JCUA | Journal of Contemporary Urban Affairs

Alanya Hamdullah Emin Paşa Üniversitesi

Journal of Contemporary Urban Affairs

Vol. 6 - Issue. 2 2022 ISSN 2475-6156

In This issue:

ISSN 2475-6156 (print)

ISSN 2475-6164 (online)

Journal of Contemporary Urban Affairs

Volume 6, Issue 2, December 2022

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www.ijcua.com
IMPRESSUM

Journal of Contemporary Urban Affairs
Volume 6, Issue 2, December 2022

ISSN 2475-6156 (print) ISSN 2475-6164 (online)
URL: www.ijcua.com
Email: editor@ijcua.com
Publisher: Alanya Hamdullah Emin Paşa Üniversitesi
Address: No: 58, Izzet Azakoğlu Boulevard, Saray Mahallesi, Alanya,Antalya, Turkey.
Faculty of Architecture, Alanya HEP University, Cikcilli Mah. Saraybeleni Cad. No:7 07400, Alanya/Antalya/Turkey
Phone: +90 506 189 99 66
Printed in: Erman Ofset, Fevzi Çakmak Mahallesi Büsan O.S.B. Özlem Caddesi No:33/G, KONYA, Turkey.
Circulation: 100 copies

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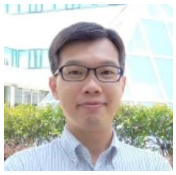

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Publisher:
Alanya Hamdullah Emin Paşa Üniversitesi
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Main Title
Journal of Contemporary Urban Affairs
Serial key title
Journal of Contemporary Urban Affairs
Abbreviation: JCUA
Serial type: Journal
Publisher: Alanya Hamdullah Emin Paşa Üniversitesi, https://www.alanyahep.edu.tr/
Postal Address: Alanya Hamdullah Emin Paşa University, Cikcilli District, Saraybeleni Street No:7 07400 Alanya/Antalya/TURKEY
Publisher's History:
Since December 2019- ongoing: Alanya, Turkey: Alanya Hamdullah Emin Paşa Universitesi
From June 2017 until June 2019: Mersin, Turkey: Anglo-American Publications LLC

Publication Medium: Printed and Electronic version
ISSN (printed): 2475-6156
ISSN (online): 2475-6164
Publication
Website: https://www.ijcua.com/index.php/ijcua
Editor-in-Chief: Assoc. Prof. Dr. Hourakhsh A. Nia
Editors: see » Editorial Team
Frequency: 2 issues per year (June and December)
Status: Active
First Year Published: 2017
The DOI Prefix allotted for JCUA is 10.25034
Content-Type: Academic/Scholarly
Language: English
Key Features: Abstracted and Indexed, Refereed, Double-Blind Peer Review.
Indexing Databases: see » Abstracting and Indexing

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- Section A- Citizenship Rights and Responsibilities: Citizenship Rights, Governances and practices, Urban and Social Identities, Walkable cities, Participatory projects, Urban ecology. Urban and social Identities, Well-Being, Acoustics, Smellscape, Authenticity, Quality of urban life, Public Health, Human behaviour and cities, Multiculturality: Inequalities and diversities, Social distress, Psychology.

- Section B-Territorial dynamics: Urban Landscapes, Human urban geography studies, Spatial analysis: GIS and remote sensing, Spatial divergences, Interregional migrations, Urban Competitiveness, Globalization, Territorial planning, Conflict and Divided Territories, Urban Sprawl, Wadi territories, Regional Planning, Gated communities, Housing,

- Section C- Urban Transformations: Urban Regeneration, Housing Studies, Urban renewal, Heritage Studies, Housing Economics, Urban Sociology, Urban Morphologies, Socio-spatial Practice, African regionalism in Architecture, Pre-colonial cities, Landscape Architecture, Heritage Preservation. Urban Renewal, Gated Communities, Rapid Urbanization, Rehabilitation, Tourism and economical sustainability. Slums, Globalization, Community development, Political economy. Mediterranean Architecture and Urbanism, Emerging Cities, Smart Cities, Sustainable Urban Development.

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- Accept the manuscript without further revision
- Accept after revision
- Ask the authors to re-submit
- Reject

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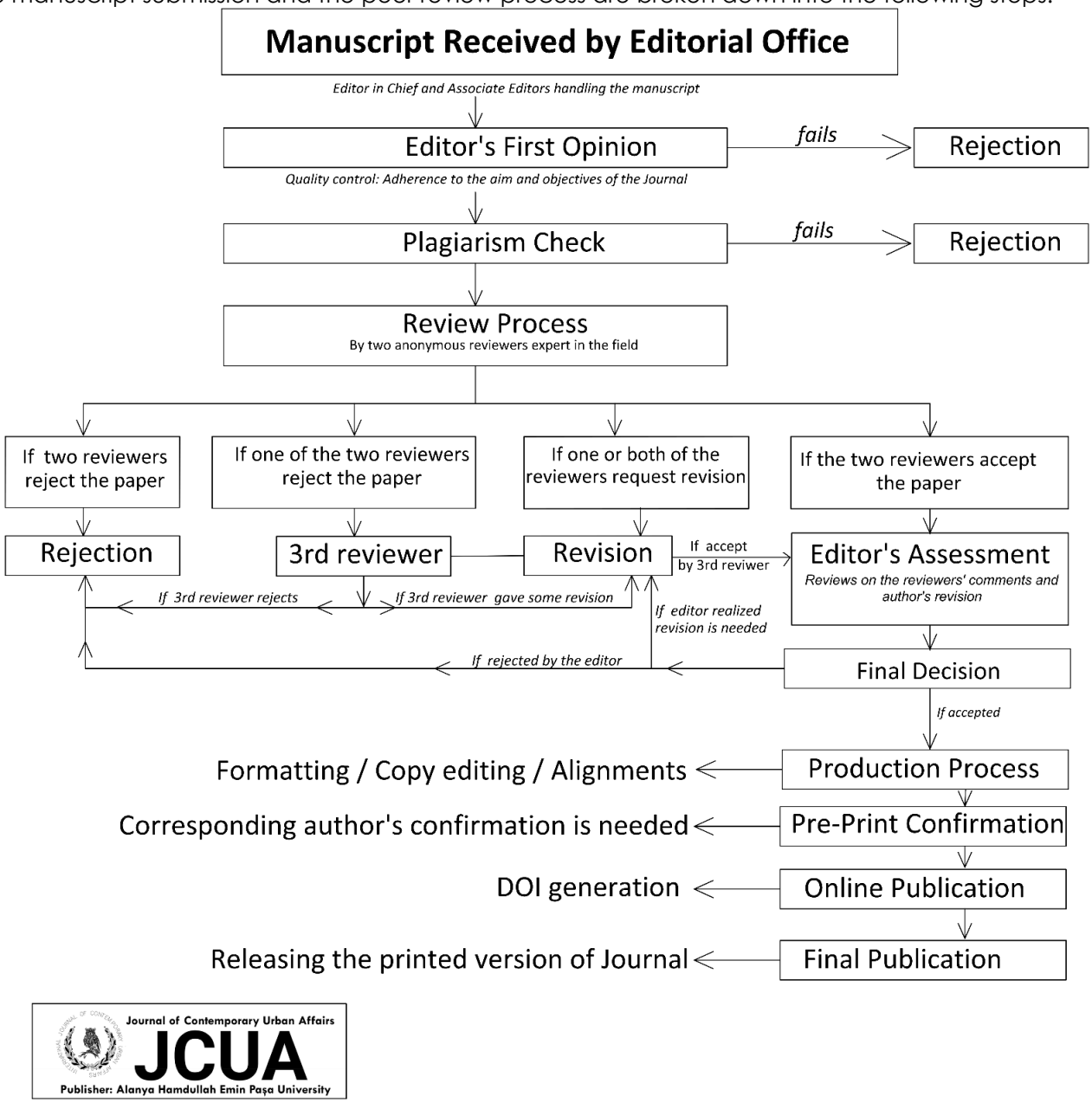

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Figure 1. Peer Review Process.

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Adapted from: Bella H. Plagiarism. Saudi J Med Sci 2014; 2:127

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When reporting on research that involves human subjects, human material, human tissues, or human data, authors must declare that the investigations were carried out following the rules of the Declaration of Helsinki of 1975 (**https://www.wma.net/what-we-do/medical-ethics/declaration-of-helsinki/**), revised

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- Accepting to write reviews in their expertise when asked
- Reviewing publication guidelines and improving them consistently
- Taking responsibility in journal's operation

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Credit Author Statement

In mid-2012 the Wellcome Trust and Harvard University co-hosted a workshop to bring together members of the academic, publishing, and funder communities interested in exploring alternative contributorship and attribution models. Following the workshop (see workshop report), and working initially with a group of mainly biomedical journal editors (and members of the ICMJE a pilot project was established to develop a controlled vocabulary of contributor roles (taxonomy) that could be used to describe the typical range of 'contributions' to scholarly published output for biomedical and science more broadly. The aim was to develop a taxonomy that was both practical and easy to understand while minimizing the potential for misuse. CRediT offers authors the opportunity to share an accurate and detailed description of their diverse contributions to the published work. CRediT (Contributor Roles Taxonomy) is high-level taxonomy, including 14 roles, that can be used to represent the roles typically played by contributors to scientific scholarly output. The roles describe each contributor's specific contribution to the scholarly output.

Role	**Definition**
Conceptualization	Ideas; formulation or evolution of overarching research goals and aims.
Data curation	Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later re-use.
Formal analysis	Application of statistical, mathematical, computational, or other formal techniques to analyse or synthesize study data.
Funding acquisition	Acquisition of the financial support for the project leading to this publication.
Investigation	Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection.
Methodology	Development or design of methodology; creation of models.
Project administration	Management and coordination responsibility for the research activity planning and execution.

Resources	Provision of study materials, reagents, materials, patients, laboratory samples, animals, instrumentation, computing resources, or other analysis tools.
Software	Programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components.
Supervision	Oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team.
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Conceptualization: J.F., S.M., R.B, M.W. **Data curation:** S.M., J.F., J.S., J.P.B. **Formal analysis:** M.W., J.F., S.M., R.B. **Funding acquisition:** J.F., S.M., R.B. **Investigation:** S.M., J.S., J.P.B., J.F. **Methodology:** J.F., S.M., R.B., M.W. **Project administration:** S.M., J.F. **Writing—original draft:** S.M., J.F. **Writing—review and editing:** J.F., S.M., R.B., J.S., M.W., J.P.B. All authors have read and agreed to the published version of the manuscript.

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Sources:

1. The presentation of the 14 roles has been adapted from the Consortia Advancing Standards in Research Administration (**CASRAI**) website.
2. https://onlinelibrary.wiley.com/doi/full/10.1002/leap.1210

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Journal of Contemporary Urban Affairs

Publication Frequency: 2 Issues per year (June & December)
www.ijcua.com , editor@ijcua.com
ISSN 2475-6156 (print)
ISSN 2475-6164 (online)
Publisher: Alanya Hamdullah Emin Paşa Üniversitesi

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Journal of Contemporary Urban Affairs

2022, Volume 6, Number 2, pages 96–111

Original scientific paper

The Right to Land: To Whom Belongs after a Reconciliation Law in Egypt

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ARTICLE INFO:

Article History:
Received: 25 October 2021
Revised: 15 January 2022
Accepted: 28 January 2022
Available online: 14 February 2022

Keywords:
Reconciliation Law;
Housing;
Property;
Regulations;
Building Violations;
Land Management;
Egypt.

ABSTRACT

A revolutionary book by De Soto to formalize land tenure by changing "dead capital" to "life capital" has become the trademark in Egypt of issuing a temporary reconciliation law of 2019 and its amendment to approve a legal certificate to the violators against a certain fee. The question is does this law legalize informal housing? Is it enough to introduce a legal certificate to secure land tenure for the violators? How would this law apply on the ground? Depending on the deductive methodology, this paper traces sociotechnical transitions concerning legalizing the status quo of building/land, tenure security, real-estate markets (formal/informal) caused by laws on buildings violations reconciliation. The idea is to take a step back and look at a wide angle of the problem in the future to arrive at a clear picture of the influences of the introduction of a new law on the land market, before making a decision. The paper assumes that the temporary reconciliation law in Egypt is opening the debate on the alteration of land management to govern the status quo of the chaos of the right to land. It concludes this temporary reconciliation law has created a state of decayed/wealth, social inclusion/exclusion of the bottom of the social pyramid nevertheless to whom the justification is affected.

JOURNAL OF CONTEMPORARY URBAN AFFAIRS (2022), ***6***(2), 96-111.
https://doi.org/10.25034/ijcua.2022.v6n2-1

www.ijcua.com

1. Introduction

Land is the main component of urban development, and it is also the source of individual and communal identity, the basis for shelter, and it is considered as financing for transit-oriented development (Home, 2020; Suzuki et al., 2015). It displays and measures the level of improvements and the degree of the quality of the built environment subsequently, determining the level of both poverty reduction and the quality of urban infrastructure. Therefore, urban expansion, infrastructure development, and resilience of cities have to be controlled by a proper land management system. Rapid population growth combined with informal spatial growth and the spreading of the shadow economy in Egypt has created a chaos-built

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How to cite this article:
Soliman, A. M. (2022). The Right to Land: To Whom Belongs after a Reconciliation Law in Egypt. *Journal of Contemporary Urban Affairs, 6*(2), 96-111. https://doi.org/10.25034/ijcua.2022.v6n2-1

environment. This has resulted in an annual housing production of 263,838 units during 1996-2006, of these, 55.6 percent were formal and the rest informal (Soliman, 2012a). It is estimated that 14.58 million housing units were out of the real estate market during 2016 in urban areas in Egypt, of which 6.40 million units were vacant and 8.18 million units were closed. On the other hand, a figure of 42 percent of the housing stock in the Greater Cairo Region is seized under rent control (CAPMAS, 2021). De Soto (2003) indicated in the year 2000 the cost of informal housing construction in Egypt amounted to US$ 241.4 billion. This housing crucible in Egypt has encouraged spontaneous housing development by which it became and will continue to be the main feature of the Egyptian landscape (Sims, 2011; Soliman, 2021).

Securing land and property rights in Egypt exists through informal means and became the preferred and affordable method for people who are most in need of housing plots. But there is evidence that the variations of security of land tenure mechanisms are poorly designed in which about 60-80 percent of violators do not benefit from the introduction of the reconciliation law (Soliman, 2021). The right to land became the main problem that faces low-income groups and the pressing need to secure women's property rights (Archambault & Zoomers, 2015; De Soto, 2003; Home, 2020; McAuslan, 2013; Payne et al., 2009). It constitutes not only for using it to construct a shelter but also as a commodity and an asset to secure their economic future from a rapid inflation process.

The main objective of the study is to arrive at a practical and legal framework to legalize and formalize informal housing, and it aims to explore the influence of applying the reconciliation law on legalizing and formalizing informal housing. The goal is to investigate the procedures of the law on the sociotechnical tendency and how are implemented on the ground (see Figure 1). The objective, aim, and goal of the paper is primarily exploratory. It combines qualitative and quantitative methods to reflect the prevailing situation, therefore, questions the instruments of the temporary reconciliation law and who would be benefited. Thus, this research enquiries the implementation of the law on the ground, and its influence on the real estate market. Conversely, the aim and objective of the study are looking to measure or analyze the effect of the introduction of the reconciliation law in simplifying land registration and legalization processes to prevent the threat of evictions or demolition. Thus, the research is likely to be quantitative, and considers quantitative data collection methods (e.g., evaluating the outcomes of issuing a new law) and analyses (e.g., statistical analysis). As illustrated in Figure (1) the research methodology is a retrospect and prospect in nature to arrive at a precise picture before a decision is taken. Thus, the research is exploratory and at the same time confirmatory in nature.

The paper highlights the assumption that the planning regulations of building and land violations of the urban agglomerations in Egypt have a disciplinary trend and cannot be separated from a set of urban planning and land management policies. It assumes the reservation of urban land management at national and local levels is the cornerstone for land supply. Also, the paper assumes the discussion on the legalization of land tenure and the formalization of the status quo of the hosing informality have to be linked by previous land reforms, land regulations, and legal-political processes that produce informal land market. Therefore, the construction challenge was one of the Egyptian most complicated issues, due to the multiplicity of laws and the interlacing of responsible authorities. The Unified Building Law No 119 of 2008 (UBL2008) came to bypass the complexities of Law 106 of 1976 to regulate construction work, Law 78 of 1974 for electric elevators, and previous planning laws. The UBL2008 regulated previous interrelation between owner and tenant of Law No. 49 of 1977 and Law No. 136 of 1981 on renting and selling premises. The gaps that appeared with the application of the UBL2008 caused an increase in problems instead of solving them, hence the state insisted on the urgent need for issuing the Buildings Violations Temporary Reconciliation Law number 17 of 2019 (BVTRL2019).

The paper here is an important contribution to poverty alleviation strategies by examining the above two assumptions through four arguments. First is the scarcity of a suitable land tenure results from the absence of land governance and management. It is due to the failure of planning and legal frameworks to afford an appropriate environment for the real estate market. Second is the preservation of the processes and mechanisms of the status quo of the informality in remodelling the prevailing legal policies to meet the Goal 11 of the SDGs of 2015. Third, land

formalization schemes have to convey other profit, for people most in need, either in kind or in cash or both to people's life. Finally, proper legal instruments and land governances are the components of the implementation of legal land rights. The findings of the study have been widely dispersed. The study concludes that reconciliation law options to formalize the building's violations and regulate land tenure are passing through complicated processes by which the final output has not afforded a concrete solution to tackle informality but sustains the status quo of the informality. The law does not provide an answer to register or secure land tenure as a concrete model to the right to land for the most in need of the population. The present work, therefore, approaches the question of reconciliation of building and land violations mainly based on the pressure between, on the one hand, the state's regulations and, on the other hand, the internal mechanisms or specific dynamics of land tenure, land registration, and ownership in the spontaneous development.

The paper constitutes of five parts: first, general background for the informal arrangements of access to land in Egypt; second, a theoretical debate on building violations; third, a discussion of the role of laws in shaping gentrification, fifth, a discussion on building reconciliation; and finally, the paper demands a future study for future actions.

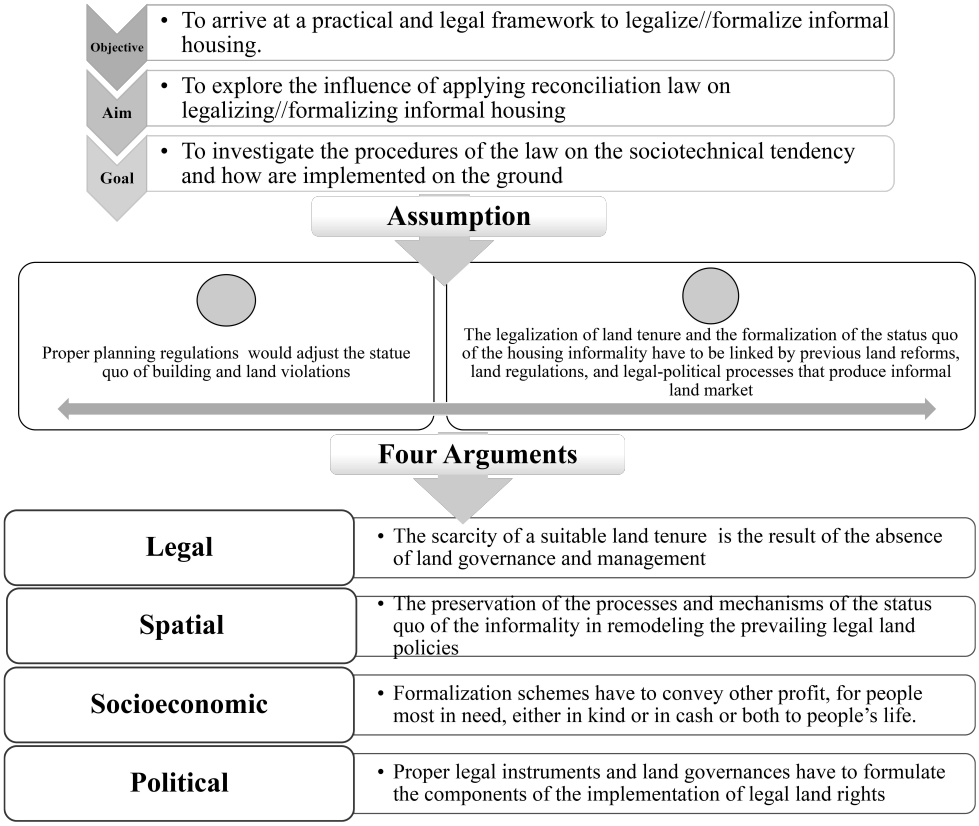

Figure 1. Illustrates the deductive methodology which is used to explore and confirm the current situation to arrive at a precise picture before a decision is taken.

2. Illegal Arrangements of Access to Land

Most of the successes of the urban poor in gaining access to land in the recent past have been through semi-legal or illegal means. The entrepreneur involved in these processes has had to resort to innovative strategies to overcome the specific legal and economic constraints in any given context. Land acquisition and the mechanisms of acquiring land have differed markedly between countries. In some countries, the poor invade or squat land, elsewhere the purchase of land from private property developers. Both cases are well represented in Egypt, where the former occurs in squatting areas, while the other in the semi-informal housing sector (Soliman, 2004). A third phenomenon is taken place in the Muslim's countries, which is renting public land

for a specific period (*Heker*) with paying a symbol rent for the government bodies. Such land often lacks planning permission from the local authorities, or it is outside the city boundary or suited on agricultural land. In some places, the poor or the international organization rent from the private landlords or from public departments to house refugees (as in Beirut and Amman). Furthermore, people might occupy land illegally sharing the luxuries of the upper-class residential suburbs. Variations of this nature have not only been observed between nations, but also within each country and between cities. For example, in Egypt as an Islamic country-, rented public land (*Wqaf or Heker*) can be found in the big cities, and religious urban centers (Such as Tanta city) or surrounding the old core of the Egyptian cities.

The form of land acquisition differs from one country to another. There are many ways of acquiring land within urban areas by individuals or a group of low-income, or squatters. The most important is the organized squatter acquisition by relatively large groups (Lipton, 2009), a phenomenon most found in Latin America. The second is the unorganized acquisition by individual households or small groups of people (Payne et al., 2009), which occurs widely throughout the Global South. The third is private formal acquisition and/or speculation of agricultural land which later subdivided illegally by private developers or small landlords and sold in the market as residential uses plots (Soliman, 2004). Finally, there is semi-organized acquisition through a co-operation or partnerships between the official bodies and/or the squatters and low-income groups. These processes depend upon the mechanisms of land acquisition and are linked with the transitions of socioeconomic, political transitions, and the level of technology that society is passing through (for example see (Kanger & Schot, 2019; Piketty, 2014).

The success and failure of land acquisition or the right to land depend on several variables. Among these are the type of tenure status, the size of people who occupy land, the willingness of landlords to sell or purchase land, and the willingness of the state backing land invasion (McAuslan, 2013). It must be emphasized that the socio-economic, political, and urban transitions reasons, all play a salient part in such acquisition. Some land acquisition occurs during election time, and others during the political crisis, and in some countries during the introduction of new socio-economic regulation of a given environment, for example, Egypt (Soliman, 2021). Also, due to the way that the state acts towards the housing policy as laissez-fair policy, which accelerates land acquisition within urban areas.

The actual land acquisition and erection processes vary according to the political and physical conditions in the city concerned, as well as the level of availability of urban land expansion. However, most acquisitions are neither well-coordinated nor financially viable, and the immediate objective is simply to settle quickly into the chosen area to obtain de facto possession by a display of group solidarity or to settle through the incremental process to obtain de-jure recognition. Most of these processes have relied on the informal economy and informal land markets (Durand-Lasserve & Selod, 2009). There are numerous detailed studies of this observed in different Egyptian cities, and within each city in Egypt. It is of particular significance because such differences occur within and between a certain city. Why are acquisitions of land permitted in some locations and not in others? How has the distribution of land use and its value within a city affected such acquisitions? Do the mechanisms of land acquisition differ within a given area? If so, why do they differ, and what are the reasons for these variations? Does the land market within a city affect land acquisition and regularization within a given setting? How do the different forms of land regularization relate to the socio-economic, political, and urban growth characteristics of a city, and what is the effect of these aspects at the national and local level? How far, to what extent, why, and when has the government been involved or participated in such acquisition or regularization?

