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ROCKING THE LANDSCAPE: STONES IN THE TRANSFORMATION OF JOS, PLATEAU STATE

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Article Info

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Abstract

Stone and concrete are foundational materials in construction, utilized globally to create durable and aesthetically pleasing structures for both commercial and residential purposes. This review provides a comprehensive overview of these vital construction materials, exploring their origins, properties, and diverse applications.

Beginning with an examination of the geological sources of stones, including igneous, sedimentary, and metamorphic varieties, we delve into the extraction and processing methods that render them suitable for construction. Additionally, we explore the properties that make stones an enduring choice, capable of withstanding environmental stressors while offering superior artistic versatility.

Concrete, another cornerstone of modern construction, is investigated in tandem with natural stone. We scrutinize the composition, mixing techniques, and curing processes that transform a blend of cement, aggregates, and water into a versatile construction material. Noteworthy is the capacity of concrete to adapt to various forms, from structural components to decorative finishes, making it indispensable in architectural design.

Furthermore, this review highlights the historical significance of stone and concrete in iconic structures worldwide. From ancient edifices associated with power and religion to contemporary architectural marvels, their enduring presence shapes skylines and landscapes across cultures.

As sustainable construction practices gain prominence, we assess the eco-friendliness of these materials. Strategies for responsible sourcing, recycling, and minimizing environmental impact are explored, shedding light on how stone and concrete can align with contemporary ecological imperatives.

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In conclusion, this review underscores the pivotal role of stone and concrete in the construction industry. By understanding their geological origins, material properties, and diverse applications, stakeholders in the construction sector can make informed decisions, ensuring the longevity, functionality, and aesthetic appeal of their projects.

1.0 Introduction

Constructions worldwide require tonnes of stone and concrete to erect structures for commercial and residential use (Mwangi, 2015). These naturally occurring rocks of igneous, sedimentary or metamorphic origin are sufficiently consolidated to enable them to be cut or made into various shapes and blocks or slabs to be used as walling, paving or roofing materials (Balsubramanian, 2017). It has been long recognized as a material of great durability and superior artistic quality, the foremost choice for buildings associated with status, power and religion (Muhammad, 2017).

The pyramid in Giza, burial chambers in the UK and temples in Malta were all built from stone over 4000 years ago and are still standing. The use of stone in construction has declined over the last hundred years, but it remains an aristocrat of building materials (Muhammad, 2017).Used in building and landscape construction for thousands of years, stones tell silent stories that grace and enrich lives when they are included in the landscape. These igneous, sedimentary and metamorphic characters bring various colours, textures, lines and degrees of strength to their hardworking and aesthetic tasks (Stone Landscaping, 2008).

Of all the materials available for landscaping, stone has the most natural-looking and enduring qualities. With its inherent versatility, structural integrity, and powerful impact, stone inspires endless design possibilities. Stone adds value and beauty to your home's setting whether you integrate it into a functional part of the landscape or use it as a strictly ornamental outdoor element (Stone Landscaping, 2008).

Contextual to this paper, a stone is defined as any type of rock that has been selected or processed by cutting, shaping, or sizing for use in building construction or for decorative purposes (Dictionary of Architecture and Construction, 2006).Similarly, Kayode, (2012), defined it as cut rocks that have been detached from the earth crust to be used for the construction of structures such as; bridges, buildings and roads, also serve as paving materials for landscaping the environment. From the Stone Age stones have been used for tools. The minerals and metals we find in stone have been essential to human civilization. The Earth's outer solid layer, the lithosphere, is made of rocks.

