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Environmental Estimates and Effectiveness of BIPV (Building Integrated Photovoltaic)-Based Sustainable Homes in Khartoum Suburban

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Abstract: This study assesses energy conservation for urban building designers. The appropriate design for daily climate factors. These two issues are essential to urban energy as the major principles, especially in developing countries with hot, dry climates. Generally, they are considered a combination of an improved design that meets the user's environmental need to apply the sustainability of urban areas that manages environmental concerns to produce the most energy-efficient urban or residential design by using BIPV. The study's primary goals are to evaluate environmental indicators in domestic settlements using BIPV in Khartoum and to develop urban planning strategies for implementing residential building design (BIPV). The method began with a survey at(Alazhari City) a Suburban of Khartoum. Citizen users of this technology, the study concluded that environmental characteristics must be included in the design to avoid errors and that the public accepts the BIPV. Architects can also design a low-cost, easy-to-maintain plan. With system funding, authorities can import it. Individually. The urban strategy level approaches are expected to have environmental and sustainability planning. The building serves the tenants' activities. A house utilizing (BIPV) systems in the urban area of Khartoum was created with high functionality, durability, and beauty, including sustainability and the whole requirement of architectural design with its adequate environmental effects.

Keywords: *Environmental, Building Integrated Photovoltaic, sustainable, Khartoum, urban*

1. Introduction

There is increasing concern about the quality of built environments for the construction and design of buildings that change over time, as well as growing awareness about the destruction of the natural environment. The building envelope is at the heart of the necessary changes.[1]. In addition, electricity demand will similarly differ [2]. Additionally, meteorological information provides typical monthly sunlight levels for various geographic regions. This considers things like altitude, humidity, and other delicate elements, as well as precipitation and cloudy days.[3, 4] observed that the During this time, the concept of sustainable development in urban areas was becoming incredibly common. This idea has been introduced in connection with various city forms, with the current version focusing on sustainability as an issue of great importance (Building Integrated Photovoltaic). Undoubtedly, it has encouraged and provoked academics and professionals from a range of disciplines to search for human settlement patterns that will satisfy sustainability standards and allow built environments to function more efficiently than they currently do[5]. As indicated by [6], the sustainable development concept has significantly influenced the impact particular urban designs might have on reducing energy usage and pollution. This issue has led experts, planners, civil society organizations, and governments, either local or beyond, to suggest purportedly new frameworks for designing and structuring metropolitan areas to achieve sustainability. As indicated by [7, 8], Various strategies addressed issues at many spatial scales: (1) regional and metropolitan levels, such as the Bio-Region strategy; (2) city scale; (3) community scale; and (4) building scale. A careful analysis of these strategies reveals a lack of consensus regarding the ideal urban shape in terms of sustainability. The key finding of this study was that BIPV(Building Integrated Photovoltaic) could be integrated into building roofs since building envelope integration is frequently required if the system is to be financially sustainable. [9]. Also, guiding them if they can create an architectural design using a low energy consideration and approximate application of BIPV since both are significant. Therefore, as [10] designing a low energy house using BIPV in terms of architectural design quality that is appropriate for the social and economic behaviour of Sudanese habits is needed. Now in Khartoum there no idea of the need to achieve a house consideration using BIPV with a sustainable design with an optimum architecture design with urban planning requirement and determine the advantages of the application and its benefits to the community. the main goal of the inquiry To determine the environmental influences of using BIPV in Alazhari City-

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Khartoum suburban and their effects such as citizen culture, local architects; design practicing in the domestic sector, weather and climate and barriers of officially distributing BIPV.

Influences of Environmental Impact of (BIPV)

According to [11, 12][12] and[13], The public's comprehension and view of this increasing renewable technology are essential since these effects and opinions of what the public sees are true are actual. The public's thoughts on whether P.V. technology is acceptable; more effective ways to get people to use this technology could be found. Even though there are a lot of helpful barriers to finding and implementing solutions for new renewable energies like P.V. [14], they shouldn't be considered rigid. Instead, they should be seen as a framework for finding and analyzing solutions. [15, 16] includes the significant factors influencing energy consumption, such as the country's development, population increase, and economic development. The proposed remedies are improving public perception of the need for a lower population growth rate, maintaining a high growth rate, or using renewable energy resources[17]. [18] evaluated the environmental impacts of traditional energy sources and cattle to calculate the environmental impact. Compared the ecological effects of conventional energy sources, computed the total environmental benefit[19], and provided information on the most significant environmental impact.[20]. [21] and [22]discussed P.V. that has an ecological effect on producing clean energy. The ideal application for P.V. in the urban environment takes advantage of the distributed nature of sunlight and electric charge [23, 24]. The benefits of BIPV systems and P.V. electrification schemes are that they could regenerate the rural areas and help the relationship with the users to be integrated; an architectural integration as an opportunity for the formation of the market[25]. In fact, the benefits from BIPV aid in the construction and thus overcome the barriers of different regimes [26].

