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Exploring the Critical Barriers Towards Women Participation in Surveying and Geo-Informatics Practices

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Abstract: Surveying and geo-informatics stand as a significant field at the intersection of science, technology, and spatial management, playing a crucial role in informing decision-making across various industries. However, the surveying and geo-informatics field suffers from the underrepresentation of women professionals. This underrepresentation carries significant implications hindering diversity of knowledge and skills. In order to build a more inclusive and equitable professional environment, the study aims to identify and analyse the identified barriers to offer insight and strategies to enhance women's participation. Data were gathered using a mixed-methods (sequential exploratory) approach, which included interviews and structured questionnaires (five Likert scale) with professionals in the field. Twenty-five participants and 138 responses were considered for the study. Statistical tests such as Cronbach's Alpha, mean ranking, one sample t-test, Chi-square, Kruskal Wallis, and factor analysis were conducted to investigate the significance and relationship between the identified barriers. The result shows that the participation of women in the surveying and geo-informatics field is low. Similarly, the study shows that the barriers are critical to the participation of women in the field, considering their significance level. In addition, a rotation of the component matrix reveals three dimensions: equity and inclusion, career advancement and assistance, and gender equality and empowerment. These factors offer a thorough foundation for comprehending the many difficulties women in the field encounter. The study developed various strategies tailored to mitigate each barrier component. The findings of this study add to the body of knowledge on gender differences in surveying and geo-informatics practises and offer policymakers, organisations, and stakeholders valuable insights. Eliminating these obstacles will improve gender diversity, encourage inclusivity, and fully utilise the talents of women, ultimately resulting in a more innovative and sustainable surveying and geo-informatics profession in Nigeria.

Keywords: *Barriers, Gender disparities, Geo-informatics, Nigeria, Surveying, Women participation*

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1. Introduction

As nations worldwide recognise the significance of precise spatial data and its uses in diverse sectors, surveying and geo-informatics practises have become essential globally. Surveying and geo-informatics play a crucial role in enabling sustainable development and informed decision-making on a global scale, from land administration and infrastructure development to environmental management and disaster response. Land management is a vital application of surveying and geoinformation techniques in every country. According to Clarkson et al. (2023), for economic development, social stability, and environmental protection, it is essential to have clear land ownership and effective land management practices. Geoinformatics technologies make the development of complete land information systems possible, supporting procedures for land-based decision-making and efficient land management (Ruiyi, 2022; Mosleh et al., 2017). In several

industries, including urban planning, environmental management, infrastructure development, and disaster response, surveying and geoinformation play crucial roles.

Despite the field's importance, there are still present underlying challenges. These challenges include technology development, data interoperability and standards, a shortage of competent experts, funding and resource limitations, and the underrepresentation of women in the profession (Clarkson et al., 2023; RICS, 2020). Women are still underrepresented in this field and face several obstacles that prevent them from participating fully and advancing. The percentage of women in the surveying profession has increased from 13% to 17% since 2009 (RICS, 2019), indicating that the female population presents an opportunity to tackle the skills shortage.

A key area of focus in establishing gender equality and fostering diversity in the professions is women's involvement in surveying and geo-informatics practices. Gender bias and assumptions that link surveying and geoinformatics to male dominance are substantial impediments (RICS, 2020). Deeply ingrained societal stereotypes frequently dissuade women from pursuing employment in these fields since they are considered more appropriate for men. Women encounter discrimination, scepticism, and fewer prospects for professional advancement in a setting with such biases (RICS, 2020). Promoting equal opportunities for women in surveying and geoinformatics requires addressing and combating these biases.

Women's capacity to acquire the skills and knowledge required for career growth may be constrained by unequal access to quality education and training options in surveying and geoinformatics (RICS, 2020; Jimoh et al., 2016). This barrier worsens the gender gap because it limits opportunities for continuous professional development and initial entry into the area. Women are frequently discouraged from careers in fields by traditional gender roles and expectations. Women's employment options may be restricted by societal pressure to fulfil traditional duties and obligations, which may deter them from pursuing careers in these male-dominated industries (Clarkson et al., 2023). It is crucial to challenge and change these standards to foster an environment that is welcoming and supportive of women's participation and achievement.

It can be challenging for women to juggle job commitments with their families and other commitments. Women may find it challenging to maintain a healthy work-life balance due to the demanding nature of fieldwork, erratic schedules, and long working hours (Abubakar et al., 2022; NAWIC, 2013). Flexible work schedules, encouraging policies, and family-friendly practices can all help to lessen this barrier and make it possible for women to succeed in their careers. Women's professional advancement in surveying and geoinformatics is further hampered by their limited access to networking and mentorship possibilities (Jimoh et al., 2016). In order to provide direction, encouragement, and inspiration for professional progress, mentors and role models are essential (Abubakar et al., 2022). Women's advancement and access to influential networks might be hampered by the underrepresentation of women in leadership roles and the absence of mentorship programmes. Creating mentorship programmes and encouraging networking events can create a positive environment that gives women the confidence they need to succeed in these fields (Clarkson et al., 2023). Young women can be inspired and motivated to pursue professions in surveying and geoinformatics by seeing visible and successful women in these fields. By showcasing and honouring the accomplishments of women in the field, preconceptions can be dispelled, and more women can be inspired to enter and succeed in these fields.

Consequently, several significant obstacles prevent women from participating in surveying and geoinformation practices. It takes a multifaceted strategy to overcome these obstacles, including adjustments to societal attitudes, educational policies, workplace procedures, and support efforts. The surveying and geo-informatics field can unlock female professionals' latent potential and produce more diverse and cutting-edge results by addressing these impediments, advancing gender equality, and fostering inclusive settings. Women only make up 17% of RICS membership globally and 31% in the UK, according to Clarkson et al. (2023), which are relatively low numbers given that women make up 49.5% of the world's population (Bank, 2022).

