacity means "the ecosystem's potential to deliver services based on biophysical properties, social conditions, and ecological functions" whereas the flow means "the actual production of the service" used or experienced by people. Finally demand is defined as "the amount of a service required or desired by society" [23].

2.2 The emergence of green infrastructure term

GI is a new term, but its idea is not a completely new. It has been related to the science of planning since a long time and its idea has gone through several stages to become widely known as GI [2].

In 1990s, the term of GI was emerged globally, especially in the field related to environmental planning and management [24]. It has evolved rapidly since it was discussed in the late 1990s [25]. Table 3 shows the stages of the infrastructure advancing history in United States of America (USA) during the time between 1900 to 2000 and above 2000. Since 2000, it is evident that green infrastructure has become the best solution for sustainability, particularly in urban areas.

Table 4 displays the frequency of the term "GI" in literature science from 1990 to 2015. The term GI has become popular among literature science since 2005. From 2010 to 2015, there were 13,300 papers published about GI. It is clear that GI imposed its idea and became the dominant term especially in the last five years [26].

2.3 Concept of green infrastructure

GI concept has its antecedents; there are many terms in the past have been referred to infrastructure or ecosystems. (1) Green line, which was emerged in 1970 [27]. (2) Greenway, which was named in the 1980s [28]. (3) Green structure, which was appeared in 1980 [29]. (4) ecological infrastructure (EI), which was mentioned by NESCO's annual report in 1984 during the meeting of the Man and the Biosphere Program (MAP) and this term was intended to achieve human and environmental growth side by side [26].

Table 4 The frequency of term "GI" appear in literatures. Source: (Lindholm, 2017)

Era	Urban 'Green Structure'	Urban 'Green-ways"	Urban "Green Infrastructure"
1990–1995	40	411	61
1995–2000	77	1,050	158
2000–2005	308	2,200	805
2005–2010	758	3,930	3,840
2010–2015	1,310	5,540	13,300

Table 3 The history of infrastructure solutions. Source: [8]

ERA	Growth Issue	Infrastructure Solutions
Last 1900	Garbage	Recycling
	Traffic congestion	Mass transit- alternative transportations
	Flooding	Stormwater management—detention
	Information management	Computer—internet
2000	Sprawl globalisation	Sound land use—smart growth
	Sustainability	Green infrastructure

The concept of GI is more developed than any other green concept. The concept of GI has gone through many stages of development [2]. The most important stages it went through are:

i. Link gardens and green spaces to each other to benefit people; and
ii. Link natural areas together to achieve biodiversity and fight fragmentation.

In 1903 the famous landscape architect Frederick Law Olmsted said. "*There is no single park, no matter how large and how well designed, would provide the citizens with the beneficial influences of nature*." Instead, parks needed "to be linked to one another and to surrounding residential neighborhoods". The idea of linking parks with one another via corridors was the spark of the GI movement [30]. In addition, biologists and environmentalists agree that the best way to protect the nature is to create a comprehensive network of GI system [2].

2.4 Concept of environmental awareness theory

This theory basically encompasses cognitive awareness, affective awareness, behavioral intentions, and social influences. While no specific scholars are credited with its development, Rachel Carson's book 'Silent Spring' in 1962 is often associated with its origins. The theory has evolved into Clayton and Opotow's Environmental Identity Theory [40], reflecting collaborative and interdisciplinary development. Factors such as gender and age influence attitudes toward the environment, as found by Boerman et al. [31], suggesting that environmental interventions should be tailored to consumer attitudes and perceptions.

3 Methodology

Awareness in this study refers to two dimensions: knowledge and attitude. Questionnaire forms were designed to contain four items to measure GI knowledge and 17 items to measure GI attitude. One-way Analysis of Variance (one-way ANOVA) provides a parametric statistical test in order to know whether the Means of several groups have significant differences or not. After that, if the means of any two groups are found to be different from each other, we relied on a hypothesis test to reject the null hypothesis. If the p-value is less than or equal to 0.05 in SPSS, then the alternative hypothesis (H1) is supported, indicating a significant difference between the items. While if p is greater than 0.5, then this will prove that the hypothesis is null hypothesis (H0), which indicates that there is no significant difference between the items [32].