2. Data of the Location

The Physical Features of (Alazhari City) Khartoum Suburban

According to [27, 28], greater Khartoum is the name given to the capital of Sudan in the urban combination of the three towns at the meeting place Khartoum, Khartoum North, and Omdurman, on the Blue and White Niles. at latitude 15◦ 36 N and 32◦ 32 and altitude 96.520 m2 above sea level. Sudanese capital covers an area above 22,122 km2 [29] and [30]. The topography of Land is generally in Alazhari City as a part of Khartoum state was flat with a gradual slope towards the north and the Nile. In the west, the Land was bear with Nubian stone and water-bearing sedimentation formation. The South is covered with 30 meters of thick darkness and a heavy slit called Gezira clay.

Climatic Conditions

[29] and [31] The climate of Greater Khartoum, which is located on the southern border of the Sahara desert, has been characterized as a hot desert. The climate is hot and dry from November to May, with a three-month milder season between December and February. From June to October, a three-month rainy season occurs. Therefore, at least 60 per cent of the annual precipitation is deficient, and the sloping ground is exposed to considerable erosion. With annual evaporation rates over 3000 mm, the average rainfall is only 150 mm. This wind direction follows a consistent pattern[32] and [33].

Grid Planning Used in Khartoum and (Alazhari City) Khartoum Suburban

The simple gridiron was used as the housing pattern in almost all urban planning. There didn't seem to be any reason to change the way planning had been done for nearly 50 years, and only a few minor changes were made. One version demonstrates the pattern in its simplified form, including all roadways travelling through the major roads and traffic surrounding the open areas. What transpired in Ash-Shabiyya is depicted in Figure 1. if the location of all the services is central Dar es Salaam, [34]; [35]. The planning of Alazhari city [36].

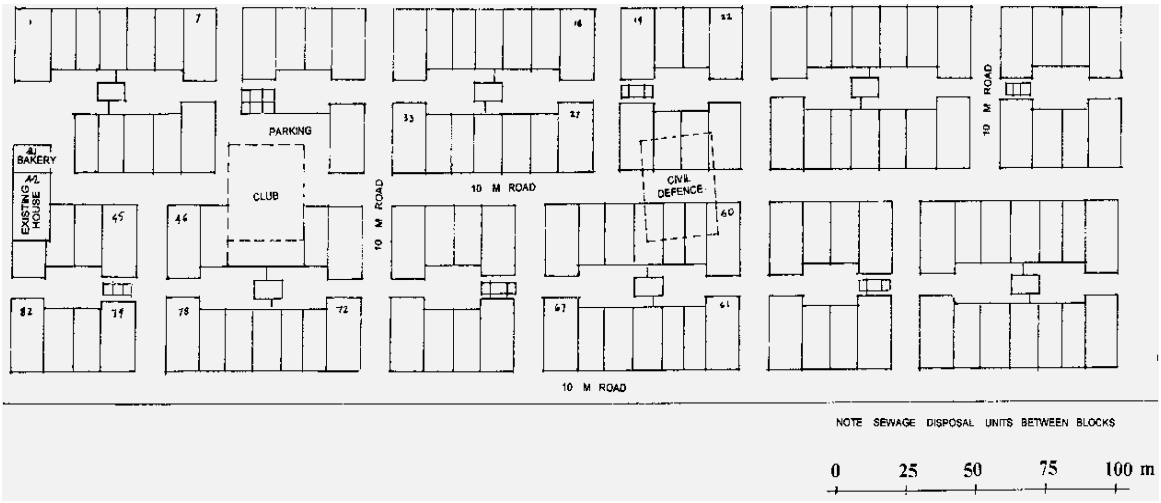

Fig.1 Grid planning in Khartoum

3. Methodology

[37] stated that this measure of understanding is a framework for analysis and the basis for determining areas that concern the research concerning public perception regarding these developing renewable energy sources. In Al-Azhari, the statistical test of all samples and the BIPV service patterns for all study blocks were produced. In the study, randomly selected participants were used to identifying the location, as shown in figure 2.

