



Appraisal and Upgrading the Prototype Landscape and Artificial Intelligence Design:

Faculty of Agriculture, University of Ibadan Signage Area

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Article Info

Article history

Received: July 9, 2024

Revised: September 23, 2024

Accepted: September 30, 2024

Keywords

Ornamental plants

Landscaping

Scale and proportion

Tolerance index

Signage

Abstract

The study examined the effectiveness of the use of artificial intelligence tools in the creation of scale and proportion using ornamental plants in the prototype design of the Faculty of Agriculture signage based on air pollution tolerance index (APTI). Transect line of 2 m x 2 m quadrants were positioned for frequency value of the plant species determination. Biochemical parameters such as ascorbic acid, total chlorophyll, relative water content and pH were determined for the calculation of APTI. Design process was based on ecological landscape design concept with the use of computer software ArchiCAD-2018, Revit - 2018 and artificial intelligence tools Planner 5D. Data were subjected to statistical analysis. *Bougainvillea x buttiana* had the highest APTI of 20.04, *Ixora coccinea* 19.72, *Tradescantia spathacea* 13.34, *Duranta repens* 12.71, and *Cynodon dactylon* having the lowest of 11.60. The study concluded that, APTI assessment serves as a major tool for identifying ornamental plants capable of thriving well in various environmental conditions while artificial intelligence algorithm aids in the generation of prototype faculty signage using ornamental plants to create the effects scale and proportion in the landscape design.

Introduction

Landscape architecture design is otherwise known as landscape design, but not to be confused with landscape architecture. In addition to the so-called greening and gardening that stereotypically complements the profession of landscape design, it also includes the planning, management and use of ecological land and the development of territorial landscape, which is an all-inclusive environmental discipline. It is a multi-disciplinary design field which integrates architecture, gardening, planning, ecology, and other disciplines (Ye, 2019). Landscape design aims to create places that meet social, environmental, cultural, aesthetics and hands-on requirements through the manipulation of the material environment (Ayuba *et al.*, 2019). The major recipient of landscape design

is the environment that is being worked on, which is referred to as the 'landscape' with regards to the research technicality in creating a sustainable urban environment as an organic fusion of architecture with natural components (Shabatura *et al.*, 2016).

The knowledge of the elements and principles of design is essential to designing a landscape and working through the design process (Hansen, 2016). Principles of design include unity, simplicity, variety, balance, scale and proportion (Williams and Tilt, 2019). These principles vary with different authors and may be referred to by different terms. For instance, unity may be referred to as harmony; rhythm is a principle of design in some papers, and scale and proportion are two separate principles and at the same time it can be combined as one principle. Also, as human needs evolve, techniques and styles change, and so do landscape design inclinations. According to Deng (2022) who states that the application of digital technology and methods can break through the limits

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of traditional design techniques and construction materials and significantly release the creativity of landscape planners. For example, modern landscape designers should not only learn the characteristics of traditional and classical garden charm, but also make full use of modern new materials and new technology, to create a beautiful environment space for people to watch, recreate and entertainment, in the modern city searching for the joy of returning to the nature (Chen, 2017).

According to Liu (2019), combining landscape construction with artificial intelligence to create a harmonious atmosphere close to nature is the key to urban landscape design. The days of pencil on paper are slowly decreasing and landscape designers must embrace the evolution that comes with the technological advancements of the 21st century. Artificial intelligence technology has been around us for many years; with greater and more expectation from the technology than ever before (Sarmah, 2019). This emphasizes the need for landscape designers to combine artificial intelligence with landscape design, of which this study employs computer - aided architectural design, and tools of artificial intelligence algorithm. At present, modern cities suffer from climate change, desiccation, flood, and good diet due to dramatic decrease of green space (Choi, 2021). There is a need for more green space, established with the vision of aesthetics and other functions offered by landscape design. In Nigeria, there is a dearth of information on the functional and aesthetic manipulation of landscapes, which results in erroneous planning of residential areas and open spaces. The aspect of proper regional and urban planning is being ignored due to overpopulation and the expedition to build more structures. Thus, the importance of green spaces decreases because many do not see the need for it. However, where proper landscape planning and design is being executed, the results may be good, but may not be the best in terms of world standard. The 21st century is the era of artificial intelligence, and this is indicated in many such areas where it has been applied to make living easier.

