Vernacular Architecture

Research

The Role of Natural Materials and Simple Techniques for Making the Sustainable Dwellings

By

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Abstract

Controlling energy consumption has been among one of the most researched areas in the field of architecture. Buildings play remarkable roles in leaving impacts on the environment and natural resources, and they utilize a great amount of energy all around the world. The world presently is confronted with a series of energy consumption and environmental challenges. The present study attempts to tackle these problems. Furthermore, so as to attain the aim of the research, vernacular materials and simple construction techniques are utilized as means of resolving the challenges which have become a major area of interest in recent decades. The methodology that is used to deal with these issues is through the description, summarizing, and the analysis of three research papers that are directly related to the study title in order to define the major results regarding the answer of the research question which is 'Is the vernacular natural materials and their simple techniques have a role for making dwellings more sustainable?'. The hypothesis states that vernacular natural materials and local construction strategies play a magnificent role in creating sustainable dwellings. The conclusion of the result discussion highlights that the vernacular materials and their simple techniques have numerous interrelated properties which have a less negative impact on the environment as opposed to industrially produced materials, and in terms of the sustainable indicators, they are acceptable environmentally, socially, and economically.

Keywords: vernacular architecture, natural material, simple technique, sustainability, dwelling

1.Introduction

Buildings have considerable effects on the environment and natural resources all over the world.(Chandel et al., 2016) According to the same reference, buildings account for 45 percent of global energy consumption. Contemporary materials absorb energy in the form of operational and embodied energy in construction transportation and maintenance. (Shukla et al., 2009)

The use of industrially manufactured materials in modern architecture has resulted in a universal architecture that is heavily reliant on energy consumption. (Crawford et al., 2006)The planet is currently confronted with a number of major energy and environmental problems. Energy demand is on the rise, and prices are constantly fluctuating. (Alrashed et al., 2017)

The associational material value looks to be strongest when the materials keep evidence of their origins.(Golden, 2017) Traditional construction materials such as wood, stone, and clay are seeing a resurgence because they provide durability where more labor-intensive and expensive materials like (reinforced) concrete, fiberglass, glass, and steel are unaffordable. (Creangă et al., 2010)

In recent decades, the perceived sustainability of vernacular architecture has become a popular issue. A large number of publications have appeared in the last fifteen years or so that examine the

degree to which particular types of vernacular architecture can be said to be sustainable, with the aim of identifying lessons to be learned for contemporary architectural design (Mileto et al., 2014) Vernacular architecture is the product of hundreds of years of practice by people living in various climates around the world. (Chandel et al., 2016) It entails using locally available resources to design and create structures based on people's natural, cultural, and historical backgrounds. This architectural style is built with climatic and energy-saving features in mind, resulting in improved thermal comfort.(Chandel et al., 2016)

Natural resources can be harnessed by using locally available building materials and traditional construction techniques to fill the gap between traditional accomplishments and new needs. Vernacular architecture, a type of architecture focused on localized needs and construction materials representing local practices, is one such application that has developed intuitively.(Aminu Dodo et al., n.d.)

This study delves into a variety of scientific papers and books that are related to the role of using natural materials such as stone, mud, vegetable materials, Bamboo, earth materials…etc. and various vernacular simple techniques like (Adobe construction, Wattle, and Daub, Timber framed, Rammed earth …etc.) for making the sustainable dwellings and their roles to solve architectural problems facing present days.

2.The problem statement and the research aim

All around the world, buildings affect environmental and natural materials and utilize 45% world's energy. Contemporary architecture is greatly relying on energy utilization which makes use of industrially produced materials.(Chandel et al., 2016) This has led the world to face a sequence of serious energy and environmental challenges.(Crawford et al., 2006)

The current review aims to deal with these problems that confront present-day architecture, and seeks the advantages of vernacular materials and simple local techniques as well as using them as an alternative for sustainable dwellings.

3.The research question

The research question of the present study is 'Is the vernacular natural materials and their simple techniques have a role in making dwellings more sustainable?'

4.The hypothesis

The hypothesis states that these natural materials and their construction techniques play a role in making sustainable dwellings.

5. Data collection and methodology

The study consists of a review of related literature on papers and books that are directly in relation to the paper title. The procedure of the review includes the following major steps: (1) defining the

research scope and defining the most important key words used to search in books and papers; (2) collecting papers and books which are direct to the research title or includes a number of important elements of the title of the research: and (3) analyzing the content and pinpointing the improvements of the research that have been shown in the articles.