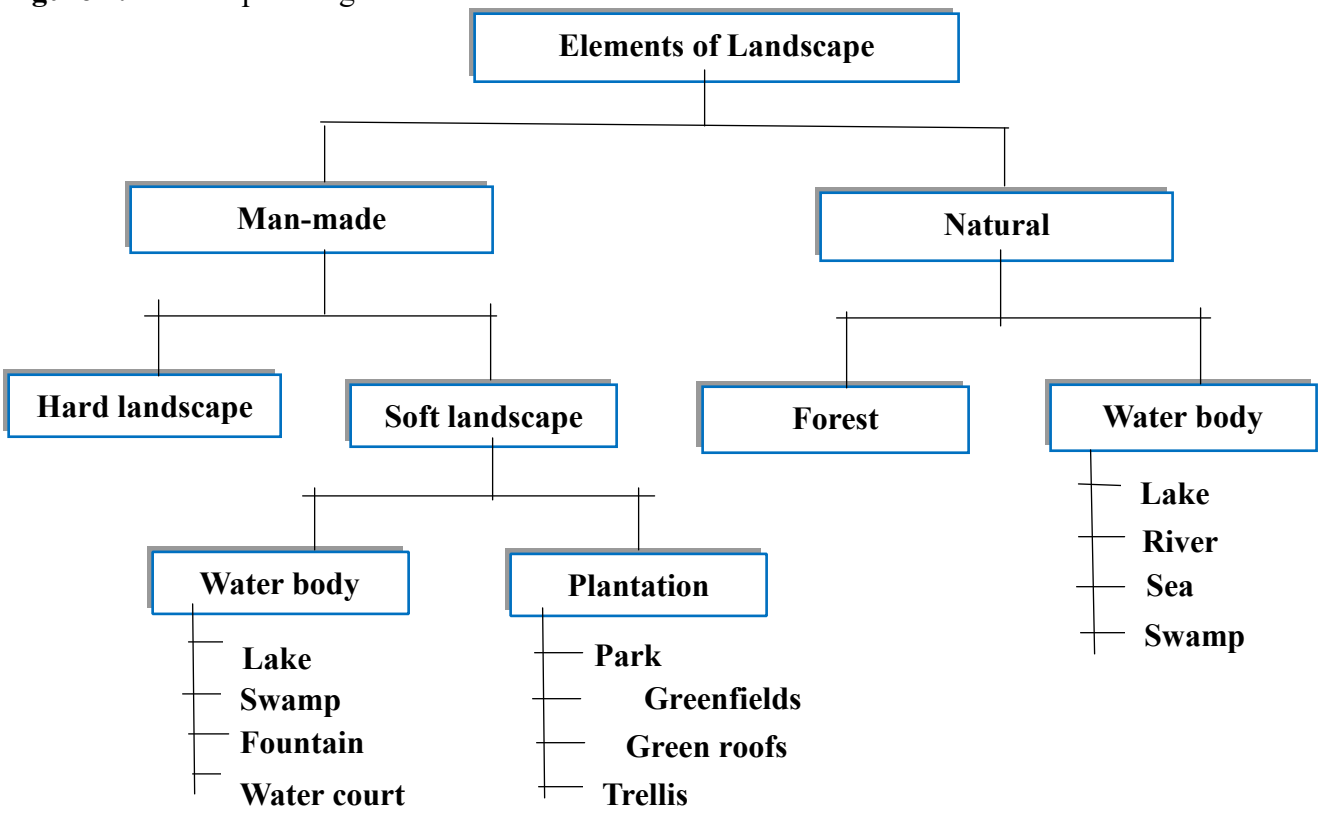
Landscaping with stone creates a framework for movement, visual definition and establishes different use areas in the landscape. Patios, walls, steps and walkways help us navigate changing elevations on site and define a variety of "places"(Stone Landscaping, 2008).A well-defined landscape space can enhance the quality of living areas which meets people`s preferences. Landscape is thus defined as 'scenery of natural and man-made features within the built and natural environment defined by man's interaction and activities within his surroundings, which often manifest in man-made landscape (Ayeni, 2012).Landscape design on the other hand is the art and science of organizing and enriching outdoor spaces through the placement of plants and structures in agreeable and useful relationship with the natural environment (VanDerZanden and Rodie 2008) as cited by Anikoh et al.,(2019). It serves a lot of purposes which includes aesthetics, enhancing functionality of spaces, improving temperature, influencing air quality of the environment and also combating security threats (Anikoh et al., 2019). Hence, landscape design elements can be classified into two such as the *soft landscape* and *hard landscape* (See Figure 1).The term hard landscape refers to inanimate elements that relate with accessibility, of course change the natural surface to paved surfaces such as kerbs, stones, steps, ramps, walls, bricks,concrete,metal,bollards, tiles, walkways, asphalt, paving, planters, sculptures (Olanrewaju, 2011; Ayeni, 2012; A Handbook of Landscape, 2013; Adekunle, et al., 2016). Hard landscape materials can be transformed into landscape features that can attract the eye, add mass and weight to the composition, create themes and add pleasure to the landscape. Not only does it