Consequently, the study aimed to achieve the following objectives: identify the critical barriers preventing women from participating in surveying and geo-informatics in Nigeria, evaluate the significance of the identified barriers preventing women from participating in surveying and geo-informatics in Nigeria, assess the professional opinions on the identified barriers preventing women from participating in the field, and develop effective strategies to enhance women participation in surveying and geo-informatics.

2. Relevant Literatures

Women are frequently not encouraged to pursue STEM-related subjects due to traditional gender norms and expectations that encourage them to pursue more "feminine" professional options (Laura, 2020). Cultural expectations that place men's career goals above those of women can prevent women from having access to education and training opportunities, which leads to a dearth of qualified female professionals in surveying and geoinformatics (RICS, 2020). This restriction includes a lack of funding, prejudice in the educational system, and unequal access to learning opportunities. Women's low participation in these professions may also be due to a lack of exposure to surveying and geoinformatics during their formative years and a lack of role models and mentors (NAWIC, 2013).

Issues with work-life balance are frequently identified as obstacles to women's full participation in geoinformatics and surveying practises (Abubakar et al., 2022; NAWIC, 2013). Women may find it challenging to balance their job responsibilities with those related to their families and personal commitments due to these professions' demanding nature, which includes fieldwork, unpredictable scheduling, and long working hours. This obstacle is further exacerbated by the absence of flexible work schedules and favourable policies, making it challenging for women to advance in their careers (Clarkson et al., 2023).

Opportunities for networking and mentoring are essential for career development. However, studies show that women in surveying and geoinformatics have difficulty connecting with mentors and other professionals (Abdullah et al., 2013). The ability of female professionals to acquire advice, support, and opportunities for career advancement is hampered by the paucity of female role models and mentors (NAWIC, 2013). By establishing mentorship programmes, developing networking opportunities, and encouraging collaboration, the participation of women can be increased in the profession and help them succeed. Women's ability to make substantial contributions to the subject may be hampered by their lack of financial resources for research, professional growth, and specialised equipment (RICS, 2020). Women's pursuit of excellence and innovation can be helped by closing this gap by granting equal access to financial opportunities and resources.

In order to ensure that women are treated fairly and equally in geoinformatics and surveying practices, the gender wage gap must be closed. Women's desire and commitment to these occupations are hampered by gender inequities caused by differences in pay and benefits between men and women (Andrew et al., 2021). In order to achieve gender equality, appropriate pay scales must be implemented, and payment structures must be made transparent. Barriers are also exacerbated by a lack of policies and programmes addressing women's difficulties in the field (Abubakar et al., 2022). A more encouraging and enabling atmosphere can be created by comprehensive policies that support gender equality, diversity, and inclusion inside organisations and educational institutions (Turrell et al., 2002). Organisations must implement policies that do away with harassment and discrimination at work, support work-life balance, and offer flexible work opportunities. Furthermore, the underrepresentation of women in surveying and geoinformatics is maintained by the lack of visibility and appreciation of their work (Clarkson et al., 2023). By acknowledging the accomplishments and knowledge of female professionals, participation can increase their exposure and motivate the next generation of female professionals.

According to research, the lack of role models can support the idea that surveying and geoinformatics are dominated by men, discouraging women from entering and advancing in these fields (Abubakar et al., 2022). Implementing laws that support pay transparency, equitable compensation, and equal opportunity for women professionals is necessary to remove this barrier. Promoting an inclusive and encouraging environment for women in surveying and geoinformatics requires supportive policies and efforts. According to studies, it is critical to put policies in place that prevent harassment and discrimination at work, offer flexible scheduling options, and promote work-life balance (Jimoh et al., 2016). Supportive programmes, including leadership training, mentoring programmes, and professional development opportunities, can increase the participation of women and help them succeed in these sectors (Hannum et al., 2014).

In order to combat gender biases and preconceptions, it is essential to make women's contributions to surveying and geoinformatics visible and acknowledged (Mahady, 2018; Hannum et al., 2014). Women's accomplishments and knowledge frequently go unrecognised or underestimated, which results in a lack of exposure and recognition. Women professionals can be encouraged to pursue professions in these industries by actively recognising their achievements, highlighting their successes through publications and conferences, and breaking down barriers (Hannum et al., 2014; Terry, 2008).

3. Materials and methods

The study adopted a mixed methods approach to explore the challenges that women experience in surveying and geoinformatics practice. Adopting this approach provided a comprehensive examination of the barriers. The research framework is shown in Figure 1. A sequential exploratory approach was used, where the first and second phases were qualitative and quantitative. The sequential exploratory design allowed researchers to gain a deep and comprehensive understanding of the research topic by integrating qualitative and quantitative data (Teddlie & Tashakkori, 2006). Also, it allowed for flexibility and adaptability (Creswell, 2014). In order to determine the pertinent factors and constructs connected to the challenges experienced by women in surveying and geoinformatics, a thorough literature review was first carried out.

Furthermore, twenty-five professionals who understand the built environment made up the study's target demographic for the interview. The professionals were purposively selected to participate in the study. The criteria for selection to participate in the study include professionals who must be chartered members of the Surveyors Council of Nigeria (SURCON) and must have a minimum of five years working experience. The participants were consulted physically and virtually to seek their opinions. The professionals were asked about the barriers to women's participation in surveying and geo-informatics. A structured questionnaire was developed based on the insights gained from the professional's responses.