Upon exploring the related books and papers on the internet so as to collect related materials on the titles, we read them and pick the ones which were very related to the title. Three related papers were left to undergo reviewing and several scientific publishes and books were employed to gather general information. (As shown in figure 1)

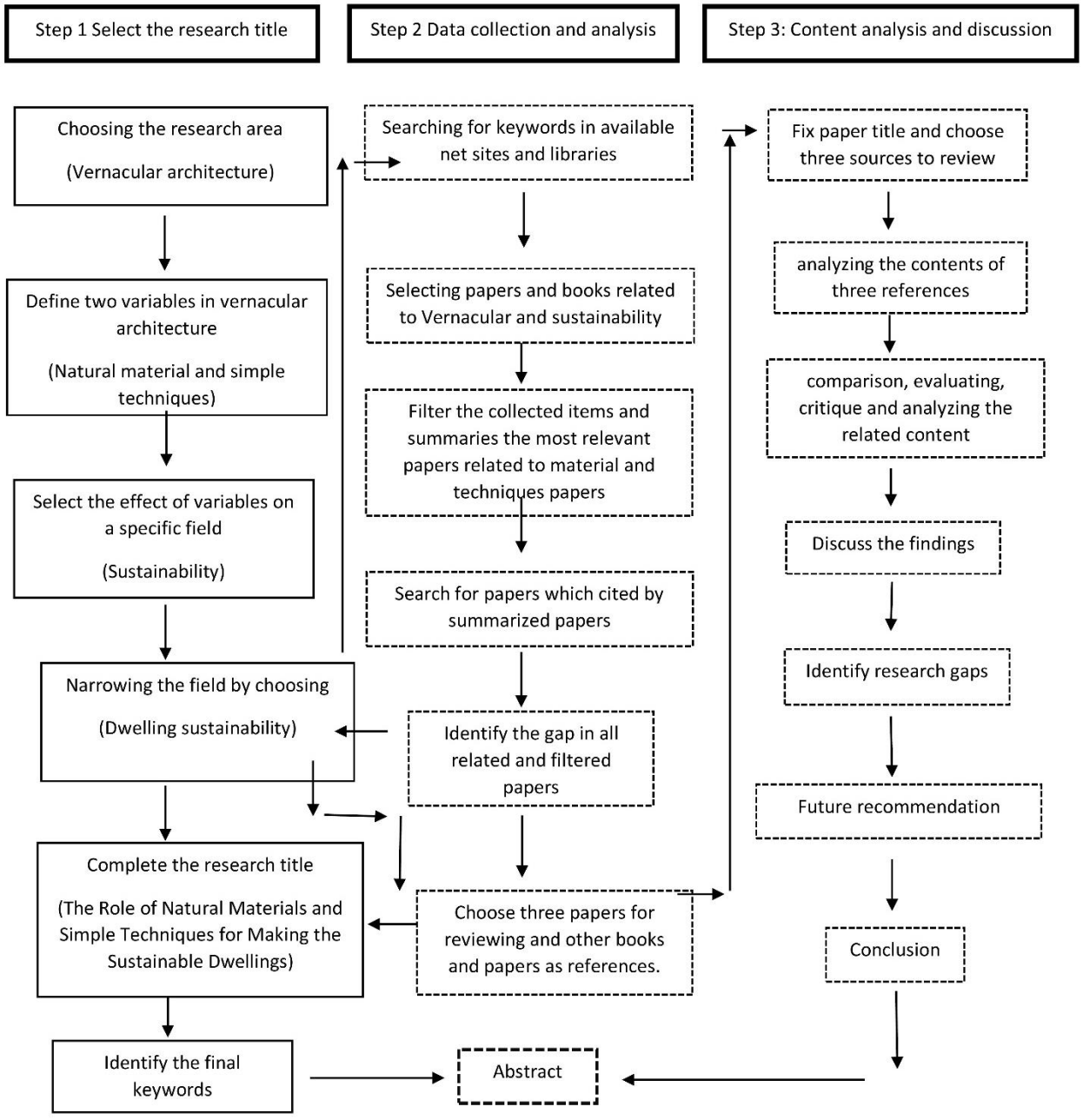

Figure (1): The data collection and methodology procedure. **Prepared by the researcher**

6. Literature review and case studies

This review paper exams vernacular materials and its simple construction techniques as variables for making sustainable dwellings by evaluating with environmental, economic and social indicators. Searching, summarizing and filtering out papers relates to this paper review title, it is concluded that three papers directly related to mentioned subject and could depended upon us references to answer the research question and achieve the aim of the study.

The first reference which is used for reviewing is (JEP Fernandes et al., 2013). This study established the benefits of natural vernacular materials and it using procedure in Portuguese and compared them with new materials and construction techniques by presenting different examples combining with quantitative and qualitative analyses using the deductive approach in research methodology. The study discussed the Portuguese vernacular architecture generally and the main natural materials such as straw, timber, and different types of earth materials, as well as the simple construction method for contextual vernacular architecture. The reference established the benefits of adopting these local materials and using methods as well as comparing to the sustainable indicators; environmentally, economically, and socially.

The second selected paper for reviewing is (Agyekum et al., n.d.). The study exams the expert's opinion about vernacular building materials and local construction techniques in Ghana by using questionaries survey make researchers enable to generalize the findings from a population sample. As a literature review, the paper defined vernacular architecture and its materials like Bamboo, timber, and grass, with their advantages in terms of sustainability, as well as local construction techniques such as Adobe construction, and Wattle and Daub. The research discussed the importance of these materials and techniques for green building in Ghana by analyzing the result responses and illustrate them with bar charts.