A lack of control of low-income land acquisition is general in most of the Egyptian cities because the factor of greatest importance to low-income groups desperate for homes is land availability. The most significant kind of available illegal land, however, is that which has a very low value, or the leeway of conversion of agricultural land to other uses and/or in bad environmental conditions for local authorities, affluent groups, and private developers. Thus, middle and low-

income groups acquire land which less profitable for the private developers, and not with the interest of the local authorities. This location usually is located either on the periphery of the city or near job opportunities, or at least connected to reasonable transport facilities, as well as, far behind the eyes of both affluent groups and the local authorities. The image of low-income locations is that they are usually sited on riverbanks, unused land, steep slopes, deteriorated agricultural land, hillsides, railway, and road rights of way. Illegal subdivided agricultural areas on peri-urban areas are affordable methods to acquire housing plots. The middleman is playing a great role to conduct informal land supply in cooperation with land speculators. This land is usually unsuitably located for residential development, or has topographical difficulties, or is badly serviced, or has low value, or includes the most polluted and worst areas in the city, or as derelict desert areas, and finally, it is usually located in a badly social-environmental condition. While high and middle and above middle-income groups occupy the healthy locations in the city, the nastiest is left to shelter the poor. Briefly, the degree of residential and land-use segregation is likely to be very great within the Egyptian cities. The mechanisms of land supply for the urban poor are quite specific in different Egyptian cities and are tended to change over time, reflecting in both economic and political terms and the commodity nature of urban land. It is argued that substantial efforts through appropriate land legalization programs would enhance the security of land tenure for the poor, subsequently, would reduce the poverty level (Home, 2020; Lipton, 2009).

Because urban low-income groups acquire land illegally, tenure statues are generally in doubt and insecure, and since the insecurity of tenure and the fear of eviction are serious obstacles preventing house improvements in low-income settlements. Tenure security in past years became a natural means for removing these obstacles (Durand-Lasserve, 2005; Payne et al., 2009), improving economic status, and alleviating poverty (De Soto, 2003). It is argued that not only the security of tenure has a direct effect on housing improvements, but also other factors are relevant(Gilbert, 2012). It may be true that the urban poor has common interests in the legal land title, but what type of land title is needed? Is it legal recognition in law (*de jure*) or legal recognition in practice (*de facto*), or is it an intermediate tenure (*customary tenure* or *hybridize tenure*)? How could the land title be provided for informal residential areas-squatting and semi-informal- and what form of the title? What are the consequences of land legislation on the housing market within informal areas and areas surrounding them? Who will benefit from such legislation? Will land legislation speed the housing process or will it make for a further reduction in the housing stock? Should the urban poor be excluded from occupying better land, or should they be integrated into the urban context? Little has been done to answer these questions and to address the relationships between the socio-economic, political, and urban growth characteristics within a city, the right to land, the land delivery system, and the action of the government towards these changes is essential.

Recently, the state of Egypt introduces a new law to legalize the status quo of informality and to eliminate the spreading of arbitrary urban growth. However, the Egyptian government issued a Building Violations Temporary Reconciliation Law No. 17 of 2019 (BVTRL2019) (Gazette, 2019), and its amendment in 2020 (ABVTRL2020) was imposed from July to September 2020. The aim is to establish a legal treaty between violators and the local authority to legalize the status quo. A down payment of 25% of the cost of building violations has to be paid in advance to the local authority to obtain the legal resolutions. The plenty would reach around 2.7 billion USA $ to cover 2.0 million violators. However, Gilbert (2012) showed that neither legal land title nor its application would not offer a luckily better situation. Therefore, the following part analyses the consequences of the reconciliation law and the degree of its gentrification. A new typology of informality has performed the Egyptian landscape; however, the following part examines these consequences.

3. Building Violations

There are huge academic debates on the way that the formulation of housing informality has been affected by the socioeconomic, political, and spatial transitions in Egypt (Doherty, 2010; Dorman, 2013; Guerzoni, 2009; Sims, 2011; Soliman, 2021) in which the

taxonomies of informality are quizzed (Khalifa, 2011; Soliman, 2004). The amelioration of the housing crisis in Egypt over time has been frustrated by which urban sprawl has dominated the Egyptian built environment (Denis, 2012; Soliman, 2012b; Soliman, 2021). This research is not intended to retrospect the Egyptian housing situation, instead, it focuses on the state's efforts to legalize or formalize the housing illegality and how, whom, when, why, and who would legalize it. After the two revolts of 2011 and 2013, Egypt observed a great loss of 150,000–200,000 Feddan[1] of agricultural land to illicit development (Soliman, 2021).

Not only does the state of chaos resulting from the two revolutions weaken the state, but also is the absence of applying planning control in the last three decades. Inappropriate land governance has led to unable the state to deal with building and land violations. Thus, the spreading of urban informality has dominated the landscape of Egyptian cities. More than 50% of the built-up areas have been characterized by illegality (Soliman, 2021). After the June 30 revolution, the search for solutions began, but it required intensive studies of the real estate market. Statistical figures and indicators confirm that the provision of housing alternatives before dealing with violations and infringements is huge. The annual population growth rate is 2.4%, while the number of populations has increased by about 20 million since 2010. This growth puts pressure on the inhabited area, agricultural lands, services, and facilities. It is estimated that Egypt is receiving a new birth per sixteen seconds and is expecting the total population will reach 180 million persons by 2050 (CAPMAS, 2021).

Looking at the bill of violations, the problem becomes miserable, as the size of the violating buildings has reached 3 million units and 240 000 real estates (CAPMAS, 2021). Informal areas spread in 226 of 234 cities, and agricultural land encroachments amounted to 1.9 million cases, and it needed to compensate for the pressure on the infrastructure to more than 86 billion pounds for drainage and drinking water projects. The matter is not an exchange of accusations and responsibilities. The responsibility is collective and shared among the state and the society. In addition to the long legacy of mismanagement of land supply since the fifties, our practices as individuals were not far from the problem. For example, it is estimated that about 14.58 million uninhabited housing units (CAPMAS, 2021), and while their owners close them without justification, no others find a suitable home. At present, most areas are no longer able to absorb more arbitrary housing production. In addition, the violations are eating the agricultural land and affecting food security. According to the Prime Minister's statements (Shawkat, 2021), city violations amounted to 50% of the size of buildings, and the percentage has risen to 70% of new construction since 2015. The alternatives are uncomfortable to provide better opportunities for life and work. The urban space must be expanded and distributed the population density over more areas instead of narrowing the currently inhabited percentage of Egypt, which does not exceed 7%, in which the state is planning to reach 12%. Will this happen? Or it is a dream in the desert (Sims, 2015).

Aerial photography is recorded to permit the state the monitor of the urban and spatial map and to determine the size of the urban sprawl. It is also verifying the expansions of the real estate and the areas of intersections as spaces suitable for construction. Cases not recorded in this photography are considered a violation, and the conditions of reconciliation for their construction outside the city's boundary do not apply. Aerial photography data related to construction on agricultural lands or in places close to residential blocks and approved urban space lines are mapped. The violations of building without a license or violating the conditions of the license, height restrictions, and the nature of use within the urban space are detected. All these areas are covered by reconciliation until April 8, 2019, which is the date of approval of the Building Violations Temporary Reconciliation Law No. 17 of 2019 (BVTRL2019). Thus, the BVTRL2019 came as a continuation of the fourth generation of the construction boom of 18 new cities, resettlements of unsafe areas and social housing, and the addition of 160,000 Feddans to the urban space. The state is forced to act due to the pressures resulting from violations and infringements, as the utility bill has jumped several times and the cost of delivering sewage

[1] One Feddan equals 0.42 hectare

to villages has reached more than 200 billion pounds due to this random expansion. The same is true in the capitals of governorates and new cities, as the building violations are putting pressure on roads and networks of facilities and services. These have affected the standard of living of citizens, so the BVTRL2019 came to control the urban informality and improve living conditions.

The restrictions of the Unified Building Law, no 119 of 2008 (UBL2008) and the two revolts in Egypt have led to the increase of violations. According to official figures, the number has reached 2800000 violating buildings, with a total of 396000 floors, comprising about 40 million units. For example, Cairo and Giza alone have about 209000 buildings violated. There are no conclusive detailed figures, but according to the estimates of the official authorities (CAPMAS, 2021), most of the violations pertain to licenses for real estate, shops, garages, change of activity, fences, etc. The high percentage of fees, fines, and the proceeds so far are from companies, investors, or capable citizens who have multiple or extensive violations in area and value. As illustrated in figure 2 building violations vary according to the nature of the abuse by the property owner, but the most prominent of them are building without a license, violating the terms of the license while not affecting construction safety. Changing the use from residential to commercial or otherwise, non-compliance with the applicable planning requirements, and violating drawings is dominated violations. Architectural and construction, heightening the roles of violation. To the point that building on agricultural land and changing its use from agricultural use to other uses, especially building housing units on them without a building permit, represents most building violations. Most of these cases may be reconciled unless they affect the safety of the property or violate the regulations of aviation laws and others.

Figure 2. Illustrates some cases of violations.

Reconciliation is prohibited in the following seven violations. Buildings that are defective in the safety of construction, Encroachment on the perpendicular organization lines and the official approved easement lines, Violations of buildings and facilities with distinctive architectural style, Exceeding the height restrictions established by the Civil Aviation Authority or exceeding the requirements of State Defense Affairs, Building on state-owned land, unless the person concerned has submitted an application to legalize his status in accordance with the law, Building on lands subject to the Antiquities Protection and Nile River Protection Law, and finally, Changing the uses of areas for which detailed plans approved by the administrative authority have been issued. The latter is also including buildings outside the urban space except for the exceptions mentioned in the UBL2008. Surface violations that fall under the category of violating the conditions of licenses are as follow. Changing the licensed property whose license includes the purpose of its construction and the purpose assigned to it. The purpose of changing the use is to transform the building or any of its units for a purpose other than the licensed purpose before obtaining the necessary approval from the competent authority is considered illegal. In this case, it is not permissible to reconcile areas with approved detailed plans. Violations of using garages fall within the scope of change of use, and if it is in an area for which approved

regulatory plans have been issued, it can be reconciled with the approval of the administration. Following the applicable regulatory procedures, and considering the estimates of the technical committees, the price per meter and the value of the land has to be estimated.

In general, the BVTRL2019 does not provide the possibility of reconciliation over crossing the lines of urban space. It sets several exceptions to this matter. The most important of which are projects and activities that serve the areas of agricultural and animal products within the framework of the government's plan and based on a proposal from the Minister of Agriculture. Also, it allows to build on agricultural lands on a private residence or establish a service building, near the estates of cities and villages and their dependencies. These completed buildings are inhabited by residents and enjoying facilities if they are on lands that have lost the elements of agriculture and according to the data of the last aerial photography. The state introduces several regulations to frustrate the spreading of urban informality on peri-urban areas and alleviate the pressure and conflict over the right to land. Subsequently, the simplification of the procedures and increasing the motivations are issued to encourage putting unused housing units for rent (UN-Habitat, 2021). The BVTRL2019 separates at this point between two matters, the first is the encroachment on state property, and the second is a violation of building without a license or outside the legal and building requirements. A reconciliation with these cases can be made to lead to the legalization of land. This would require a decision to accept the reconciliation before submitting proof of reconciling the situation according to Article 89 of the executive regulations of the BVTRL2019.

Urban expansion does not stop. Replanning the urban space in the old areas, launching several social housing projects, and implementing new cities in all governorates, are all in progress. According to official figures, the state added 480,000 Feddan to the urban space between 2008-2018 to accommodate 24 million people with a density of 50 per Feddan. The truth is that the problem is not related to the narrowness of the urban space or the scarcity of land, but rather it is the culture and practices of the society. For example, the construction areas in the villages witness price speculation. Instead of a citizen is selling a plot of agricultural land to buy a suitable location for construction, the citizen decides to build his house on his land out of jealousy from his neighbour or a refusal to take advantage of the price.

4. The role of laws in shaping gentrification

Shaping gentrification has been organized by the public authority through various forms. This is done by imposing new regulations to guide, support, promote, and steer how gentrification develops in specific urban contexts. Consequently, the modalities of 'gentrification' in Egypt are determined by laws and regulations. The state of Egypt issued a Buildings Violation Temporary Reconciliation Law No. 17 of 2019 (BVTRL2019) to eliminate and prevent the chaos of the building and to regulate urbanization processes. The objectives of the BVTRL2019 are to reconcile violations of the UBL2008 and codify the conditions of previous violations, to control the construction conditions in Egypt, reorganize the urban map, and work to develop the system of facilities and services. The BVTRL2019 aims to:

- Correct the error, legalize the situation, and provide resources to address the problems of pressure on facilities.
- Issue a safety certificate or a birth certificate for each property or reconciled that will serve as a national number for the property to give it a legal status
- Achieve a stable, civilized urban appearance, and achieve the citizens' interest in owning an organized and fully serviced society.
- Represent an advanced step towards saving millions of buildings from the sword of the UBL2008, which provided for the removal or confiscation of the unit. On the contrary, the law does not aim at demolishing real estate.
- Open the door to reconciliation and legalization of the situation and does not include procedures regarding confiscation or imprisonment for violators.
- Limit the demolition of buildings to lands of aggression against public facilities, roads and railways, or encroachment on state property and lands of river dumping.
- Avoid any property on land owned by personal property that falls within the

BVTRL2019 and does not face the risk of removal.

The law has been introduced to tackle spatial chaos, control arbitrary situations, and regulate the real estate sector. So far, not a single case of removal of an inhabited property has been carried out, even inland encroachments and usurpation of state property. But most of these types of violations are unused, and they are constructions of an investment nature carried out by their owners to place possessions, seize the site, and profit from resale or use in other activities, not for personal accommodation. Building violations built on squatters' lands have not been excluded from the executive regulations of the law (Gazette, 2019). Squatting and encroachments on state lands are two separate violations. This requires submitting a request for reconciliation and then legalizing the status of the land itself with its subsidiary.

After meeting these requirements, the violator will enjoy the opportunity to conciliate and will give the property a legal form. The opposite is true for public land where buildings on state property involve two violations, first, require legalization of laying the land and then reconciling the building later. The law regulates the issue of reconciliation by granting the right to each owner or occupant of a unit to apply to reconcile the violations prescribed in it. It means that no requirements to apply for reconciliation for all the roles or the property's unit, but if there is no attempt by some individuals to restrain the state or obstruct dealing with roles. The law did not specify the identity of who must apply for reconciliation. It leaves the opportunity for all those who wish to reconcile. According to the text of the third article of the executive regulations of the law, each stakeholder, whether owner, occupant, or union of occupants, has the right to apply for reconciliation. This requires providing a request for confirmation of its capacity and its connection to the property. The text of the second article of the law indicated that the technical committee would decide on the applications. This committee is headed by a consulting engineer specializing in structural engineering, with the membership of two engineers. One of whom is civil engineering, and the other is architecture, provided that the experience of each of them is not less than five years, in addition to a representative of the Ministry of Interior from the Civil Protection Department.

4.1 The submission mechanisms to reconciliation

With the implementation of the BVTRL2019, some problems emerged. The Amendments to the Temporary Reconciliation Law issued No. 1 of 2020 (ATRL2020) (Gazette, 2020) came to facilitate the citizens' procedures, and the report of an ordinary engineer was satisfied. Regarding the submission mechanisms, required documents and payment systems are all simplified. The exaggeration of the consultancy offices has simplified and put in force for the safety report's fees, and the exclusion of the previous violations of the UBL2008. The government did not specify the mechanisms for completing the reconciliation documents. The matter came within the texts of the BVTRL2019. The law stipulated that a construction safety report be attached to the property from a consultancy office. With the difficulty of this matter and the exaggeration of offices, Parliament moved to mitigate it by the ATRL2020. The issue is that stipulating the certificate be through Ordinary Union Engineer, without requiring the approval of a consultancy office or the approval of the Engineers Syndicate.

The Prime Minister announced procedural solutions to apply for reconciliation with the least number of papers, to obtain Form 3 to secure the legal status of the property, and stop any measures taken against it (Shawkat, 2021). An additional period has been given to complete the papers and the rest of the reconciliation procedures. As illustrated in figure 3 the processes of the submission mechanisms to reconciliation are composed of three stages: initial stage, intermediate stage, and finally final stage. The first stage composes the required documents and details information of violation. The order begins by applying to the neighbourhood or the device to which the property belongs with the least number of documents. The completion of the papers is required within a certain period, including the engineering file, and payment of the examination fee. The second stage requires the completion of the down payment of the fees to pass the documents to the specific committee for the final inspection. If initially accepted, the seriousness of the

reconciliation is paid. The value of the fine can be paid in cash or 3 annual instalments without interest and a down payment of 25%. The final stage passes through filtrations of the documents and evaluates the final fees. Form 3 is issued which is considered as a certificate to be used for the installation of services.

All governorates have taken executive measures to facilitate citizens, most notably increasing the number of progress outlets and technology service centres, cancelling workers' leave, extending work until nine in the evening. The responsible bodies are preparing a weekly report on the progress, and forming committees headed by deputy governors to follow up on the file, in addition to discussion seminars and guidance and awareness activities in each region. Form 3 is a certificate obtained by the person wishing to reconcile under the text of Article 3 of the BVTRL2019. It includes the citizen's data and the property and its area and represents an acknowledgement from the local unit or the administrative authority to start the reconciliation procedures for violations. After finishing the inspection of the property and the evaluation processes of the documents submitted by the citizen, the date of committing the violation, and paying the required fees, the license in the form of a certificate is issued. This certificate serves as confirmation from the administrative authority to accept the reconciliation request procedurally and to take the legal and administrative path to present it to the competent committee. This form allows the immediate cessation of all lawsuits related to the violation in court, and the suspension of the implementation of judgments, decisions, and procedures issued regarding the violation until the settlement request is decided.

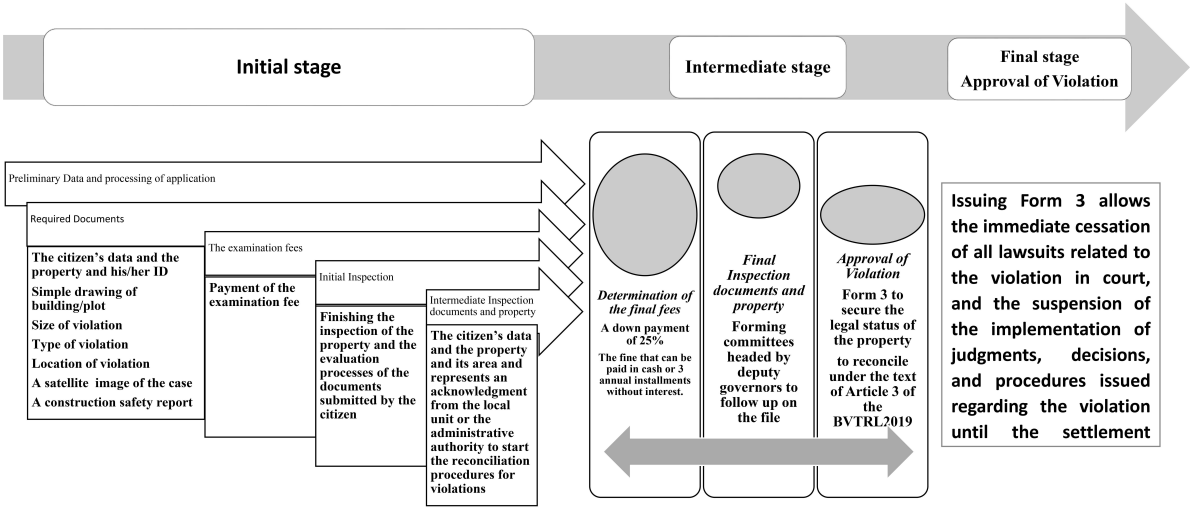

Figure 3. The processes of the submission mechanisms to reconciliation.

Each property or reconciled unit will obtain a safety certificate or a birth certificate. It serves as a national number for the property that gives it a legal status and a sound existence so that the owner can register it in the Property Proclamation Department (PPD), and deal with it by selling, and formally delivering facilities and services. Accordingly, it increases the value of the property and increases safety and stability rates for its inhabitants. The time course of reconciliation is not related to the government. It is related to the legal text that specified 6 months from the date of issuing the executive regulations of the BVTRL2019, which expired at the end of January 2020, and with the issuance of ATRL2020 and then its executive regulations in March, the period was renewed until the end of September 2020. The date of a final submission is a legal deadline that cannot be exceeded.

4.2 The value of fees

The law defines the mechanism for forming the committee concerned with determining the value of the reconciliation. The committee includes two representatives of the competent administrative authority, two specialists in real estate appraisal with their approval by the

Financial Supervisory Authority, and a representative of the Ministry of Finance. The law does not leave the matter at all and stipulates considering geographical and urban considerations, the level of the region, and the extent to enjoying the facilities and services. Because the law does not aim at levying, but rather to correct the error, legalize the situation and provide resources to address the problems of pressure on the facilities. The law has set the value of the fine. It is started from 50 pounds and up to 2000 pounds per square meter as a maximum. It means that a unit of 100 square meters will not exceed the value of the reconciliation over 5000 EGP in the villages and 200,000 EGP in the most luxurious and luxurious areas. The government announced many facilities during the recent period. The deadline was extended for completing papers for an additional two months and further for six months to be ended in September 2020. The Prime Minister announced that re-examination of prices, assessment of fines, accepting applications with the fewest documents are acceptable. The most important deceleration is granting applicants Form 3 to stop all legal procedures immediately against violators. The law sets percentages of fines according to the type of violation. Table 1 illustrates the estimated value of the meter price in the area. The values of fees were reduced, and the fine was allowed on a credit basis over 3 years. All violators were allowed for all real estate to benefit from the reconciliation.

Table 1. The estimated value of fines of the meter price in the area.

Type of violation	Fines % of the value of square meter	Comments
Building with a license while exceeding the requirements of planning or changing use	100	The main problem is how would calculate or assess the price of the square meter of each area. Also, who will assess the property value, what are the criteria used in the assessment.
Building without a license while conforming to the requirements of planning	100	
Violating the architectural and construction drawings of the license	50	
Violating the architectural and construction drawings of the license	25	
Violating the number of floors and heights	25	
Violating the construction drawings and matching the architectural drawings, the flat and the number of floors	25	
Violating the architectural drawings and matching the construction drawings and violating the number of floors	20	
Violating the architectural drawings while matching the construction drawings and the number of floors	5	

Source: (Gazette, 2019)

The seriousness of reconciliation is limited to 25% of the total value of a square meter of the unit/land, with a maximum of fees of 5,000 and 20,000 EPG for villages and cities in violation respectively. A reduction of 10% and 40% for violation for villages and cities respectively in violation of responses authorized buildings lines. Further reductions of 12% and 50% for villages and cities respectively are given in increasing the surface area of rooms. Also, a reduction of 20% and 80% for villages and cities in violations of building the entire roof, and 40% and 16%for villages and cities in violations of building without obtaining a license. The value of the penalty is 250 thousand EPG for provincial capitals and 30 thousand EPG for villages and 120 thousand EPG for cities in converting the basement into an unlicensed activity. Indeed, the governorates reduced the reconciliation rates between 10 and 55%, according to some regions. Cairo, for example, set a 20% reduction in the eastern region, 20% in Suez, Dakahlia and Menoufia, 25% in Minya, Alexandria, Ismailia, Sharqia, Aswan, Matrouh, South Sinai, 30% in Luxor and Port Said, 35% in Fayoum, 40% in Kafr El-Sheikh, Sohag, the Red Sea, and finally 50% in New Valley and Damietta.

The law provides for the payment of a fee for examining the application submitted regarding the violating property or unit. These fees start from 125 EGP and 500 EGP for villages and cities respectively. A maximum of 5,000 EGP according to the geographical area, size of the unit/plot, market value, and type of violation. Reconciliation is not a levy law as

some claim, with evidence that it set a low minimum price per square meter, and a maximum that cannot be exceeded, regardless of the nature of the area. The idea of financial fines is to enhance spending on services and facilities in areas of unplanned sprawl after the violations caused pressure on utility networks to the extent that it needs more projects and expansions. The proceeds of the reconciliation will not go to finance the sections of the general budget or the annual deficit in it. Rather, it will be transferred to a special account in the public treasury for collection and redistribution, provided that the proceeds of each governorate are spent within the same governorate. This fund will be used to develop facilities and services and strengthen infrastructure, including 25% for the Social Housing and Development Fund, 39 % for infrastructure, water, and wastewater.

4.3 Law enforcement period

The amendments to the BVTRL2019 allowed extending the period of law enforcement, controlling administrative procedures, and evaluation mechanisms to ensure that the value of the violation is not exaggerated. It also forces the administration authorities to receive all requests, provided that the decision on them is a matter of the competent committees only. In addition to dealing with violations according to their types, nature, and value of areas market, the law is considering the social dimension and fair application of controls and requirements.