Fig. 3 Location of Mukalla City. Source: [42]

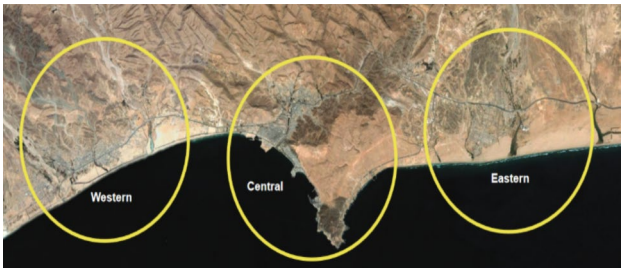

Fig. 4 The main zones of study area (Mukalla City). Source: [42]

For this research, the study area selected is Mukalla city, Yemen. Mukalla city was chosen as the study area for its historical significance and ongoing development in economic, social, and physical aspects. The city also boasts unique tourist attractions that need careful planning and management, especially regarding GI. Mukalla city is the capital of Hadhramaut governorate, located on the shores of the Arabian Sea in the southeast part of Yemen at longitude 49.10 degrees and latitude 14.33 degrees (Fig. 3). The city is in the southern part of the Arabian Peninsula on the Gulf of Aden, on the shores of the Arabian Sea, about 480 km east of Aden. It is surrounded by a group of medium-rise mountains in a curved manner. Additionally, it has several valleys that flow into its coastal sea [33]. It is the key port city in the Hadhramaut governorate and the sixth-largest city in Yemen, with a population of approximately 595,000 as of 2023. The city consists of three main zones (Fig. 4):

i. The central main zones are al Mukalla, Al-Sharj, Al-Deis, and Khalaf;
ii. The Western main zones are Embikha, Fowah Hella, New Hella, and Al-Sheqayn; and
iii. The Eastern main zones are the settlements of Joul Masha', Al-Harshiyyat, Khalaf, Roukob, Buwaysh, Al-Eis, Falak, and Al-Rayyan.

The survey commenced by distributing ninety-six questionnaires to government and non-government agencies responsible for planning and designing urban areas in Mukalla city. We personally contacted the senior officials in Mukalla City and specifically focused on those directly engaged in the physical planning and development of the city to ensure ethical considerations in data collection. However, a limitation could be the exclusion of other professions such as engineering and architecture. Ultimately, eighty-five questionnaires were returned. After excluding incomplete responses, only eighty-two questionnaires were considered appropriate for the study (resulting in 85.41% response rate).

4 Result

4.1 Practitioners' profiles

This part of the research focuses mainly on demographic factors for practitioners with a total of 82, which have categories including gender, age, type of agency, years of experience, and educational qualifications. The demographic factors for practitioners in the city of Mukalla is summarised through percentages and frequencies in Figs. 5, 6 and Table 5. Figure 5 shows that the survey had 63 male respondents and 19 female respondents, indicating a male dominance.

Moving to the age of the respondents, Fig. 6 displays the results. The younger group, ranging from 24 to 39 years old, was the main group with 71 respondents, while only 11 respondents were between 40 and 54 years old. This indicates that the majority of the respondents are in the active working age.

Meanwhile, it can be seen from Table 5 that the majority of the respondents come from private agencies, with 55 of them. In terms of work experience, only seven of them have between 5 to 10 years of experience. Furthermore, the majority of them, 70 in total, have a bachelor's degree as their highest level of education, which indicates that their