reduce maintenance costs, it in addition helps divide and define spaces in the landscape, orchestrate the way the landscape is viewed and enhance its beauty (Ayeni, 2012).

As noted by Kayode, (2012), Nigeria being a country in which stone is readily available in all its six geopolitical zones, makes minimal use of stone in the various landscape projects that is being carried out by the government at both federal and state level.

A reconnaissance survey carried out within the metropolis reveals that about 65% of landscape projects makes use of stones. However, requisite knowledge on how best to use stone in landscaping the environment and as a finishing material is lacking. The focus of this research is to examine the uses of stone for outdoor landscape development within Jos metropolis with a view to create an awareness on the importance of stone in landscape development and its use in environmental beautification. The specific research objectives are to: (1) carryout a geological classification of stones used in landscaping in the study area, (2) examine the physical properties of stones, (3) investigate suitable stones for landscape projects

Figure 1: Landscape Design Elements



Source: Authors' construct 2019, as adapted from Ale, et al., 2019

Figure 1 shows the classification of landscape elements grouped into man made and includes hardscape, soft cape, water bodies and plantation and natural that is the forest, rocks, ground form and water body (Authors' construct 2019, as adapted from Ale, et al., 2019)

2.0 Literature Review 2.1 Geological classification of Stones

Stones are naturally occurring rocks of igneous, sedimentary or metamorphic origin. Most of the rocks are sufficiently consolidated to enable them to be cut or made into various shapes and blocks or slabs to be used walling, paving or roofing materials (Balsubramanian,2017).Used in building and landscape construction for thousands of years, stones tell stories that grace and enrich lives when they are included in the landscape. These igneous, sedimentary, and metamorphic character bring various colours, textures, lines, and degrees of strength to their hardworking and aesthetic tasks.

i. **Igneous Rocks:** The igneous rock is a fiery rock formed due to the cooling and solidification of molten materials within the earth that is caused by either an increase in temperature, decrease in pressure or change in rock formation that gives rise to the melting of a an existing rock (Kayode, 2012). Solidification into rock occurs either below the surface as *intrusive rocks* or on the surface as *extrusive rocks*. Stones such as diorite, gabbro, granite, pegmatite, and peridotite, andesite, basalt, dacite, obsidian, pumice, rhyolite, scoria, rhyolite and tuff (See Plate i, ii, iii & iv)are identified as igneous rocks (Balsubramanian,2017).

Plate i: Granite is a coarse-grained, light-colored Intrusive igneous rock

Plate ii: Basalt is a fine-grained, dark-colored Extrusive igneous rock

Source: Archives of National Metallurgical Development Centre (NMDC) Jos, 2018.

Plate iii: Pegmatiteis a light-colored, extremely Coarse-grained intrusive igneous rock.

Plate iv: Rhyolite is a light-colored, fine-grained Extrusive igneous rock.