The third reviewed reference is (Aminu Dodo et al., n.d.), The reference focuses on using vernacular materials and their construction techniques to solve nowadays problems in a sustainable way. The paper presents the various lessons from the Sukur region's vernacular architecture by discussing three main types of vernacular materials which are; stone, mud, and vegetable materials. As well as comparing with new contemporary materials to reveal the importance of vernacular materials and their using techniques. The study methodology is consisting of building documentation based on interviews in the kingdom. (As shown in table 1)

This review paper will discuss and analyze the major relevant contents of the abovementioned papers, and we will conclude the fundamental study findings related to our article title at the end of each subject.

Table (1) summarizes the references used for reviewing. **Prepared by the researcher**

	Reviewed reference (JEP Fernandes et al., 2013)	**Reviewed reference** (Agyekum et al., n.d.)	**Reviewed reference** (Aminu Dodo et al., n.d.)
Reference title	"The contribute of using vernacular materials and techniques for sustainable building"	"Professionals' views of vernacular building materials and techniques for green building delivery in Ghana"	"Lessons from Sukur Vernacular Architecture: A Building Material Perspective"
General content	This research reveals the benefits of using vernacular materials and local construction techniques in the Portuguese context as well as making comparisons between vernacular and new materials using the environment as an indicator.	This study establishes professional's opinions about using vernacular materials and simple techniques for construction local buildings in Ghana.	This paper focuses on constructing buildings with vernacular materials and techniques in a sustainable way to solve problems that face present-day. The paper presents different lessons from the Sukur kingdom's vernacular architecture.
Specific content related to the review article	Natural material and techniques discussed in this study: 1.Thatch/straw: to make roofs 2.Rammed earth and adobe: Made from soil using for site construction. 3.Brick for vaulted ceiling 4.Loam: for roof system 5.Timber: to use as structural elements for house construction.	Discussed natural materials in this paper: 1.Bamboo: using for wall structures. 2.Timber: (structural) is using for load-bearing walls and frames. (Non-structural) is using for wall sidings, floors, and ceilings. 3.Earth (Laterite and clay) are using construction. 4. Grass: is using for the roof covering construction Discussed simple construction techniques: 1.Adobe construction 2.Wattle and Daub	In this study, four main vernaculars have discussed: 1.Stone: is using for foundation, decoration of worship places. 2.Mud:(Adobe Daga and Pise) are using for roofs, walls, and furniture. 3.Vegetable materials: are using for roofing system, reinforcement, and construction generally.
Methodology	The research methodology of this paper is relying on presenting various examples of Portuguese vernacular architecture by combining quantitative and qualitative analyses and using a deductive approach.	The research paper used a quantitative approach to illustrate professional's views of materials and techniques of Ghana's vernacular architecture. The structured questionnaire survey was used making researchers generalize their research findings from the population sample.	In this study, the methodology was based on interviews with the chief son and others from the Sukur kingdom about building documentations and vernacular materials.
References	36 references have been used, including published papers, books, and formal websites.	This paper is the richest reviewed source in terms of references, depending on 50 different sources, including books, published papers, and formal websites.	This paper has used only 13 references, which are published papers books, and webs.

7.Results and discussion

Vernacular architecture responds to environmental conditions, often using low-energy strategies and passive techniques to provide comfortability for humans by using various strategies that are integral to the building orientation, form, materiality, and representing an economical use of local sources of buildings and their social impacts as well as its role in social and cultural aspects. Lore in buildings and traditional wisdom, using renewable sources and original skills socially suitable and economically considering as effective solutions to the world's facing day problems. It is therefore vernacular architecture considered as an ideal source for sustainable design in contemporary design.(Wahid, 2012)

In this chapter the advantages of vernacular natural materials and their local techniques will be discussed, as well as their roles in making sustainable dwellings by analyzing with the sustainable indicators, including; environment, economy, and social. (As shown in figure 2 and table 2)