The combination of artificial intelligence with landscape design has not been properly discovered, and this leads to under-utilization of both human and land

resources. Although, many landscape designers are familiar with the basics of computer – aided design (CAD), there is the need for knowledge development in the application of computer - aided design technology to landscape design. According to Tian (2022), computer - aided technology has a good application in all aspects, especially in the field of landscape planning and design, there is a hazier prospect, and landscape designers need to strengthen the study and its applications. The landscape effects are more realistic, richer in colours and has a stronger sense of hierarchy (Xu and Wang, 2022). Therefore, the proposed design has a better chance of being considered as a prototype for actual physical representation and construction on the Faculty of Agriculture signage area, University of Ibadan. With the outcome of this study, the proposed landscape design using ornamental plants, provides beautification of the faculty's signage area and attracts visitors, as well as beneficial insects, to the area. Ornamental plants and gardens have always been sources of inspiration and ties for cultures and civilizations all over the world, guaranteeing aesthetic and recreational values, and fonts of stimulus for cultures, arts, educational and spiritual values, and identity (Francini *et al.*, 2022).

Considering that there is limited knowledge on landscape design in Nigeria, that is evident in the recently developing field of landscape horticulture, this study will add to the growing body of knowledge and create awareness on the importance of landscape design in a country like Nigeria where it is assumed to be only for the elite population. Scale and proportion refers to the comparison of each part of the building space with the natural object and is not to be neglected in the landscape design (Chen, 2017), thus the priority of this study. Using scale and proportion to enhance harmony and contrast can boost dramatic impact, even in small spaces (Steffen, 2019). In the creation of scale and proportion in the proposed artificial intelligence prototype landscape design, this study makes use of ornamental plants. According to Tian (2022), plants occupy an important proportion in landscape formative and play the role of creating atmosphere and improving quality in landscape design blueprints. The objective of the study is to employ artificial intelligence machine learning algorithm tools in the creation of scale and

proportion using ornamental plants tolerance index for the prototype design of the Faculty of Agriculture signage.

Materials and Methods

Description of experimental location

The study area was the signage area at the Faculty of Agriculture, University of Ibadan, Nigeria. The land is majorly demarcated by the existing flora, and located between latitude 7.449137°N and longitude 3.896110°E. The existing flora at the time of the study were: *Cynodon dactylon*, *Tradescantia spathacea*, *Acalypha wilkesiana*, *Ruellia simplex*, and *Codiaeum variegatum* (Plate 1).

Site analysis

Site analysis was carried out to determine the existing hard and soft-scape features, to understand the best way possible to go about the design. The principles

of design such as simplicity, rhythm, scale and proportion, balance and repetition were employed in the creation of the design. They were identified using Google Lens (Bilyk *et al.*, 2021), an artificial intelligence tool, and taken to the Herbarium at Forestry Research Institute of Nigeria (FRIN) for authentication.

Plant selection and determination of frequency distribution

Plant selection was done based on quadrats of 2 m x 2 m established in the nursery garden for each species using line transect. Occurrence of the selected species in each quadrat was recorded (Table 1). The frequency of each species was determined as follows:

Frequency

$$= \frac{\text{Number of occurrence of each species}}{\text{Total number of all occurrences}} \times 100$$



Plate 1: Study area

Table 1: Proposed selected ornamental plants species for the landscape design

Botanical Name	Common Name	Family
<i>Bougainvillea x buttiana</i> Holttum & Stadley	California Gold	Nyctaginaceae
<i>Tradescantia spathacea</i> (Sw)	Oyster Plant	Commelinaceae
<i>Duranta repens</i> (L.)	Yellow Bush	Verbenaceae
<i>Ixora coccinea</i> (L.)	Jungle flame	Rubiaceae
<i>Cynodon dactylon</i> (L.)	Carpet grass	Poaceae

Determination of relative water content

Relative Water Content (RWC) was calculated by the formula (Li *et al.*, 2023):

$$RWC = \frac{(FW - DW)}{(TW - DW)} \times 100$$

FW - weight of fresh sampled leaves, *TW* - weight of sampled leaves after soaking in deionized water overnight; *DW* - dry weight of sampled leaves (all in grams); *RWC* - relative water content (%).