The technical committees formed for this purpose issue their decisions regarding the request for reconciliation. Reports are submitted to the governors or heads of the bodies with jurisdiction, and the decision to accept or reject the reconciliation request is within four months from the date of submitting the request. According to Article 4, the applicant has the right to complete the documents later after the closing date, with the applicant's right to appeal if the request is rejected (Gazette, 2020). The technical committees, governorate authorities, and city agencies are responsible for issuing estimated price lists according to regions, urban and civilization level, and availability of services. While the calculation is according to indicative percentages according to the type of violation, which ranges between 5 and 100% of the square meter value if this is not less than 50 EGP and not more than 5000 EGP per square meter in all cases.

The amendments to the law made it possible to pay the value in three annual instalments. The applicant who is wishing to reconcile pays 25% of the value as a conciliation within 60 days of the committee's approval of the request. Bearing in mind that if any instalment is delayed or two consecutive instalments are not paid during the three years the settlement decision shall be cancelled. In all cases, a final decision shall not be issued to reconcile until after the full amount has been paid. According to the text of the law, the owner of the violated unit/land or the person wishing to reconcile must pay the consideration for reconciliation and legalization of the situation. Alternatively, the owner has to apply for instalments, accompanied by evidence of payment of the advance payment within 60 days of the committee's approval, and then paint the existing and unfinished facades of the building. As stated in the text of the law, the effects produced by the reconciliation are to legalize the status of the property and give it a legal entity and the possibility of enjoying the facilities and services in an official way. The law stipulates that accepting the reconciliation does not result in any violation of property rights, and the issuance of the committee's decision and the completion of the reconciliation. Payment procedures are considered a license that produces all the effects of licenses for violating works. The law specifies 60 days from the date of the committee's approval of the request to pay the value of the reconciliation, or the advance payment and the instalment request. and decisions issued regarding real estate.

According to the advantages provided by the BVTRL2019 on some building violations, once the application is submitted, all decisions or actions taken against the property are frozen. Form 3 indicates the unpaid fines, and the fines previously paid will be calculated within the total value of the reconciliation. In the absence of an owner of the property, the occupiers' union, or the owner of any unit in the property, can apply for reconciliation with proof of its relationship to the unit. This path can be disabled through the RL2019, once the application is submitted and Form 3 is obtained. All legal procedures and lawsuits against the property are stopped, and even the provisions in effect are suspended even if

they imprison the violator. Upon acceptance of the reconciliation and the compellation of procedures, the violator is released. According to Article 10 of the law, a person whose application is rejected, or a high fine is imposed on him may file a complaint within 30 days from the date applicant was notified of the decision. Decide on the grievance within 90 days, and the expiry of the period without a decision is considered as acceptance of the grievance.

The BVTRL2019 regulates the legal process regarding the violating real estate and its owners. Legislatively, the mandate will return to the UBL2008, and in implementation, the state authorities have moved to put in place effective mechanisms to prevent infringements and building violations. In turn, the Ministry of Housing has established a central unit to follow up on violations of new cities. It is continuous periodic monitoring, preparing a database of licenses, and monitoring compliance with violations. It also addresses and eliminates violations in the bud, granting broader powers to security directors and city agencies. By legalizing the conditions of the violating real estate and buildings, the population density in each area can be accurately counted, the utility networks re-planned. The needs of each city or village are determined, and investments are made to spend on the water, sewage, electricity, and other projects. These improvements provide better services and reduce pressure on the family's resources that go to purchase needs that compensate for the absence of amenities, and thus the eminence of life will improve the standard of living.

Recently, the Egyptian Cabinet (Shawkat, 2021) approved two draft laws amending some provisions of the Real Estate Registration Law No. 114 of 1946, and the Income Tax Law promulgated by Law No. 91 of 2005. The amendments to the provisions of the Real Estate Registration Law aim to facilitate the procedures for registering property, through three steps. The first is separating tax payment from registration procedures and fees. Second is the possibility of registration despite the absence of a sequence of registered property in several cases. These are; if the registration applicant has a valid document, 5 years of possession and good faith, and the presence of a final judgment of ownership or other real rights in kind. The third is the seizure of possession for a period of more than 15 years with the intention of ownership with the realization of the interest of the real estate registry. These amendments will open new disputes among the landowners and might lead to the defragmentation of land ownership in Egypt. Also, these amendments do not touch the reconsolidation law nor are setting up clear steps for land registration.

5. Conclusions

What is happening in recent years is serious accountability of the localities, by increasing oversight, controlling procedures, and embargoing corruption through administrative control and amendments to the UBL2008 and the liberalization of the licensing system. It has been inherited for many years and the perpetrators are no longer serving or legally moving against them, and many of them have passed away. Although the state is moving at all levels, on the one hand, it is working to legalize the conditions of violations to control informal urbanization and increase the value of real estate wealth and facilitate its circulation by buying and selling on the other hand. A serious stand with erection on peri-urban areas to stop the bleeding of crop production and reach food security for 100 million citizens, is a matter of survival. The state does not evade its responsibility and has recognized that part of the problem is caused by mismanagement and corruption of localities over the past decades. The arbitrary gentrification should stop looking for solutions, especially since most villages and regions have become overcrowded and unable to support their residents and provide housing and job opportunities suitable for them.

The problems were the complexity, overlap, and overlapping of the authorities responsible for construction, and in addition to neglecting the approach of reconciliation and legalizing the situation. Also, there is no clear-cut policy for formalizing land status or at least finding a simple way for land registration, hence the right to land went into chaos. The BVTRL2019 sets difficult conditions that caused the spread of slums and illegal construction and entrusted the technical inspection body with the task of monitoring and follow-up to all the parties concerned with planning and organizing. Because of the limitations of the apparatus, the law became powerless. Moreover, the new amendments of the BVTRL2019 included simplifying the procedures and applying the

one-stop system. It defines tasks and responsibilities for licensing, tightening control, and follow-up during construction operations, ensuring that works matched licenses. It also is considering the social dimension and geographical nature. None of the persons concerned with the law or those concerned with the file of building violations or encroachment on state lands and planning lines were interested in questioning, research, or aspiration for knowledge. Also, the governorates and localities were not interested in the explanation and clarification of the law. Thus came the state of shock and surprise with the start of the application. From this point, the law was reviewed in all its details, the construction conditions in the past and the laws regulating them, the extent of the risks that threatened Egypt.

The law applies to all real estate violates since 2008, and the amendment issued No. 1 of 2020 was intended to open the door to previous violations of the UBL2008. But these applied only to those who are addressed by the law have a registered violation or a lawsuit regarding the violation, or they received communications from neighbourhoods and authorities concerned with the violation. The law applies to violating cases in cities and areas planned according to urban estates and planning lines that are subject to reconciliation. As for real estate built in villages before this date, it is not covered by the law, because before the issuance of the UBL2008, it was not required to obtain a building permit in villages and rural areas. But the law has contradicted as stated that all violations within the UBL2008 are under the umbrella of the BVTRL2019. While the Reconciliation Law includes all violations until the date of the last aerial photography on July 22, 2017, including unlicensed or violating residential buildings, shops, and change of use, with the possibility of reconciliation on buildings that infringe on the regulation lines or state property in case of agreement and legalization of the situation with the authority in charge.

The TRL2019, and its ATRL2020, and its executive regulations No. 1631 of 2019, and its amendments of the executive regulations No 800 and 936 of the year 2020 issued by Prime Minister Dr. Mustafa Madbouly, has passed through obstacles during its application on the ground. The law has opened intense controversy and uninterrupted questions. In this regard, and the fact that the crisis was not in the TRL2019, nor in the amendments, nor the executive articles, but rather the lack of interest in the law on the part of public opinion, and the lack of explanation of its articles and dialogue on them. The law caused a state of confusion and anxiety with its entry into force. It represents an important positive opportunity to prevent the deterioration of real estate, raises the value of buildings and units owned by citizens, and lays stable foundations to correct inherited errors and start planning for the future in a more conscious and disciplined manner. As we are approaching the beginning of 2022, there is not a single certificate has issued for violators, except for collecting the required fees of 40 billion EG. The question is why the state issued the TLR2019, what the main benefits are gained by the violators, has this law prevented or at least eliminate the spreading of the urban informality? Has this law opened a window to adjust the right to land or allow registering land/unit? Till now no single violator has formalized their land status nor legalized their unit.

Even though the law should issue a safety certificate or a birth certificate as a national number for the property, till now none has been issued. While it does not specify how this certificate gives a legal status to the violator. Also, this certificate does not meet the right to land nor represents a legal land transaction or does not valid to be presented to the Property Proclamation Department. The land ownership does not reflect in the building license rather the latter allows for the legal construction process. Therefore, the legalization of a piece of land is still vague and not legalized. The law might open a new dispute between the actual landowner and the housing property. Also, the certificate does not represent a legal document as collateral in front of the commercial banks to apply for a loan. In general, the law might provide a sort of legalization document for the housing units but does not legalize the tenure status of the land. In other words, legalization of the status of real estate does not give it a legal existence and the ability to trade, and to be a financial asset that can be invested, partnered in, and borrowed with its guarantee, rather it exhaustive the provision of financial of the violators. In short, the law does not provide security of land tenure, or an official document to be used to formalize real estate status nor authorize the informality. Rather the law has

introduced a new status of official recognition in the form of "hybridization recognition". This recognition does not present a legal document in the Property Proclamation Department to officially register the land. It could be said that the law has gone away the right to land with the wind, nor provides a complete legal status for the violators, but open new disputes and conflicts between the violators and the state. Also, this law created or decayed wealth, social inclusion/exclusion, and increased/decreased the wealth of the bottom strata of the society. Last, it is hoped that this study is opening a new debate in the research arena to question the right to land and further in-depth research is required to understand these issues in the Global South.

Acknowledgements
The author wishes to acknowledge the editor and reviewers in the Journal of Contemporary Urban Affairs for their constructive feedback during the review process.

Funding
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interest
The Author(s) declare(s) that there is no conflict of interest.

Data availability statement
The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Ethics statements
Studies involving animal subjects: *No animal studies are presented in this manuscript.*
Studies involving human subjects: No human studies are presented in this manuscript.
Inclusion of identifiable human data: No potentially identifiable human images or data is presented in this study.

CRediT authorship contribution statement
Ahmed M. Soliman: *Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Resources, Software Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.*

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How to cite this article:
Soliman, A. M. (2022). The Right to Land: To Whom Belongs after a Reconciliation Law in Egypt. *Journal of Contemporary Urban Affairs, 6*(2), 96-111. https://doi.org/10.25034/ijcua.2022.v6n2-1

Journal of Contemporary Urban Affairs

2022, Volume 6, Number 2, pages 113–141

Original scientific paper

Data Mining as a Method for Comparison of Traffic Accidents in Şişli District of Istanbul

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ARTICLE INFO:

Article History:
Received: 13 March 2022
Revised: 15 June 2022
Accepted: 25 June 2022
Available online: 7 July 2022

Keywords:
Geographic Information Systems;
Kernel Density Method;
Traffic Accidents;
Decision Trees;
Artificial Neural Networks;
Logistic Regression;
Naive Bayes.

ABSTRACT

Studies to reduce traffic accidents are of great importance, especially for metropolitan cities. One of these metropolitan cities is undoubtedly Istanbul. In this study, a perspective on reducing traffic accidents was trying to be revealed by analyzing 3833 fatal and injury traffic accidents that occurred in the Şişli district of Istanbul between 2010-2017, with Data Mining (DM), Machine Learning (ML) and Geographic Information Systems methods (GIS), as well as traditional methods. It is aimed to visually determine the streets where traffic accidents are concentrated, to examine whether the accidents show anomalies according to the effect of the days of the week, to examine the differences according to the accidents that occur in the regions and to develop a model. For this purpose Kernel Density, decision trees, artificial neural networks, logistic regression and Naive Bayes methods were used. From the results obtained, it has been seen that some days are different from other days in terms of traffic accidents, according to the accident intensities and the performances of the modelling techniques used vary according to the regions. This study revealed that the 'day of the week effect' can also be applied to traffic accidents.

JOURNAL OF CONTEMPORARY URBAN AFFAIRS (2022), ***6***(2), 113-141.
https://doi.org/10.25034/ijcua.2022.v6n2-2

www.ijcua.com

1. Introduction

Traffic accidents have become an important problem in Turkey due to the increasing urban population and the parallel increasing unplanned urbanization and vehicle use. Traffic accidents that occur every year cause serious traumas, injuries, and deaths as well as material and moral consequences. According to the Turkish Statistical Institute Highway Traffic Accident Statistics 2020 news bulletin, 983.808 traffic accidents occurred even in 2020 alone, and 833.533 of these accidents resulted in property damage and 150.275 deaths and injuries (TURKSTAT, 2020). In the stage of sustainable development of cities related to transportation, the main cause of the accidents cannot be determined due to the lack of an applicable transportation policy. For this reason, it is thought that analysing big data by using new data technologies will contribute significantly to the reduction of future traffic accidents

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How to cite this article:
Ersen, M., Büyüklü, A. H., & Taşabat, S. E. (2022). Data Mining as a Method for Comparison of Traffic Accidents in Şişli District of Istanbul. *Journal of Contemporary Urban Affairs*, *6*(2), 113-141. https://doi.org/10.25034/ijcua.2022.v6n2-2

(Camkesen & Bayrakdar, 1999). Regarding big data; the use of new data technologies such as Data Mining (DM), machine learning, cloud computing and the internet of things contributes significantly to eliminating the transportation problem and reducing traffic accidents in the cities of the future (Khokale & Ghate, 2017). It is very difficult to benefit from big data using traditional methods and technologies. For this reason, various methods have been tried to be developed to analyse and interpret big data (Lin, Wang, & Sadek, 2014). DM, which is one of these methods, has an important place in obtaining meaningful information from databases where a very large amount of information is stored and it is very important to support it with developing technology (Bayrak & Kirci, 2019). When the previous studies are examined, it has been revealed that there is no study to determine the traffic accident points in Şişli district and to reduce the accidents in the regions where these accidents are concentrated.

Accident analysis studies are mostly based on statistical data. Since analyses will be made based on big data with this study, we can call the accident analysis as "Accident Analytics". Another reason why accident analysis is named as accident analytics in the study is that traffic accidents cannot be determined in advance in terms of place and time and cannot be interpreted well enough (Ersen, Büyüklü, & Taşabat, 2021). Accident analytics, which enables traffic accident analysis based on concrete traffic accident data and traffic information, will help you to understand the accidents in detail and to determine what can be done to prevent future traffic accidents and will help to minimize traffic accidents (Ersen, Büyüklü, & Taşabat, 2021). Traffic Accident Analytics aims to create safe road and vehicle usage opportunities by establishing smart systems using the latest technologies based on the most appropriate scientific methods. While doing this, it discovers the meaningful pattern in the data by using the available data structures, optimization, simulation methods, data analytics and data mining (Ersen, Büyüklü, & Taşabat, 2021).

In these analyses, methods such as the accident frequency (number) method and accident recurrence rate method are used to determine accident points. In addition, this study aimed to visualize the regions where the accidents are concentrated, determined by the accident analysis studies with the Kernel Density Estimation method (Thakali, Kwon, & Fu, 2015; Mohaymany, Shahri, & Mirbagheri, 2013). Identifying the cause of location-based similar accidents is very important in terms of ensuring the safety of people in traffic and reducing the number of accidents (Gündoğdu, 2010; Saplıoğlu & Karaşahin, 2006). During the determination of these processes, the location of the accidents was visualized with GIS, making the information easier to understand (Erdogan, Yılmaz, Baybura, & Gullu, 2008; Dereli & Erdogan, 2017; Le, Liu, & Lin, 2019).

In order to develop effective road safety measures that can be used to reduce traffic accidents, it is necessary to identify the regions (hot spots) where the accidents are concentrated (Xie & Yan, 2008). The Kernel Density estimation method is the most common method used in spatial analysis studies in GIS and it is known to give successful results in determining hot spots (Ersen, Büyüklü, & Taşabat, 2021). The Kernel Density estimation method is based on the process of determining the accident intensity by weighting in a determined impact area. In this method, the density of the points falling into the circle with a defined radius and the point density that changes as you move away from this source are expressed (Xie & Yan, 2013; Bil, Andrasik, & Janoska, 2013).

For this purpose, first of all, the streets where traffic accidents are concentrated in Şişli district were determined with Exploratory Data Analysis Tools (EDA). The distribution of the accidents according to the intersections and streets of the region was analysed with the SAS Enterprise Guide software. The kernel Density estimation method was used to visualize the accident densities at these intersections. By making use of the ArcGIS 10.7 software, information was visualized with GIS and it was made easier to understand the places where the accidents were concentrated. Then, the outputs of the results obtained on the day-based significance analysis of the accidents were examined for the effect on the day of the week and the differences were interpreted according to the streets where the accident density was determined. Finally, the data set and divided into 3 parts with SAS Enterprise Miner software for training, validation and testing purposes and appropriate models (Decision Trees, Artificial Neural Networks, Logistic Regression and Naive Bayes) are selected. The ratios of training, validation and test sets were determined as 60%, 30% and 10%, respectively. The success of the modelling techniques used was determined by the accuracy, error rate and ROC values, and it was observed that the successful performances of the models changed on the streets with high accident density.

2. Materials and Methods

In this study, the effect of the day of the week on the accidents was investigated after the statistical information about the traffic accident density was analysed. The day of the week approach, which is frequently used in studies on financial markets and explains the price behaviour of stocks, which is expressed as an anomaly, has been examined for traffic accidents (Orhan, Emikönel, & Emikönel, 2021; Aharon & Qadan, 2019). A total of 3833 traffic accidents death and injury occurred in the whole Şişli district between 2010 and 2017 and the traffic accidents on the streets where the accident density was determined in the Kernel Density maps, the differences in the days in terms of the effect of the day of the week were evaluated according to the regions. It is important for the units and researchers to see that some days differ from other days in traffic accidents so that they can make a more effective assessment (Yılmaz & Akkaya, 2020; Cengiz, Bilen, Büyüklü, & Damgacı, 2017). Daily traffic accidents were used to investigate the effect on the day of the week for a total of 3833 fatal and injury traffic accidents that occurred in Şişli between 01.01.2010 and 31.12.2020 and on the traffic accidents on the streets where the accident density was determined.

Day of the week anomaly in traffic accidents was investigated through the linear regression equation (1) using dummy variables (Evci, 2020; Ersen, Büyüklü, & Taşabat, 2021).

$$DTAN_t = \beta_1 + \sum_2^7 \beta_i D_{it} + \varphi Z_t + \varepsilon_t \qquad (1)$$

$DTAN_t$ = Daily traffic accidents by numbers

β_1 = Base day

Because of the multicollinearity problem we left one day dummy. This dummy shows up on the beta one.

β_i = Average traffic accident for each day of the week

D_{it} = Dummy variable for days of the week

φZ_t = Independent variables

ε_t = Error term with zero mean and constant variance

In regression analysis, the dependent (affected) variable is frequently affected by qualitative variables as well as numerical values. Therefore, it is important, how to include qualitative variables in the model. Since qualitative variables usually indicate the presence or absence of a feature, dummy variables that take values of 0 or 1 are used to quantify these features. A variable's value of 0 indicates the absence of a feature and a value of 1 indicates the presence of a feature. In the models established for traffic accidents, the dummy variable takes the value of 1 for observations corresponding to that day and 0 for other observations. In this context, in the models established for the day, the null hypothesis is that the average traffic accidents of the days are equal and the alternative hypothesis is that there is a difference in the average traffic accidents of the days and the effect on the day of the week effect (Gujarati & Porter, 2009). No additional independent variables were added to the linear regression equation established for the day of the week. This is because this study aimed to determine whether some days in traffic accidents are statistically different from other days in terms of traffic accidents by using only OLS (Least squares) t-test and ANOVA analysis (Gujarati & Porter, 2009).

Dummy variables can be used as easily as quantitative variables in the regression model. However, in a regression model, all explanatory variables can consist of dummy variables. These models are called ANOVA models. In addition, models in which qualitative and quantitative variables coexist are called the ANCOVA model. Since no quantitative explanatory variables were used in the established models, these models were accepted as equivalent to the ANOVA model. In this study, only fatal and injury accidents were studied, and material damage accidents and much information could not be obtained. If this information could be obtained, the model could be expressed with the ANCOVA model since an additional quantitative variable would be added to the model (Gujarati & Porter, 2009; Ersen, Büyüklü, & Taşabat, 2021).

Finally, decision trees, artificial neural networks, logistic regression and Naive Bayes models were used in this study for modelling techniques, respectively, and the success of these methods in classifying traffic accident results as fatal and injury accidents were compared in the whole Şişli district and on the streets where the accident density was determined (Yavuz, Ergül, & Aşık, 2021; Özden & Acı, 2018; Singh & Kaur, 2016; Chong, Abraham, & Paprzycki, 2005). Thus, it is aimed

to determine the most appropriate classification method according to the regions in reducing the future traffic accidents by determining the fatal and injury accident points with the Kernel Density method.

2.1 Decision Trees

Decision trees are one of the most preferred DM approaches for classification and prediction problems. It is simpler than other classification methods because it can be expressed visually, easily interpreted and understood (Zhao & Zhang, 2008; Çalış, Kayapınar, & Çetinyokuş, 2014). Decision trees start with a single root and continue with the formation of a leaf node (internal node) after each split. It represents a decision whose outcome is expressed in probabilities at each internal node. Decision trees are advantageous for decision-makers due to their ease of understanding and interpretation, low cost and good reliability. However, the disadvantages of decision trees are that they can produce complex trees that do not explain the data well, that they are not very successful in estimating continuous values and that they fail to build a model when the number of classes is large and the number of learning cluster samples is small. One of the most important issues in decision trees is to determine the best separation criterion. The separation rule determines by which criteria the target variable should be divided. The most commonly used separation rules are entropy, Gini and the chi-square test. A decision tree method has been developed for each different separation rule in decision trees. For example; in decision tree methods such as ID3, C4.5, C5 the most distinguishing feature is determined by entropy (Long, Griffith, Selker, & D'Agostino, 1993; Emel & Taşkın, 2005). On the other hand, Gini in the CART method and chi-square division rule in the CHAID method are selected. Since the type of the target variable in SAS Enterprise Miner is binary scale, entropy, Gini and chi-square can be selected as separation methods in the Nominal Target Criterion. In this study, the entropy separation method is preferred among these methods. In the Sub-layer split node property (Split Search Subtree node), Largest is selected for the method option and Misclassification is selected from the Assessment Measure property (Walsh, 2005; Şahin, 2018; Yılmaz, 2012). These options were chosen because they gave the best results experimenting with different ways.

2.2 Artificial Neural Networks

After the decision tree analysis, the artificial neural networks (ANN) model was examined secondly. ANN method, one of the most powerful methods in DM, is an artificial intelligence research field inspired by the working principle of the human brain. The first studies in this method started with the modelling of neurons that make up the human brain and their application in computer systems. In recent years, with the developments in the computer system, it has become a method that can be used in many areas (Budak & Erpolat, 2012; Olutayo & Eludire, 2014). ANN method; it is examined in three main layers, namely the input layer, the intermediate (hidden) layer and the output layer. This method is likened to a black box since the exact relationship between the input and output layers cannot be established. The reason for making a black box analogy to this method is related to the unknown, what is in the hidden layer. In the ANN method, only the results are concerned. Therefore, the formation of the results with this method cannot be explained. In the ANN method, this situation causes, the researchers to lose their confidence. In addition, one of the most important disadvantages of the model is that it produces very complex models. However, in recent years, studies in artificial neural networks, which are frequently used in almost all fields from financial fields to medicine, from the defence industry to automation and control fields, have increased the interest in this method. The biggest advantage of the artificial neural network model over traditional methods is that it can give positive results in solving problems that are complex to solve, the data set is not linear, there are missing or incorrect data and multidimensional. Also, when compared with statistical methods, another advantage of this method is that it does not make any assumptions about data properties and distributions (Budak & Erpolat, 2012; Duran, Pamukçu, & Bozkurt, 2014).

The formulas used to combine the information produced in the hidden layer in SAS Enterprise Miner are located in the hidden layer combination functions section. The formulas used to transform the combined value in the hidden layer are in the hidden layer activation functions section. The outputs of one layer are expressed as the inputs of the next layer. In addition, there are combinations and activation sections for units in the target layer in SAS Enterprise Miner. The formulas used to

combine the information produced in the target layer are in the target layer combination functions and the formulas used to transform the combined value in the target layer are in the target layer activation functions section. The target variable activation function is used to interpret the information produced in the target layer. Combination and activation processes in the hidden layer and the target layer are important elements in a neural network model. For this reason, many artificial neural network models are produced by SAS Enterprise Miner from the options of hidden layer combination function, hidden layer activation function, target layer combination function and target layer activation function. In our model, when the hidden layer combination function, hidden layer activation function, target layer combination function and target layer activation function settings are set as default, it is seen that the success rate of the model is high. In this study, the model selection criterion property is set to the Profit/Loss. When the model selection criterion is set to the Profit/Loss; for the cases in the validation data set, the model that maximizes the profit or minimizes the loss is selected (Şahin, 2018).