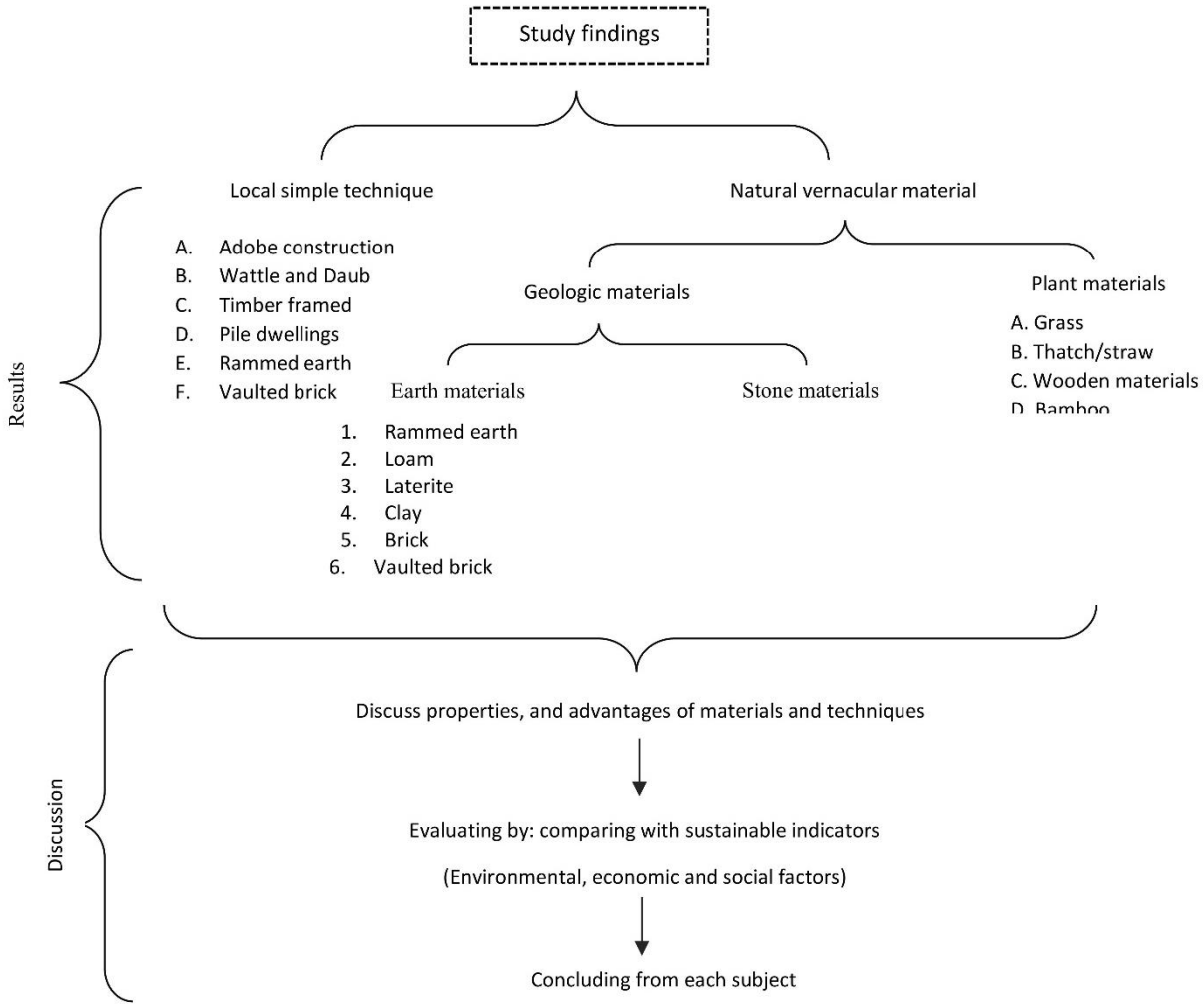

Figure (2) The study findings and discussion, **prepared by the researcher**

7.1 Discuss using vernacular materials

The reference (Golden, 2017) classified vernacular natural materials into two main categories; geologic materials and plant materials. The reference categorizes geologic materials into two subdivisions which are earth and stone materials. as well as divided plant materials into other parts, including; reeds and grass, wood materials, and bamboo. In this chapter, the vernacular materials; their properties, and advantages will be reviewed, as well as evaluating them by comparing with sustainable indicators, and establishing their benefits in present-day architecture. (As shown in Fig.2 and table 3)

1 Geologic material

A. Earth materials

Earthen construction materials are one of the most experimented with technologies in terms of environmental, economic, and social issues in sustainable housing. Earthen material is an important type of vernacular material that has various kinds such as soil, rammed earth, loam, Laterite, and clay.(Agyekum et al., n.d.)

Soil is uncemented mineral grains and shaped by the rock weathering that includes water and organic matter. This type of material does not lead to source depleting if used and managed correctly, as well as if comparing with the conventional building materials, increases in biological changes or pollution. .(Agyekum et al., n.d.)

Rammed earth is one of the widespread vernacular materials which is available widely. Where there is not the availability of stone, in buildings construction mostly use adobe. Earth materials like Rammed earth or adobe reduce the environment's negative impacts on human health. There are many other advantages of this natural material, including; it has the role of indoor air quality, behaving as moisture regulators, safe for human health (from 40 to 60 percent), low environmental influence and low carbon emissions, low-cost material, and contributing of the interior microclimate stability as well as earth materials can be reused indefinitely. (JEP Fernandes et al., 2013)

Loam is distinguished by its physical dynamic behavior and proper for the dryness and high-temperature climates. This material allows ventilation continuously in the summer season and due to natural gum quality, with the first rains it will become a waterproof material. Furthermore, it is a friendly environmental material, and in construction, there is no need for special requirement, as well as the construction maintenance easily carrying out with a very simple technique, by using another loam layer. (JEP Fernandes et al., 2013)

Laterite is a vernacular natural material that can be found widely in regions that have enough amount of rainfall. It is “tropically weathered residual, reddish, and non-residual soils types which including laterite rocks”. Among the significant characteristics of this material is socially and economically

acceptable, and ecologically friendly. Laterite is considered important construction material with a natural compressive strength between 0.5 and 1.5 MPa. It is made up of both cohesionless and cohesive soils with gravel shapes ranging from 2 to 20 mm, sands ranging from 0.06 to 2 mm, silts ranging from 0.002 to 0.06 mm, and clays ranging from 0.002 to 0.002 mm.(Agyekum et al., n.d.)