Determination of pH of leaf samples

The pH was determined by standardizing fresh leaf samples (2.5 g) in 25 ml of deionized water, after which the leaf extract was filtered and the pH determined after calibrating pH meter with a buffer solution of pH 7 (Li *et al.*, 2023, Kakde and Tak, 2017).

Estimation of total chlorophyll (Tch)

Total Chlorophyll content was determined using clean water, 20 - 25 ml of 80% acetone and magnesium carbonate, leaf extract content was centrifuged at 2000 rpm. The green solution optical density was determined at 645 nm (D645), and 663 nm (D663) using a spectrophotometer (Kakde and Tak, 2017).

Ascorbic acid (AA) content analysis

The 2,6-dichlorophenol indophenol method was used to analyze the ascorbic acid content. One gram of each sample was extracted in 4% oxalic acid and diluted to 20 ml. The sample was then centrifuged for 5 mins at 4500 rpm. After pipetting 5mL of the supernatant, 10 ml of oxalic acid was added, and the mixture was titrated against the dye until it turned pink (Li *et al.*, 2023).

Calculation of air pollution tolerance index (APTI)

The air pollution tolerance index (APTI) was measured using the method proposed by Singh and Rao (1983). $APTI = A(T + P) + R/10$ = Ascorbic acid content in (mg/g) of leaves (A), Total chlorophyll in (mg/g) fresh weight (T), pH of leaf extract (P) and Relative Water Content (%) (R) were used. The results obtained were interpreted with the use of categorization scale in which APTI value of < 11 was considered sensitive; between 12 -16 was considered intermediate and > 17 was considered tolerant to air pollution (Gautam and Shukla, 2020).

Design process with plant species

Application of some basic design processes (site analysis, aesthetic, spacing, selection, climatic and soil characteristics) and principles of design were used in the design of prototype site layout plan. These principles consist of various uses of line, form, texture, colour, repetition, variety, balance, and emphasis. All these terms apply to any aesthetic composition or work of art. Scale: more variety and less repetition can be used in a small-scale design such as a residential garden or the faculty area signage garden and in contrast to a large-scale design such as an urban park (Carpenter and Walker, 1990; Alabi, 2021; Alabi *et al.*, 2023).

Artificial intelligence algorithm and computer aided architectural design

It was based on the concept of ecological landscape design; Planner 5D software of artificial intelligence tools were employed in recognizing and mapping out natural processes in the landscape. Computer software ArchiCAD-2018 and REVIT-2018 were used to determine the formulation of site plan, and perspective of the prototype faculty agriculture signage design (Liu, 2019; Alabi, 2021; Tian, 2022).

Data analysis

Data on biochemical parameters were obtained using four replicates per plant species. Thereafter, data obtained were condensed to give the mean values of the respective biochemical parameters. Analysis was done using Microsoft Excel and the Statistical Package for the Social Sciences (SPSS) version 26.

Results

Selected trees species in the study area

Among the ornamental plant species, *Duranta repens*, *Bougainvillea x buttiana* and *Ixora coccinea* were dominated with frequency of 40.67%, 26.00% and 17.67% respectively. The species with least occurrence in the nursery landscape were *Tradescantia spathacea* and *Cynodonn dactylon* had the least occurrence in the nursery landscape (Table 2).