2.3 Logistic Regression

When the dependent variable is continuous, the linear regression equation is usually used, whereas when the dependent variable is categorical, logistic regression is used. The logistic regression method is used in many fields of study such as economy, education, health, Biostatistics, banking, finance sector and marketing. In the logistic regression model, assumptions such as the normal distribution of the error terms in the linear regression model, the expected value of the error terms being zero, the error terms being constant to the same variance, the absence of autocorrelation and the independent variable not being a random variable are not sought (Şen, 2014).

In logistic regression analysis, the "Maximum Likelihood" method is used to estimate the coefficients of the variables. In logistic regression, unlike normal regression, the dependent variable is binary; the dependent variable can take the value 1 with probability q, or 0 with 1-q probability.

Normal regression can be represented by equation (2).

While $(x_1, x_2 ..., x_n)$

$$P(x) = \alpha + \beta x \qquad (2)$$

The value of $P(x)$, a logistic function other than the linear function must be used to constrain it from 0 to 1 by changing monotonically with x.

Equation (in 3, 4 and 5) shows the calculation of $P(x)$ and $Q(x)$ values, respectively.

$$P(x) = \frac{e^{-(\alpha+\beta x)}}{1+e^{-(\alpha+\beta x)}} \qquad (3)$$

$$Q(x) = 1 - P(X) = \frac{e^{-(\alpha+\beta x)}}{1+e^{-(\alpha+\beta x)}} \qquad (4)$$

In this case, the output can be represented by equation (5) in the input logistic regression model.

$$Q(x) = \frac{1}{1+e^{-(\alpha+\beta_1 x_1+\beta_x x_2+...+\beta_n x_n)}} \qquad (5)$$

The significance of the coefficients estimated by the maximum likelihood method is determined by the "likelihood ratio test, G statistic" based on likelihood functions, or the "Wald test" using the standard normal distribution approach of the distribution of the test statistic of interest (Yavuz & Çilengiroğlu, 2020).

Odds ratios are used to interpret the coefficients in logistic regression. The "odds ratio" can be defined as the ratio of preference to not preference in any event. For example, if the probability of an event of interest is (p), the probability of the other event occurring will be (1-p). If the odds value is between 0 and 1, the risk factor is "protective" for the outcome variable, if the odds value is 1, there is no difference between the risk factor and the outcome variable and if the odds ratio is greater than 1, there is a difference between the risk factor and the outcome variable and it is stated that this difference will be explained mathematically by a multiple. In addition, the confidence interval for the odds ratio should not include 1 (Yavuz & Çilengiroğlu, 2020).

2.4 Naive Bayes

Naive Bayes classification is one of the most preferred classification methods in which class estimation is based on Bayes theorem. In this method, how the data is classified is more important than its classification. The most important rule of the Naive Bayes method is that it estimates the class condition probabilities unbiasedly, assuming that the attributes are independent of each other. All attributes are considered to be equally

important. The probability of the outcome is expressed by multiplying the probabilities of all the attributes that affect that outcome (Yavuz, Ergül, & Aşık, 2021).

While Bayes theorem is used for classification, the case with the highest probability among the resulting probabilities is chosen as the target class as in equation (6).

$$S_{hedef} = \arg\max P(s_j \mid v) \quad s_j \in S \qquad (6)$$

But when (v) the input instance (v) has more than one attribute, the Bayesian formula changes to a different form. In the target class prediction for the data sample with the intersection view of many features, the product of the conditional probabilities for all features should be calculated as in equation (7).

$$P(v_1, v_2, ...v_n \mid s_j) = \prod_{i=1}^{n} P(v_i \mid s_j) \qquad (7)$$

The most important difference to be noted in the calculations of the Naive Bayes classifier and Bayes Theorem is that the classifiers try to find the target class rather than the probability value. Therefore, the value in the denominator can be neglected, as it is common to the probability calculations of all target classes (Orhan & Adem, 2012). For this reason, the formula that we will pay attention to while finding the target class is shown in equation (8).

$$S_{hedef} = \arg\max[P(s_j)\prod_{i=1}^{n}(s_j \mid v)] \quad s_j \in S \qquad (8)$$

The Naive Bayes method is an advantageous method because it is easy to understand, can be trained simply with a small data set, and works very quickly compared to other methods. However, it also has disadvantages as it accepts that each attribute is independent of each other and the relationship between the variables cannot be shown.

2.5 Comparison of Models

It is necessary to look at some comparison criteria in evaluating the classification performance of models made using datasets. Accuracy rate, error rate and ROC (Receiver Operating Characteristic Curve) were used in this study (Şahin, 2018; Duran, Pamukçu & Bozkurt, 2014). The classification matrix showing the result and the actual situation as a result of the classification technique is given in table 1.

Table 1. The classification matrix used in the analysis.

		Actual Situation	
		True (+)	**False (-)**
Estimation of Classification Method Result	**True (+)**	TP	FP
	False (-)	FN	TN

TP (True Positive): Number of True Positives = Number of True Positive Samples
TN (True Negative): Number of True Negatives = Number of True Negative Samples
FP (False Positive): Number of False Positives = Number of False Positive Samples
FN (False Negative): Number of False Negatives = Number of False Negative Samples
N = TP+ TN+ FP+ FN

2.5.1 Accuracy Rate

The percentage of samples correctly classified. The calculation is done as shown in equation (9).

$$Accuracy\ Rate = \frac{TP + TN}{TP + FP + TN + FN} \qquad (9)$$

2.5.2 Error Rate

It is calculated as the opposite of the accuracy rate method. The percentage of samples that were incorrectly classified. Calculation is done as shown in equation (10).

$$Error\ Rate = 1 - Accuracy\ Rate = \frac{FP + FN}{TP + FP + TN + FN} \qquad (10)$$

2.5.3 Receiver Operating Characteristics Curve (ROC)

One of the most preferred methods for evaluating the performance of classification systems is the Receiver Operating Characteristic Curve (ROC). This curve is another method that allows us to compare the models by measuring the accuracy of the estimation of the established model.

The Receiver Operating Characteristic Curve (ROC) is an effective method that uses classifiers by visualizing them according to their performance. The ROC curve is a probability curve used to show the balance between the true positive rate and the false positive rate of a classifier. The X-axis of a ROC curve shows the false positive rate and the Y-axis the true positive rate. With this curve, the differences between the classes to be estimated as a result of the model can be observed. The ROC-AUC measure represents the area under the ROC curve. It is understood

that ML models with a large covered area are more successful than other methods in distinguishing given classes. The ideal value for AUC is 1. The advantages of using this curve are that the Roc curve can be directly compared to the curves of different models and a summary of the performances of the models with the area under the curve (AUC) is shown (Duran, Pamukçu, & Bozkurt, 2014).

3. Application Results

In this study, when the Kernel Density map is examined, Şişli district is handled in 2 regions based on traffic accidents and in 3 sections as Büyükdere Street. This distinction was made due to the high accident densities in 2 regions and some parts of Büyükdere Street. Thematic accident maps of the determined regions according to accident occurrence types and accident density maps with the Kernel Density method were examined with the help of statistical analysis. Then, the year, month and day data of the traffic accidents occurred and it was investigated whether the accidents in these regions had a statistically significant day effect. Thus, the differences according to the day of the week affect of the accidents according to the accidents occurring in the regions were interpreted. Finally, by establishing decision trees, artificial neural networks, logistic regression and Naive Bayes models as modelling techniques, the success of the methods according to each other; The accuracy rate was compared with the error rate and ROC value. The independent variables included in the analysis; are accident month, accident day, accident time zone, traffic accident type, weather condition, day status, road surface, road geometric horizontal, road geometric vertical, road geometric intersection, road geometric walkway, lane line, lighting, sidewalk, traffic lamp, type pf road and number of vehicles. The target variable, which is the dependent variable, is the "accident result" variable. The names of the variables used in the analysis, their roles in the model, variable type, value names and label values are given in table 2 below.

Table 2. Table of variables used in the analysis.

Variable Name	The Role of the Variable in the Model	Variable Type	Value Names	Label Values
Accident Month	Input	Nominal Scale	January(1), February(2), March(3), April(4), May(5), June(6), July(7), August(8), September(9), October(10), November(11), December(12)	1-12
Accident Day	Input	Nominal Scale	Monday(1), Tuesday(2), Wednesday(3), Thursday(4), Friday(5), Saturday(6), Sunday(7)	1-7
Accident Time Zone	Input	Ordinal Scale	00:00-04:00(1), 04:00-08:00(2), 08:00-12:00(3), 12:00-16:00(4), 16:00-20:00(5), 20:00-24:00(6)	1-6
Traffic Accident Type	Input	Nominal Scale	Head-On Collision(1), Rear Impact Collision(2), Side-Impact Collision(3), Side-to-Side Collision(4), Hitting a Stationary Vehicle(5), Multiple Vehicle Collision(6), Multiple Hitting(7), Hitting Fixed Objects(8), Hitting Pedestrian(9), Animal Impact(10), Vehicle's Rolling Over(11), Run-Off Road(12), Falls from Vehicles(13)	1-13
Weather Condition	Input	Nominal Scale	Sunny(1), Cloudy(2), Foggy(3), Rainy(4), Snowy(5), Stormy(6), Strong Wind(7)	1-7
Day Status	Input	Nominal Scale	Daytime(1), Night(2), Twilight(3)	1-3
Road Surface	Input	Nominal Scale	Dry(1), Wet(2), Snowy(3), Iced(4), Flood(5), Other Floating Floor(6)	1-6
Road Geometric Horizontal	Input	Nominal Scale	Flat Road(1), Bend(2), Dangerous Bend(3)	1-3
Road Geometric Vertical	Input	Nominal Scale	Without Slope(1), Sloping(2), Dangerous Slope(3), Overhead(4)	1-4
Road Geometric Intersection	Input	Nominal Scale	Three Way T Intersection(1), Three Way Y Intersection(2), Four Way Intersection(3), Roundabout(4), Interchange(5), Other Intersection(6), No Intersection(7)	1-7
Road Geometric Walkway	Input	Nominal Scale	Controlled Railway(1), Uncontrolled Railway(2), School Crossings(3), Pedestrian Crossing(4), No Passage(5)	1-5
Lane Line	Input	Nominal Scale	Available(1), Faulty(2), Unavailable(3)	1-3
Lighting	Input	Nominal Scale	Available(1), Faulty(2), Unavailable(3)	1-3
Sidewalk	Input	Nominal Scale	Available(1), Not Suitable(2), Unavailable(3)	1-3
Traffic Lamp	Input	Nominal Scale	Available(1), Faulty(2), Unavailable(3)	1-3
Type of Road	Input	Nominal Scale	Divided Road(1), One Way Road(2), Two-way road(3), Other(4)	1-4
Number of Vehicles	Input	Interval Scale	1, 2, 3, 4, 5, 6, 7, 8, 9	1-9
Accident Result	Target	Binary Scale	Fatal Accident(0), Injury Accident(1)	0, 1

The "accident result" variable, which is determined as the target variable in the current data set, is at two levels as fatal and injury and the number of fatal accidents are considerably lower than the number of injury accidents. However, in this study, this special case was not taken into account in the data set, as the aim of this study is to help predict which possible accidents will be involved in the future by classifying fatal and injury traffic accidents and to offer a different perspective to the studies in this field. From the results given in detail in the later parts of the study, it was seen that this situation did not affect the model success rates.

3.1 The Entire District of Şişli Results

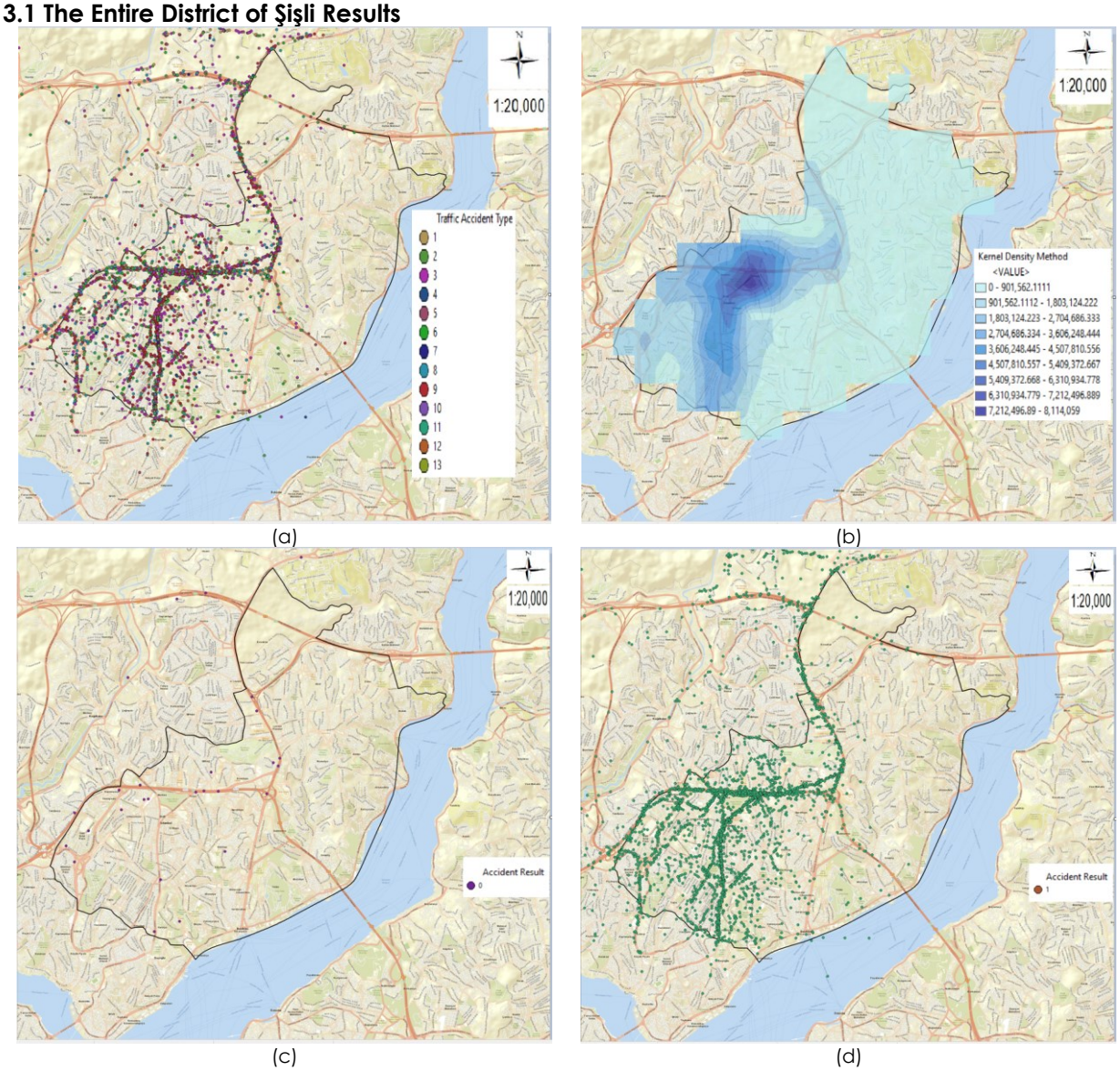


Figure 1. Maps of traffic accidents in Şişli district: (a) Thematic accident map by type of accident; (b) Kernel Density method map; (c) Thematic accident map of fatal accidents; (d) Thematic accident map of injury accidents.

In figure 1, maps of a total of 3833 fatal and injured traffic accidents that occurred between 2010 and 2017 in Şişli district are given. When we examine the thematic accident map according to the type of accident in figure 1 (a) and the Kernel Density method map in figure 1 (b), it is seen that the streets with the highest number of accidents are Büyükdere Street, Halaskargazi Street and Cumhuriyet Street. When the thematic accident map of fatal accidents in figure 1 (c) and the thematic accident map of injury accidents in figure 1 (d) are examined, it is observed that fatal accidents are scattered and injury accidents spread in a clustered manner at certain points. The meaning of the

label values of 13 types of accidents in figure 1 (a) and the label values of the accident result values in figure 1 (c) and figure 1 (d) are given in table 2. In the examination made with the help of frequency analysis, it was seen that 3833 fatal and injury traffic accidents occurred in Şişli district, 3805 of which occurred as injury accidents and 28 accidents resulted as fatal accidents. When we evaluate the fatal accidents, according to the type of accident, it is seen that the most accident is in the form of hitting a pedestrian, followed by the accidents that occur in the form of hitting a stationary vehicle. When we examine the accidents that resulted in injury, according to the type of accidents, it was found that the most accidents were in the form of side collisions, followed by pedestrian collisions and rear collisions. When we look at the points where fatal accidents occurred in figure 1 (c), it was observed that the highest number of fatal accidents occurred on Büyükdere Street with 9 accidents. It was observed that 1 fatal accident occurred on Halaskargazi Street and Cumhuriyet Street, which are the other streets examined in this study. When we look at the points where the injury accidents occurred in figure 1 (d), it was found that the most injury accident occurred on Büyükdere Street with 800 accidents. It was concluded that 288 injury accidents occurred on Halaskargazi Street and 146 injury accidents occurred on Cumhuriyet Street, which is one of the other streets examined. It is aimed to analyze the dangerous accident points in reducing the accidents by correctly classifying the accident results of fatal and injury traffic accidents in the whole Şişli district and on the streets where the accident density is determined by the most successful DM method.

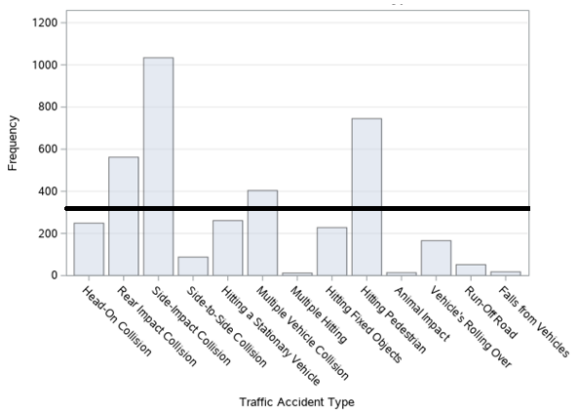


Figure 2. Bar graph of traffic accidents in Şişli district by accident type.

When the thematic accident map according to the type of accidents in figure 1 (a) and the bar graph made for the type of accidents in figure 2 are examined, it is seen that the accidents occurred in the form of a side-impact collision the most, followed by the accidents that occurred in the form of hitting the pedestrian and rear impact collision. It was observed that 13 types of accidents occurred on the thematic accident map by type of accident. In the variable name column of table 2, the type of accident and label values between 1 and 13 are given.

Table 3. Number of accidents by streets.

Street Name	Street Length	Number of Accidents	Number of Accidents Per Meter
Halaskargazi Street	1300 m	289	0.222
Cumhuriyet Street	1300 m	147	0.113
Büyükdere Street	4200 m	809	0.192

As can be seen in table 3, it is seen that in Şişli district, the most fatal and injury accident with 809 accidents was on Büyükdere Street, followed by the accidents on Halaskargazi Street with 289 accidents and Cumhuriyet Street with 147 accidents. When the number of accidents per meter is examined, it is concluded that the street with the highest accident density is Halaskargazi Street.

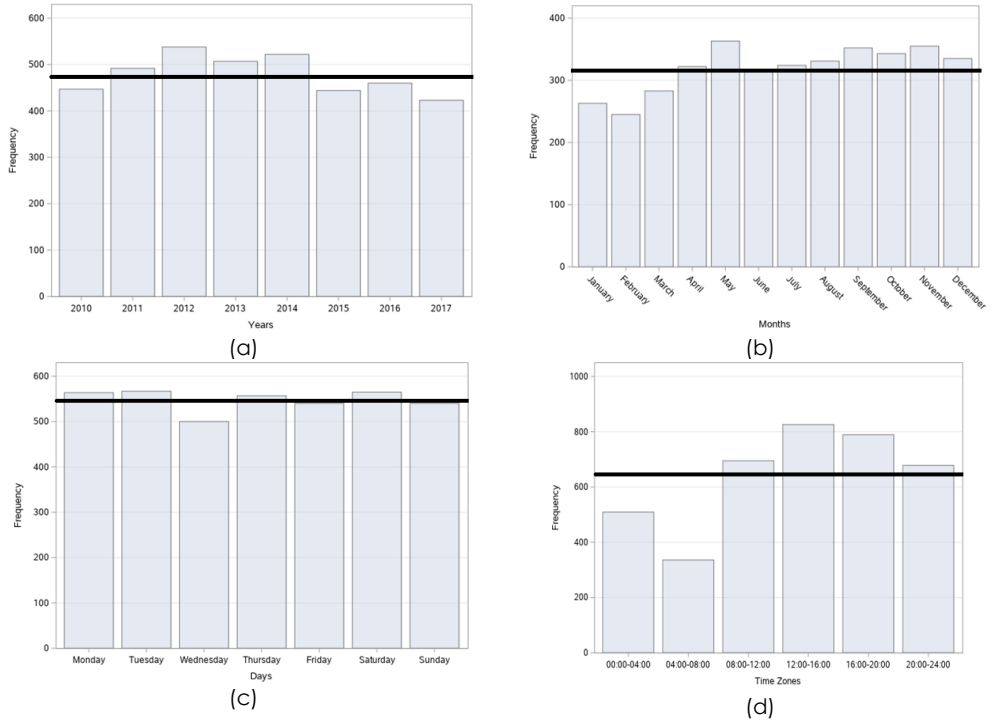


Figure 3. Bar graphs of the number of traffic accidents in Şişli district: (a) By years; (b) By months; (c) By days; (d) By time zones.

In figure 3, bar graphs of the number of accidents, according to years, months, days and time zones, respectively, of a total of 3833 fatal and injury traffic accidents that occurred in the Şişli district between 2010-2017 are given. When we examine it according to the years in figure 3 (a), it is seen that the highest number of accidents was in 2012 with 538 accidents and the least accident was in 2017 with 423 accidents. In figure 3 (b), when we examine it by months, it is observed that the highest number of accidents occurred in May with 363 accidents, and the least accident occurred in February with 245 accidents. When we examine it according to the days in figure 3 (c), it is seen that the highest number of accidents occurred on Tuesday with 567 accidents and the least number of accidents was on Wednesday with 500 accidents. When we examine these accidents, according to the time zones in figure 3 (d), it is concluded that the highest number of accidents occurred between 12:00 and 16:00 with 826 accidents and the least accident occurred between 04:00 and 08:00 with 336 accidents.

First of all, it was investigated whether the traffic accidents have a statistically significant day effect on the year, month and day data in the whole Şişli district.

Table 4. Showing data entry in excel in the model established to determine whether there is a day effect on the accidents.

Year	Month	Daily Accident Numbers	Friday	Saturday	Sunday	Monday…	Thursday
2010	January	1	1	0	0	0	0
2010	January	0	0	1	0	0	0
2010	January	2	0	0	1	0	0
2010	January	1	0	0	0	1	0
…	…	…	…	…	…	…	…
2017	December	0	0	1	0	0	0
2017	December	1	0	0	1		

In order to investigate whether a total of 3833 fatal and injured traffic accidents that occurred between 2010-2017 in the Şişli district have a day effect, they were entered as shown in table 4. Here, the daily accident number value in the first line shows that 1 accident occurred on Friday, January 1, 2010, and the daily accident number value

in the last line shows that 1 accident occurred on Sunday, December 31, 2017. As the daily accident number values change year, month and day, the data entry of the model was made by looking at the number of accidents that occurred on that day. Since January 1, 2010, coincided with Friday, the data were started on Friday.