Clay is a sustainable vernacular material, which traditionally used for building construction. Its particle sizes do not exceed 0.002 mm. Clay is not stable, unlike gravel and sand, but its humidity level is quite sensitive. Clay has become a preferred material and frequently recommended by experts and professionals for different types of green buildings, because of its special specifications such as (thermal superiority, energy-efficient, better indoor environment quality, and durability). (Agyekum et al., n.d.)

Brick is the specific product of clay and considers a common traditional building material. Clay brick is manufacturing locally and has sustainable characteristics such as energy efficiency and environmentally friendly**.** (Agyekum et al., n.d.)

B. Stone

Is one of the vernacular materials widely using for structural purposes such as foundation and walls. (Aminu Dodo et al., n.d.)Stone has valued for stability and permanence, and for many different cultures served as a primary building material. Construction with stone needs great physical labor for gathering, cutting, and lifting from the ground; material transporting also required a considerable and expensive effort. Masonry of stone can be laid both dry, without mortar, or wet, with earth mortar. Dry masonry of stone traditionally used for structure constructions such as dwellings, bridges, fences retaining walls, and storage buildings. Meanwhile, dry stone used for the contraction and expansion of materials. Stone can be reused easily after ending the structure life. (Golden, 2017)

2 Plant materials

A. Grass

The grass is an extensively used vernacular material in architecture, particularly on roofs. According to the study (Agyekum et al., n.d.), numerous types of a roofing construction can be done with thatch or straw, including but not limited to gable-ended, double-pitched, and hemispherical or conical roofs. Smaller elements of bamboo and sticker are linked to the main timer, rafters, and using twine or raffia during the construction procedure of any sort of this roofing. The study indicates that after completing the structure, different packs of fresh grass, normally fastened in three or four layers, and finally, this works as the roof covering structure element. (Agyekum et al., n.d.)

B. Thatch/straw

Thatch or straw is a waste production of cereal material. As a vernacular material used for making roofs in regions with rye crops and harsh winters. This coating provides rain protection and some thermal insulation at the same time. This natural material has many sustainable characteristics,

including; low-cost material, biodegradable, has a sufficient performance against rain and snow and works as an insulation sustainable material. In contemporary sustainable design, it is conceivable to use thatch or straw because it has a proper potential in terms of integrating with new contemporary materials. (JEP Fernandes et al., 2013)

C. Wooden materials

Wooden material products like timber are considered as sustainable local material, which used as a structural component in the overall dwelling designs. Wooden construction materials have many ecological properties, including; it is renewable, recyclable, and biodegradable. As well as requires slight construction processing and reduces construction waste because it permits prefabrication. Based on construction methods it is considered economic maintenance and it is possible piece-by-piece replacing without changing building structures. Using timber as raw material and local production reduces transportation costs which impact environmental performance construction. (JEP Fernandes et al., 2013)

This vernacular material is categorized as structural and non-structural. Structural timbers are used as load-bearing walls and frames, while non-structural timbers are used for non-loading works such as floors, ceiling, and siding. (Agyekum et al., n.d.)

D. Bamboo

Bamboo is a renewable vernacular material, generally available in most regions, and it is an environmentally friendly material. Bamboo is versatile and has low weight with high strength. Bamboo outperforms the majority of other construction materials including steel reinforcement because of its tensile strength properties. It is considered as an economical material for construction relating to its growth and transport rates. Despite it has many benefits because of its sustainable properties, Bamboo is considered as a buckling material, but it is easy to be corrected. This vernacular material is the fastest natural growing material worldwide.

Concluding from this discussion:

Various kinds of natural materials were discussed and categorized under two main types, earth and plant materials. According to the previously mentioned references, all the discussed vernacular materials share a significant value and are acceptable with sustainable indicators. Each of the materials has its own properties and is used in different stages of construction in diverse regions according to their availability. The abovementioned vernacular materials have many mutual advantages, including health safety, low cost, ease to provide, economically and socially acceptable, naturally convenient, renewable and recyclable, and numerous other benefits which render this type of material suitable for making sustainable dwellings and could be used in these days.