Source: Archives of National Metallurgical Development Centre (NMDC) Jos, 2018.

ii. **Sedimentary Rocks:** Sedimentary rocks are formed by the accumulation of sediments.Sedimentary rocks are identified by the presence of fossils and are usually curved or flat. Sedimentary rocks are the most common rock types which are freely exposed on the earth's surface. (Balsubramanian, 2017).

There are three basic types of sedimentary rocks which namely *Clastic sedimentary rocks* such as breccia, conglomerate, sandstone (See Plate vi), siltstone, and shale are formed from mechanical weathering debris; *Chemical sedimentary rocks,* such as rock salt, iron ore (See Plate vii), chert, flint, some dolomites, and some limestone, form when dissolved materials precipitate from solution and *Organic sedimentary rocks* such as coal (See Plate v), some dolomites, and some limestone, form from the accumulation of plant or animal debris (Balsubramanian,2017).

Plate v: Coal an organic sedimentary rock Formed from plant debris

Plate vi: Sandstone a classic sedimentary rock made up of sand-size weathering debris.

Source: Archives of National Metallurgical Development Centre (NMDC) Jos, 2018.

Plate vii: Iron Ore is a chemical sedimentary rock that forms when iron and oxygen (and sometimes other substances) combine in solution and deposit as a sediment.

Source: Archives of National Metallurgical Development Centre (NMDC) Jos, 2018.

iii. **Metamorphic Rock:** Metamorphic rocks have been modified by heat, pressure, and chemical processes, usually while buried deep below Earth's surface. Exposure to these extreme conditions has altered the mineralogy, texture, and chemical composition of the rocks (Balsubramanian, 2017).There are two basic types of metamorphic rocks. *Foliated metamorphic rocks* such as gneiss, phyllite, schist, and slate (See Plate ix & xi) have a layered or banded appearance that is produced by exposure to heat and directed pressure and *Non-foliated metamorphic rocks* such as hornfels, marble, quartzite,(See Plate viii & x) and novaculite do not have a layered or banded appearance (Balsubramanian,2017).

Plate viii: Quartzite is a non-foliated metamorphic rock produced by metamorphism of sandstone

Plate ix: Slate is a foliated metamorphic rock rock produced through metamorphism of shale

Source: Archives of National Metallurgical Development Centre (NMDC) Jos, 2018.

Plate x: Marble is a non-foliated metamorphic rock produced by metamorphism of limestone has a banded appearance and is made up of granular It is composed of calcium carbonate. mineral grains. It typically contains abundant Quartz or feldspar minerals.

Plate xi: Gneiss is a foliated metamorphic rock that produced

Source: Archives of National Metallurgical Development Centre (NMDC) Jos, 2018.

2.2 Physical Properties of Stones

According to Balsubramanian, (2017), stones possess certain physical properties and these should be considered before selecting them for construction/engineering works

i. **Appearance:** Appearance is a primary requirement for all stones. The colour and ability to receive polish are important factors. ii. **Colour:** A stone with uniform and attractive colour is durable, if grains are compact. Stones with much iron should be discouraged as the formation of iron oxides disfigures them and brings about disintegration. Marble and granite get very good appearance, when polished. iii. **Durability:** Stones selected should be capable of resisting adverse effects of natural forces like wind, rain and heat. iv. **Hardness:** It is an important property to be considered when stone is used for flooring and pavement. For road works coefficient of hardness should be at least 17. For building works stones with coefficient of hardness less than 14 should not be used. The stone used in floors and pavements should be able to resist abrasive forces caused by movement of men and materials over them.

v. **Percentage Wear:** It is measured by attrition test. It is an important property to be considered in selecting aggregate for road works and railway ballast. A good stone should not show wear of more than 2%.