These identified barriers formed the basis for the questionnaire's development, and experts in the field were consulted to ensure the validity and reliability of the questionnaire. A larger sample of built environment experts with knowledge of the topic was then given the questionnaire. The questionnaire was sent digitally utilising an online platform (Google Forms) to guarantee a broad audience and easy data gathering. In order to achieve statistical significance, 138 responses were received and considered for statistical analysis. This sample size was considered adequate based on previous construction-related studies (Olanrewaju et al., 2020). Overall, a thorough quantitative analysis of the data gathered for this study was provided by combining the reliability test, mean ranking, one-sample t-test, Kruskal-Wallis test, and factor analysis.

The reliability test was used to determine the consistency and reliability of the data for analysis (Maree & Pietersen, 2016). The mean ranking indicated the level at which the respondents perceived each barrier, and this was used to rank the barriers on their level of importance. Similarly, the one-sample t-test was adopted to investigate the significance level of the hypothesised barriers with a 95% confidence and 3.5 threshold. The Kruskal-Wallis test was used to assess the differences in opinions among the respondents on the barriers. Consequently, factor analysis comprises a range of multivariate statistical techniques utilised for diverse purposes, including simplifying numerous variables into a more concise set of variables known as factors (Williams et al., 2010). With these statistical methods, it was possible to examine how essential impediments were viewed, establish significant discrepancies across demographic groups, and investigate the underlying causes of the challenges women in surveying and geoinformatics faced.

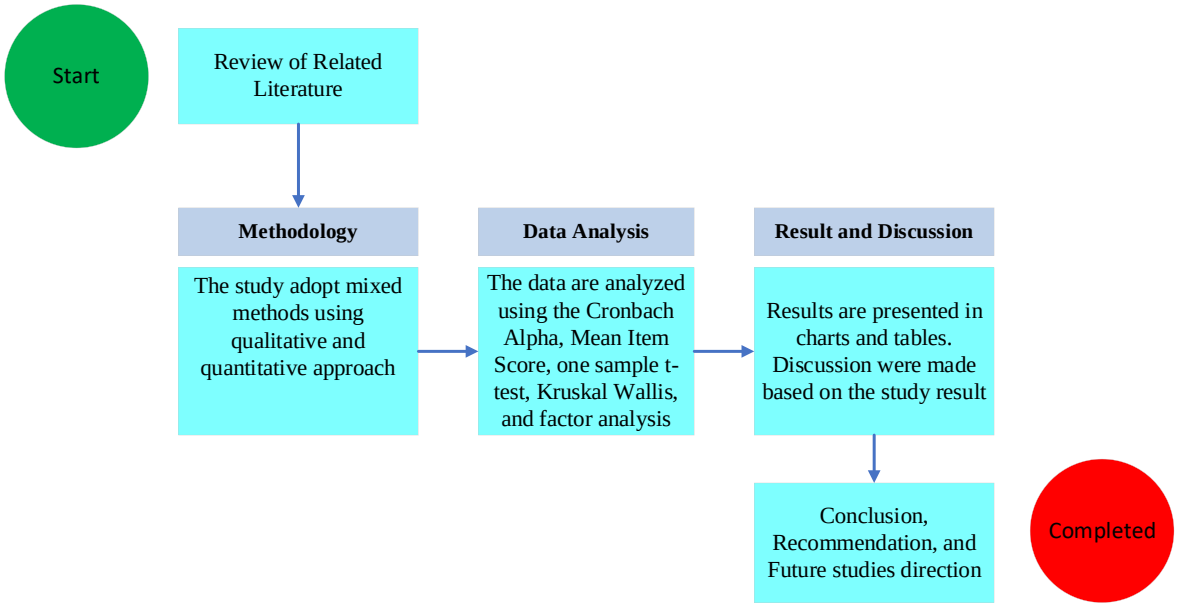


Figure 1: Research Framework

4. Results and discussion

4.1. Respondents background

The respondents' demographics show a diverse sample of 138 individuals, as shown in Table 1. In terms of age range, the majority (45.65%) falls within the 31-40 age bracket, followed by 30.43% between 20-30, 15.22% between 41-50, and 8.70% aged 51 and above. Regarding gender, most respondents (73.91%) identify as male, while 26.09% identify as female. In their professional background, the most significant respondents (62.32%) are surveyors, 24.64% are civil engineers, and 13.04% in other built environment-related professions. As for the highest academic qualification, 56.52% hold a Bachelor's degree, 24.64% have a Master's degree, and 18.84% possess a Doctorate. In terms of experience, the distribution is as follows: 12.32% have 0-5 years of experience, 23.19% have 6-10 years, 42.75% have 11-15 years, 13.77% have 16-20 years, and 7.97% have 21 years and above of experience. The survey respondents represent diverse age groups, gender identities, professional backgrounds, academic qualifications, and years of experience, providing valuable insights into the research study.

Table 1: Respondent's Background

Respondent Background		Frequency	Percentage
Age Range	20-30	42	30.43

	31-40	63	45.65
	41-50	21	15.22
	51 above	12	8.70
	Total	138	100.00
Gender	Male	102	73.91
	Female	36	26.09
	Total	138	100.00
Profession Background	Surveyor	86	62.32
	Civil Engineer	34	24.64
	Others	18	13.04
	Total	138	100.00
Highest Academic Qualification	Bachelor Degree	78	56.52
	Master's Degree	34	24.64
	Doctorate Degree	26	18.84
	Total	138	100.00
Years of Experience	0-5 Years	17	12.32
	6-10 Years	32	23.19
	11-15 Years	59	42.75
	16-20 Years	19	13.77
	21 Years Above	11	7.97
	Total	138	100.00

4.2. Current level of women participation in surveying and geo-informatics practices

Figure 2 represents the current level of women's participation in surveying and geo-informatics practices in Nigeria based on the responses from 138 participants. It shows that the distribution is quite varied. A small percentage of respondents (9.42%) perceive women's participation as "Very High," while an additional 8.70% consider it "High." This result shows that some professionals believe that women have a significant presence and involvement in these fields. Approximately 16.67% of respondents view women's participation as "Moderate." The result shows that many respondents acknowledge some level of women's involvement but perceive room for improvement.