The statistical model used is as in equation (11):

$$DTAN_t = \beta_1 + \beta_2 Tuesday + \beta_3 Wednesday + \beta_4 Thursday + \beta_5 Friday + \beta_6 Saturday + \beta_7 Sunday + \varepsilon_t \quad (11)$$

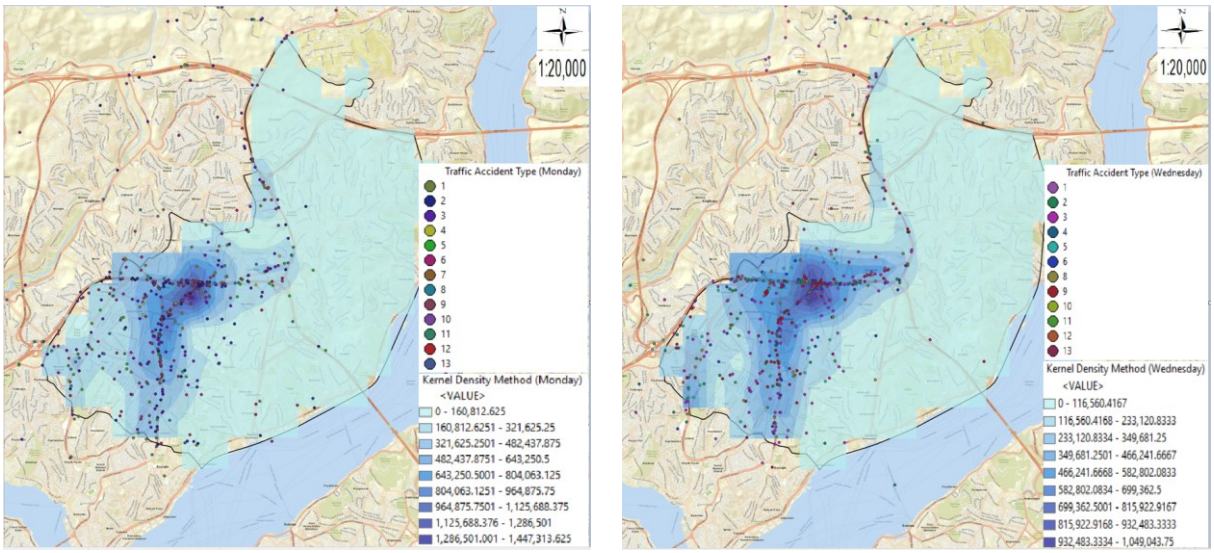
To avoid multicollinearity, Monday was taken as the base day and excluded from the model. The regression outputs of the model are given in table 5.

Table 5. Table of coefficients in the model established to determine whether there is a day effect on accidents.

	Unstandardized Coefficients		Standard Coefficients		
Model	B	Standard Error	Beta	t	Significance Level
Constant	1.343	0.057		23.449	0.000***
Tuesday	0.022	0.081	0.006	0.266	0.790
Wednesday	-0.144	0.081	-0.043	-1.777	0.076*
Thursday	-1.293E-15	0.081	0.000	0.000	1.000
Friday	-0.053	0.081	-0.016	-0.660	0.509
Saturday	0.006	0.081	0.002	0.079	0.937
Sunday	-0.049	0.081	-0.015	-0.601	0.548

*** 1% significance level
* 10% significance level

Table 5 shows (***) 1% significance level, (*) 10% significance level. During the day-based significance study, it was observed that Wednesday was different from other days in terms of accident numbers at the 10% significance level. It has been observed that the other days, except Wednesday, do not have a significant day effect, with Monday as the base day. The constant was found to be statistically significant at the 1% significance level. This indicates that Monday has a significant day effect on traffic accidents. When the units trying to prevent traffic, and accidents deal with this study, they should investigate the reason why Monday and Wednesday show anomalies from other days.



(a) (b)

Figure 4. Kernel Density method maps of traffic accidents on Monday and Wednesday in Şişli district: (a) Kernel Density method map of accidents on Monday; (b) Kernel Density method map of accidents on Wednesday.

In figure 4, the Kernel Density method maps of traffic accidents on Monday and Wednesday, respectively, are given. When the Kernel Density method map of the accidents on Monday is examined in figure 4 (a), it is seen that the accidents are more in Büyükdere, Halaskargazi, Cumhuriyet, Abide-i Hürriyet, Mecidiyeköy Road, Piyalepaşa Boulevard, Cendere, Darülaceze and Talatpaşa streets. On Monday, it was observed that most accidents occurred in the form of side collisions on Büyükdere, Halaskargazi and Cendere streets. It has been observed that in the accidents on Cumhuriyet Street on Monday, the most accidents occurred in the form of rear-end collisions, and on Piyalepaşa Boulevard, the highest number of accidents occurred as rear-end collisions and pedestrian collisions. On Monday, it was concluded that the highest number of accidents occurred in the form of pedestrian collisions on Mecidiyeköy Road, Darülaceze and Talatpaşa streets. In the accidents that occurred on the Abidei Hürriyet Street on Monday, it was observed that the highest number of accidents was equally in the form of chain collisions and pedestrian collisions. When the Kernel Density method map of the accidents on Wednesday is examined in figure 4 (b), it is understood that the accidents are mostly in Halaskargazi, Abidei Hürriyet, Kurtuluş, Ortaklar, Piyalepaşa Boulevard, Ayazağa, Büyükdere, Cendere, Cumhuriyet and Darülaceze streets. When we examine the accidents that took place on Wednesday, it was seen that the most accidents in Abidei Hürriyet, Ayazağa, Büyükdere and Cumhuriyet streets were in the form of side collisions. On Wednesday, it was concluded that the most accidents on Piyalepaşa Boulevard were equally rear-ending and side-impacted. In the accidents that took place on Wednesday, it was observed that the most accident occurred in the form of pedestrian collisions in Halaskargazi, Kurtuluş, Ortaklar and Darülaceze streets. On Cendere Street, on Wednesday, it was observed that most accidents were in the form of mutual collisions. The meaning of the label values of the type of accidents in figure 4(a) and figure 4(b) is given in table 2. On Mondays and Wednesdays, the type of accidents in places where accidents are concentrated were tried to be analysed by adding the type of accidents given in table 2 to the obtained Kernel Density maps. The colour indications of the accident type label have been changed accordingly on Monday and Wednesday due to the fact that the colours cannot be seen clearly due to the differences in the locations where the accidents are intense. In addition, it was observed that there was no 7th type of accident in the accidents on Wednesday.

Table 6. Table of variance in the model established to determine whether there is a day effect on accidents.

Model	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance Level
Regression	8.193	6	1.365	0.998	0.425
Residual	3986.782	2915	1.368	-	-
Total	3994.975	2921	-	-	-

Table 6 examines whether the model is significant as a whole. It was concluded that the model was not significant.

As modelling techniques, firstly, decision trees, artificial neural networks, logistic regression and Naive Bayes models were established in the whole Şişli district and the results were examined.

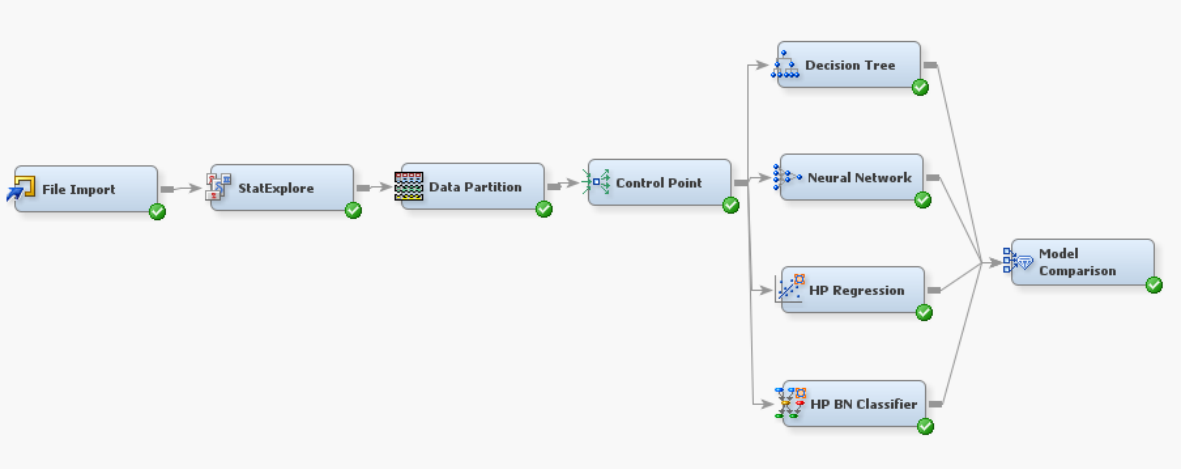


Figure 5. SAS Enterprise Miner interface demonstration.

In figure 5, the interface of the SAS Enterprise Miner software, where the application is made, is given.

Since the missing data were excluded from the analysis during the creation of the data set, it was seen that there was no amount of missing data. It has been observed that the kurtosis value obtained is at a normal level and there is no need to transform this variable. After these processes, the training, testing and validity rates of the models to be used were selected. As a result of various trials, it was decided to select the ratios of training, validity and test set as 60%, 30% and 10%, respectively.

Table 7. Model comparison fit statistics.

Model	**Accuracy Rate**			**Error Rate**			**Roc Value**		
	Training	Validity	Test	Training	Validity	Test	Training	Validity	Test
Decision Trees	0.99	0.99	0.99	0.01	0.01	0.01	0.99	0.48	0.476
Artificial Neural Networks	0.99	0.99	0.99	0.01	0.01	0.01	0.97	0.67	0.325
Logistic Regression	0.99	0.99	0.99	0.01	0.01	0.01	0.98	0.67	0.445
Naive Bayes	0,82	0.84	0.831	0.18	0.16	0.169	0.85	0.83	0.405

When we compare the accidents in Şişli district, according to accuracy and error rates in table 7; it has been seen that all methods except Naive Bayes give successful results in training accuracy, training error, validity accuracy, validation error, test accuracy and test error rates. When we make a comparison, according to ROC values, it is seen that the decision trees method according to the training ROC value, the Naive Bayes method according to the validity ROC value and the decision tree method according to the test ROC value are more successful than the other methods. When we make a general comparison, it is seen that the decision tree method gives more successful results than other methods in comparison criteria.

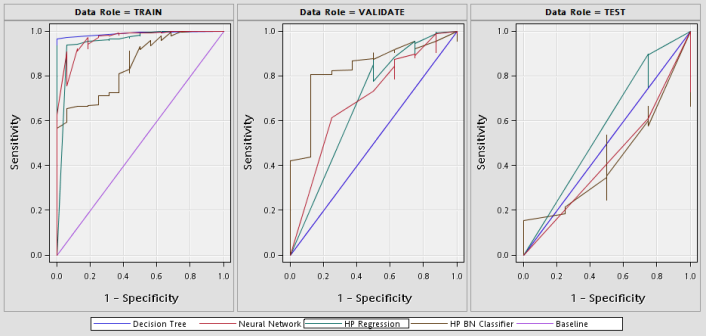


Figure 6. ROC curve comparison results.

In figure 6, ROC curves of all accidents in Şişli district are given according to all models. The area under the curve shows the accuracy rate of accidents that resulted in fatal or injury. The area under the curve represents the ROC values. The baseline curve in the ROC curve comparison chart represents a model without predictive power. The predictive power of the curve is as it approaches the ideal point where the specificity value is 0 and the sensitivity value is 1. Therefore, when compared with ROC value, the predictive power of the model is related to its closeness to 1.
In order to better see the legends and other elements that cannot be seen clearly on the big map, Şişli district is divided into 3 regions and a detailed analysis of these streets has been made.

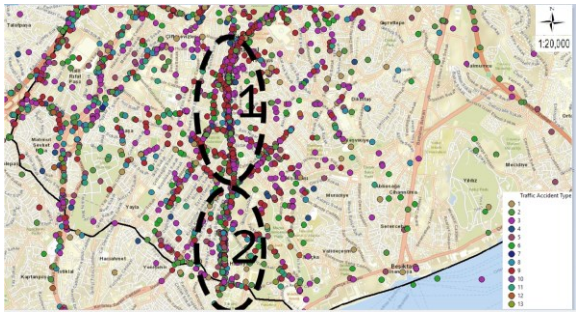
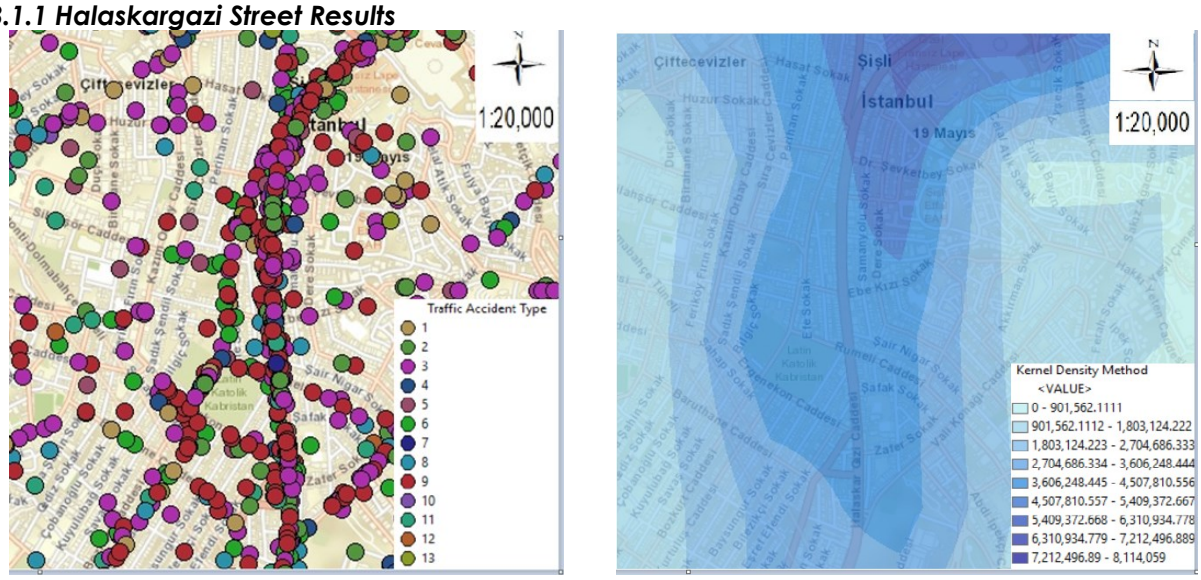


Figure 7. Representation of the 2 separated regions of traffic accidents in Şişli district.

Figure 7 shows the division of the parts of Şişli district outside of Büyükdere Street into regions. The separation of Büyükdere Street was also examined as the 3rd region. The decomposition is as follows;

3.1.1 Halaskargazi Street Results



(a) (b)

Figure 8. Maps of traffic accidents on Halaskargazi Street in Şişli district: (a) Thematic accident map by type of accident; (b) Kernel Density method map.

In figure 8, maps of a total of 289 fatal and injured traffic accidents that occurred between 2010-2017 on Halaskargazi Street in the Şişli district are given. The thematic

accident map according to the type of accident is given in figure 8 (a) and the Kernel Density method map is given in figure 8 (b). Thus, Halaskargazi Street, where the intensity of the accidents cannot be clearly understood on all Şişli maps, is better understood with the decomposed maps provided. It has been seen that the places where the accidents are intense in the Şişli Halaskargazi Street are the streets leading to Istanbul Şişli Hamidiye Etfal Training and Research Hospital and the Istanbul Provincial Directorate of the Turkish Social Security Institution Şişli Security Center. In this street, it has been determined that the pedestrian line is incorrect at the points where the accident density is determined and therefore, the accidents that occur in the form of hitting the pedestrian are high.

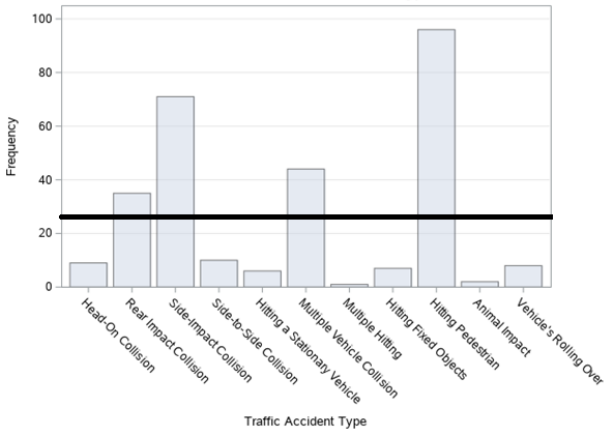


Figure 9. Bar graph of traffic accidents on Halaskargazi Street in Şişli district by accident type.

When the thematic accident map according to the type of accidents in figure 8 (a) and the bar graph made for the type of accidents in figure 9 are examined, it is seen that the accidents occurred in the form of hitting the pedestrian the most, followed by the accidents that occurred in the form of side impact collision.

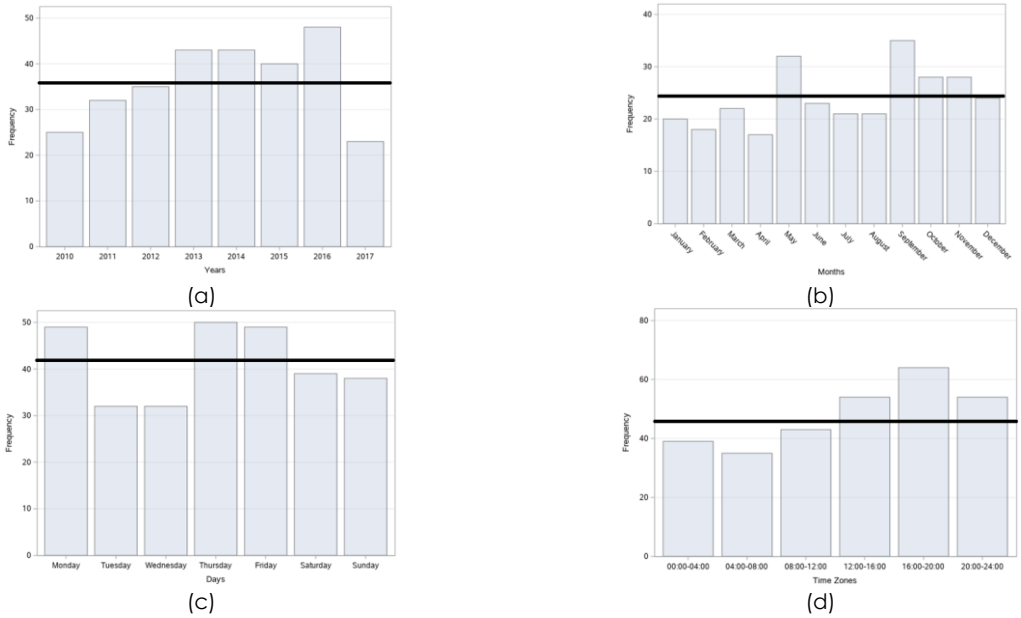


Figure 10. Bar graphs of traffic accidents on Halaskargazi Street in Şişli district: (a) By years; (b) By months; (c) By days; (d) By time zones.

In figure 10, the bar graphs of the number of accidents by years, months, days and time zones, respectively, of a total of 289 fatal and injury traffic accidents that occurred on Halaskargazi Street in Şişli district between 2010 and 2017 are given. When we examine it according to the years in figure 10 (a), it is seen that the highest number of accidents occurred in 2016 with 48 accidents and the least accident occurred in 2017 with 23 accidents. When we examine the figures according to the months in figure 10 (b), it is observed that the highest number of accidents occurred in September with 35 accidents and the least accident occurred in April with 17 accidents. When we analyse it according to days in figure 10 (c), it is concluded that the highest number of accidents occurred on Thursday with 50

accidents and the least number of accidents occurred on Tuesdays and Wednesdays with 32 accidents. When we examine these accidents, according to the time zones in figure 10 (d), it is understood that the highest number of accidents occurred between 16:00 and 20:00 with 64 accidents and the least number of accidents occurred between 04:00 and 08:00 with 35 accidents.

As we have examined all the accidents in Şişli district, the accidents that occurred in Halaskargazi Street were also examined to investigate the effect of the day of the week. The data entered in the excel table of the accidents and the statistical model equations used were made as in all the accidents in Şişli district.

Table 8. Table of coefficients in the model established to determine whether there is a day effect on accidents.

	Unstandardized Coefficients		**Standard Coefficients**		
Model	**B**	**Standard Error**	**Beta**	**t**	**Significance Level**
Constant	0.120	0.016		7.691	0.000***
Tuesday	-0.043	0.022	-0.047	-1.958	0.050**
Wednesday	-0.043	0.022	-0.047	-1.958	0.050**
Thursday	2.140E-15	0.022	0.000	0.000	1.000
Friday	-0.003	0.022	-0.003	-0.122	0.903
Saturday	-0.027	0.022	-0.029	-1.207	0.227
Sunday	-0.031	0.022	-0.035	-1.424	0.154

*** 1% significance level
** 5% significance level

Table 8 shows (***) 1% significance level, (**) 5% significance level. During the day-based significance study, it was observed that Tuesday and Wednesday were different from other days in terms of the number of accidents at the 5% significance level. It was observed that the other days except Tuesday and Wednesday did not have a significant day effect, with Monday as the base day. The constant was found to be statistically significant at the 1% significance level. This indicates that Monday has a significant day effect. By frequency analysis, the accident causes of the days showing anomaly on this street were trying to be investigated. It was observed that in the accidents on Halaskargazi Street on Monday, there were 15 accidents in the form of side collisions, followed by hitting the pedestrian with 14 accidents. When we examine the side impact accidents on Monday, according to vehicle types, it has been observed that the most accidents are made by motorcycle vehicles, and in accidents that occur in the form of pedestrian collisions, it is observed that the most accidents are made by automobile vehicles. When the accidents on Tuesday were examined, it was seen that the highest number of accidents occurred in the form of hitting the pedestrian with 12 accidents, followed by the accidents in the form of multiple vehicle collisions with 6 accidents. When we analysed the pedestrian crashes that occurred on Tuesday, according to vehicle types, it was found that the highest number of accidents was made by automobiles. In the multiple vehicle collisions that occurred on Tuesday, it was understood that most accidents were caused by motorcycle vehicles. When the accidents in Halaskargazi Street on Wednesday were examined, it was seen that the highest number of accidents was pedestrian collisions with 12 accidents, followed by side collisions with 6 accidents. It was concluded that pedestrian collision accidents that occurred on Wednesday were mostly caused by motorcycles and automobiles. It was found that the accidents in the form of a side-impact collision on Wednesday were mostly caused by motorcycles.

Table 9. Table of variance in the model established to determine whether there is a day effect on accidents.

Model	**Sum of Squares**	**Degrees of Freedom**	**Mean Square**	**F**	**Significance Level**
Regression	0.976	6	0.163	1.605	0.142
Residual	295.440	2915	0.101	-	-
Total	296.416	2921	-	-	-

Table 9 examines whether the model is significant as a whole. It was concluded that the model was not significant.
Decision trees, artificial neural networks, logistic regression and Naive Bayes models were established in Halaskargazi Street and the results were examined.

Table 10. Model comparison fit statistics.

Model	Accuracy Rate			Error Rate			Roc Value		
	Training	Validity	Test	Training	Validity	Test	Training	Validity	Test
Decision Trees	0.994	1.000	1.000	0.006	0.000	0.000	0.971	-	-
Artificial Neural Networks	1.000	1.000	0.933	0.00	0.000	0.067	1.000	-	-
Logistic Regression	1.000	1.000	1.000	0.00	0.000	0.000	1.000	-	-
Naive Bayes	0.740	0.663	0.767	0.260	0.337	0.233	0.869	-	-

When we compare the accidents in the Şişli Halaskargazi Street according to accuracy and error rates in table 10; it has been seen that artificial neural networks and logistic regression methods in training accuracy and training error rates, all methods except Naive Bayes in validity, accuracy and validation error rates, decision trees and logistic regression methods in test accuracy and test error rates. When we make a comparison, according to the ROC values, it was seen that only the training ROC values were calculated due to the scarcity of data. It has been observed that artificial neural networks and logistic regression methods give successful results according to the training ROC values. When we make a general comparison, it was found that the logistic regression method gave better results than other methods in all comparison criteria.

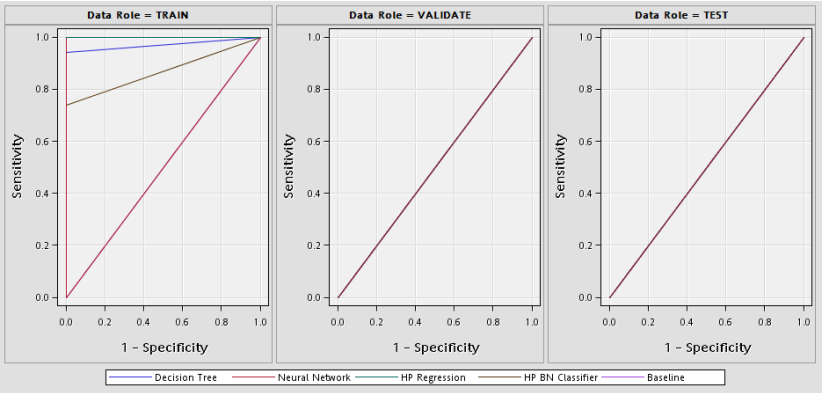


Figure 11. ROC curve comparison results.

In figure 11, ROC curves of the accidents in Halaskargazi Street are given according to all models. The area under the curve shows the accuracy rate of accidents that resulted in fatal or injury. The area under the curve represents the ROC index values.