vi. **Resistance to Heat or Fire:** Resistance to heat means that the stone must have a very low amount of expansion due to large increase in temperature. Silicious materials are good at areas where resistance to fire is required. Sand stones resist fire better. Argillaceous materials, though poor in strength, are good in resisting fire. vii. **Specific Gravity:** Heavier variety of stones should be used for the construction of dams, retaining walls, docks and harbours. The specific gravity of good building stone is between 2.4 and 2.8. viii. **Strength:** Strength is an important property to be looked into before selecting stone as building block. Indian standard code recommends, a minimum crushing strength of 3.5 N/mm2 for any building block. Due to nonuniformity of the material, usually a factor of safety of 10 is used to find the permissible stress in a stone. Hence, even laterite can be used safely for a single storey building, because in such structures expected load can hardly give a stress of 0.15 N/mm2. ix. **Cost:** Cost is an important consideration in selecting a building material. Proximity of the quarry to building site brings down the cost of transportation and hence the cost of stones comes down.

x. Texture: Fine grained stones with homogeneous distribution look attractive and hence they are used for carving. Such stones are usually strong and durable. **xi. Weight and Density:** Building stones must be heavy. Denser stones are stronger. Light weight stones are weak. Hence stones with specific gravity less than 2.4 are considered unsuitable for buildings. **xii. Dressing:** Giving required shape to the stone is called dressing. It should be easy to dress so that the cost of dressing is reduced. However the care should be taken so that, this is not be at the cost of the required strength and the durability. **xiii. Porosity and Absorption:** All stones have pores and hence absorb water (See Table 1). The reaction of water with material of stone causes disintegration. Absorption test is specified as percentage of water absorbed by the stone when it is immersed under water for 24 hours. For a good stone it should be as small as possible and in no case more than 5. Building stone should not be porous. If it is porous rain water enters into the pour and reacts with stone and crumbles it. In higher altitudes, the freezing of water in pores takes place and it results into the disintegration of the stone. Permissible limits of water absorption for some the commonly used building stones are as follow.

Table 1: Water limits absorption for building stones

S/No	Type of Stone	Maximum limit of Water Absorption (%)
1.	Sandstone	10
2.	Limestone	10
3.	Granite	1
4.	Shale	10
5.	Slate	1
6.	Quartzite	3

Source: Adapted from Balsubramanian, 2017

Other properties include Seasoning, Sensitivity to moisture, Weathering, Toughness, Ease in Dressing, Biodeterioration.

2.3 Stones for Landscape Projects

Stones selected for landscape use must have the fineness of grains, good strength and porosity to bear the weight of imposed loads, durable and of good aesthetic quality (Kayode, 2012).Stones are classified by the natural shape and its use in the landscape:

i. **Granite:** Granites are intrusive igneous rocks. Their colour varies from light gray to pink (Balsubramanian, 2017).In general, granites are the strongest and most durable of all building stone, with very low porosity and are water absorbent and easiness to maintain and the fact that they can be carved and crafted to form artefacts and sculptures (Kayode, 2012). However, they are the most difficult to work with (Muhammad, 2017).Granite is highly heat, scratch and stain resistant, and is commonly used to face commercial and institutional buildings and

monuments (Balsubramanian, 2017). ii. **Sandstone:** Sandstone which is not so hard-wearing or beautifully patterned is used for garden walls and paths in landscaping (Stone Landscaping, 2008). iii. **Building Stone:** Can be any type of stone. Pieces are roughly shaped at the quarry so they can be fine-tuned on site by craftsmen. They are used in building retaining walls or fireplaces (Stone Landscaping, 2008). iv. **Flagstone:** Flagstone is quarried from layers of sedimentary rock. A fundamental characteristic of flagstone is that it can be split into relatively flat layers of varying thickness. It is ideal for patios, pool decks, wall caps, and garden walkways (Stone Landscaping, 2008).