Fig.2 Module Placing on Top of the House's Roof at Alazhari City

3.1 Methods used in Collecting Data

According to [38], questionnaires are a reasonable method for collecting data from a significant number of respondents. They are frequently the best feasible way to reach many critics to facilitate statistical outcomes analysis. In the study, we investigate how some families' conditions have changed over time. As part of this research, the historical overview of the location was done as detailed in Chapter 3 to identify the location's background and determine the barriers and positive views concerning the use of BIPV, as shown in Figure 3.

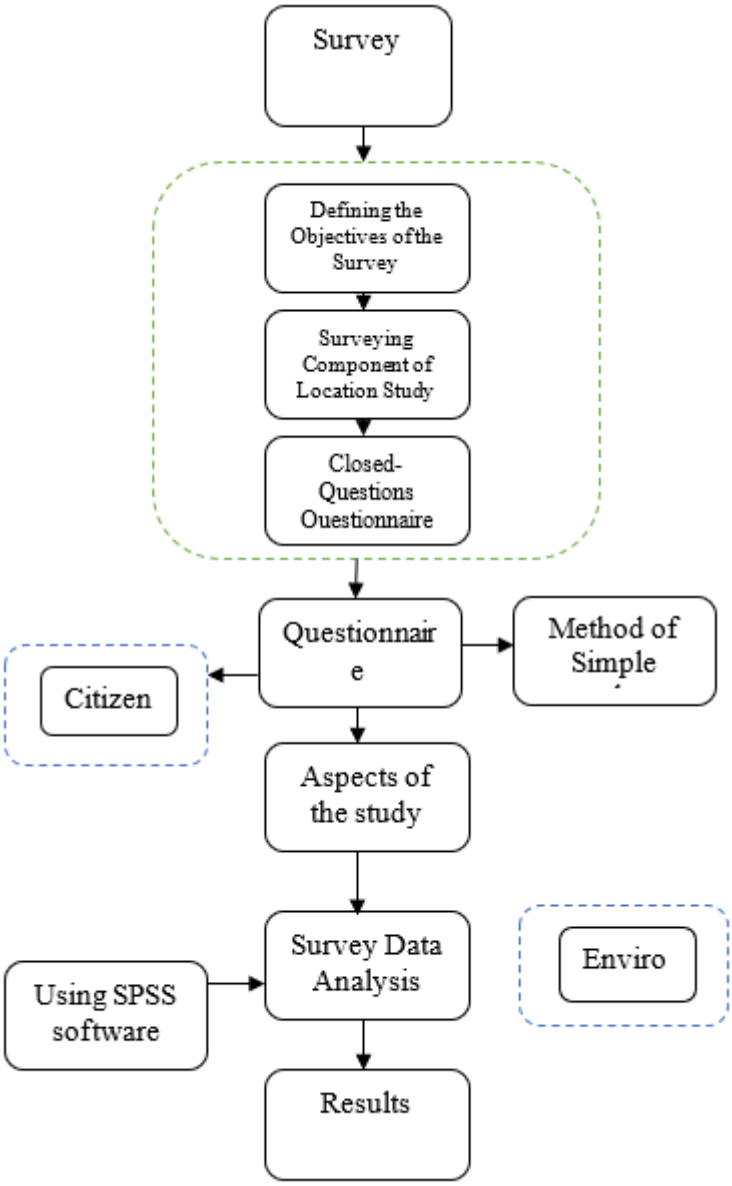

Fig. 3 Flow Chart of Survey

Objectives of the Survey

This part of the study demonstrates the importance of well-defined objectives in the survey location: Collecting data for further users. Assessing the public perception of the acceptance of P.V. technology can be considered a more effective strategy in applying the programmes for the adoption of this technology, not only to identify the issues facing the residents of the location studied in the provision of BIPV. Developing BIPV has a variety of roles for the authorities, communities and householders in the area.

Surveying Component of Location Study

This study is applied to the area under Investigation, Alazhari City, through personal meetings with individuals in government and at the local level, by direct observation of the area, the population, and the public services related to this study. Surveying, registering, and analyzing the services rendered to the inhabited regions of Alazhari City, including its three classes. The details of the location requirements are shown later in this chapter. The central aspect of the study is the Environmental Aspect, Studying health and environmental threats because of improper usage of services and how individuals are affected by inappropriate environmental behaviour and the role of formal authorities in this phenomenon.