Biochemical parameters and air pollution tolerance index (APTI)

The air pollution tolerance index (APTI) is an indicator of the plant's capacity to counter air pollution stress, and it was derived from four biochemical parameters: Relative water content, pH, total chlorophyll content, and ascorbic acid. From the values

Table 2: Frequency value of the selected ornamental plants

Botanical name	Common name	Frequency (%)
<i>Bougainvillea x buttiana</i>	California gold	26.00
<i>Tradescantia spathacea</i>	Oyster plant	7.33
<i>Duranta repens</i>	Yellow bush	40.67
<i>Ixora coccinea</i>	Jungle flame	17.67
<i>Cynodon dactylon</i>	Carpet grass	8.33

for the air pollution tolerance index, ranges from 11.60 to 20.04 (Table 3), with the standard deviation ranges of (± 0.029 to ± 0.058). The highest APTI values were observed in *Bougainvillea x buttiana* (20.04 ± 0.029) and *Ixora coccinea* (19.72 ± 0.243), while moderate APTI of 11 – 17 was observed in *Tradescantia spathacea* 13.34 ± 0.058 > *Duranta repens* 12.71 ± 0.156 > *Cynodon dactylon* 11.60 ± 0.257 (Table 3). APTI indices in plants revealed that the plants vary in their response to environmental pollution and their tolerance to air pollution was determined by their ability to mitigate the stress induced by pollutants through the antioxidant. Thus, the combination of the plants was sufficient to withstand the amount of air pollution that may occurred in the experimental site.

Design process with plant species

Artificial intelligence algorithm and computer aided architectural design

With the plant samples and principle of scale and proportion in view, the proposed design for the experimental location/study area were shown below: A site plan (Plate 2) is a scale drawing that shows the entirety of the site with the proposed design of the site and the surrounding structures. The site plan was drawn at a scale of (1:100). The unit of measurement is millimeters; the dimensions of the width of the walkway (1, 200 mm) and road (6,000 mm).

Perspective 3D prototype design

The three-dimensional image showcase what the design will look like in real life before the model is adopted. The image is a realistic/lifelike depiction of the intended design for the experimental location (Plate 3).

Table 3: Mean values of biochemical parameters and APTI of the ornamental plants

Plants	RWC (%)	pH	Tch (mg/g)	AA (mg/g)	APTI	Response
<i>B. x buttiana</i>	56.71 ± 0.067	6.05 ± 0.008	0.02 ± 0.000	23.68 ± 0.029	20.04 ± 0.029	Tolerant
<i>I. coccinea</i>	50.71 ± 0.055	4.80 ± 0.088	0.03 ± 0.000	30.32 ± 0.712	19.72 ± 0.243	Tolerant
<i>D. repens</i>	52.59 ± 0.461	5.41 ± 0.116	0.01 ± 0.000	13.74 ± 0.075	12.71 ± 0.156	Moderate
<i>T. spathacea</i>	65.73 ± 0.096	5.50 ± 0.026	0.02 ± 0.000	12.26 ± 0.075	13.34 ± 0.058	Moderate
<i>C. dactylon</i>	53.50 ± 0.408	4.38 ± 0.151	0.03 ± 0.000	14.17 ± 0.022	11.60 ± 0.257	Moderate

Where RWC = Relative Water Content; APTI = Air Pollution Tolerance Index; Tch = Total Chlorophyll; AA = Ascorbic Acid



Scale 1:100; Walkway: 1, 200 mm; Road: 6000 mm

Plate 2: Site plan



Plate 3: Perspective 3D prototype design of the signage area

Discussion

Mostly, ornamental plants are regarded for their aesthetic qualities rather than their functional values. Yet, they can be used for so much more (Alabi, 2021). The plant samples selected for the proposed artificial intelligence prototype design were subjected to various assessment, which include determination of relative water content (RWC), pH, ascorbic acid content (AA) and total chlorophyll (Tch). These assessments were carried out to determine the air pollution tolerance index of each plant, which gives each plant a certain worth in terms of functionality. One of the functional uses of ornamental plants is that the foliar surfaces of plants act as sinks for air pollutants. Thus, plants that are tolerant (as determined by the APTI) will serve as better tools for mitigating the effect of air pollution in the environment (Manjanath and Reddy, 2019). Given that the study location is an open site, subject to a large amount of pollution, as it is beside the road, the proposed plants are highly suitable for establishment on it. This arises from the fact that all the proposed plants are moderately tolerant for upgrading the landscape design of the study areas.