v. **Fieldstone** (Boulders): Unlike flagstone, fieldstone is not quarried. It is found near the Earth's surface in rock outcrops or in areas that contain ancient glacial deposits. This rough surfaced, weathered stone comes in irregular shapes, and with rounded edges. A key feature of fieldstone is its craggy edges, scars, and numerous crevices that naturally support the growth of beautiful moss or lace lichen. Fieldstone works very well when used in fire places, waterfalls and around ponds (Stone Landscaping, 2008). vi. **Stone Slabs:** Slabs are usually cut 3″ to 5″ thick and are used for stairway steps, stepping stone walkways, and waterfalls (Stone Landscaping, 2008). *vii.* **Nite:** Nite another stone type is used for architectural construction, ornamental stones and monuments (Stone Landscaping, 2008). viii. **Gravel:** Gravel or pebbles make an excellent surface for a pathway. They can be excellent ground cover, and require amazingly low-maintenance and naturally need no water (Stone Landscaping, 2008).Also they serve as natural mulch, they protect plant roots and retain moisture efficiently while allowing air to circulate. This is especially valuable in combination with plants that tend to suffer from root rot such as Ice plant

3.0 Methodology 3.1 Source of Data

The study employed the use of two data sources which were primary and secondary data. The primary data involved the collection and identification of stones suitable for landscaping. A trained expert in geology from the National Metallurgical Development Centre (NMDC) Jos, gave us more information into their uses within the environment and specifications (See Table 2). This confirms with the previous studies of Kayode, (2012); Stone Landscaping, (2008); & Balsubramanian, (2017) as presented in item 2.3 above. Also the use of digital camera to capture images of interest in the study area. While the secondary data used include documented information of internet, electronic journals, dissertations and geographical maps of study site and Plateau State, Nigeria.

Table 2: Specification of common stones

S/No	Types of Stone	Colour	Specific Gravity	Compressive Strength (N/mm2)	Water Absorption (%)	Crushing Strength (MN/m^2)
1.	Granite	Brown, Grey, Pink	2.64	100-250	< 1	110-140
2.	Basalt and Trap	Dark grey, Black	2.96	200-350	-	70-80
3.	Sandstone	White, Grey, Red, Brown	1.85-2.7	20-170	5-25	-
4.	Slate	Dark grey, Greenish grey, Black	2.6-2.7	100-200	1	-
5.	Laterite	Red, Yellow, Brown	1.85	1.9-2.3	-	-
6.	Marble	White, Pink	2.65	70-75	-	-

Source: Archives of National Metallurgical Development Centre (NMDC) Jos, 2018 and Balsubramanian, 2017.

3.2 Study Area

Geographically, Jos – North local government is located at the extreme north of Plateau State on Latitudes 09^0 53^1 and 09^0 59^1 North, and Longitudes 08^0 51^1 and 09^0 02^1 East. It shares boundary to the North with Toro Local

Government Area of Bauchi State; to the South with Jos-South Local Government area; to the North-East with Jos-East Local Government Area; and to the West with Bassa Local Government Area (Aliyu, et al., 2019).
Jos-North Local Government enjoys a temperate climate with average temperatures of between 28^{0}C (81.7^{0}F) maximum and 11^{0}C (51.7^{0}F) minimum. It covers the total land area of 291 km^2 (112 sq mi) with the 2006 provisional population census figure of 429,300 people. The warmest temperatures usually occur in the dry season months of March and April (Aliyu, et al., 2019).Similarly, Jos-North Local Government is characterized by a mean annual rainfall of between 1317.5mm (131.75cm) and 1460.00mm (146.0cm), mostly in May to August. The Onset and Cessation of rainfall in Jos-North are experienced in April (±15 days in April), and October (±15 days in October). Relative humidity is characterized by a marked seasonal variation (Aliyu, et al., 2019). Figure 2 below shows map of Nigeria (top) and Plateau State (bottom) showing the study area.

Figure 2: Map of Nigeria (top) showing Jos and Map of Plateau State (down) showing Study area.
Source: Adapted from Orewere, et al., 2019.