Field Study Procedure of Research Sample

- **Citizens**

The researcher tested the samples through a random selection of localities at Alazhari City. At that point, the researcher started selecting a model in Alazhari City Block No.10. This involved 723 households, of which 249 used BIPV. The researcher refers here to community members who use BIPV directly. These citizens have a right to have input into where their contributions are being

spent. Even in locations where communities have voiced disapproval of new facilities, they have been built anyway. Furthermore, the exclusion of concerned citizens negates the possibility for conversation towards innovative social change and holistic inclusion as stead by [39, 40]

Method of Simple Random Sampling

The stated objectives of statistical application are collecting, presenting, analyzing, and interpreting data. The first process is gathering information. The assumption of the randomization applied in data collection is the foundation for the majority of methods for statistical analysis. [41]. The applications of statistical analysis and the related interpretation of the analysis are useless when the assumption of randomized controlled sampling cannot hold. Therefore, before studying the methodology of statistical analysis, one must obtain knowledge of sample.

- **Sample of the Study**

Obtain a representative sample of eligible respondents and a list of households [42]. The database randomly selected 50% of the total households (n = 249) and 50% of households that used BIPV. The list indicated each householder's name, mailing address, and race of each potential respondent. The focus for selecting a random sample is on the statistical sampling and estimation methods. It focuses on sampling applications, covering the design and implementation of sampling for the surveys, including the three different questionnaires used. The researcher chose the sample from Alazhari City Block No.10. Of the 723 families that live there, 294 use a BIPV system. The researcher took a random sample house by house, and the sum of this sample was 147 (50%) of the basis of the field of study.

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4. Result and Discussion:

BIPV Statius at Alazhari City Block 10 suburban of Khartoum:

The installed BIPV roofing systems produce from 0.35 to 1.25 kW D.C. Households are connected to the local distribution system for home and apartment owners can illustrate power while combined as they need it. The grid-connected system generates additional electricity. Location; Alazhari City, south of Khartoum state, Product; P.V.: integrated with the roof, translucent clear laminated glass. Gross PV Surface Area; is an area of 1-2 m2. P.V. Cell Type; Monocrystalline silicon. The solar system installed in the city is shown in Figure 4.

Environment Impact Citizens Participant

The research data was collected using questionnaires and processed using the SPSS statistical software. The variables of this study were defined and processed for further analysis. However, there are two types of variables: (1) Demographic variables and (2) The measurements of different concepts regarding this study. Demographic characteristics included gender, race, education level, age, the number of families residing in a specific home, homeowners, and household income. Gender Category In this research, both male and female citizens were questioned about their opinion. The sample of the citizens consisted of 80.27% (n = 118) from the male category, while female respondents represented 16.33% (n = 24). Age Category The outcomes of this research also indicated that 48 (32.65%) of the respondents were over the age of 51, 83 (56.46%) of the respondents were in the 40–50 age group, but 3 (2.04%) of the respondents were younger than the age of 25, 12 (8.16%), in the 26–39 age range, and 83 (56.46%) were in the 40–50 age group. The results showed that the 22–23-year category forms the majority of respondents, with 32% of the total respondents. Level of Education It has been found that 48.98% of the respondents had a secondary school qualification, while those with university degrees represent 30.61% of the citizens participating in this study. On the other hand, citizens who finished only their intermediate school represent about 17.01%. This was done to gather data on the perception of both these sets of citizens. Consequently, it significantly challenges minimum knowledge about P.V. to define BIPV. Refer to Table 4.1. The obstacle to addressing this problem is the public's lack of understanding of P.V. technology that serves as [43, 44]. Number of Families in the House, Housing Ownership and Income, The number of families in the house was found in the category of one family is 125 (85.03%), whereby two families categories represent 17 (11.56%). In addition to this information, citizens were also asked for their house ownership, whereby only 3% stayed in governmental houses. The income of this group majorly fell in the category of 500,000 to 999,000 Sudanese pounds, representing about 80.95% of the study samples. People's income of more than one million and above represent 15.64%, while those with average incomes (25,000 to 50,000 Sudanese pounds) are 3.4% identical in Table 1.