A significant portion of respondents (34.06%) perceive women's participation as "Low," indicating a noticeable underrepresentation of women in surveying and geo-informatics practices from their perspective. Additionally, a slightly higher percentage of respondents (31.16%) perceive women's participation as "Very Low," indicating a substantial concern about the lack of women's presence in these fields. The chart highlights a diversity of opinions regarding the current level of women's participation in surveying and geo-informatics practices. While some respondents see a relatively high level of participation, others express concerns about the low representation of women in these fields. This data underscores the importance of addressing barriers and implementing initiatives to promote gender equality and inclusion within surveying and geo-informatics professions.

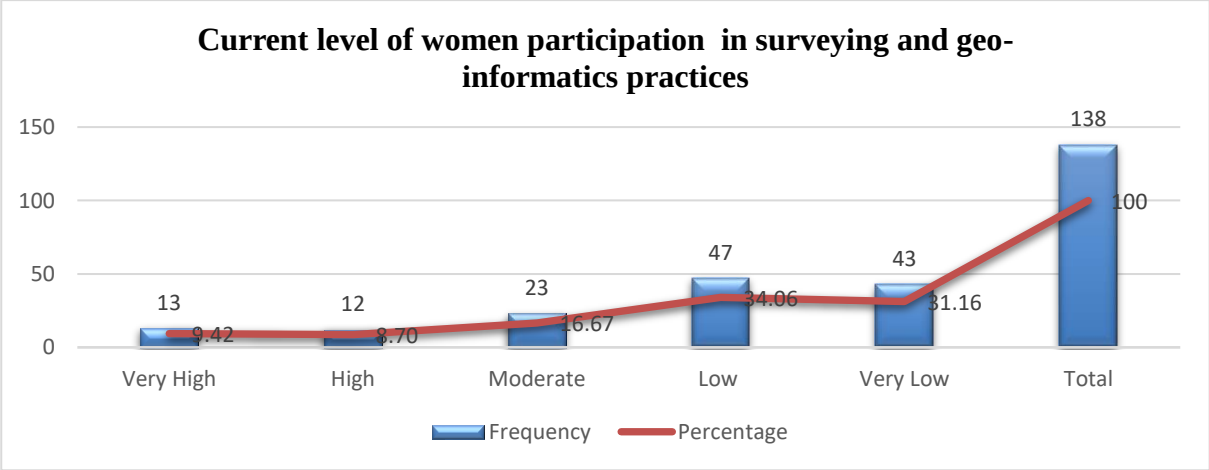


Figure 2: Level of women participation

4.3. Reliability test

The result of Cronbach's Alpha for this study is 0.909, indicating a high level of internal consistency among the items included in the measurement scale, as shown in Table 2. Cronbach's Alpha is a commonly used statistic to assess the reliability or consistency of a measurement scale or instrument. In this case, the measurement scale consists of 17 items. The Cronbach's Alpha value of 0.909 suggests that the items within the scale are highly correlated and collectively measure the construct or concept of interest effectively (Maree & Pietersen, 2016). This high internal consistency implies that the items consistently measure the same underlying construct, and the scale is reliable in measuring that construct.

Table 2: Data reliability

Cronbach's Alpha	N of Items
0.909	17

4.3. Mean ranking of the identified barriers

The provided results present a comprehensive overview of the barriers faced by women in surveying and geo-informatics practices, as shown in Table 3. Each barrier is represented by its standardised skewness (SKS) and standardised kurtosis (KTS) values, as well as the sample size (N), mean, standard deviation (SD), test value, t-value, degrees of freedom (df), and significance level (Sig). Additionally, the R column indicates the rank of each barrier based on the mean value from highest to lowest. The standardised skewness (SKS) and standardised kurtosis (KTS) values provide information about the distribution of responses for each barrier. Positive skewness values indicate a distribution that is skewed to the right. In contrast, negative values indicate a distribution skewed to the left. The standardised kurtosis values measure the extent of peakiness or flatness in the distribution. Both skewness and kurtosis values help assess the normality of the data distribution for each barrier.

The t-values and corresponding significance levels (Sig) indicate the statistical significance of the differences between the mean scores of each barrier and a hypothetical test value of 3.5. This benchmark has been set in built environment-related studies (Bello et al., 2023a; 2023b). A significant t-value suggests that the mean score for a particular barrier significantly differs from the test value. According to the mean rankings, "Lack of representation" (R = 1) emerges as the most significant barrier, with a mean ranking of 4.94. This outcome suggests a strong consensus among the participants that the lack of representation of women in surveying and geo-informatics practices is a significant obstacle. This result can be linked to the outcome of (Clarkson et al., 2023 Ellison, 2001) study, which established that the lack of women's representation in the surveying profession negatively impacts the increase of women's participation and reduces their field. Similarly, "Limited role models" (R = 2) and "Workplace discrimination and harassment" (R = 3) also receive high mean rankings of 4.86 and 4.84, respectively, indicating their considerable impact on women's participation in these fields. As observed in the study of (Abubakar et al. 2022; RICS, 2020; NAWIC, 2013), these two barriers significantly affect the participation of women in the surveying profession.