4.0 Results and Discussions

Landscaping with stone creates a framework for movement, visual definition and establishes different use areas in the landscape.A reconnaissance survey carried out within the metropolis reveals that about 65% of landscape projects makes use of stones which is functional and interesting. Although some form of challenges of using stones were noticed. This is evident from Plates xii to xxi. Picture on Plate xii shows cut flagstone slabs leading to the art gallery at Jos, Zoo. Plate xiii reveals the construction of a retaining wall constructed from building stones at the Jos Zoological garden while Plate xiv shows cut flagstone used for pool decks, patios and garden walkways at Hill Station Hotel, Jos. Plate xv and xvi shows stone with good appearance used as face works on fences and buildings in town.

The picture in Plate xvii reveals how the base of water fountain which serves as focal points at Jos Zoo and the Jos University Teaching Hospital (JUTH) permanent site are constructed from cobble stones. In Plate xviii natural cut stones is used as steps at Hill Station Hotel, Jos and construction and fencing of animal cages (Hyena cage) at the Jos Zoo (Plate xix). Plate xx reveals the use of stones as sidewalk way and in Plate xxi gravel is used as natural mulch and ground cover at the School of Post-Graduate studies, University of Jos.

Photographic images gotten during the course of this study however revealed some challenges associated with stone application in landscape project work. The crushed granite stones used as mulch and ground cover material at School of Post-Graduate studies, University of Jos was identified to be easily displaced by heavy rainfall, daily pedestrian traffic movement as they get broken down into little bits due to weights acting on them. Retaining walls and drainage walls within the Jos zoo was observed to have cracks on their mortar joints as a result of the constant contraction and expansion of the stones due to various weather conditions which has resulted into the collapse of some walls and falling off of some of the stone used. While some joints have lichen and moss growing on them due to constant dampness and lack of maintenance. Furthermore, the studies carried out at the art gallery of Jos Zoo and the Jos University Teaching Hospital (JUTH) permanent site reveals that unskilled hands carried out the installation of most stones used for the water fountain as cognizance were not given to the shapes and sizes of the stones before instalment hence, creating an uneven and unbalance appearance.

Landscape stones are quite expensive and require professionalism when installing. Also, the durability and ability of stones to withstand physical weight and harsh weather condition thereby still retaining its chemical properties and appearance makes a better choice for hardscaping. The Author's observed that proper application of stone in outdoor landscape development adds value to the natural environment due to their ability to absorb heat and reflect back light to the surrounding landscaped area.

4.1 Photographic Illustrations of the use of stones in landscape development

Plate xii: Irregular cut flagstone slabs steps leading to the art gallery at Jos, Zoo
Source: Author's field work, 2019

Plate xiii: Retaining walls constructed from cut stones/ building at the Jos Zoological Garden

Plate xiv: Cut flagstone made from limestone used for pool decks, patios, wall caps and garden walkways at Hill Station Hotel, Jos.
Source: Author's field work, 2019

Plate xv: A mortared stone wall made from Limestone used for fencing at G.R.A. Jos.
Source: Author's field work, 2019

Plate xvi: Stone with good appearance used as face works on buildings at Hill Station Hotel, Jos