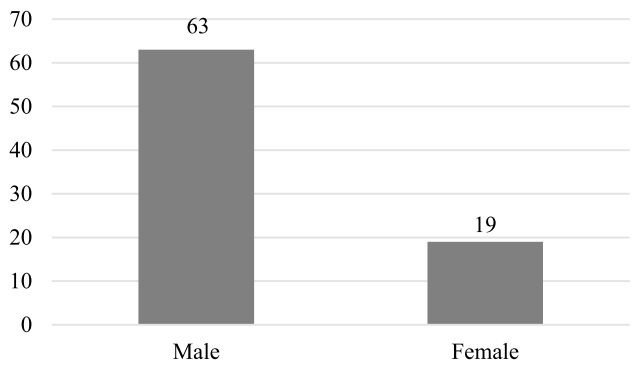

Fig. 5 Gender of the respondents

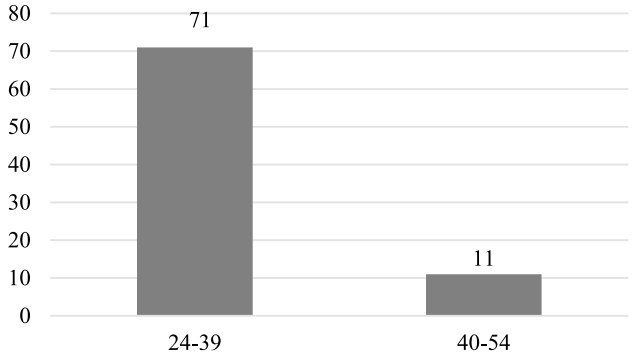

Fig. 6 Age groups of the respondents

responses are based on their knowledge in the field of GI practice in Yemen.

4.2 Testing hypotheses

This part of the research focuses mainly on testing the following hypotheses:

H1 *Practitioners' gender significantly influences their awareness about GI concept.*

H2 *Practitioners' age significantly influences their awareness about GI concept.*

H3 *Practitioners' agency significantly influences their awareness about GI concept.*

H4 Practitioners' experiences (professional GI domain) significantly influence their awareness about GI concept.

H5 Practitioners' education significantly influences their awareness about GI concept.

Referring to Table 6, it is clear that some demographic factor contains more than two items. For example, the factor of education contains four items. In this case One-way ANOVA test was selected because of its ability to deal with factors that consist of more than two items. In this part awareness identified as (dependent variable), while demographic factors were identified as (independent variables). Preliminary tests (reliability, normality, and homogeneity test) were performed to make sure that items fulfill the requirement of one-way ANOVA test. Tables 6 and 7 display the calculated values of preliminary tests.

It is clear from Table 6 that the value of alpha coefficient of the 21 awareness items equals to 0.911. According to Altunışık et al. [34], the minimum acceptable alpha coefficient value is 0.7, so the value of 0.911 is acceptable, reliable and appropriate for one-way ANOVA test.

Table 5 Demographic information of practitioners

Demographic Factors	Code	Item	N	%
Type of agencies	GO	Government agencies	27	32.90
	PR	Private agencies	55	67.10
Experience years	EX1	Less than 5 years	75	91.50
	EX2	5 to less than 10	7	08.50
Educational qualification	ED1	Graduate from high school	-	-
	ED2	Graduate from technical institute	5	06.10
	ED3	Bachelor's degree	70	85.40
	ED4	Postgraduate degree	7	08.50

Table 6 Reliability tests for awareness section

Reliability Statistics	
Cronbach's alpha	No of items
.911	21

Furthermore, the one-way ANOVA test requires that the *p*-values of the normality and homogeneity tests should not be significant at the 0.05 level or higher. To demonstrate this, Table 7 shows the calculated *p*-values of the two tests.

It is clear from Table 7 that the *p* values were not significant at 0.05 ($p > 0.05$) level or more in both NOR and HOM tests. Hence, all items fulfill the second requirements of one-way ANOVA test. From the analysis, it deduced that all demographic factor (gender, age, type of agency, experiences, and education) are fit for one-way ANOVA test.

On the other hand, in order to accept or reject the hypothesis, if *p* values of F test ≤ 0.05 this will prove that the hypothesis is alternative hypothesis (H1), which indicates that there is a significant difference between the variables. while if $p > 0.05$ this will prove that the hypothesis is null hypothesis (H0), which indicates that there is no significant difference between the variables [32].

H0: $\mu 1 = \mu 2 = \mu 3 \ldots$

H1: $\mu 1 \neq \mu 2$ or $\mu 1 \neq \mu 3$or $\mu 2 \neq \mu 3 \ldots$.

4.3 Gender and level of awareness on GI concept

In order to find out the level of practitioners' awareness on GI concept according to gender, $\bar{x}$ was calculated. Table 8 displays the calculated values of $\bar{x}$ according to gender.