The subsequent barriers, ranked from R = 4 to R = 17, continue to highlight significant challenges faced by women. "Lack of mentorship and networking opportunities" (R = 4), "Bias in recruitment and promotion processes" (R = 5), and "Lack of awareness and outreach" (R = 6) all receive mean rankings above 4.7, reflecting their perceived importance. These barriers are evident in the previous related study (Clarkson et al., 2023; Jimoh et al., 2016). Other barriers, such as "Work-life balance challenges" (R = 7), "Sociocultural norms and expectations" (R = 8), and "Gender bias and stereotypes" (R = 9), also receive relatively high mean rankings. Indicating their impact on women's participation in surveying and geo-informatics practices and evident in the literature (Abubakar et al., 2022; RICS, 2020)

Furthermore, barriers such as "Limited access to professional networks" (R = 10), "Insufficient representation in decision-making bodies" (R = 11), and "Limited access to education and training" (R = 12) are ranked among the top barriers, highlighting their significance in hindering women's participation. "Gender pay gap" (R = 13) and "Lack of supportive policies and initiatives" (R = 14) also receive relatively high mean rankings, suggesting the detrimental effects of unequal pay and inadequate support mechanisms on women in these fields.

In contrast, barriers such as "Inflexible work environments" (R = 15), "Limited access to funding and resources" (R = 16), and "Lack of visibility and recognition" (R = 17) are ranked lower but still significant, indicating their impact on women's participation in surveying and geo-informatics practices. The statistical significance of the findings, with all barriers having p-values (Sig) of 0.000, further strengthens the importance and reliability of the results. The mean rankings highlight the critical barriers to women's participation in surveying and geo-informatics practices. The barriers related to representation, role models, workplace discrimination, mentorship, bias in recruitment, and awareness are consistently ranked high, indicating their significant impact. These findings provide valuable insights for addressing these barriers and fostering a more inclusive and equitable environment for women in these fields.

Table 3: Mean ranking of identified barriers

Barriers	SKS	KTS	N	Mea	SD	Test Value = 3.5	R

				n		t	df	Sig	
Lack of representation	-1.825	1.814	138	4.94	0.235	72.227	137	0.000	1
Limited role models	-1.745	1.313	138	4.86	0.392	40.561	137	0.000	2
Workplace discrimination and harassment	-1.258	0.274	138	4.84	0.387	40.719	137	0.000	3
Lack of mentorship and networking opportunities	-1.738	1.360	138	4.81	0.520	29.608	137	0.000	4
Bias in recruitment and promotion processes	-1.785	1.227	138	4.70	0.521	26.948	137	0.000	5
Lack of awareness and outreach	-1.230	0.478	138	4.67	0.515	26.781	137	0.000	6
Work-life balance challenges	-1.428	0.918	138	4.62	0.621	19.975	125	0.000	7
Sociocultural norms and expectations	-1.314	0.627	138	4.60	0.622	20.787	137	0.000	8
Gender bias and stereotypes	-1.124	0.150	138	4.55	0.640	19.281	137	0.000	9
Limited access to professional networks	-0.470	-0.663	138	4.43	0.591	18.451	137	0.000	10
Insufficient representation in decision-making bodies	-0.702	-0.835	138	4.22	0.904	9.413	137	0.000	11
Limited access to education and training	-0.597	-0.795	138	4.17	0.876	8.939	137	0.000	12
Gender pay gap	-0.954	-0.358	138	4.15	1.146	6.687	137	0.000	13
Lack of supportive policies and initiatives	-0.805	-0.612	138	3.98	1.270	4.424	137	0.000	14
Inflexible work environments	-0.150	1.000	138	3.51	1.148	0.074	137	0.941	15
Limited access to funding and resources	0.071	-1.418	138	3.01	1.472	-3.931	137	0.000	16
Lack of visibility and recognition	0.729	-1.271	138	2.36	1.704	-7.842	137	0.000	17

4.4. Variation in opinion among the respondents based on profession

The Chi-Square and Kruskal-Wallis tests were utilised to analyse the data and examine the significance and relationships among the identified barriers to women's participation in surveying and geo-informatics practices, as shown in Table 4. The Chi-Square test is a non-parametric test used to determine if there is a significant association between two categorical variables. In contrast, the Kruskal-Wallis test is a non-parametric test used to compare the medians of three or more independent groups. In this study, both tests were employed to understand the barriers and their relative importance in the context of women's participation in surveying and geo-informatics practices.

The Chi-Square test results revealed significant associations between specific barriers and their perceived importance. For example, limited access to funding and resources, gender pay gap, lack of supportive policies and initiatives, lack of visibility and recognition, workplace discrimination and harassment, lack of mentorship and networking opportunities, limited role models, inflexible work environments, lack of representation, limited access to education and training, bias in recruitment and promotion processes, lack of awareness and outreach, insufficient representation in decision-making bodies, limited access to professional networks, sociocultural norms and expectations, and work-life balance challenges all yielded significant Chi-Square values. These results indicate that these barriers are perceived as important and influential factors affecting women's participation in the field.

Overall, based on the Kruskal-Wallis test results, it can be concluded that there is no significant difference among the respondents regarding the perceived importance of the barriers to women's participation in surveying and geo-informatics practices. This result implies a consensus among the respondents in the study sample regarding the significance of these barriers. This study comprehensively analyses the relationships and relative importance of the identified barriers by employing the Chi-Square and Kruskal-Wallis tests. The Chi-Square test provided insights into the associations between barriers, while the Kruskal-Wallis test allowed for comparisons of the perceived importance ratings among the barriers.

This combined approach enables a deeper understanding of the barriers and their implications for women's participation in surveying and geo-informatics practices.