Table (2) Illustrates the discussed vernacular materials. **Organized by the researcher**

Classification vernacular materials according to [book4] Main-category	Sub-category	Material type mentioned in reference (JEP Fernandes et al., 2013)	Material type mentioned in reference (Agyekum et al., n.d.)	Material type mentioned in reference (Aminu Dodo et al., n.d.)
Geologic Materials	Earth materials	Rammed earth Adobe Brick Loam	Laterite Clay	Mud, Adobe, Daga, Pise
	Stone	Not Use	Not Use	Stone
Plant Materials	Wood	Timber	Timber	Not Use
	Bamboo	Bamboo	Bamboo	Not Use
	Reed and graces	Thatch Straw	Grass	Using vegetable materials generally
Local simple technique types		Material type mentioned in reference (JEP Fernandes et al., 2013)	Material type mentioned in reference (Agyekum et al., n.d.)	Material type mentioned in reference (Aminu Dodo et al., n.d.)
Techniques using geologic materials		Vaulted brick Loam roofs	Adobe construction Wattle and Daub Rammed earth	Stone wall
Techniques using plant materials		Straw roof	Timber framed Pile dwellings	Vegetable materials

7.2 Using local simple techniques

In the previous centuries, technology for maximizing interior thermal comfort was lack, passive approaches were used in building construction. The vernacular techniques were simple and clever which relied on available resources and a criteria range like insolation, orientation, geographical characteristics, form, and materials. In vernacular construction, nothing was wasted or ignored, because societies learned from practice and experience that their lifestyle will be continued depending on maintaining and keeping harmony with the environment surrounding them. (Jorge Fernandes et al., 2015) In this section, various vernacular construction techniques will be discussed due to these three reviewed articles in the study.

A. Adobe construction

This vernacular construction technique has been existence for many centuries, and it is considering one of the most widely spread construction techniques especially in regions where materials like stone are not available. (Fernandes et al., 2013) Recent studies concluded that more than %30 of the world's population lives in adobe or earth buildings. As an earthen vernacular technique, adobe construction has many economic and environmental advantages especially for developing countries that have many building construction problems such as; material costs, type of method construction, and labor. The building cost has a strong relationship with the type of construction method because of the availability of used material in a region, and it makes the construction type very useful for the environment, because it is a very simple technique, and no sophisticated process involved. (Agyekum et al., n.d.) (As shown in figure 3)

Fig (3) Typical Adobe building in Ghana. Source: reference (Agyekum et al., n.d.) [2]

B. Wattle and Daub

This vernacular method of construction is specific to building walls. In the construction, fresh earth material places on support. The technique differs from a country to another, in Ghana for example the method quite different, in which the building's anticipated outline is mostly marked out by setting out. Following the construction outline, the appropriate pits or trenches are excavated at regular intervals using simple techniques. After the excavation is complete, vertical props are inserted into the pits and firmly kept in place with stones rammed around the base. The other frame systems are completed until the entire building structure is finished and ready for use. (Agyekum et al., n.d.) (As shown in figure 4)

Fig (4) Typical Wattle and Daub building in Ghana. Source: reference (Agyekum et al., n.d.)

C. Timber framed

This vernacular technique is commonly used in forest and coastal places, where the wood material is mostly available. This construction technique requires material precision in order to create the necessary timber elements in the right size for construction. The lack of machine tools in primitive places made this form of construction impossible. Local indigenes, on the other hand, can erect timber elements using very simple local techniques. This local construction technique is considered to be significant because using wood as the main material source which has high-performance building material and environmentally friendly. (Agyekum et al., n.d.) (As shown in figure 5)

Figure (5) Timber framed in Ghana. Source: reference https://www.culturalencyclopaedia.org

D. Pile dwellings

This technique also used to float structures in wetlands or communities built in swampy areas. According to the reference (Agyekum et al., n.d.), this construction is often launched by the environmental situation in a specific region or country. This vernacular structure is a floating system that could improve vertical mobility in response to changing water levels and currents in all directions. Ghana has numerous of these examples, one of which is in the western region. Figure (6) shows the method of this construction type with pile dwelling at Nzulezu.

Figure (6) A typical pile dwelling in Ghana. Source: reference https://www.culturalencyclopaedia.org

E. Rammed earth

Rammed earth is a mixture of raw materials such as sand and gravel. This material type is very durable, thermally massive, highly non-combustible, and considers a strong material. During construction, the rammed materials are mostly compacted layer by layer among formworks. This unique construction method can only implement by most experiment practitioners. Figure (7) is a detailed description of this vernacular construction which shows rammed earth building with the eco-friendly property

Fig (7) A Typical Rammed earth building in Ghana. Source: reference (Agyekum et al., n.d.)

F. Vaulted brick

Vault construction with brick is an ancient vernacular technique and it was continuing and used widely till the beginning of the twentieth century when construction with reinforced concrete slab increased. According to (Fernandes et al., 2013) (Sanz-Calcedo et al. 2012), creating a vault with brick is more sustainable compared to slab concrete which requires 75% less energy for construction, produces less CO2 by %69, has less construction cost, and producing lower waste. The same study established that this vernacular technique meets current sustainability criteria and can be incorporated into current construction techniques, as well as it is very functional and economic. The study (Agyekum et al., n.d.) supports that the vaulted brick technique keeping practicable in contemporary construction, and the study emphasized the significance of training on this technique in order to more spreading globally. (As shown in figure 8)

Figure (8) A Typical Vaulted brick building in Ghana. Source: reference (Agyekum et al., n.d.)