3.1.2 Cumhuriyet Street Results

(a) (b)

Figure 12. Maps of traffic accidents on Cumhuriyet Street in Şişli district: (a) Thematic accident map by type of accident; (b) Kernel Density method map.

In figure 12, maps of a total of 147 fatal and injured traffic accidents that occurred between 2010-2017 on Cumhuriyet Street in Şişli district are given. The thematic accident map according to the type of accident is given in figure 12 (a), and the Kernel Density method map is given in figure 12 (b).

Thus, the density of accidents cannot be clearly understood on all Şişli maps, and Cumhuriyet Street is better understood with the decomposed maps provided. It has been observed that the places where the accidents are intense in the Şişli Cumhuriyet Street are in the streets leading to the Istanbul Lütfi Kırdar International Convention and Exhibition Center, Istanbul Congress Center, Cemil Topuzlu Open Air Theatre and the Hilton Istanbul Bosphorus hotel. It is thought that accidents can be prevented by increasing pedestrian safety around the venues where the events are held.

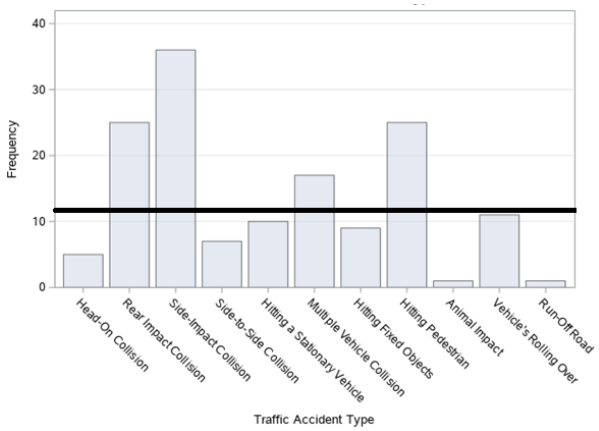


Figure 13. Bar graph of traffic accidents on Cumhuriyet Street in Şişli district by accident type.

When the thematic accident map according to the type of accidents in figure 12 (a) and the bar graph made for the type of accidents in figure 13 are examined, it is seen that the accidents occurred in the form of side-impact collision the most, followed by the accidents that occurred in the form of rear-impact collision and hitting the pedestrian.

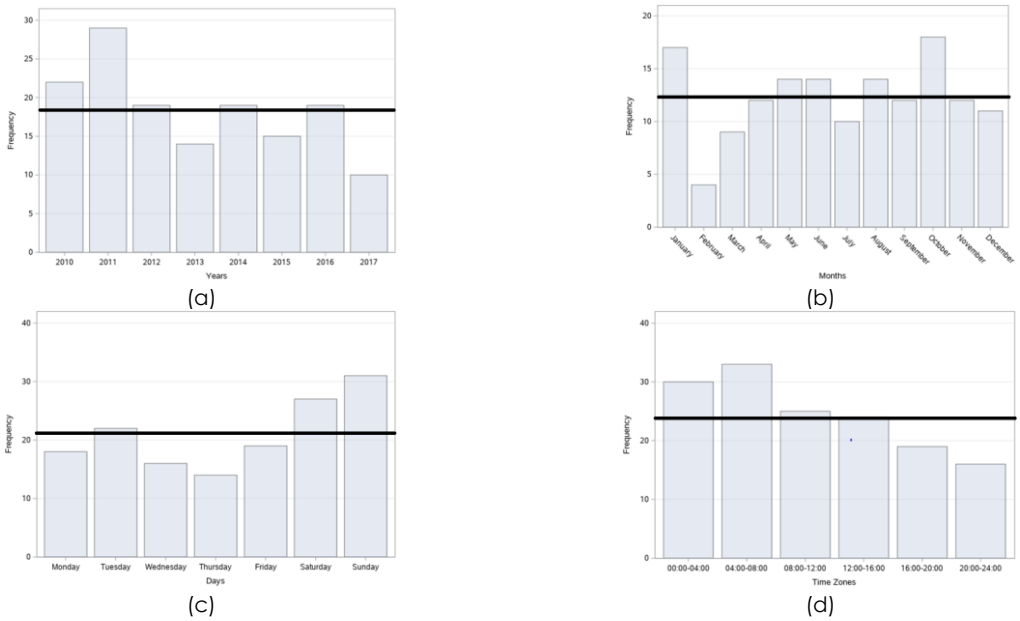


Figure 14. Bar graphs of traffic accidents on Cumhuriyet Street in Şişli district: (a) By years; (b) By months; (c) By days; (d) By time zones.

In figure 14, the bar graphs of the number of accidents according to years, months, days and time zones, respectively, of a total of 147 fatal and injury traffic accidents that occurred on Cumhuriyet Street in Şişli district between 2010-2017 are given. When we examine it according to the years in figure 14 (a), it is seen that the highest number of accidents occurred in 2011 with 29 accidents and the least accident occurred in 2017 with 10 accidents. When we analyse the figure 14 (b) by months, it is observed that the highest number of accidents occurred in October with 18 accidents and the least accident occurred in February with 4 accidents. When we examine it according to the days in figure 14 (c), it is understood that the highest number of accidents occurred on Sunday with 31 accidents and the least accident occurred on Thursday with 14 accidents. When we examine these accidents, according to the time zones in figure 14 (d), it is concluded that the highest number of accidents occurred between 04:00 and 08:00 with 33 accidents and the least number of accidents occurred between 20:00 and 24:00 with 16 accidents.

As we have examined all the accidents in the Şişli district, the accidents that occurred on Cumhuriyet Street were also examined to investigate the effect on the day of the week. The data entered in the excel table of the accidents and the statistical model equations used were made as in all the accidents in the Şişli district.

Table 11. Table of coefficients in the model established to determine whether there is a day effect on accidents.

	Unstandardized Coefficients		**Standard Coefficients**		
Model	**B**	**Standard Error**	**Beta**	**t**	**Significance Level**
Constant	0.043	0.011		3.773	0.000***
Tuesday	0.010	0.016	0.014	0.593	0.553
Wednesday	-0.005	0.016	-0.007	-0.296	0.767
Thursday	-0.010	0.016	-0.014	-0.593	0.553
Friday	0.002	0.016	0.003	0.142	0.887
Saturday	0.021	0.016	0.032	1.325	0.185
Sunday	0.031	0.016	0.046	1.917	0.055*

*** 1% significance level
* 10% significance level

Table 11 shows (***) 1% significance level, (*) 10% significance level. During the day-based significance research, it was observed that Sunday was different from other days in terms of the number of accidents at the 10% significance level. It has been observed that

the other days, except Sunday, do not have a significant day effect, provided that Monday is taken as the base day. The constant was found to be statistically significant at the 1% significance level. This indicates that Monday has a significant day effect. By frequency analysis, the accident causes of the days showing anomaly on this street were trying to be investigated. It was observed that in the accidents that took place on Cumhuriyet Street on Monday, the highest number of accidents was a rear-impact collision with 5 accidents, followed by side-to-side collisions with 4 accidents. It was found that most of the rear impact and side-impact collisions on Monday were caused by automobiles. When the accidents on Sunday on Cumhuriyet Street were examined, it was observed that the highest number of accidents was in the form of rear-impact collisions with 7 accidents, followed by pedestrian collisions and vehicles rolling over equally with 5 accidents. It was concluded that the rear impact collisions on Sunday were mostly made by automobiles, and hitting the pedestrian were equally made by motorcycles and automobiles. On the other hand, it was observed that the accidents that occurred in the form of a vehicle rolling over on Sunday were mostly caused by automobiles.

Table 12. Table of variance in the model established to determine whether there is a day effect on accidents.

Model	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance Level
Regression	0.533	6	0.089	1.628	0.135
Residual	159.072	2915	0.055	-	-
Total	159.605	2921	-	-	-

Table 12 examines whether the model is significant as a whole. It was concluded that the model was not significant.

Secondly, decision trees, artificial neural networks, logistic regression and Naive Bayes models were established on Cumhuriyet Street and the results were examined.

Table 13. Model comparison fit statistics.

Model	Accuracy Rate			Error Rate			Roc Value		
	Training	Validity	Test	Training	Validity	Test	Training	Validity	Test
Decision Trees	0.989	1.000	1.000	0.011	0.000	0.000	0.971	-	-
Artificial Neural Networks	1.000	1.000	1.000	0.000	0.000	0.000	1.000	-	-
Logistic Regression	1.000	1.000	1.000	0.000	0.000	0.000	1.000	-	-
Naive Bayes	0.943	1.000	0.933	0.057	0.000	0.067	1.000	-	-

When we compare the accidents in the Şişli Cumhuriyet Street according to accuracy and error rates in table 13; it has been seen that artificial neural networks and logistic regression methods in training accuracy and training error rates, all methods in validity, accuracy and validity error rates, all methods except Naive Bayes in test accuracy and test error rates. When we make a comparison, according to the ROC values, it was seen that only the training ROC values were calculated due to the scarcity of data. According to the training ROC values, it was observed that other methods other than decision trees gave successful results. When we made a general comparison, it was found that artificial neural networks and logistic regression methods gave better results than other methods in all comparison criteria.

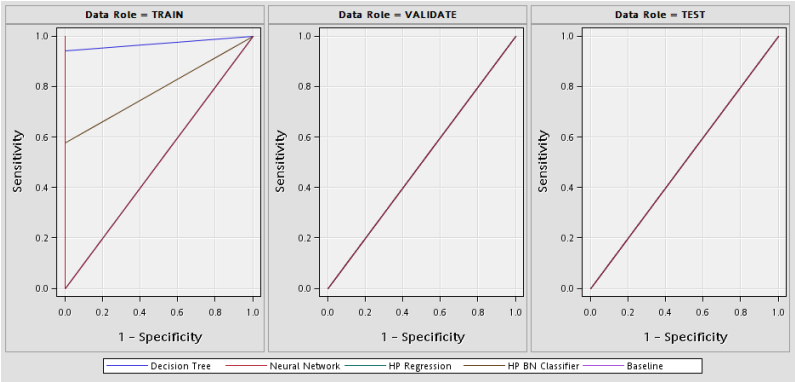
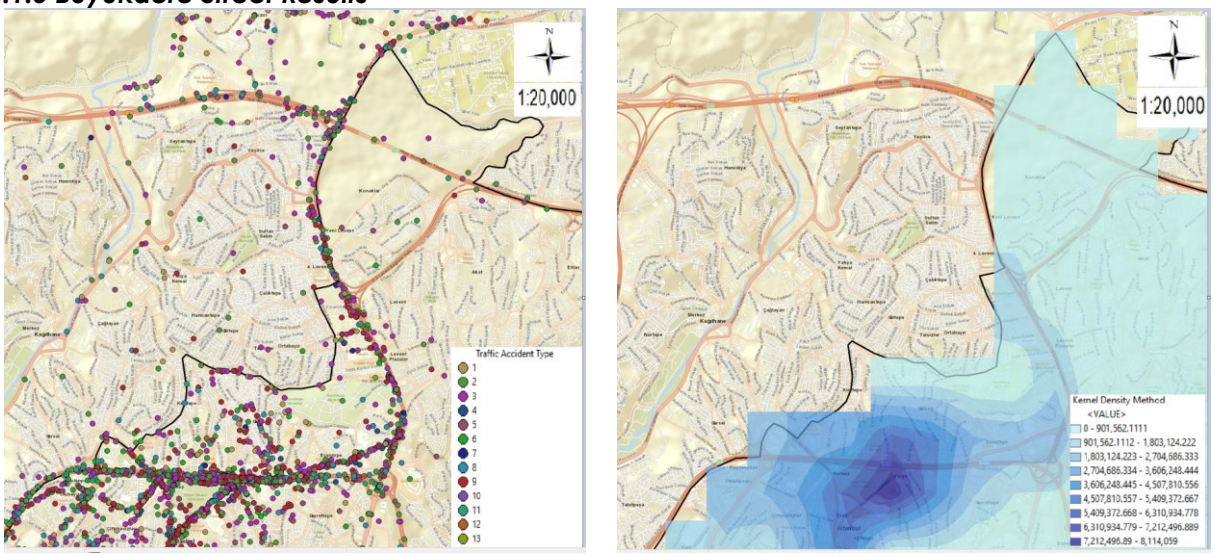


Figure 15. ROC curve comparison results.

In figure 15, ROC curves of the accidents on Cumhuriyet Street are given according to all models. The area under the curve shows the accuracy rate of accidents that resulted in fatal or injury. The area under the curve represents the ROC index values.

3.1.3 Büyükdere Street Results



(a) (b)

Figure 16. Maps of traffic accidents on Büyükdere Street in Şişli district: (a) Thematic accident map by type of accident; (b) Kernel Density method map.

In figure 16, maps of a total of 809 fatal and injured traffic accidents that occurred between 2010-2017 on the Büyükdere Street in Şişli district are given. The thematic accident map according to the type of accident is given in figure 16 (a) and the Kernel Density method map is given in figure 16 (b).

Thus, Büyükdere Street, where the intensity of the accidents cannot be clearly understood on all Şişli maps, is better understood with the decomposed maps provided. It has been observed that the points where the accidents are intense in Şişli Büyükdere Street are the places that lead from Garaj Street and Ortaklar Junction to Büyükdere Street. It has been observed that there has been a decrease in the number of accidents on this street only since 2015. When the reason for this is investigated, in 2015, in the Şişli-Mecidiyeköy direction of the Istanbul Metropolitan Municipality; it has been observed that the section of Büyükdere Street between Aytekin Kotil Street and Ortaklar Street has partial lane narrowest, giving vehicle traffic to 2 lanes, and creating a pedestrian passage corridor between the construction site and buildings, providing safe passage for pedestrians. Thus, after 2015, there has been a decrease in accidents that occur in the form of hitting pedestrians in this direction. In addition, in the Mecidiyeköy-Şişli

direction, it provides vehicle traffic flow by giving it over Bahçeler Street (1 round-1 arrival) between Aytekin Kotil Street and Ortaklar Street, for vehicles continuing on Mecidiyeköy Road Street, the Connection Road under the D-100 Highway and first Geçit Street and the works carried out to enable them to reach Şişli side from Büyükdere Street by proceeding from Abide-i Hürriyet Street and the traffic light arrangement on the Büyükdere Street connection section of Aytekin Kotil Street and the work done to ensure the participation of vehicles in the Şişli direction was effective in reducing traffic accidents. It is thought that there will be a decrease in accidents as a result of the correction of the negativities detected in this study.

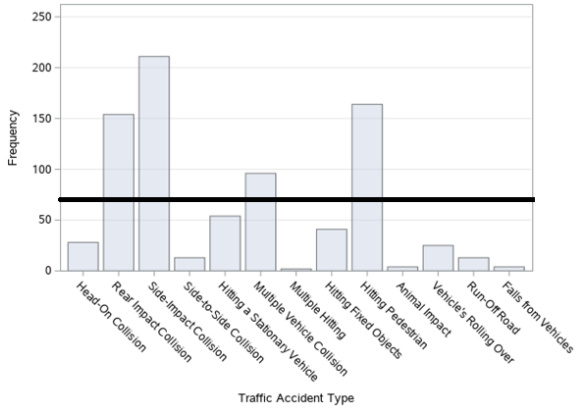


Figure 17. Bar graph of traffic accidents on Büyükdere Street in Şişli district by accident type.

When the thematic accident map according to the type of accidents in figure 16 (a) and the bar graph made for the type of accidents in figure 17 is examined, it is seen that the accidents occurred in the form of side-impact collision the most, followed by the accidents that occurred in the form of hitting the pedestrian.

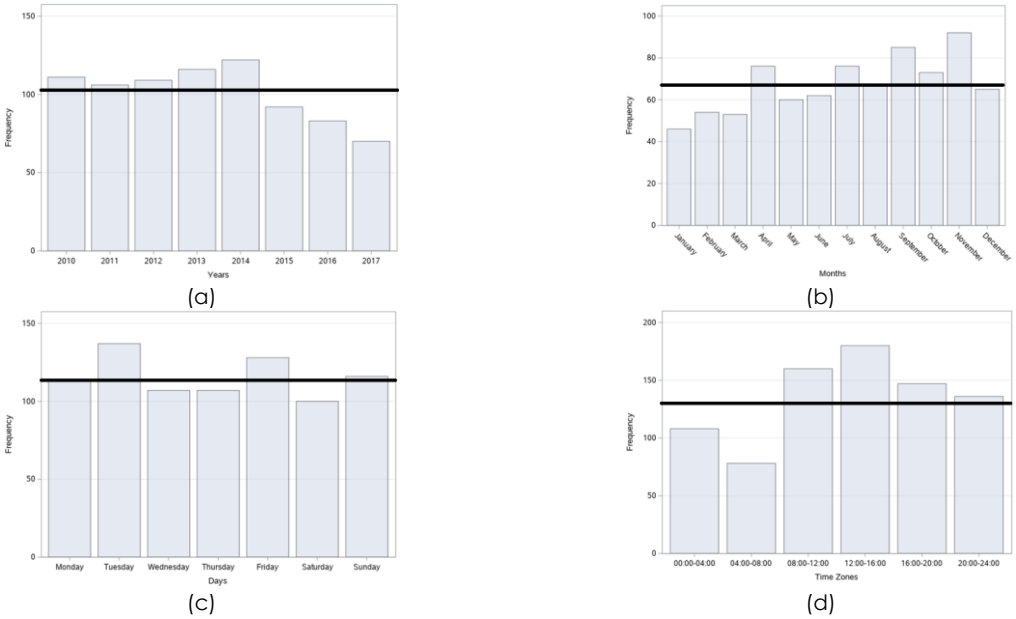


Figure 18. Bar graphs of traffic accidents on Büyükdere Street in Şişli district: (a) By years; (b) By months; (c) By days; (d) By time zones.

In figure 18, the bar graphs of the number of accidents according to years, months, days and time zones, respectively, of a total of 809 fatal and injury traffic accidents that occurred on Büyükdere Street in Şişli district between 2010-2017 are given. When we examine it according to the years in figure 18 (a), it is seen that the highest number of accidents was in 2014 with 122 accidents and the least accident was in 2017 with 70 accidents. When we examine the figures according to the months in figure 18 (b), it is observed that the highest number of accidents occurred in November with 92 accidents and the least accident occurred in January with 46 accidents. When we examine it according to the days in figure 18 (c), it is understood that the highest number of accidents occurred on Tuesday with 137 accidents, and the least number of accidents occurred on Saturday with 100 accidents. When we examine these accidents according to the time zones in figure 18 (d), it is concluded that the highest number of accidents occurred between 12:00 and 16:00 with 180 accidents and the least number of accidents occurred between 04:00 and 08:00 with 78 accidents. As we have examined all the accidents in Şişli district, the accidents that occurred in Büyükdere Street were also examined to investigate the effect of the day of the week. The data entry in the excel table of the accidents and the statistical model equations used were made as in all the accidents in Şişli district.

Table 14. Table of coefficients in the model established to determine whether there is a day effect on accidents.

	Unstandardized Coefficients		**Standard Coefficients**		
Model	**B**	**Standard Error**	**Beta**	**t**	**Significance Level**
Constant	0.271	0.026		10.465	0.000***
Tuesday	0.050	0.037	0.033	1.375	0.169
Wednesday	-0.007	0.037	-0.005	-0.196	0.844
Thursday	-0.012	0.037	-0.008	-0.327	0.743
Friday	0.035	0.037	0.023	0.963	0.336
Saturday	-0.032	0.037	-0.021	-0.868	0.386
Sunday	0.007	0.037	0.004	0.178	0.858

*** 1% significance level

Table 14 shows (***) 1% significance level. During the day-based significance survey, it was seen that there was no significant day effect on any day provided that Monday was taken as the basic day. Constant was found to be statistically significant at the 1% significance level. This means that Monday has a meaningful day effect. With the frequency analysis, the causes of accidents of the days showing anomalies on this street were trying to be investigated. When the accidents on Büyükdere Street on Monday are examined, it is seen that the highest number of accidents is side-impact collisions with 29 accidents and hitting the pedestrian with 27 accidents. It was found that the accidents in the form of a side-impact collision and hitting the pedestrian on Monday were mostly caused by automobiles.

Table 15. Table of variance in the model established to determine whether there is a day effect on accidents.

Model	**Sum of Squares**	**Degrees of Freedom**	**Mean Square**	**F**	**Significance Level**
Regression	1.996	6	0.333	1.190	0.308
Residual	815.020	2915	0.280	-	-
Total	817.016	2921	-	-	-

Table 15 examines whether the model is significant as a whole. It was concluded that the model was not significant.

Finally, decision trees, artificial neural networks, logistic regression and Naive Bayes models were established on Büyükdere Street and the results were examined.

Table 16. Model comparison fit statistics.

Model	Accuracy Rate			Error Rate			Roc Value		
	Training	Validity	Test	Training	Validity	Test	Training	Validity	Test
Decision Trees	0.992	0.988	0.976	0.008	0.012	0.024	0.989	0.492	0.738
Artificial Neural Networks	1.000	0.988	0.964	0.000	0.012	0.036	1.000	0.353	0.670
Logistic Regression	1.000	0.955	0.916	0.000	0.045	0.084	1.000	0.400	0.401
Naive Bayes	0.718	0.724	0.627	0.282	0.276	0.373	0.887	0.334	0.694

When we compare the accidents in Şişli Büyükdere Street, according to accuracy and error rates in table 16; it has been seen that artificial neural networks and logistic regression methods in training accuracy and training error rates, decision trees and artificial neural network methods in validity, accuracy and validity error rates and decision tree methods in test accuracy and test error rates are more successful than other methods. When we compare according to ROC values, artificial neural networks and logistic regression methods according to training ROC values, the decision tree method according to validity ROC values and when we compared according to test ROC values, it is observed that the decision trees method gives more successful results than other methods. When we make a general comparison, it is seen that the decision tree method gives more successful results than other methods in comparison criteria.

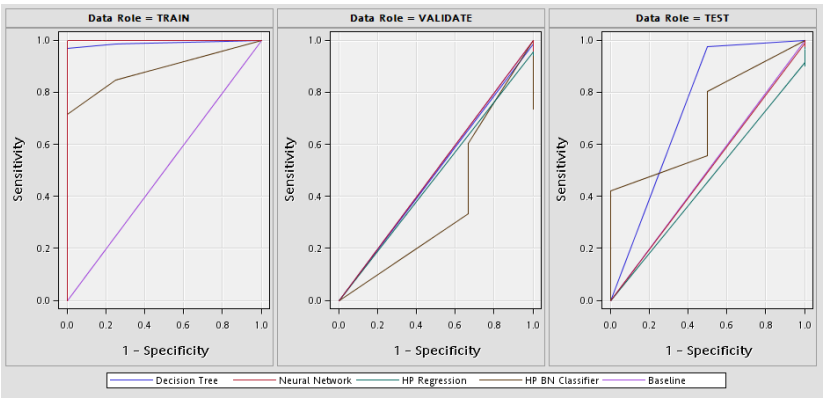


Figure 19. ROC curve comparison results.

In figure 19, ROC curves of the accidents on Büyükdere Street are given according to all models. The area under the curve shows the accuracy rate of accidents that resulted in fatal or injury. The area under the curve represents the ROC index values.

4. Discussion

It is very important to make decisions based on data to follow and control traffic accidents. For this reason, the method of detecting anomalies with the day of the week effect approach, which is known in the field of finance, has been adapted to traffic accidents. Determining the days that differ from the anomaly detection in traffic accidents can enable faster measures to be taken for the incidents that cause the accidents (Örnek, Vatan, Sarıoğlu, & Yazıcı, 2018).

In this study, the streets with high traffic accidents were determined by the Kernel Density method and then the days when the accidents showed anomalies on these streets were determined. Thus, it is thought that the units trying to prevent traffic accidents can take the necessary measures in a narrower

area, according to the causes of the accident by examining the days when the accidents show an anomaly in different locations according to the changing conditions. This will also save cost and time.

Since the database of the General Directorate of Security has only data on fatal and injury accidents, data on accidents with material damage could not be obtained. However, the fact that the data we requested from the Insurance Information and Monitoring Centre could not be obtained partially negatively affected this study to be carried out in more detail.

In this study, the accident coordinates obtained from the General Directorate of Security were used in the spatial analysis in the Kernel Density method. The Kernel Density method was preferred because it gives better results visually than other spatial methods in the studies carried out to determine accident densities. In this study, it has been seen that it is more efficient in terms of results to include narrowed location-based analysis instead of studies that will take all of the regional data in our spatial analysis.