Fig. 4. BIPV Systems were Installed on a different building at Alazhari City

Table 1 Distribution of Frequencies of Gender, Age, Level of Education, House Ownership and Income (Total of Samples = 150)

Variables	Frequency	Percentage
Age		
20-25 years old	3	2.04
26-39 years old	12	8.16
40-50 years old	83	56.46
51 years and above	48	32.65
Gender		
Male	118.00	80.27
Female	24.00	16.33
Level of Education		
Illiterate	1	0.68
Intermediate	25	17.01
Secondary school	72	48.98
University	45	30.61
Postgraduate	2	1.36
No of Families in the House		
One family	125	85.03
Two Families	17	11.56
Housing Ownership		
Cement block House	3	2.04
Brick Cement	53	36.05
Earthmen	38	25.85

Redbrick	50	34.01
House Hold Income		
Average (250, 000 to 500,000) Sudanese pound	5	3.40
High (500, 000 to 999,000) Sudanese pound	119	80.95
Very High (One million and above)	23	15.64

Distribution of Houses According to Heights, No of Rooms, Direction of building and Module Direction

Based on the results, it was determined that as many as 114 respondents (77.55%) built their houses in one block format, 23 respondents (16.65%) built their homes in multiple floor format, and nine respondents (6.12%) had a place in different design. Houses of citizens involved in this study have other numbers of rooms. Houses with one room are 14 (9.52%), two rooms are 45 (30.61%), three rooms are 61 (41.50%), and four rooms and above are 27 (18.37%). In Sudan, most of the houses have the direction South. Similarly, in this study, citizens' homes have the same trend (n = 142, 96.60%). Table 2 shows the distribution of houses according to the heights, the number of rooms, and the direction of the building and inlet direction that obtain residential areas. These are not considered in the third class of electricity plan for services. These are often around 40% of the population of Khartoum state. This segment is the essential target for future users of BIPV techniques. The possibility of power outages is considerable. Therefore, it is a must to be used in various ministries and state institutions for their ability to afford the initial cost, which constitute one of the most important problems facing the use and proliferation [45].

Table 2. Distribution of Houses (Total of Samples = 150)

Variables	Frequency	Percent
Height of the Buildings		
One block	114	77.55
Multiple floor	23	15.65
Other	9	6.12
No of Rooms		
One room and toilet	14	9.52
two rooms and toilet	45	30.61
Three rooms and toilet	61	41.50
Four rooms and above	27	18.37
Height of the Buildings		
Wooden modules	31	21.09
Cement block	84	57.14
Marsellia	24	16.33
Slopping Marsellia	7	4.76
Directions of Buildings		
North/South	142	96.60
East/West	0	0
Others	5	3.40

Inlet Direction		
North/South	140	95.24
East West	1	0.68
Others	5	3.40
Positioned in inlets		
Distributed in inlets	133	90.48
Horizontally Positioned in inlets	9	6.12
Vertically Positioned in inlets	5	3.40
Inlets Height Form The Ground		
> 90cm	1	0.68
> 120cm	2	1.36
150cm	7	4.76
Very High	137	93.20

Descriptive Statistics for Measure of the Use of BIPV (Natural)

The use of the modules in the homes (natural) of Sudanese citizens was evaluated by the citizens themselves. A grading scale of the significance (low, medium, high and very high) of the 23 items forming the measure was adopted. The frequency of the detailed response of the total sample was (n = 150) is shown in Figure 5. Some factors have been scared to be of high importance, such as 'It doesn't affect the home environment', 'It doesn't occupy a large space in the house', 'It has no repeated failure to distribute the current', 'Installation on the roofs is positive', 'Placing cells in the house yard will expose it to break down', 'The movement in the yard will be easy if the cell space is small' and 'The building aesthetic appears when cells are placed on the roofs'. The quality of these modules used in the design is relatively easy to install and maintain, which is suitable for its efficiency [44]. The Sudanese Building Integrated P.V. Programme has been used since 1995, but it was not influenced a majority of the urban residential population in Khartoum [46] and [43] and [47]. What was obtained the citizens found Their presence as an essential part of the design of the house did not affect this building or its efficiency, which helped the architect to design with flexibility, efficiency and beauty [48].

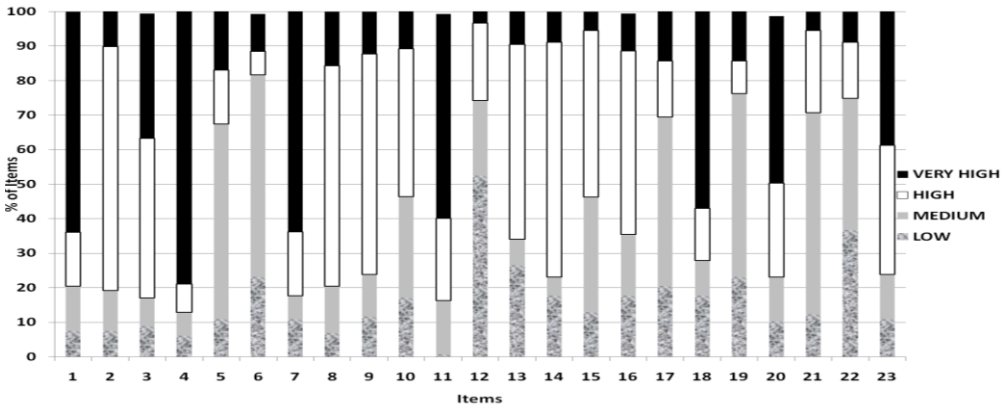

Fig. 5. Perception of Citizens on the use of Modules in Homes (Natural)