It is seen from Table 8 that the level of awareness on GI concept among female practitioners was moderate with $\bar{x} = 3.72$. as well as among male practitioners was moderate with $\bar{x} = 3.35$. From the result, it is deduced that female practitioners have higher level of awareness on GI concept compared to male practitioners. In order to find the relationship between gender of the practitioners and their level of awareness on GI concept, the following hypothesis was

Table 8 Gender and level of awareness on GI concept. Source: (Data Analysis of Primary Survey, 2019)

Category	No	Item	Average $\bar{X}$	Level
Gender	1	Female	3.72	Moderate
	2	Male	3.35	Moderate

Table 7 Preliminary tests of one-way ANOVA

Variable	Item	Recommended Value	NOR (Kolmogorov-Smirnova)	HOM	Result
Gender	Male	$p > 0.05$	.200*	0.082	Accepted
	Female		.200*		Accepted
Age	Young (18–34 Years)	$p > 0.05$	.200*	0.651	Accepted
	Old (Above 35 Years)		.200*		Accepted
Type Of Agency	Government Employers	$p > 0.05$	.142	0.611	Accepted
	Private Employers (Non government)		.200*		Accepted
Experiences	Less (0–10 Years)	$p > 0.05$	.200*	0.68	Accepted
	High (Above 10 Years)		.200*		Accepted
Education	Diploma	$p > 0.05$	.200*	0.583	Accepted
	Bachelor		.200*		Accepted
	Postgraduate		.200*		Accepted

Table 9 Gender and level of awareness on GI concept (ANOVA Test)

Hypothesis	Variable	Item		ANOVA TEST			Accepted Hypotheses
				F	*p*	SIG	
H1	Gender Against Awareness	1	Male	8.97	.004	Significant At 0.01 Level ($p \leq 0.01$)	Alternative Hypothesis (H1)
		2	Female				

Table 10 Age and level of awareness on GI concept

Category	No	Item	Average $\bar{X}$	Level
Age	1	Young	3.40	Moderate
	2	Old	3.66	Moderate

framed and tested with the help of one-way ANOVA test. The detailed results of the test are shown in Table 9.

H0 There is no relationship between practitioners' gender and their level of awareness on GI concept.

H1 *There is a relationship between practitioners' gender and their level of awareness on GI concept.*

The results from Table 9 show a significant difference in practitioners' awareness of the GI concept based on gender ($F(1–24) = 8.97; p < 0.01$). This supports the Environmental Awareness Theory or the findings of Boerman et al. [31]. Therefore, the null hypothesis (H0) was rejected, and the alternative hypothesis (H1) was accepted, indicating a relationship between practitioners' gender and their awareness of the GI concept.

The result of this part confirms the results obtained by some of the previous studies conducted in developing countries [35], it was found that gender is statistically significant variable and positively associated with the awareness of GI. This result also confirms the results obtained by some of the previous studies conducted in middle east countries [36] it was found that gender in Jordan is statistically significant factor for environmental awareness (female has more aware of environmental issues than male). They also argued that women in the Middle east have high awareness on environmental issues due to their daily routine (childcare management and household issues of water rationing and so on).

4.4 Age and level of awareness on green infrastructure

In order to find out the level of practitioners' awareness on GI concept according to age, $\bar{x}$ values was calculated. Table 10 displays the calculated values of $\bar{x}$ according to age.

It is observed from Table 10 that the level of awareness of the GI concept among young practitioners was moderate, with $\bar{x} = 3.40$, and among old practitioners was moderate, with $\bar{x} = 3.66$. The results suggest that old practitioners have a higher level of awareness of the GI concept compared to young practitioners.

In order to find the relationship between age of the practitioners and their level of awareness on GI concept, the following hypothesis was tested with the help of one-way ANOVA test. The detailed results of the test are shown in Table 11.

H0 There is no relationship between the practitioners' age and their level of awareness on GI concept.

H1 *There is a relationship between the practitioners' age and their level of awareness on GI concept.*

According to the results from Table 11, it was found that $F(1–24) = 2.69$; p $(0.104) > 0.05$). In light of this result, it is clear that there is no significant difference in the practitioners' awareness on the GI concept, between young and old practitioners. Therefore, the null hypothesis (H0) was accepted and the alternative hypothesis (H1) was rejected. the accepted hypothesis state that "there is no relationship between the practitioners' age and their level of awareness on GI concept".