For this reason, it has been seen that it will be more effective to reduce the accidents by examining the regions where the accidents are intense with frequency analysis and anomaly approach, and offering solutions if possible. In addition, classification methods are emphasized by using traffic accident data in these regions. The success of the models according to the regions was evaluated by applying various ML methods in classifying the results of traffic accidents as fatal and injury. For this, decision trees, artificial neural networks, logistic regression and Naive Bayes models were tried to observe the differences in the results according to the streets where the accidents were intense. The main purpose of developing the models according to different locations is to help reduce accidents by deciding on the most appropriate model in a more restricted area in classifying the result of traffic accidents as fatal and injury accidents. As a result, it was concluded that although the examined models showed high performance, they showed differences according to the locations where the accidents occurred.

5. Conclusions

It is important to investigate the cause of the accidents that occurred in the same location in order to reduce traffic accidents and ensure the life safety of people. To take effective measures regarding road safety, it is necessary to determine and analyse the regions where the accidents are concentrated. With the locational determination of the black spots, the factors causing the accidents should be investigated.

When the integrated density maps of the Şişli district were examined, it was decided to examine the district separately as 3 separate regions. Among the spatial methods, the Kernel Density method was preferred because its vitality is better. With this method and statistical analysis, firstly the determined regions were analysed and then the effect on the day of the week for traffic accidents in these determined regions was investigated and the days showing anomalies were evaluated according to the regions. During the day-based significance research on death and injury accidents in the whole Şişli district between 2010 and 2017, it was seen that Wednesday was different from other days in terms of accident numbers at the 10% significance level. In the analysis made separately according to the streets, it was seen that Tuesday and Wednesday were different from other days in terms of the number of accidents at the 5% significance level, in the day-based significance research of the fatal and injury accidents that occurred between 2010-2017 on Halaskargazi Street. Secondly, it was observed that Sunday was different from other days in terms of the number of accidents at the 10% significance level, in the day-based significance study of fatal and injury accidents that occurred on Cumhuriyet Street between 2010-2017. Finally, in the day-based significance research of fatal and injury accidents that occurred on Büyükdere Street, it was concluded that there was no significant day effect on any day, based on Monday.

In this study, decision trees, artificial neural networks, logistic regression and Naive Bayes models were established as modelling techniques and the performance of the methods in classifying the target variable as fatal and injury accidents was compared

according to accuracy, error rates and ROC values for these streets. In this way, it was ensured that a possible accident in the future would result in death or injury and assisted the relevant units in the measures to be taken. Model building studies were also carried out in terms of other target variables. A successful model could not be obtained in model studies with variables such as target variable accident occurrence type and vehicle type. It was concluded that these target variables are completely random and cannot be predicted within the framework of classification models. In the results obtained, the success of different classification techniques [decision tree for the whole Şişli (Table 7), logistic regression for Halaskargazi Street (Table 10), artificial neural networks and logistic regression for Cumhuriyet Street (Table 13) and decision tree for Büyükdere Street (Table 16)] is due to the structure of the existing data and it is possible for the results to change according to a different data set.

This study has shown that necessary measures should be taken by examining a narrower area with the help of spatial analysis in the prevention of fatal and injury accidents. It has been seen that the place examined with the help of statistical analysis of the entire Şişli district is not very effective in taking measures to reduce accidents. For this reason, with this study, which is a guide for the units trying to prevent traffic accidents, it has been seen that the researches made by dividing into regions and using the differentiated analysis give more realistic results for the solution proposals to be produced. This study predicts that making arrangements to take into account the types of vehicles involved in accidents in certain locations together with the day effect will be more effective in reducing fatal and injury accidents. It is thought that the application of a known method in the field of finance in terms of traffic accidents will provide a new perspective for future studies.

Acknowledgements

We would like to thank the General Directorate of Security for providing the data they have for the completion of this study. We would also like to thank the 100/2000 YÖK doctoral scholarship program.

Conflicts of interest

The Author(s) declare(s) that there is no conflict of interest.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Ethics statements

Studies involving animal subjects: *No animal studies are presented in this manuscript.*

Studies involving human subjects: No human studies are presented in this manuscript.

Inclusion of identifiable human data: No potentially identifiable human images or data is presented in this study.

CRediT authorship contribution statement

Conceptualization: M.E., A.H.B., S.E.T. **Data curation:** M.E., A.H.B., S.E.T. **Formal analysis:** M.E., A.H.B., S.E.T. **Investigation:** M.E., A.H.B., S.E.T. **Methodology:** M.E., A.H.B., S.E.T. **Project administration:** M.E., A.H.B., S.E.T. **Writing—original draft:** M.E., A.H.B., S.E.T. **Writing—review and editing:** M.E., A.H.B., S.E.T. All authors have read and agreed to the published version of the manuscript.

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How to cite this article:
Ersen, M., Büyüklü, A. H., & Taşabat, S. E. (2022). Data Mining as a Method for Comparison of Traffic Accidents in Şişli District of Istanbul. *Journal of Contemporary Urban Affairs, 6*(2), 113-141. https://doi.org/10.25034/ijcua.2022.v6n2-2

Journal of Contemporary Urban Affairs

2022, Volume 6, Number 2, pages 143–155

Original scientific paper

The Psychological Effects of Park Therapy Components on Campus Landscape Preferences

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ARTICLE INFO:

Article History:
Received: 13 March 2022
Revised: 25 June 2022
Accepted: 20 July 2022
Available online: 12 August 2022

Keywords:
Park therapy components;
Landscape preferences;
Mood states;
Anxiety level;
Visitor-employed photography;
Image tagging;
Psychological effects.

ABSTRACT

COVID-19 has doubled the prevalence of mental health problems among young adults. In Indonesia, it extends the vulnerability of families, increases economic uncertainty, interrupts food security, and affects psychological well-being. Accordingly, this research examined the correlation between psychological effects and preferred landscape elements. Experiments were conducted in a campus park, arboretum, and a road. Participants captured attractive views during the walk using the Visitor-Employed Photography method and evaluated psychological effects using the Profile of Mood States (POMS) and the State-Trait Anxiety Inventory (STAI) pre-and post-walking. Google Cloud Vision API was used to get the image annotation keywords. The results indicated a correlation between psychological effects and preferred landscape elements. Park therapy components, including plant, flower, and sky, were negatively correlated with negative moods and anxiety levels. These findings presented scientific evidence for the psychological relaxation outcome of walking and prominent components of park therapy to support therapeutic campus greenspace planning.

JOURNAL OF CONTEMPORARY URBAN AFFAIRS (2022), ***6***(2), 143-155.
https://doi.org/10.25034/ijcua.2022.v6n2-3

www.ijcua.com

1. Introduction

The COVID-19 global pandemic impacted Indonesia in the early 2020s, where health and human services and agriculture growth have emerged. In contrast, information and communication, as well as utilities, had the highest growth rates (Asian Development Bank, 2022). The mental health of youth (15-24 years) has deteriorated significantly in the past couple of years. In most countries, mental health problems have become twice as prevalent among this age group as they were in the past due to the COVID-19 pandemic, such as depression and anxiety symptoms. Many factors contribute to mental health deterioration, including disruptions in healthcare services, school closings, and a job market crisis that disproportionately affects young people (OECD, 2021). According to a study on family resilience during the COVID-19 outbreak in Indonesia, respondents were

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How to cite this article:
Pratiwi, P. I., Sulistyantara, B., Sisriany, S., & Lazuardi, S. N. (2022). The Psychological Effects of Park Therapy Components on Campus Landscape Preferences. *Journal of Contemporary Urban Affairs*, *6*(2), 143-155. https://doi.org/10.25034/ijcua.2022.v6n2-3

concerned about losing/death of family members (74%), family finances (60.2%), children's futures (58.1%), and own death (56.7%) (Sunarti et al., 2022). Young people have the potential to influence change in the development and promotion of mental health and well-being (MHWB) programs (Raviola et al., 2019). Previous research has proven that mental health is closely associated with human physical health. Due to the benefits of exposure to the natural environment, campus green space is a valuable resource for students' daily living routines, working, and learning. Shinrin-yoku (forest bathing) is one of the most cost-effective methods of getting in touch with nature (Park et al., 2007, 2010; Tsunetsugu et al., 2007). Research has shown that walking in forests and urban parks for 15 minutes improved mood, reduced anxiety (Song et al., 2013, 2014), increased meditation and attention (Hassan et al., 2018), lowered pulse rate, diastolic blood pressure, and LF/(LF+HF) components of heart rate variability (Park et al., 2010) and reduced salivary cortisol levels (Tsunetsugu et al., 2007).

Increasing access and awareness of green spaces and enhancing the quality and quantity of green spaces could be beneficial for stress reduction in university settings (Holt et al., 2019; Seitz et al., 2014). Eckbo (1964) stated that green space is a tool in campus life. It accommodates various disciplines' learning activities, social communication, and reciprocal relationships. Also, it provides a place for recreation and rest, promotes mental well-being, and awakens positive emotions (Foellmer et al., 2021). A well-designed campus environment is important for the educational mission and users' mental well-being. Therefore, physical, social, symbolic, and experienced spaces should be created to create a therapeutic landscape (Völker & Kistemann, 2015). The Dramaga Campus, IPB University, Bogor, West Java, Indonesia, which is designated as the green campus, is expected to shape the behaviour of the academic community to be green, active, and energy-efficient. While there are many parks at IPB University, there has been no active movement or health promotion to use parks to enhance the mental health and well-being of the young academic community. In this regard, it would be worthwhile to examine the health and well-being of students on campus (Elsadek et al., 2019; Foellmer et al., 2021; Ghorbanzadeh, 2019; Guo et al., 2020). Campus planning should emphasize potential effects on disparities in students' satisfaction, well-being, and academic success (Foellmer et al., 2021).

Forest and park therapy studies have been proven from the stimulus carried out in the laboratory (Jo et al., 2019) and on-site surveys (Park et al., 2010, 2011; Pratiwi et al., 2020). In the era of technology disruption, the usage of virtual stimuli (Benzina et al., 2019; Guo et al., 2020) and cloud computing were applied for landscape planning or evaluation (Richards et al., 2018; Urech et al., 2020; Włodarczyk-Marciniak et al., 2020). Landscape preference is yet to be evaluated through forest and park therapy programs. Human landscape preferences are believed to be associated with their moods (Gao et al., 2019; Li et al., 2021; Pratiwi et al., 2020). Furthermore, Luo et al. (2022) suggest that adding elements desired by individuals to resting environments may result in a generalized healthy environment setting, such as lush greenery, water bodies, and meadows. Spatial arrangement and the type of environment should be considered to improve the restorative quality of urban environments and satisfy the recreational demands of residents on a greater scale (Gao et al., 2019). In the previous research, we found that walking in the campus park and arboretum resulted in lower and decreased heart rate and decreased negative emotion and anxiety status (Pratiwi & Sulistyantara, 2021). However, no study has declared what kind of park elements are needed to improve psychological benefits. This present study was designed to provide such evidence to be considered in guidelines of landscape planning to support an active and healthy academic community. This study examined the correlation between the psychological effects and preferred landscape elements. Our study hypothesized that landscape preferences shown by the captured photographs would correlate with decreased psychological responses of negative moods and state anxiety.

2. Materials and Methods

2.1 Experiment Sites

The experiment was carried out from August to September 2021 in the green space of the Dramaga campus of IPB University, Bogor, Indonesia, with the Academic Event Plaza and Arboretum as the experimental site (Figure 1) and the Jalan Raya Dramaga as the control site (Figure 2). IPB University has been recognized as a Biodiversity Campus since 2011. Among the green spaces at IPB, there was a lake, a forest, an arboretum, and a plantation. In contrast, blue spaces are characterized by lakes and three rivers throughout the campus, contributing to a high diversity of habitats. A green campus must maintain biodiversity to provide a convenient environment for the campus academic community (Satria et al., 2021). Academic Event Plaza (AEP) park is one symbolic place on the IPB University campus. It becomes an axis line that connects Graha Widya Wisuda (graduation hall) and the Rectorate building as generators of axial motion and unifying elements (Simonds and Starke, 2013). AEP serves recreation, education, and socialization place for students, lecturers, and staff, especially during big events such as graduation and student orientation. Arboretum holds documented collections of plants and landscaped gardens. The managing institution creates resources for scientific research, education and outreach programs, public displays, garden specimens and technologies for biodiversity conservation, plant production and services based on plants (Kuzevanov, 2013). The existence of this arboretum on the IPB University campus has a very high role as an absorber of air pollution. The arboretum as a green belt between the densely populated off-campus area and busy transportation routes with the area within the campus is supported by a high level of vegetation diversity and a site condition close to natural. The comfort created by this arboretum not only has a positive effect on the environment but can also increase the productivity of the IPB academic community. The students usually access this arboretum during practicum hours, weekend physical activity, and organizational activity. Therefore, it is necessary to examine user preferences in campus landscape planning and design to improve the health benefits and aesthetic and thermal comfort. The criteria for site selection for the experiment are 1) length of 1 trip of at least 400 m; 2) flat slope; 3) well-managed circulation (Pratiwi et al., 2020; Song et al., 2013, 2014, 2019). The walking distance on the walking courses at AEP, arboretum, and Jalan Raya Dramaga are 815.36 m (round trip), 1.18 km (round trip), and 740.92 m (round trip), respectively.

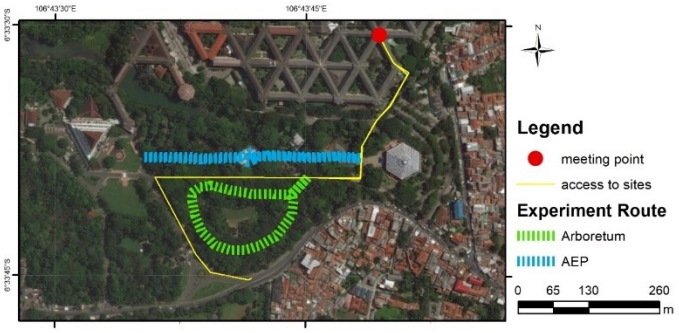

Figure 1. Experimental Route.

Figure 2. Control Route.

2.2 Participants

The subjects were selected through snowball sampling through 10 key informants from various faculties. The participants were recruited in the following steps: 1) posters and Google Forms distribution through social media, Whatsapp; 2) explanation of research procedures and delivery of experiment schedules with Zoom meetings. They have been informed about what activities will be carried out, the types of questionnaires, the incentives they will receive, and the detailed research protocol. This research protocol was inspected by the doctor in charge of the research from the IPB University Polyclinic. The eligibility criteria for experimental participants were: (1) IPB students aged 19-27 years, (2) students living in Bogor and its surroundings, (3) not being treated for cardiovascular disease and hypertension, and (4) in a healthy condition, walk for 20 minutes or more without a problem. The consideration in the selection of participants was IPB University students because they were the primary users of the campus landscape who lived close to campus. It is consistent with the previous study that local communities play a role and participate in structuring the urban landscape (Amen, 2022; Amen & Nia, 2018; Pratiwi et al., 2014, 2020; Pratiwi & Furuya, 2019). A total of 32 student participants lived in the City and

Regency of Bogor. Several previous studies with a sample size of 9-19 participants have demonstrated significant results (Lee et al., 2009, 2015; Ochiai et al., 2015; Park et al., 2009; Pratiwi et al., 2019, 2020; Song et al., 2013, 2014, 2017; Takayama et al., 2017). Thus, 32 subjects were sufficient to produce significant results in the experiment. Eight males and twenty-four females (mean age, 21.5 ± 2.3 years) participated in the park therapy experiment. The experimental procedures follow the regulations of the Research Ethics Commission Involving Human Subjects, IPB University (Number: 456/IT3.KEPMSM-IPB/SK/2021).

2.3 Experimental Design

Thirty-two participants were divided into two groups (park and road) in one day. Each group consists of 2 participants. Each participant is only allowed to participate in the experiment once. Before the experiment, participants were required to conduct a health check by the medical team at the polyclinic. Then the participants brought their health certificates on the day of the experiment. All participants assembled in the meeting room, and then all staff conducted screening by 1) measuring body temperature (no fever at 38 °C and 2) checking general health conditions (no cough, runny nose, or shortness of breath). Then participants filled out and signed the consent form. Participants received explanations and finished questionnaires to evaluate their moods and anxiety state before experimenting. Each participant walked on a predetermined course during the experiment while photographing impressive landscape elements for 15 minutes. The participants later returned to the break room to finish the questionnaires. In this experiment, a washout period of at least 30 minutes was considered sufficient to negate the interventions applied in the previous research (Pratiwi et al., 2019, 2020; Song et al., 2013; Elsadek et al., 2019). During the experiment, the health protocol to prevent the transmission of Covid-19, participants were required to 1) wear a mask, 2) keep a distance, 3) not smoke, 4) not eat, and 5) not drink drinks containing caffeine, during experiments (walking and filling out the questionnaires).

2.4 Research Tool and Materials

Participants were asked to complete the Profile of Mood States (POMS) and the State-Trait Anxiety Inventory (STAI) before and after the experiment. An evaluation of the mood state was conducted using the POMS, which consists of 35 questions covering six subscales: "anger-hostility" (A-H), "confusion-bewilderment" (C-B), "depression-dejection" (D-D), "fatigue-inertia" (F-I), "tension-anxiety" (T-A), and "vigor-activity". (V-A). A Likert scale with five points ranged from 0 (not at all) to 4 (extremely). A total mood disturbance score (TMD) was generated based on the after formulas: A-H + C-B + D-D + F-I + T-A - V-A (Konuma et al., 2015; Lin et al., 2014). An evaluation of the current state of anxiety was conducted using the STAI state-anxiety scale after exposure to greenspace consisting of 20 questions. The scale used was 4 Likert scales starting from 1 (not at all) to 4 (very much so) (Fernández-Blázquez et al., 2015; Julian, 2011).
The Visitor-Employed Photography (VEP) method was utilized to collect photographs at the experimental site. VEP is an effective method that quickly measures on-site and real-time responses (Oku & Fukamachi, 2006). The photographs were taken with an iPhone with GPS (Geographical Positioning System) function and Bluetooth connection provided by researchers. Next, the photographs were sent to the Google Cloud Vision API software to get image annotation keywords (Dutta et al., 2018; Richards et al., 2018; Shi, 2020). Finally, the landscape preferences questionnaire consisted of questions regarding preferred view, landscape elements, and their reasons for each site delivered to the subjects (Hadi et al., 2017, 2018). A landscape preferences questionnaire was used to evaluate the subject's most preferred scenery and landscape elements in each site and describe why they chose those scenery and landscape elements.

2.5 Analysis Methods

The analysis method included correlation analysis between psychological responses and preferred landscape elements, as reported in previous research that physiological and psychological responses were correlated with park therapy imagery (Pratiwi et al., 2020). The data analysis procedure is depicted in Figure 3.

2.5.1 Correlation analysis of preferred landscape elements in the three locations

The first stage is to analyze the consistency of the appearance of landscape elements on the two experimental and one control sites detected with the Google Image API and through a manual questionnaire with correlation analysis. Spearman correlation was employed to analyze the correlation between preferred landscape elements of the experimental location.

2.5.2. Correlation analysis of psychological responses and preferred landscape elements

The following analysis stage is to formulate park therapy components into a healthy and safe campus green space model based on user preferences during a pandemic. Spearman correlation was employed to verify the correlation between psychological responses and preferred landscape elements. The outputs are arranged to explain the criteria for park therapy components that are appropriate and effective in reducing negative moods and anxiety levels. Statistical differences were examined significant at $p < 0.05$ using JASP 0.15 (The University of Amsterdam, Amsterdam, The Netherlands).

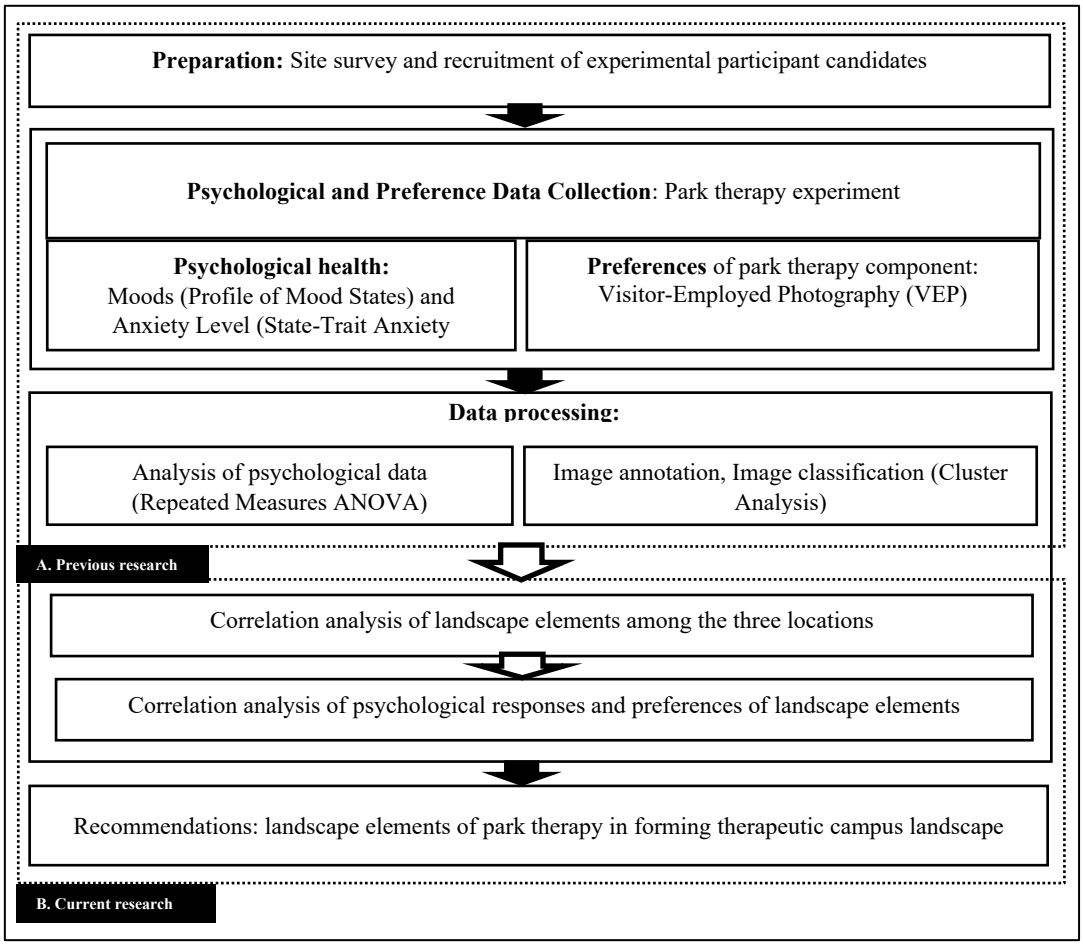

Figure 3. Research Methodology.

3. Results

The practice of park therapy in the park and campus arboretum decreased negative moods and anxiety. A significant reduction was detected in 4 negative moods including "confusion-bewilderment", "depression-dejection", "fatigue-inertia", and "tension-anxiety". Location factors, especially the arboretum and time (before and after walking), significantly reduce depression and tension. While an anxiety reduction was found after walking in the arboretum, followed by Academic Event Plaza and Jalan Raya Dramaga.

Data on experimental subjects' preference for park therapy components were gained by gathering 837 photographs. The most photographs were taken in the AEP with 380 photographs, followed by the arboretum with 347 photographs, and Jalan Raya Dramaga with 110 photographs. The Google Vision API identified 68-word terms. The top five labels for AEP were Plant (335), Sky (181), Tree (151), Natural Landscape (67) and Cloud (58). The top five labels for the Arboretum were Plant (330), Sky (171), Tree (121), Natural Landscape (54), and Flower (52), whereas the top five labels for Jalan Raya Dramaga were Plant (206), Sky (47), Flower (27), Cloud (21), and Road Surface (4) (Pratiwi & Sulistyantara, 2021). The examples of photographs taken by the subjects are presented in Figure 4. Based on the number of photographs captured at each location, experimental participants stated that AEP and arboretum had more preferred landscape elements than Jalan Raya Dramaga.

Figure 4. Geo-tagged Photographs. (a) Academic Event Plaza; (b) Arboretum; (c) Jalan Raya Dramaga.

3.1 Correlation of landscape elements from images detected by Google API

The correlation analysis of landscape elements detected automatically through the Google Vision API showed a significant correlation from each location. It exhibited that the subjects have the same consistency of preferences for landscape elements even though they moved to other locations. The two highest labels detected by the three locations were Plant and Sky. The analysis showed a high correlation between the landscape elements in the AEP and the arboretum (r = 0.971). Information can be seen in Table 1.

Table 1. Landscape Elements Correlation Analysis collected by Google Vision API.