1 It doesn't affect the home environment.
2 Easy access and inclusion.
13 Inlets are suitable for installation.
14 The number of modules used increases as a result of increase in customers.

3 Easily maintained.
4 It doesn't occupy a large space at the house.
5 It supplies the required energy at a suitable price.
6 It has no repeated failure to distribute the current.
7 It is an alternative to the power supply for the national electricity corporation.
8 Easy access to the solar energy.
9 It must be preceded with enlightenment.
10 I will buy it if it is available at market.
11 Installation on the roofs is positive.
12 The wall is suitable for installation.
15 Government units will adapt this invention.
16 It is preferable to be under private companies.
17 Placing cells in the house yard will expose it to break down.
18 The movement in the yard will be easy if the cells space is small.
19 Using the cells integrated on shading is more easily.
20 The building aesthetic appears when cells are placed on the roofs.
21 The building aesthetic appears when cells are placed on the walls.
22 The building aesthetic appears when cells are placed on the shading on window.
23 Integrates the cell on the window close the air movement and sunlight.

Descriptive Statistics for Measure of Environmental Aspects of Cells on the Surroundings

The citizens themselves evaluated the environmental aspect use of a Sudanese citizen. A score scale of the significance (low, medium, high and very high) of the nine items forming the measure was adopted. The frequency of the detailed response of the total sample (n = 150) is shown in Figure 6. Some factors have been scored high, and the cell will be damaged if it is integrated with a window; The rainy season isn't influential to the cell; Some factors have been scored to be of the medium; P.V. cells are not a source of heat at night, The array price for the sufficient energy is affordable. The cells are damaged if it integrates on the wall; Silicon cells are the strongest type. They resist environmental factors, and it doesn't occupy a large space in the home. Some factors have been scored to be low; the cells might be damaged if the inclusion is positioned on top of the roof because of the effect of the sun's rays, especially in Sudan, since the damages often occur on P.V. modules due to heat and direct solid sun rays which is a typical case in Sudan. 83.8% of respondents thought utilizing renewable energy would decrease environmental issues. [43] and [45]. The study found that the basic modules of Alazhari City do not significantly affect the surrounding environment but positively serve the environment. As [49] found, it is easier for citizens to deal with the modules in all environments than the usual power generation.

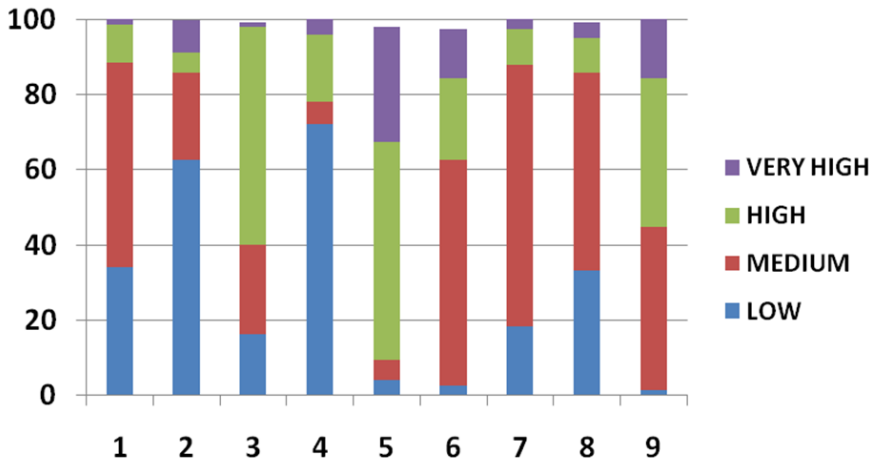

Fig. 6. Descriptive Statistics for Measure of Citizens of Environmental Aspect

1 P.V. cells are not source of heat at night.
2 P.V. cells are always damaged by sun rays and cause failure to the cell
6 The cells are damaged if it integrates on the wall.
7 Sun beam and erosion factors will weaken the cells.