Table 11 Age and level of awareness on GI concept (ANOVA Test)

Hypothesis	Variable	Item		ANOVA TEST			Accepted Hypotheses
				F	*p*	SIG	
H2	Age Against Awareness	1	Young	2.69	.104	Not Significant ($p > 0.05$)	Null Hypothesis (H0)
		2	Old				

Table 12 Type of agency and level of awareness on GI concept

Category	No	Item	Average $\bar{X}$	Level
Type of Agency	1	Government	3.57	Moderate
	2	Non-Government	3.37	Moderate

4.5 Type of agency and level of awareness on green infrastructure

In order to determine the level of practitioners' awareness of the GI concept based on their agency, the mean ($\bar{x}$) was calculated. Table 12 shows the calculated mean values according to the type of practitioners' agencies (government or non-government).

It is perceived from Table 12 that the level of awareness on GI concept among government practitioners was moderate with $\bar{x} = 3.57$. as well as among private (non-government) practitioners were moderate with $\bar{x} = 3.37$. From the result, it is deduced that government practitioners have higher level of awareness on GI concept compared to private practitioners.

The following hypothesis was formulated and tested using the ANOVA test to determine the association between the type of practitioners' agencies and their level of GI awareness. Table 13 displays the test's comprehensive results.

H0 There is no relationship between the type of agency and the level of awareness on GI concept.

H1 *There is a relationship between the type of agency and the level of awareness on GI concept.*

Table 13 demonstrates that ($F\ (1–24) = 3.15$; $p\ (0.07) > 0.05$). In light of this result, it is clear that there is no significant difference in the practitioners' awareness on the GI concept, between government and non-government practitioners. Therefore, the null hypothesis (H0) was accepted and the alternative hypothesis (H1) was rejected. the accepted hypothesis state that "there is no relationship between the practitioners' agency and their level of awareness on GI concept".

Table 14 Experiences and level of awareness on GI concept

Category	No	Item	Average $\bar{X}$	LEVEL
Experiences	1	Less Experienced (0–10 Years of Experiences in GI Domain)	3.44	Moderate
	2	High Experienced (10 Years of Experiences in GI—Domain Above)	3.44	Moderate

Table 15 Education and level of awareness on GI concept (Cross-Tabulation)

Category	No	Item	Average $\bar{X}$	Level
Education	1	Diploma	2.88	Low
	2	Bachelor	3.46	Moderate
	3	Postgraduate	3.57	Moderate

4.6 Experiences and level of awareness on green infrastructure

In order to find out the level of practitioners' awareness on GI concept according to experiences, $\bar{x}$ was calculated. Table 14 displays the calculated values of $\bar{x}$ according to experiences.

Table 14 demonstrates that the level of awareness on GI concept among practitioners was equal between less experienced practitioners and high experienced practitioners with $\bar{x} = 3.44$. As such, the null hypothesis (H0) was accepted and the alternative hypothesis (H1) was rejected. the accepted hypothesis state that "there is no relationship between the practitioners' experience and their level of awareness on GI concept".

4.7 Education and level of awareness on green infrastructure

In order to discover the level of practitioners' awareness of the GI concept based on education, the mean ($\bar{x}$) was calculated. Table 15 shows the calculated mean values according to education level. It can be inferred from the table that the level of awareness of the GI concept among diploma practitioners was 2.88, among bachelor practitioners was 3.46, and among postgraduate practitioners was 3.57. The results indicate that

Table 13 Type of agency and level of awareness on GI concept (ANOVA Test)

Hypo	Variable	Item		ANOVA TEST			Accepted Hypotheses
				F	*p*	SIG	
H3	Type of Agency Against Awareness	1	Gov	3.15	.079	Not Sig ($p > 0.05$)	Null Hypothesis (H0)
		2	Non-Gov				

the postgraduate group has a higher level of awareness of the GI concept compared to the other education groups.

To examine the correlation between practitioners' educational qualifications and their understanding of the GI concept, the following hypothesis was formulated and evaluated using the ANOVA test. The detailed results of the test are shown in Table 16.

H0 There is no relationship between education and the level of awareness on GI concept.