Thus, the design embodies the use of a hedge, which is made up of the *Ixora coccinea* plant intertwined with *Duranta repens*, in its early growth stage, hence the complete greenness of the hedge. In blooming season, the gold edge of the *Duranta* plant and the red colour of the *Ixora* plant provide a warm sensation to passers-by, since *Bougainvillea x buttiana* was also an outlier, it stands out in few numbers as a tall ornamental structure within and just outside of the site. The plant height also helps to balance the shorter surrounding hedge plants. In addition, fewer taller plants make the experimental location less intimidating for humans and more body – size friendly. The landscape was completed with the Bahama grass (*Cynodon dactylon*) in the middle, surrounded by *Tradescantia spathacea*, which is a darker shade of purple and green compared to the model in the design. The *Tradescantia* plant also creates a contrast with the brighter colours of the hedge plants during bloom. From the upgrading of the study area, it was also shown that there is an affinity between *Tradescantia spathacea* and *Cynodon dactylon*. The use of artificial intelligence software and the component tools in this

design helped to efficiently bring out the objective of creating scale and proportion in the design which was in line with the observation of Liu (2019). The user – friendly interface, and automated options allowed for the easy production of the design. In particular, the software used: Revit, possesses tools for easy creation of site elements such as the roads and sidewalks, capturing the full essence of the design as reported by Tian (2022). The highlight of using the software was the depiction of the realistic image of the proposed design prototype.

As seen in the 3D Rendered Image, the tall trees were arranged such that their presence was not overwhelming. They were also arranged at a proportionate distance from one another. The mass of each plant species contributes to the creation of scale and proportion in the landscape, allowing for effective movement and plant interaction. The varying heights of the plants used also emphasize contrast and a balance, which allows for proportion with the human body. This was in consonant with the report of Hansen (2016) that some people feel secure in smaller open areas, while others feel better with overhead conditions. It was also noticeable that the tall plants are relatively the same height as the signage – this is evidence of the ornamental plants complementing the structure at the site in terms of scale. With maintenance and grooming, a scale – appropriate plant height can be attained. One of the goals was for humans to feel comfortable in this landscape, and the design had effectively achieved that when compare it with the former landscape design of the areas.

The presence of the walkway also helps to direct movement. There was also a good use of the principle of proportion, seeing that there is a good amount of open space as well as an equal and proportionate amount of soft scape and hardscape elements in the landscape. The hardscape elements to note were the overhead lighting, other lighting structures arranged along the hedge, the neon lighting of the signage, the water fountain around the signage and of course, the paved walkway. The design was simple, harmonious and obeys the principle of scale and proportion, with the good relationship between the plants, hardscape components, and the human body. To salvage the former fading environment, there is the need for an

effective landscape design, in terms of aesthetics and functionality, as stated in the objectives. However, Yadav and Nikam (2023) had earlier reported that to ensure faster and easier work, especially in tandem with the technological advancements of this age, the use of computer – aided design (CAD) technology through artificial intelligence algorithm tools were a necessity for landscape designers to get more accurate design prototypes. With regards to functionality, this design examined the air pollution tolerance index values of the plant samples proposed to be used on the experimental location for the artificial intelligence prototype design, and ascertained the effectiveness of such plants, given the amount of air pollution around the site.

Conclusion

The study concluded that, few indigenous landscape authors were found, with reference to the subject of artificial intelligence in landscape horticulture/design. Air pollution tolerance index assessment served as a major factor for identifying ornamental plants capable of thriving well in various environmental conditions while artificial intelligence algorithm aided in the generation of prototype faculty signage using ornamental plants to create the effect known as scale and proportion in the landscape design. Thus, it is recommended that more enlightenment be made about the importance of landscape design in the Department of Horticulture in the tertiary institutions, to encourage more research and practice of the holistic principles of landscape horticulture.

Acknowledgments

The principal author is grateful to Dean, Prof. A.B. Omojola, (Faculty of Agriculture) and Prof. J.A. Fagbayide, (Head, Department of Crop and Horticultural Sciences) both of University of Ibadan, for their support and provision of enabling environment for study.

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