3 The rainy season doesn't influence the cell.

4 The cell is damaged if inclusion in the roof.

5 The cells are damaged if it integrated with window.

8 Silicon cells are the strongest type and resist environmental factors.

9 It doesn't occupy a large space in the home.

Table 3. Reliability Coefficient of Study Instruments

Study Instruments	Number of items	Cronbach alpha
The use of modules in homes (natural)	24	0.78
Environmental impact of cells on the surroundings	9	0.74
Social aspects of the solar energy	13	0.94

Correlation of overall indices (The use of modules in homes (natural), The technical aspects, The economic aspects, the Environmental impact of cells & Social factors of the solar energy) Using Pearson Correlation Coefficients concerning Benforroni alpha.

The relationship between the variables (The use of modules in homes (natural), the technical aspects, the economic aspects, and the environmental impact of cells & Social factors of solar energy) was studied using the Pearson Product Moment Correlation coefficients. Data of such variables were tested for the assumption of linearity and normality of the distribution; however, these variables are interval data constructed through the computation function in SPSS. The items on each scale were summated and divided by their number to obtain the average cumulative score for each variable. The data have shown no violation of the assumption of normality. The correlation coefficient was tested for its statistical significance using statistics, and the respective probability value was corrected using Benforroni Method [50, 51] and[52]. This Benforroni correction was made to avoid the misleading inflation of type 1 error. As shown in Table 3 , the strongest linear relationship is noticed between the technical aspects and the environmental impact of cells on the surroundings ($r = 0.748$, $p = 0.00$). This relationship between the technical aspects and environmental impact of cells on the surroundings has a positive direction which means that the environmental impact of cells on the surroundings could be improved by the concentration of the factors that lead to the increase of the level of the technical aspects also [53].

The second highest relationship was found between the social aspects of solar energy and the economic aspects ($r = 0.546$, $p = 0.00$). This relationship could be described statistically as a moderate positive linear relationship Table 3. The next highest relationship was noticed between the economic aspects and the environmental impact of cells on the surroundings ($r = 0.523$, $p = 0.00$). Surprisingly no significant relationship was observed between the use of modules in homes (natural) and the Environmental impact of cells on the surroundings ($r = 0.021$, $p = 0.804$). In the same range. [54] using SPSS, The Chi-square (2, p. 05) test and other non-parametric tests were used to look for statistically significant correlations and associations with data that was not regularly distributed. Afterwards, the analysis was carried out using the six main categories of Trudgill's framework: agreement, knowledge, technology, economic, social, and political. So, the urban housing market isn't adequately informed on BIPV technology. To combat this, a more comprehensive BIPV education program should be introduced using more prominent communication channels, such as television and the internet. Table 4 Correlation of overall indices (The use of modules in homes (natural), The technical aspects, The economic aspects, Environmental impact of cells & Social factors of the solar energy) using Pearson correlation coefficients with its respect to Benforroni alpha also [55] and [56] observed same results.

Table 4 Correlation of Overall Indices

		USE	ENVIRO
USE	Pearson Correlation	1	0.021
	P-value		0.804
	P-value		0.017
ENVIR	Pearson Correlation		1
	P-value		

* Statistical significant correlation at 0.05 (Error Type 1)

** Statistical significant correlation at 0.01 (Error Type 1)

USE: The use of modules in homes (natural), ENVIRO: Environmental impact of cells on the surroundings.

Comparison between male and females in the overall indices (The use of modules in homes (natural), and Environmental Impact of Using t-test

The t-test determines if the two groups' means differ statistically, as shown in Table 5. Any time you want to compare the means of two groups, this technique is acceptable. The mean difference in USE (The use of modules in homes (natural)) between males (n = 118) and females (n = 24) was compared using a two-tailed independent samples t-test. The alpha = 0.05 Type I error rate was chosen. Males (M = 2.73, SD = 0.21) and females (M = 2.76, SD = 0.15), according to the data, do not significantly differ from one another (t (140) = -0.769, p = 0.446). Using a two-tailed independent sample t-test with a significance level of 0.05, the mean TECH (The technical aspects) for males (n = 118) and females (n = 24) was statistically compared. According to the data, there is no statistically significant difference between the mean scores for men (M = 2.36, SD = 0.26) and women (M = 2.37, SD = 0.23), p = 0.782. Similarly, there is no substantial difference between men and women on social elements of solar energy. Male (n = 118) and female (n = 24) ECONO means were statistically compared using a two-tailed, independent sample t-test with a significance level of = 0.05. t (140) = -3.230, p = 0.002 indicates that average male scores (M = 2.41, SD = 0.17) are considerably lower than average female scores (M = 2.53, SD = 0.17). Similarly, there are considerable differences between males and girls in the environmental influence of cells.