Table 4: Kruskal Wallis (One-Way Analysis of Variance)

Barriers	Chi-Square	df	Sig	K-W	df	Sig
Limited access to funding and resources	107.855[a]	1	0.000	5.876	4	0.209
Gender pay gap	157.942[b]	4	0.000	62.758	4	0.359
Lack of supportive policies and initiatives	133.884[b]	4	0.000	35.362	4	0.601
Lack of visibility and recognition	110.913[b]	4	0.000	8.950	4	0.062
Workplace discrimination and harassment	168.304[c]	2	0.000	4.301	4	0.367
Lack of mentorship and networking opportunities	178.609[c]	2	0.000	1.969	4	0.741
Limited role models	180.696[c]	2	0.000	10.590	4	0.214
Inflexible work environments	30.913[b]	4	0.000	13.808	4	0.111
Gender bias and stereotypes	4.899[b]	4	0.298	17.493	4	0.374
Lack of representation	95.609[c]	2	0.000	6.515	4	0.164
Limited access to education and training	50.464[d]	3	0.000	9.454	4	0.059
Bias in recruitment and promotion processes	185.826[d]	3	0.000	7.707	4	0.103
Lack of awareness and outreach	63.957[c]	2	0.000	9.327	4	0.053
Insufficient representation in decision-making bodies	66.116[d]	3	0.000	6.499	4	0.165
Limited access to professional networks	78.826[c]	2	0.000	9.489	4	0.072
Sociocultural norms and expectations	49.609[c]	2	0.000	9.748	4	0.450
Work-life balance challenges	76.934[e]	2	0.000	13.484	4	0.331

4.5. Factor analysis for the identified barriers

The rotated component matrix provides insights into the underlying factors or components related to the identified barriers to women's participation in surveying and geo-informatics practices. The KMO measure of sampling adequacy (MSA) and Bartlett test of sphericity (BTS) were conducted on the barriers to assess the suitability of the data for analysing the barriers to women's participation in surveying and geo-informatics practices. These criteria establish the threshold the data must meet for further analysis. The KMO, ranging from 0 to 1, provides a starting point 0.50 (Field, 2013). The Bartlett test compares the identity matrix with the correlation matrix to determine if there is a significant difference. Meeting the significance threshold of the Bartlett test indicates data suitability for analysis (Field, 2013). The BTS yielded a significant result at $p = 0.000$, and the KMO value was 0.875, exceeding the recommended threshold of 0.50, as shown in Table 5.

Table 5: KMO and BTS Test for Sampling Adequacy

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.875
Bartlett's Test of Sphericity	Approx. Chi-Square	927.911
	df	136
	Sig.	0.000

This outcome indicates that the data is factorable, surpassing the suggested KMO value of 0.6 by Kaiser (1970) and demonstrating statistical significance, according to Bartlett (1954). Figure 3 presents the scree plot, which indicates satisfactory results. The matrix displays the loadings of each barrier on the three components extracted from the analysis, as shown in Table 6.

Table 6: Rotated Component Matrix[a]

Barriers	Component			Variance	Cumulative %	Categorisation
	1	2	3			
Lack of awareness and outreach	0.819			30.34%	30.34%	Gender Equality and Empowerment
Sociocultural norms and expectations	0.762					
Insufficient representation in decision-making bodies	0.754					
Limited access to education and training	0.714					
Work-life balance challenges	0.656					
Limited access to professional networks	0.650					
Bias in recruitment and promotion processes	0.562					
Lack of representation	0.507					
Gender bias and stereotypes		-0.814		23.80%	43.65%	Career Advancement and Support
Inflexible work environments		-0.746				
Lack of mentorship and networking opportunities		0.699				
Limited role models		0.571				
Limited access to funding and resources		0.523				
Gender pay gap			0.771	17.81%	60.53%	Equity and Inclusion
Lack of supportive policies and initiatives			0.738			
Lack of visibility and recognition			0.605			
Workplace discrimination and harassment			-0.503			

a. Rotation converged in 5 iterations.

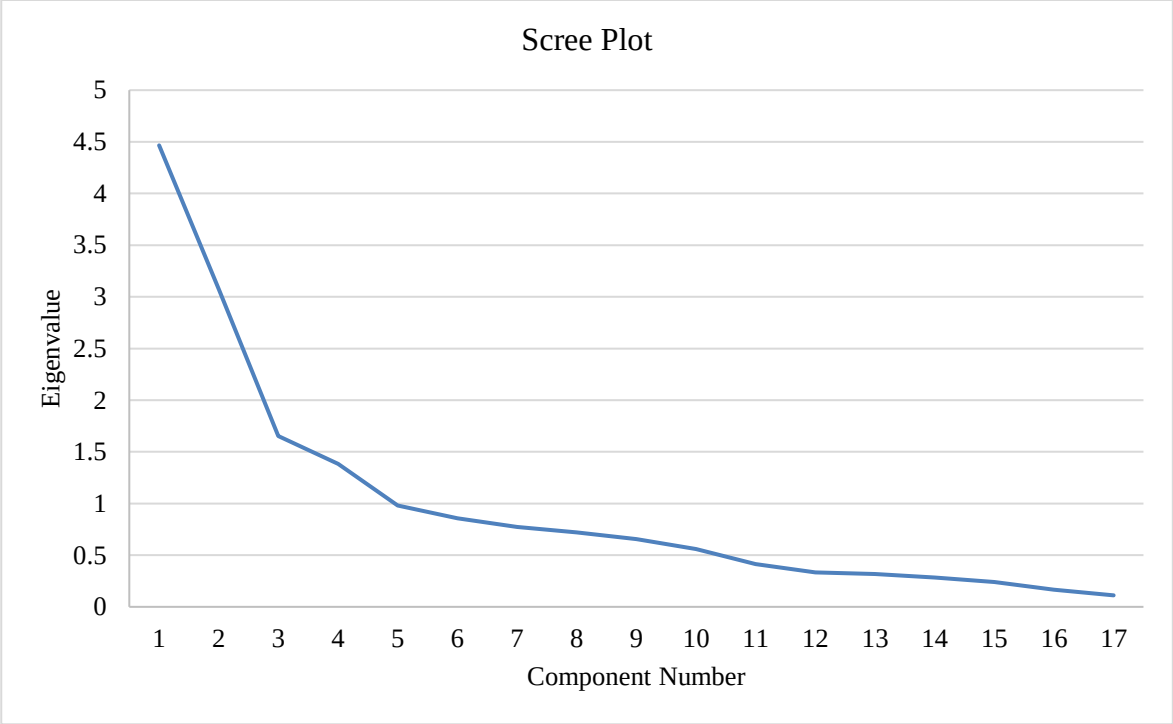
Component 1: This explains 30.34% of the variance, which can be labelled as "Gender Equality and Empowerment" related barriers. It includes barriers such as lack of awareness and outreach, sociocultural norms and expectations, insufficient representation in decision-making bodies, limited access to education and training, work-life balance challenges, limited access to professional networks, bias in recruitment and promotion processes, and lack of representation. These barriers contribute to gender inequality and hinder women's empowerment in the field. They highlight the need to address systemic and structural issues to create a more inclusive and supportive environment for women in surveying and geo-informatics practices.