H1 *There is a relationship between education and the level of awareness on GI concept.*

According to the results from Table 16 we found that (F (1–24) = 3.63; p (0.03) < 0.05). In light of this result, it is clear that education makes difference with respect to GI awareness among practitioners. Therefore, the null hypothesis (H0) was rejected and the alternative hypothesis (H1) was accepted. the accepted hypothesis state that "there is a relationship between practitioners' education and their level of awareness on GI concept". In order to find the reason of this difference Scheffe test was conducted between the three groups of education (diploma, bachelor and postgraduate). The detailed results of the test are shown in Table 17.

Table 17 indicates the comparisons and the differences in education groups. The reason for the existence of significant differences was, because the p values between the technical institute and the other two high qualifications resulted in a significant difference (bachelor with $p = 0.032$ and postgraduate $p = 0.016$). It is clear that awareness tends to postgraduate with $p = 0.016$. This result corroborates the result of [37], they argue that the attitude among those who have higher education, will be different from those with lower level of education.

5 Conclusion

This study provides quantitative insights into the factors influencing practitioners' awareness of GI concepts in Yemen. The findings reveal that gender and education significantly impact awareness levels as propagated in the theorical studies. Female practitioners demonstrated a higher awareness (mean $\bar{x} = 3.72$) compared to male practitioners (mean $\bar{x} = 3.35$), with an ANOVA test result of F (1–24) = 8.97 and $p = 0.004$, indicating a statistically significant relationship ($p \leq 0.01$). Similarly, education level plays a crucial role, with postgraduate practitioners exhibiting the highest awareness (mean $\bar{x} = 3.57$), followed by bachelor's degree holders (mean $\bar{x} = 3.46$) and diploma holders (mean $\bar{x} = 2.88$). The ANOVA results (F (1–24) = 3.63, $p = 0.03$) confirm the significance of education ($p \leq 0.05$).

Age, type of agency, and experience did not show significant differences in GI awareness. Older practitioners had slightly higher awareness levels ($\bar{x} = 3.66$) compared to younger ones ($\bar{x} = 3.40$), but the ANOVA results (F (1–24) = 2.69, $p = 0.104$) indicated no significant relationship ($p > 0.05$). Government practitioners ($\bar{x} = 3.57$) had slightly higher awareness than non-government practitioners ($\bar{x} = 3.37$), but the ANOVA test (F (1–24) = 3.15, $p = 0.079$) showed no significant difference ($p > 0.05$). Experience level did not affect awareness, with both less-experienced (0–10 years) and highly experienced (10 + years) practitioners reporting the same mean awareness ($\bar{x} = 3.44$). Both the government and private sectors in Yemen will demonstrate the implementation of GI, despite the current absence of a legally binding framework for GI guidance in the country.

The study suggests that awareness programmes should target practitioners with lower levels of education and

Table 16 Education and level of awareness on GI concept (ANOVA Test)

Hypo-thesis	Variable	Item		ANOVA TEST			Accepted Hypotheses
				F	p	SIG	
H5	Education Against Awareness	1	Diploma	3.63	.03	Significant At 0.05 Level ($p \leq 0.05$)	Alternative Hypothesis (H1)
		2	Bachelor				
		3	Postgraduate				

Table 17 Scheffe test multiple comparisons according to education qualification

Multiple Comparisons (Scheffe)			
Educational Qualification	Mean Difference	Sig	Item status
Bachelor's Degree—Postgraduate Degree	–	–	Not Statistical Significance
Technical Institute—Postgraduate Degree	0.73	0.032	Statistical Significance
Technical Institute—Bachelor's Degree	1.01	0.016	Statistical Significance

male practitioners to address knowledge gaps. Further research should explore the factors contributing to gender disparities in environmental awareness theory and create strategies to enhance education for all practitioner demographics, as discussed in the theoretical studies. This may result in a more diverse group of participants, allowing for a more comprehensive understanding of public responses. In addition, this study acknowledges its limitations with the framework of approach. Therefore, it is advisable to widen the group of respondents to include relevant disciplines such as engineering, architecture, and real estate. It is expected that the findings might provide new insights into the perspective of GI.

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Declarations

Competing interests There is no competing interest involved in this paper.

Human participants This research was conducted with the respondents' permission, and informed consent was obtained from all participants. They were informed of the research's purpose and the confidentiality and anonymity measures in place.

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