Concluding from this discussion:

According to available material sources, different simple techniques were discussed. Through the utilization of natural resources basic construction strategies conducted in a witty way and in various steps, people made a vernacular architecture appropriate with the context, harmony with nature. In relevance to the above section discussion, all the construction techniques emerged from accumulated experience and continuing into the present. The techniques vary from a territory to another through employing different materials, climate, and cultural behavior, but all vernacular techniques have sustainable approval.

7.3 Discuss the effect of natural materials and simple techniques on sustainable dwellings

Vernacular architecture is a human concept which outcomes from the interrelations between environmental, economic, material, and social and political factors (Alrashed et al., 2017)Throughout history, many vernacular materials and techniques shaped by the local weather, culture, and geographical location were working around the world. Furthermore, many of these materials and techniques have been used in different provinces with various environmental conditions and cultural backgrounds. (Alrashed et al., 2017) In this section, the sustainability's effect of vernacular material and techniques will be discussed in terms of its three principles; environmental, economic, and social effects.

7-3-1 Discuss Environmental effects

The primary purpose of sustainability in architectural design is to develop an environmentally sustainable building that is suitable with the surrounding conditions of a specific place and has a longer life span. (2017) (Salgn et al.) Buildings that use vernacular techniques and materials are thought to be more sustainable in terms of the environment, thermal efficiency, and energy efficiency. Vernacular architecture has significant characteristics such as versatility and durability, and hence. Furthermore, the significance of selecting local construction materials in the nearby environmental context, as well as combining their appropriate processes and methods into the sustainable building. (Agyekum et al., n.d.)

This section presents the result of using vernacular natural materials and simple techniques regarding the selected papers for reviewing. As well as their impact on sustainable dwellings. negative impact on global warming, while vernacular materials such as straw, rammed earth, and timber have a positive role environmentally.

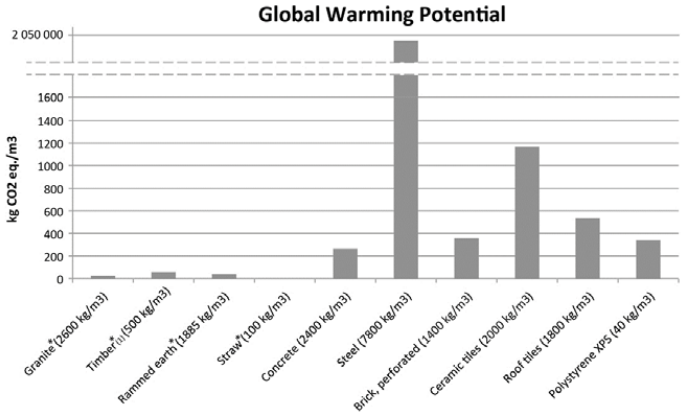

Figure (9). Global Warming Potential; comparison between some vernacular and industrial building materials. Source: reference (Fernandes et al., 2013)

Reference (Fernandes et al., 2013) compares vernacular materials and industrially produced materials, regarding environmental aspects and illustrated it in a diagram chat. As showed in figure. (9) The result shows the industrial materials like steel, ceramic tiles, roof tiles, and concrete have a

On the other hand, the reference (Agyekum et al., n.d.) shows the level of importance of eight different vernacular materials and seven local techniques in bar charts based on analyzing questionnaire survey responses. The findings show the mean score, standard deviation, standard errors, and p-value of the materials and procedures, demonstrating the significance of these materials and approaches to green building construction in Ghana.

Table (3) displays the mean values of vernacular material relevance. The mean values range from 2.567 to 4.537, with the result emphasizing that the mean values of six out of eight materials are larger than 3.0, indicating that these materials are vital to green building in Ghana. While “Sandcrete block and Grass's” have a rating less than 3.0, their contribution to green building is not perceived to be` substantial.

Table (3) Mean values for vernacular building materials. Source: reference (Agyekum et al., n.d.)

Materials	Mean	Std. Deviation	Std. Error	P-value	Rank
Timber	4.537	0.66	0.090	0.000	1st
Bamboo	4.204	0.88	0.119	0.000	2nd
Laterite	4.074	0.97	0.132	0.000	3rd
Sand	3.926	0.93	0.126	0.001	4th
Clay/Clay bricks	3.926	1.15	0.156	0.009	5th
Stone	3.815	1.07	0.145	0.034	6th
Sandcrete block	2.625	1.20	0.164	0.181	7th
Grass	2.576	1.16	0.158	0.907	8th

For the vernacular techniques, the study results of reference (Agyekum et al., n.d.) reveal that the mean score of local techniques ranges between 1.534 and 4.093. The findings show that the mean value of five of the seven building local approaches is larger than 3.0. This indicates that these vernacular techniques are crucial for green building in Ghana. The mean value of two other vernacular techniques which are “pile dwellings” and “Mashrabiya” less than 3.0. This implies that this technique's importance is not perceived as significant statically. As shown in table (4).