Component 2: Accounting for 23.80% of the variance, can be categorised as "Career Advancement and Support" related barriers. It encompasses barriers such as gender bias and stereotypes, inflexible work environments, lack of mentorship and networking opportunities, limited role models, and limited access to funding and resources. These barriers specifically impact women's career advancement opportunities and the support they receive within the industry. Addressing these barriers would create an environment that fosters the career growth and development of women professionals in the field.

Component 3: To discuss, 17.81% of the variance can be labelled as "Equity and Inclusion related barriers. It includes barriers such as the gender pay gap, lack of supportive policies and initiatives, lack of visibility and recognition, and workplace discrimination and harassment. These barriers highlight the need for equity and inclusion measures within the industry to ensure fair compensation, supportive policies, and a work environment free from discrimination and harassment.

The rotated component matrix demonstrates the interrelationships among the barriers. It provides a framework for understanding the underlying dimensions contributing to women's underrepresentation in surveying and geo-informatics practices. By identifying these components, policymakers, organisations, and stakeholders can focus on developing targeted interventions and strategies to address the specific challenges within each category. This comprehensive approach is crucial for creating a more inclusive and equitable environment that promotes women's full participation and advancement in the field.

Figure 3: Scree Plot



4.6. Strategies for encouraging/enhancing women's participation in the surveying and geo-informatics practices

The study developed effective strategies towards encouraging women's professional participation in surveying and geo-informatics practices in Nigeria. The strategies were developed based on each categorised barrier. Implementing the developed strategies can significantly mitigate the identified barriers, encouraging women's professional participation in the field. Figure 3 presents a model for the developed strategies targeting each category of barriers. Table 7 presents the expert validation by ten experts across three developing countries: Ghana, Nigeria, and South Africa. The validation outcome shows that all the experts are in consensus on the developed strategies for each category of barriers. The outcome further strengthens the strategies' significance towards enhancing women's participation in surveying practices.

Table 7: Expert Validation

Strategies	Expert Validation										Percentage	
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	Accept	Reject
Gender Equality and Empowerment related barriers												
Equal Opportunity	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	100	0
Empowerment Programs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	100	0
Education and Awareness	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	100	0
Work-Life Balance	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	100	0
Career Advancement and Support related barriers												
Training and Development	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	100	0
Performance Evaluation and Feedback	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	100	0
Mentorship and Sponsorship Programs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	100	0
Networking and Professional Associations	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	100	0
Equity and Inclusion related barriers												
Accountability and Measurement	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	100	0
Cultural Sensitivity and Training	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	100	0
Employee Resource Group (ERGs)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	100	0
Diverse Hiring Practices	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	100	0

Inclusive Policies and Benefits	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	100	0

Gender Equality and Empowerment:

i. Education and Awareness: Promote education and awareness programs that address gender stereotypes, biases, and discrimination. This approach includes implementing a gender-sensitive curriculum, organising workshops, and conducting awareness campaigns to challenge societal norms and promote gender equality.

ii. Equal Opportunities: Advocate for policies and practices that ensure equal opportunities for individuals of all genders. Encourage organisations to establish gender-neutral recruitment and promotion processes, create mentorship programs, and provide equal professional development opportunities.

iii. Empowerment Programs: Implement programs that empower women and marginalised genders, such as leadership training, negotiation skills workshops, and entrepreneurship support. These initiatives can help individuals build confidence, develop necessary skills, and navigate gender-related career challenges.

iv. Work-Life Balance: Promote work-life balance by encouraging flexible work arrangements, parental leave policies, and affordable childcare options. This helps to address the disproportionate burden of caregiving responsibilities often placed on women and allows individuals to balance their personal and professional lives more effectively.

Career Advancement and Support:

i. Mentorship and Sponsorship Programs: Establish mentorship and sponsorship programs that pair experienced professionals with individuals seeking career advancement. Mentors can provide guidance, support, and advice. At the same time, sponsors can advocate for their mentees' career growth and provide opportunities for visibility and advancement.

ii. Training and Development: Offer training and development programs focusing on building skills necessary for career advancement. This can include leadership, communication, negotiation, and strategic thinking workshops to help individuals develop the competencies required for higher-level positions.

iii. Performance Evaluation and Feedback: Implement fair and objective performance evaluation systems that recognise and reward merit. Ensure that evaluation criteria are transparent and bias-free, and provide constructive feedback to employees to support their professional growth.

iv. Networking and Professional Associations: Encourage networking opportunities and participation in professional associations relevant to individuals' fields. These connections can provide access to valuable resources, information, and potential career opportunities.