Table 5 Results of an Independent Sample t- Test Based on Respondents' Gender

Variables	Sex	N	Mean	SD	t	sig-t
USE	Male	118	2.73	0.21	-0.769	0.446
	Female	24	2.76	0.15		
ENVIRO	Male	118	2.20	0.30	2.786	0.004
	Female	24	2.02	0.25		

SD (standard error), t (t-test), p (value of the test), sig-t (significant test), F (statistic ratio for ANOVA), N (Number)

USE: The use of modules in homes (natural), , ENVIRO: Environmental impact of cells on the surroundings.

Comparison between categories of Age, Level of Education, Ownership & Income in the overall indices (The use of modules in homes (natural), environmental impact of solar energy cells) using the One method ANOVA.

One-way variation analysis (abbreviated one-way ANOVA) is a statistical technique for comparing the means of two or more samples (using the F distribution). This method can only be applied to numerical data. The ANOVA test the assumption that samples from two or more groups came from the same population. Comparison between categories of income the overall indices (The use of modules in homes (natural), The technical aspects, The economic aspects, the Environmental impact of cells & Social aspects of solar energy). One ANOVA test revealed that there is a significant difference ($p<0.05$) among citizens with varying incomes. Comparison between categories of house ownership and the overall indices (The use of modules in homes (natural), The technical aspects, Environmental impact of cells) using One way ANOVA revealed that there is a significant difference ($p<0.05$) based on their house ownership except for the social aspects of the solar energy ($p>0.05$). On the other hand, citizens from different levels of education are statistically different in all the indices ($p<0.05$) except for the use of modules in homes (natural) ($p>0.05$). The economic aspects index is statistically different between different categories of age. Age does not affect statistically ($p>0.05$) the indices of the use of modules in homes (natural) as [49], environmental impact of cells & and solar energy. Table 6 shows the comparison between categories of Age, Level of Education, Ownership & Income in the overall indices (The use of modules in homes (natural), the environmental impact of cells & social aspects of solar energy) using One way ANOVA.

Table 6 Comparison between Categories

Variables	Age		Level of Education		Ownership		Income	
	F	Sig.	F	Sig.	F	Sig.	F	Sig.
The use of modules in homes (natural)	2.09	0.10	0.58	0.68	2.67	0.049	17.66	0.00
Environmental impact of cells	2.34	0.08	4.50	0.00	3.24	0.020	12.24	0.00

5. Conclusion

As a developing nation, Sudan is experiencing a rapid urbanization process; the percentage of urban areas is expected to increase significantly shortly. Thus, it is essential to identify the obstacles to urban housing in Sudan and to study and develop strategies for the penetration of architectural integration into public housing in Sudan. The study's objective was to explain and describe the evolution of designing a clean and low-energy home with BIPV towards green architecture and technological innovation of BIPV systems in Alazhari city as a prerequisite for urban design in a city. The concluding results of this research were from a survey of the citizen of participants. The survey was tested and evaluated using BIPV from the three respondents' perspectives. Concluding that the most common uses of BIPV atheistic residential areas are not considered in the third class, a residential area which is a significant class. Most BIPV technologies are at an early stage of technological development and market penetration, and the amount of information on technology and resources is limited; therefore, the design of BIPV systems in Khartoum State-Sudan is not well known. The electricity plans for services often cover around 40% of the population of Khartoum state, and the possibility of power outages is considerable. These third-class residential areas segment is the essential objective of applying the BIPV in the location. The study concluded that the BIPV could also be used in various ministries and governmental institutions since they can afford the initial cost, which constitutes one of the most critical problems facing its use and proliferation. In terms of utilization, the study concluded that the arrays used in the existing design are relatively easy to install and maintain and are suitably efficient since the integrated arrays on the roof of the house, which is easier and economical to install, were the most suitable for efficiently generating energy more than integrating it with any other part of the building. Besides, it is comparatively easy to install on the roof and quicker. It is more aesthetically acceptable than any other part of the structure. The study concludes that it is environmentally friendly and easier for consumers to deal with in all environments. Compared to the usual provision of power from the National Electricity Corporation, it produces large rates. The study of the social concludes that it is accepted by the community to share BIPV system in more than one house. Most studies of consumer choice of power systems have shown that consumers will choose "clean energy", i.e., renewable, even if their cost is slightly more than that produced by conventional fossil fuel or nuclear plants

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