Table (4) Mean values for vernacular building materials Source: reference (Agyekum et al., n.d.)

Techniques	Mean	Std. Deviation	Std. Error	p-value	Rank
Timber Framed Construction	4.093	0.900	0.122	*0.000*	1st
Sun - dried brick walling (Adobe)	3.852	*1.120*	0.153	*0.025*	2nd
Rammed Earth or Atakpame walling (from laterite)	3.593	*1.170*	0.160	0.000	3rd
Straw bale method	3.407	*1.140*	0.155	0.014	4th
Wattle and Daub	3.333	*1.010*	0.137	0.026	5th
Pile Dwellings	1.864	*1.080*	0.146	0.107	6th
Mashrabiya	1.534	0.960	0.131	*0.231*	7th

7-3-2 Discuss economic effects

There is a great need for skilled labor and manpower which are accounting for a significant economic and social benefit of using local techniques. In addition, it is more economically acceptable to distribute profits among more stakeholders than to allocate it to the price of material, and because of this enables finding jobs for unemployed citizens (JEP Fernandes et al., 2013) asserts that an ecological building construction should have its production units close to the point of consumption, utilizing local renewable resources and relying on low-energy, low-pollution processes.
He also claims that decentralization will increase corporate decision-making centers and give them a better understanding of the context in which they work, especially the relationships between decision-makers and local resources. Redevelopment of rural areas has a great effect on preventing or halting urban sprawl and city expansion. (Fernandes et al., 2013)

7-3-3 Discuss social effects

It is important to the social parameters in order to achieve genuinely sustainable growth. The social aspect has a great role in improving sustainability, including; employment, safety, health, comfort, culture and heritage, and educational training skills. According to the abovementioned properties of vernacular materials and their construction techniques, the advantages are fit to all social parameters of sustainable concepts. (Fernandes et al., 2013)

There is a high demand for local skilled labor, which accounts for a large social advantage of local techniques and allows unemployed persons to obtain work. Furthermore, the demand for skilled labor leads to education and training in these vernacular building systems, which help to preserve and maintain cultural heritage and local heritage. (Agyekum et al., n.d.)

The fact that these materials and techniques were sourced from the same local climatic conditions, they have the following benefits; increasing durability and make greater adaptability, in addition, they are quite appropriate relating to human health, because of their natural originality with low toxicity. Some of them capable of temperature regularity and indoor air quality (Fernandes et al., 2013)

Concluding from this discussion:

In the previous section, the role of vernacular material and its construction techniques were discussed in terms of environmental, economic, and social aspects. The findings of research case studies uncovered that in comparison with the industrially contemporary materials, the vernacular materials attribute less negative impact on global warming potential. Furthermore, by evaluating the study findings, it has been demonstrated that the majority of vernacular materials and local processes are essential for green building. Moreover, for the economic and social aspects, the results discovered that employing these materials and techniques contribute to profits within the region and provide better job opportunities, as well as the unique harmony of these materials and techniques, are appropriate with the cultural life of the regions. This implies that the vernacular materials and their construction strategies are economically and socially acceptable. For these reasons, the research results suggested that it is possible to develop these natural materials and simple techniques and apply them to modern building designs.

8.Study gaps and future recommendations

The findings of the research were discussed in-depth, with several facets of vernacular materials and techniques relating to sustainable dwellings being studied, and it was discovered that there are gaps in the study field. We would propose the following as future recommendations:

- Replicating a similar issue in the Kurdistan region and assessing it with its special indicators.
- Improving vernacular materials and techniques and enhanced utilization matched with contemporary design.

9.Conclusion

In the present, industrially manufactured materials are utilized on a broader spectrum that are heavily reliant on energy demand. The planet is confronted with a slew of environmental concerns. (Agyekum et al., n.d.) In this regard, the use of locally available vernacular materials and building techniques harnesses renewable resources, bridging the distance between conventional accomplishments and contemporary needs (Aminu Dodo et al., n.d.). Following our exploration, we collected several references relating to the title, and after reading and reviewing them, we were left with the three most relevant articles for studying, all of which were closely pertaining to the research scope.

The study examined two main types of vernacular materials: earth materials and plant materials. The study focused on the properties and advantages of all sub-divisions of these two sections, as well as the fact that all vernacular materials share a number of mutual features. As compared to modern industrially manufactured materials, it is concluded that vernacular materials have a lower environmental impact, such as global warming. Vernacular materials and their simple techniques play significant roles for green buildings, and contributes long-term benefits within the region and provide more job opportunities.

Moreover, the uniqueness of these materials and their techniques are appropriate to nature and cultural life. Drawing from these indicators, the study concludes that these material types and their techniques are approved in terms of environmental, economic, and social aspects. Hence the study answers the research question which is the vernacular materials and their simple techniques have an instrumental role in making sustainable dwellings, and therefore the hypothesis is accepted. Future studies could revolve around tackling the study's problem in the Kurdistan region, as well as, developing vernacular materials and their techniques, and using them in an innovative manner in a contemporary design.

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