Equity and Inclusion:

i. Diverse Hiring Practices: Adopt inclusive hiring practices to increase organisational diversity. This includes actively recruiting candidates from underrepresented groups, implementing blind resume screening, and providing diversity and inclusion training for hiring managers.

ii. Inclusive Policies and Benefits: Develop and enforce policies that promote equity and inclusion, such as anti-discrimination policies, flexible work arrangements, and accommodations for individuals with disabilities. Provide comprehensive benefits packages that support diverse needs, including healthcare, parental leave, and mental health resources.

iii. Employee Resource Groups (ERGs): Establish ERGs representing and supporting different affinity groups within the organisation. ERGs provide a platform for employees to connect, share experiences, and advocate for inclusive practices within the workplace.

iv. Cultural Sensitivity and Training: Conduct diversity and inclusion training for employees at all levels. This training should raise awareness about unconscious biases, foster cultural sensitivity, and promote respectful and inclusive workplace interactions.

v. Accountability and Measurement: Regularly assess and measure progress towards equity and inclusion goals. Establish accountability mechanisms that hold individuals and the organisation responsible for creating and maintaining an inclusive work environment. This may include conducting diversity audits, collecting employee feedback through surveys, and setting diversity-related targets.

Figure 3: Developed strategies for enhancing women's participation

5. Conclusion

This study examined the critical barriers towards women's participation in surveying and geo-informatics practices, with a specific focus on the context of Nigeria. Through a sequential exploratory approach, including interviews, surveys and statistical analyses, valuable insights were gained regarding women's barriers in this field. The study established low participation of women in surveying and geo-informatics practice in Nigeria due to several barriers as established in this study. The findings highlighted several key barriers, including lack of representation, limited role models, workplace discrimination and harassment, and limited access to funding and resources.

The study's results underscore the significance of addressing these barriers to enhance women's participation in surveying and geo-informatics practices. By recognising and mitigating these obstacles, it is possible to create a more inclusive and supportive environment for women professionals in the field. These include promoting gender equality and empowerment, providing career advancement opportunities and support, and fostering equity and inclusion through fair policies and practices. The study's implications extend beyond Nigeria and can inform initiatives and interventions in other developing countries. The developed strategies emphasise raising awareness, challenging societal norms, and

providing access to education, mentorship, and professional networks. Furthermore, it highlights the need for supportive policies, training and development, work-life balance, empowerment programs and diverse hiring practices for women in the field. This study's outcome is consistent with previous related studies on women's participation in the built environment industry.

This study contributes to the existing body of knowledge by shedding light on women's critical barriers in surveying and geo-informatics practices. By addressing these barriers, stakeholders can create an environment that promotes diversity, equality, and inclusivity, fostering women's active participation and contribution to the field. This research serves as a call to action for policymakers, organisations, and stakeholders to collaborate and implement strategies to pave the way for increased women's participation and success in surveying and geo-informatics practices.

Based on the findings exploring barriers towards women's participation in surveying and geo-informatics practices, the following recommendations are proposed:

i. Increase awareness and outreach efforts: Develop targeted campaigns and programs to raise awareness about surveying and geo-informatics as viable career options for women. This can include initiatives like mentorship programs, career guidance sessions, and outreach activities in schools and universities.

ii. Address sociocultural norms and expectations: Implement measures to challenge and overcome societal and cultural biases discouraging women from pursuing careers in surveying and geo-informatics. Promote gender equality and challenge stereotypes through education, awareness campaigns, and cultural interventions.

iii. Enhance access to education and training: Improve access to quality education and training opportunities for women in surveying and geo-informatics. Develop scholarship programs, promote gender-inclusive curriculum development, and foster partnerships between academic institutions and industry professionals to provide practical training opportunities.

iv. Promote work-life balance: Implement policies and practices that support work-life balance, such as flexible working hours, family-friendly policies, and supportive organisational culture. This will enable women to balance their personal and professional responsibilities effectively.

v. Increase representation and diversity: Take proactive measures to increase the representation of women in decision-making bodies, leadership positions, and professional networks within the surveying and geo-informatics industry. Encourage organisations to adopt diversity and inclusion policies and set targets for gender representation.

vi. Address bias in recruitment and promotion processes: Implement fair and transparent recruitment and promotion processes that actively challenge biases and promote equal opportunities for all candidates. Provide unconscious bias training for recruitment and selection panels to minimise gender-based biases.

vii. Foster mentorship and networking opportunities: Develop mentorship programs that connect women professionals in surveying and geo-informatics with experienced mentors who can provide guidance, support, and networking opportunities. Encourage the formation of women-focused professional networks to facilitate knowledge-sharing and career development.

viii. Improve access to funding and resources: Advocate for increased funding and resource allocation to support women's participation and advancement in surveying and geo-informatics. This can include scholarships, grants, research funding, and access to necessary equipment and technologies.

ix. Enhance supportive policies and initiatives: Advocate for developing and implementing supportive policies and initiatives that address the unique challenges women face in the field face. These can include policies related to parental leave, flexible working arrangements, gender equity, and workplace harassment prevention.

x. Increase visibility and recognition: Promote the visibility and recognition of women professionals in surveying and geo-informatics by highlighting their achievements, expertise, and contributions. Encourage industry awards and recognition programs that actively promote gender balance and diversity.

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