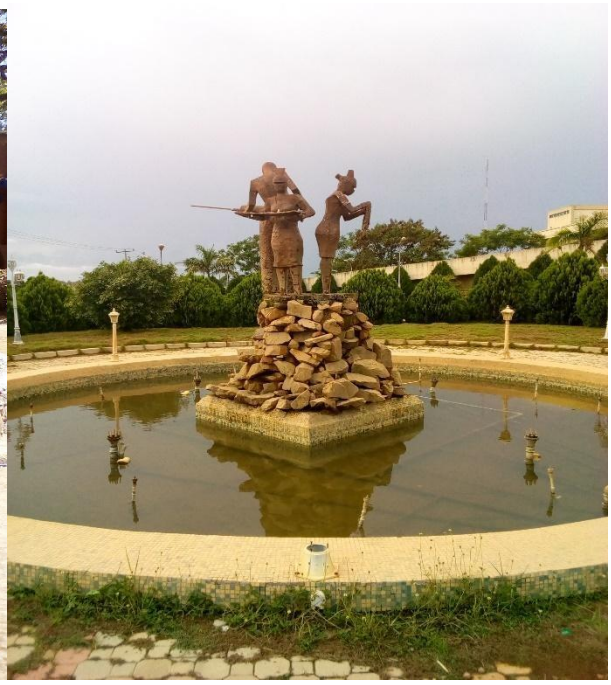



Plate xvii: Cobbles used as the base of water fountain which serves as focal points at the art gallery of Jos Zoo and the Jos University Teaching Hospital (JUTH) permanent site. Source: Author's field work, 2019

Plate xviii: Natural cut stones uses as steps at Hill Station Hotel, Jos
Source: Author's field work, 2019

Plate xix: Construction and fencing of animal cages (Hyena house)at the Jos Zoo

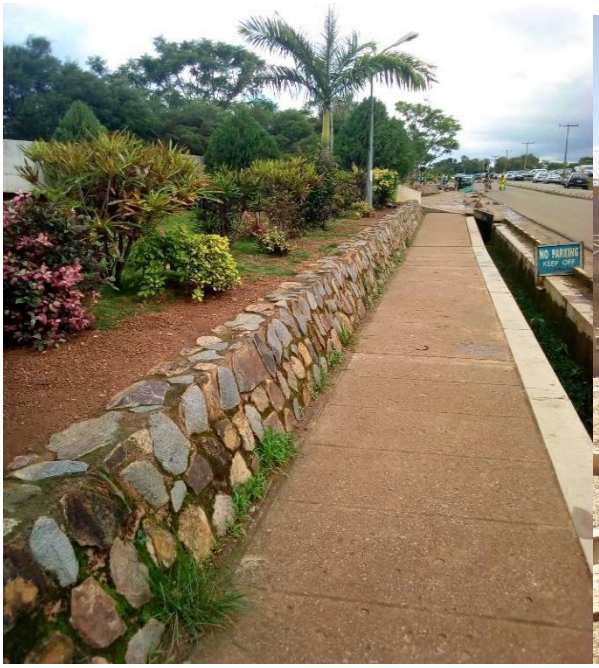


Plate xx: Sidewalk ways as hardscape element at Jos University Teaching Hospital,(JUTH) **Plate xxi:** Gravel used as mulch and natural ground cover at School of Post-Graduate studies, UNIJOS. Source: Author's field work, 2019.

5.0 Conclusion

This research work has laid a good foundation for showcasing the uses of stone for outdoor landscape development. A hardscape material which is user-friendly, adds dimension and style to an environment, as well as transform characterless area to places of peace and pleasure for human comfort. Stone materials of different kinds should be adopted in landscaping of the city centres in order to improve the urban imagery.

Another conclusion of note is the need to encourage Landscape Architects and Individuals involved in landscape construction works to use more of stones in their landscape projects, as it has no side effect on plants and the ecosystem. Landscaping stones might be pricier than mulch, yet they are very advantageous when sued as ground covers. It is very durable and can last a lifetime. They also add an eye catching contrast to your deep coloured foliage, thereby brighten up any shady portion of outdoor spaces. However, there is need for consideration in terms of the choice of material so as to reduce the effect of solar insolation, glare and to ensure the maintenance of thermal comfort at all times of the day and year.

6.0 Recommendation

This research advocates that professionals such as landscape architects and other allied professionals handling landscape project jobs should use more of stones as it has no side effects on the ecosystem or soft scape elements. There is need for adequate funding of landscape projects as well as sensitization to users' to show more concern and respect for the environment. Training centers for unskilled persons on how to apply and install stones in a landscape project should be set up by government at various levels of work.

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