Location	Pearson r	Spearman rho	Kendal tau B
AEP-Arboretum	0.998***	0.971***	0.953***
AEP-Jalan Raya	0.883***	0.486***	0.428***
Arboretum-Jalan Raya	0.907***	0.511***	0.452***

* $p < 0.05$, *** $p < 0.01$, *** $p < 0.001$

3.2. Correlation of landscape elements from questionnaire data

Preference data was also collected manually by filling out questionnaires by the subjects. The results showed 21 attractive landscape elements according to the subjects. The most chosen landscape elements by the subjects were "trees" (89), "roads" (47), "paving blocks" (40), "flowers" (38), and "bushes" (37). The correlation analysis of landscape elements collected manually by questionnaire showed that only the arboretum had a significant correlation with AEP (r = 0.674) and Jalan Raya Dramaga (r = 0.608). At the same time, there was no significant correlation between the elements selected in AEP and Jalan Raya Dramaga (Table 2). It exhibited that the preference of landscape elements based on the questionnaire does not show consistency among all locations. Based on the correlation analysis of the two data sources, it can be stated that the landscape elements determined automatically from the photograph analysis of the VEP method using the Google Vision API had a better preference consistency. Therefore, the formulation of park therapy components will use a list of landscape elements from photograph analysis.

Table 2. Landscape Elements Correlation Analysis from Questionnaire Data.

Location	Pearson r	Spearman rho	Kendal tau B
AEP-Arboretum	0.829***	0.674***	0.551***
AEP-Jalan Raya Dramaga	0.668***	0.349	0.254
Arboretum-Jalan Raya Dramaga	0.849***	0.608***	0.515***

* $p < 0.05$, *** $p < 0.01$, *** $p < 0.001$

3.3. Correlation of Psychological Responses and Landscape Elements

The results of the correlation analysis show that there is a correlation between psychological responses and park therapy components. Psychological response to anxiety status (STAI) has a significant correlation with three landscape elements, namely "plant community" (r = -1), "plant" (r = -0.999), "flower" (r = -0.999), and "sky" (r = -0.997). The correlation

between anxiety status and the three elements of the landscape shows a negative correlation (Table 3). The negative correlation showed that the addition of the elements "plant community", "plant", "flower", and "sky" could reduce anxiety status after walking. Figure 5 shows a heat map of the correlation of anxiety status with the three landscape elements. In addition, Total Mood Disturbance negatively correlates with one landscape element, "plant community" (*r* = -0.999). The negative correlation between the two showed that adding "plant community" elements can reduce mood disturbances after walking (Table 4 and Figure 6).

Table 3. Correlation Analysis between STAI and Landscape Elements.

Variable		Plant	Flower	Sky	Plant community	STAI 2
1. Plant	Pearson's r	—				
	p-value	—				
	Spearman's rho	—				
	p-value	—				
1. Flower	Pearson's r	1.000*	—			
	p-value	< .001*	—			
	Spearman's rho	1.000*	—			
	p-value	0.333	—			
2. Sky	Pearson's r	0.999	0.999*	—		
	p-value	0.021	0.021	—		
	Spearman's rho	1.000*	1.000	—		
	p-value	0.333	0.333	—		
3. Plant community	Pearson's r	0.999*	0.999*	0.998*	—	
	p-value	0.022	0.022	0.043	—	
	Spearman's rho	0.866	0.866	0.866	—	
	p-value	0.333	0.333	0.333	—	
4. Natural Landscape	Pearson's r	0.988	0.988	0.993	0.983	
	p-value	0.097	0.097	0.076	0.119	
	Spearman's rho	1.000	1.000	1.000	0.866	
	p-value	0.333	0.333	0.333	0.333	
5. STAI 2	Pearson's r	-0.999*	-0.999*	-0.997*	-1.000*	—
	p-value	0.027	0.048	0.048	0.005	—
	Spearman's rho	-0.500	-0.500	-0.500	-0.866	—
	p-value	1.000*	1.000	1.000	0.333	—

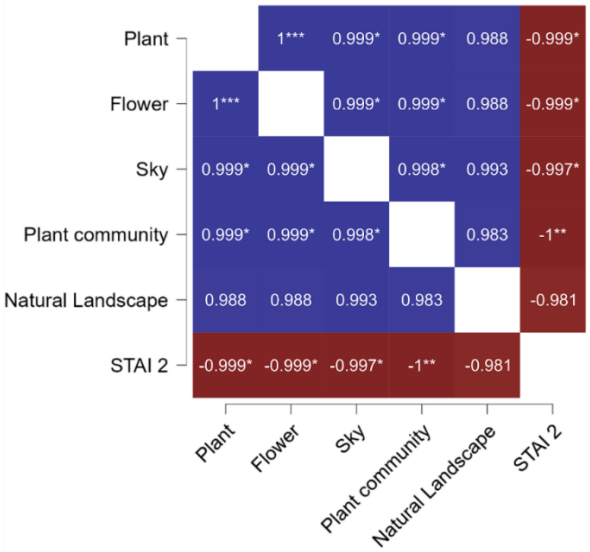

Figure 5. Heat map of correlation between anxiety status and landscape elements of park therapy.

Table 4. Correlation Analysis of POMS and Landscape Elements.

Variable		Plant community	TMD 2	TMD 1
1. Plant community	Pearson's r	—		
	p-value	—		
	Spearman's rho	—		
	p-value	—		
2. TMD 2	Pearson's r	-0.999*	—	
	p-value	0.035	—	
	Spearman's rho	-0.866	—	
	p-value	0.333	—	
3. TMD 1	Pearson's r	-0.286	0.338	—
	p-value	0.815	0.780	—
	Spearman's rho	0.000	0.500	—
	p-value	1.000	1.000	—

* $p < .05$, ** $p < .01$, *** $p < .001$

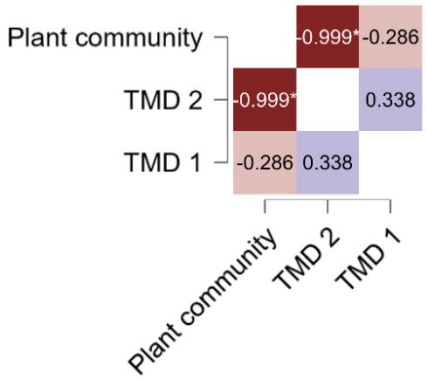

Figure 6. Heat Map Correlation of Total Mood Disturbance and Landscape Elements of Park Therapy.

4. Discussions

The environment becomes the main stimulus that can give the effect of wanting to move and have an activity (refuge and prospect) or move away (escape). Green space is an inseparable part of an academic landscape where students can interact, learn, observe, and research. A campus landscape with vista, spaces and appropriate design can form students' good behaviour and nature awareness of the surrounding landscape, grow a sense of pride in their university and lead to their satisfaction and academic motivation (Ghorbanzadeh, 2019). The previous studies showed that the type of natural green space could affect the psychological response of students. The type of landscape affects the decrease in psychological responses, especially negative moods such as "depression-dejection" and "tension-anxiety" detected in the arboretum. It was in line with Gatersleben & Andrews (2013) that an arboretum might have a high prospect (clear vision) and a low refuge (place to hide) so that it becomes a restorative natural green space. Walking in the campus park and arboretum affected decreased almost all negative moods, including "confusion-bewilderment", "depression-dejection", "tension-anxiety", and "fatigue-inertia" as well as anxiety status. The previous studies also exhibited significant differences in moods and state anxiety after walking in urban parks (Lyu et al., 2019; Song et al., 2013, 2014, 2015, 2019). Furthermore, parks have positive psychological effects by offering recreational aims for users with mental disorders (Tok et al., 2020).

4.1 Consistency of landscape elements correlation among the three locations

Based on the correlation analysis, it was discovered that the preference for landscape elements was consistent in the three locations. The two highest labels detected by the three locations were “plant” and “sky”. It shows that the openness of views to the sky (high prospect) and the plants along the walking course were mostly chosen by young adults. Gatersleben & Andrews (2013) proved that natural landscapes with high prospects and low refuge created restorative places. Moreover, the AEP with an

artificial landscape (plaza) and its feature also provide high prospects and low refuge, which establishes potential benefits of psychological restoration (Subiza-pérez et al., 2020). Plant and the sky are natural landscape elements providing pleasurable experiences through the human senses and significantly affect tension, confusion, and depression (Wang et al., 2019). Plant strongly influences human perceptions, preferences, and physiological and psychological effects because the organs of plants, from the roots to the flowers, can produce and release BVOCs that humans can perceive via their five senses (Loreto et al., 2014). Thus, practising forest bathing in space with high prospects and low refuge by integrating stimulation of the five senses in the natural landscape leads to beneficial psychological and physiological effects (Antonelli et al., 2020).

4.2 Restorative Park Therapy Components

The therapeutic landscape element cannot be seen in landscape photographs while walking on the courses. The correlation between image labels and the psychological effects after walking was explored further. It was found that anxiety levels were negatively related to landscape elements. The only landscape element, plant community, was negatively correlated with Total Mood Disturbance. While, plant community, plant, flower, and sky were correlated with a state of anxiety. The more these elements were detected by Google API, the lower the mood disturbance and state of anxiety. Campus green space was considered among the most preferred feature by students, showing the significance of creating alternative campus habitats for students (Bostancı & Akdağ, 2020). Greenery and flowers, as natural stimuli, become prominent seasonal landscape elements that correlate with physiological and psychological responses, such as a reduction in diastolic blood pressure and an increase in vigor after walking in urban parks (Pratiwi et al., 2020). This study proved a correlation between landscape preference in different sites. Moreover, park therapy components, including plant, flower, and sky, were negatively correlated with negative moods and anxiety levels. Thus, the hypothesis of this research (namely, that preferred landscape elements would correlate with decreased psychological responses of negative moods and state anxiety) was supported.

5. Conclusions

The prevalence of mental health problems has doubled among young adults due to the COVID-19 pandemic. Many studies have proved physiological and psychological of taking the atmosphere in a forest landscape, namely Shinrin-yoku. Still, they lack study regarding the relation between landscape preference and the psychological effects of Shinrin-yoku. The eminence of image annotation using Google API is effective and has potential in formulating park therapy components. Park therapy components, including plant, flower, and sky, were negatively correlated with negative moods and anxiety levels. The campus green space with high visibility to the sky view, proper planting design, and fascinating landscape elements can potentially overcome psychological disturbances for the academic community. Therefore, managing tree canopy management regularly, proposing a compact and mass planting design, and selecting flowering landscape plants are needed to get optimal psychological relaxation results.

Future research should seek to discover therapeutic campus greenspace design criteria based on academic community preference. Physical, social, symbolic, and experienced spaces in the campus landscape must be integrated into campus greenspace planning to encourage thorough health restoration in the academic campus landscape.

Funding

The research was funded by Community Fund, Research and Community Service IPB University under the Rector's Decree of 2022 Number: 68/IT3/PN/2021 dated May 31 2021.

Conflicts of interest

The Author(s) declares(s) that there is no conflict of interest.

Data availability statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author/s.

Ethics statements

No potentially identifiable human images or data are presented in this study.

CRediT author statement

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Funding acquisition: P.I.P., B.S. Investigation: P.I.P., S.S. Methodology: P.I.P. Project administration: P.I.P., B.S., S.S., S.N.L. Writing—original draft: P.I.P., S.S., S.N.L. Writing—review and editing: P.I.P., B.S., S.S., S.N.L. All authors have read and agreed to the published version of the manuscript.

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How to cite this article:
Pratiwi, P. I., Sulistyantara, B., Sisriany, S., & Lazuardi, S. N. (2022). The Psychological Effects of Park Therapy Components on Campus Landscape Preferences. *Journal of Contemporary Urban Affairs*, *6*(2), 143-155. https://doi.org/10.25034/ijcua.2022.v6n2-3

Journal of Contemporary Urban Affairs

2022, Volume 6, Number 2, pages 159–173

Original scientific paper

Influence of Green Infrastructure on Residents' Endorsement of the New Ecological Paradigm in Lagos, Nigeria

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ARTICLE INFO:

Article History:
Received: 24 February 2022
Revised: 15 June 2022
Accepted: 29 June 2022
Available online: 6 August 2022

Keywords:
Environmental attitudes;
Green infrastructure;
Residents' endorsement
New ecological paradigm;
Lagos metropolis;
Pro-environmental behaviour.

ABSTRACT

Given the significance of green infrastructure in enhancing social, economic and ecological sustainability of the built environment, it is important to unearth how green infrastructure can influence pro-environmental behaviours among the urban population. This research assessed the influence of green infrastructure on residents' endorsement of the New Ecological Paradigm (NEP) in Lagos Metropolis, Nigeria. A total of 1560 residents recruited through the multi-stage sampling technique participated in the survey, and the data gathered were subjected to descriptive and regression analyses. The participants generally felt that the available green infrastructure in their neighbourhoods was of low quality and rapidly disappearing, but it positively influenced all the key variables of the NEP and its endorsement. The size of neighbourhood green spaces, availability of green spaces for relaxation and its proximity to the people were found to be the three attributes of green infrastructure with the most noticeable influence on residents' endorsement of NEP. This study implies that the availability and accessibility of a reasonable quantity of green areas within urban neighbourhoods can enhance a better understanding of the role of green infrastructure and promote favourable environmental behaviours among the urban population within and outside Nigeria.

JOURNAL OF CONTEMPORARY URBAN AFFAIRS (2022), ***6***(2), 159-173.
https://doi.org/10.25034/ijcua.2022.v6n2-4

www.ijcua.com

1. Introduction

With the alarming rate of environmental challenges, it is important to intensify efforts that can promote a better understanding of the environment and engender positive ecological behaviours among the urban population across

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How to cite this article:
Dipeolu, A. A., Ibem, E. O., & Oriola, O. A. (2022). Influence of Green Infrastructure on Residents' Endorsement of the New Ecological Paradigm in Lagos, Nigeria. *Journal of Contemporary Urban Affairs, 6*(2), 159-173. https://doi.org/10.25034/ijcua.2022.v6n2-4

the globe. One major area of research in the built environment that can promote local and global ecological sustainability is the exploration of different strategies for deepening understanding of the environment as the basis for human existence. Researchers generally agree that such strategies must be geared towards an understanding of people's feelings and attitudes toward environmental issues (Kovács et al., 2014; Steg et al., 2014). Empirical studies have confirmed a strong relationship between attitudes and ecological behaviours as evidenced in the various environmental attitudes (EA) scales developed over the years. Moreover, research on the environment is gaining momentum, especially arising from the need to develop strategies to mitigate human-induced environmental problems. Several studies have argued that many of these problems are products of human behavioural tendencies (Giusti & Samuelsson, 2020; Ogunbode, 2013; Santiago et al., 2015; Steg & Vlek, 2009; Zuniga-Teran et al., 2019). Thus, studies that help to improve understanding of people's way of life, organization and their use and disposition toward their environment are necessary for identifying strategies for encouraging environmental attitudes that can promote a quality and sustainable environment in the population (Erdogan, 2009; Steg et al., 2014; Vlek & Steg, 2007).

However, in the quest to develop a positive attitude among urban dwellers it is also imperative to explore the influence of green infrastructure in residential neighbourhoods, which is the simplest form of nature, on residents' understanding of several concepts used in the assessment of how humans relate with the natural ecological system. The green infrastructure consists of natural and semi-natural spaces like parks, gardens, green roofs, sports fields, streams, fountains, river banks, horticulture, community gardens, street trees, school yards and others (Dipeolu & Ibem, 2020; Jiang et al., 2018; Yu et al., 2019; Zijlema et al., 2020). The potential benefits of green infrastructure range from improving individuals' health and well-being (Maes et al., 2015), strengthening social cohesion within the community (Kim et al., 2013), and providing environmental services like reducing urban heat islands, carbon sequestration, flood control, create a micro-climate and reconnecting fragmented natural environment (Ignatieva et al., 2010; Naumann et al., 2011; Venter et al., 2020).

In suggesting solutions to environmental challenges, different assessment parameters, scales and paradigms for assessing peoples' concern and care for the environment have been put forward and empirically tested in different studies. Some of these include but not limited to a- the Maloney-Ward ecology inventory scale that measures knowledge, emotion and verbal and/or practical commitment; b-new environmental paradigm(NEP) scale that measures the extent to which people endorse the then-emerging worldview; (Dunlap & Van Liere, 1978) c- the ecological and human-centred scales for assessing the motivations of individuals to protect the natural environment because of its intrinsic values (Thompson et al., 1994) ; Thompson and Barton (1994) ; d- motivation toward the environment scale for measuring individuals rationale for engaging in environmentally-friendly behaviours (Pelletier et al., 1998); e- the scale that measures the level of connectedness and emotional feeling attached to natural environment (Mayer & Frantz, 2004) the integration-opposition scale used to measure the appreciation of human-nature interactions (Carrus et al., 2004) and f: the human-centred scales designed by Thompson et al. (1994) to assess individual value of nature-based on the materials or physical benefits it offers to man. Of specific interest to this study is environmental attitude measurement derived from the revised new ecological paradigm (NEP) scale by Dunlap et al. (2000), which among other things measures the magnitude of the approval human beings give to the ability of man to effectively manage the environment, the extent of industrial development within the environment's carrying capacity, and the need to preserve and care for the environment. Although this scale has been used globally to assess environmental attitude in the literature as noted by previous authors (Dunlap, 2010; Hawcroft & Milfont, 2010), the extent to which the availability of green infrastructure in residential neighbourhoods could affect residents' endorsement of the NEP scale is still grossly under-researched, especially in neighbourhoods in most Africa nations. This is probably because the existing literature seems to concentrate more on discovering the psychometric properties of the scale of measurement of the NEP without assessing its

relationship with green infrastructure, especially in emphasising the variables common to developing nations.

Given this, it has become imperative for urban planners and managers to widen their search for specific strategies that can promote positive environmental attitudes by taking advantage of the green infrastructure facilities within the built environment. Thus, the need for this research in selected residential neighbourhoods in the Lagos metropolitan area of southwest Nigeria. This study specifically attempted to provide answers to three key research questions:

i.What are the perceptions of residents on the general characteristics of green infrastructure in Lagos Metropolis?

ii. To what extent has the availability of green infrastructure influenced the endorsement of the revised NEP scale by dwellers in Lagos Metropolis?

iii. Which characteristics of green infrastructure mostly influence the endorsement of the NEP by residents in the Lagos metropolitan area, Nigeria?

The research created a novelty in its potential to deepen our understanding of the capacity of green infrastructure in shaping the environmental attitude of the public in the area of study. In addition, by revealing the attributes of green infrastructure which mostly influence the endorsement of the NEP scale among the urban population in Lagos, the study findings are expected to inform urban planners and policymakers on the characteristics of green infrastructure that should be given priority attention in aiding urban residents to imbibe pro-environmental behaviours, which are vital in achieving sustainable urban environments in Nigeria and beyond.

2. Review of related literature

2.1 Urban Green Infrastructure

Several definitions and conceptions of green infrastructure are available in both research and policy literature. Many of these definitions and conceptions are based on professional and disciplinary perspectives. For example, whereas some authors viewed grasses, flowers and trees in the cities as green infrastructure because of their visual green components, others have referred to green infrastructure as specially designed structures such as water treatment facilities or allocated recreational spaces or buildings that are designed to be environmentally friendly. It has also been observed that people sometimes confuse the term "infrastructure," and think of it as grey infrastructures like road kerbs and signposts, or infrastructural facilities like health centres, shopping malls, train stations or hotels (Bao, 2010). Facilities in this category are called built infrastructure and are distinct from green infrastructure (Beauchamp & Adamowski, 2013). Further, Mell (2010) observed that the definitions of green infrastructure adopted by authors reflect their area of interest in green infrastructure research. For instance, recreational and landscape specialists usually focus on the benefits derived from contact with nature (Dipeolu et al., 2021; Frumkin et al., 2017; Jiang et al., 2018), and urban planners and managers are mostly attracted to the policy implementation aspect (Alaimo et al., 2016; Austin, 2014), while conservationists and ecological specialists tend to articulate the ecological and biodiversity components of green infrastructure (Benedict et al., 2012; Naumann et al., 2011). Although the definitions and components of urban green infrastructure may vary, green infrastructure is described as natural or semi-natural urban environments having a reasonable quantity of green spaces (Dipeolu et al., 2021; Wolch et al., 2014; Zhang et al., 2017).

Green infrastructure provides vital ecological services to the built environment, enhancing the functionality of the micro-climates and strengthening the quality of life of urban residents. Urban green infrastructure provides facilities and spaces for relaxation, socialisation and emotional connectivity to nature for individuals and families. Previous studies have argued that the most significant contribution of green infrastructure is the psychological well-being of individuals (Maes et al., 2015; Venter et al., 2020; Zhang et al., 2017). Other benefits associated with urban it includes an increase in worker productivity, reduction of stress and increase in motivation to undertake new challenges (Kim & Song, 2019; Zuniga-Teran et al., 2019). Additionally, green spaces have been linked to fostering social interactions, reducing the crime rate, and enhancing the social cohesion within the community (Arnberger & Eder, 2012; Cooper et al., 2014; Dipeolu et al., 2021; Santiago et al., 2015), reducing energy costs (Gómez-Muñoz et al., 2010), regulating ambient air temperatures, providing the

opportunity for carbon sequestration and improving water and air quality (Barthel et al., 2013; Brantley et al., 2014). These benefits might help to explain why the importance of green infrastructure in the contemporary urban development and sustainability discourse cannot be over-emphasized.

2.2 *The New Ecological Paradigm (NEP)*

The idea of a new ecological paradigm (NEP) scale, originally known and described as the "*new environmental paradigm*," was initially conceived by Dunlap and Van Liere in 1978 to evaluate the relationship between humans and nature, specifically on the belief that activities in the modern world were altering the ecological balance, the existing growth limit, and intensifying the human-centred attitude toward nature (Chaves, 2012; Dunlap, 2010). In general, NEP is hinged on the understanding that human relationships with nature should be handled with more care now than ever before. Therefore, individuals adapting the NEP philosophy see grave danger in the present condition of the earth; and thus, canvass the need to rethink how humans relate to the natural environment and curtail human activities within the carrying capacity of the ecological environment (Amburgey & Thoman, 2011). Approving these basic tenets of the NEP by an individual is a measure of the extent of concern about the environment in such an individual (Chaves, 2012; Erdogan, 2009). Therefore, the NEP scale has been seen as the most widely used among other several measures of environmental attitude among the public (Schultz et al., 2004).

The scale derived from the revised NEP has been adopted by different authors and researchers from various cultural backgrounds (Lee & Paik, 2011; Milfont & Duckitt, 2010). For example, in a study to measure environmental attitude among middle-income household heads in Cebu city of Philipines, it was discovered that respondents agreed that there were dangerous outcomes from the severe abuses the environment was being subjected to, and their NEP ratings indicated poor concern for the environment(Chaves, 2012). In another study in Arad, Romania, and Faro in Portugal, that sought to uncover the level of approval of the NEP by the residents using their demographic characteristics and the NEP scale, it was reported that people partially endorsed the NEP and that this was influenced by opportunities technology offers and the belief in the existence of unlimited resources. Also, in a related study to explore the degree to which 1295 undergraduates in four universities in Turkey were endorsing the NEP, Erdogan (2009) reported that about 56% of the respondents held pro-NEP views, while around 24.9% embraced the dominant social paradigm (DSP) views and 19.1% indicated ambivalent views. In a like manner, previous studies targeted at interest groups such as environmental organisations and other pro-environmental groups consistently found that environmentalists and other pro-environmental groups obtained better scores on the NEP compared to the laymen or the non-environmentalists (Dipeolu, 2017; Wiidegren, 1998)

Although, Dunlap et al. (2000) argued that some items in the NEP scale are an obsolete set of beliefs that indicate human perceptions of nature and the environment, several authors (Amburgey & Thoman, 2011; Hawcroft & Milfont, 2010; Kovács et al., 2014) also believe that the NEP consists a logical pattern of beliefs toward the environment and represents a criterion that predicts human behaviours. Howbeit Dunlap and Van Liere (1978) have noted that the NEP scale has established research validity among different groups, Thompson et al. (1994) insist that the findings of studies relating to perceptions of the NEP scale were the outcome of individual experiences, especially in natural environments. Nonetheless, despite the challenges of determining the behaviours and attitudes of humans as it relates to the natural environment, research has shown a strong link between the items in the NEP and some aspects of human behaviours, including self-reported and observed behaviours (Kovács et al., 2014; Milfont & Duckitt, 2010). Despite these, it is still not clear how these behaviours relate to the existence of green spaces in the built environment and how the quantity and quality of green infrastructure around residential environments can influence residents' endorsement of the environmental attitude measurement under the NEP scale. These are the key issues the current study sought to address using survey data derived from residents of the rapidly growing city of Lagos, southwest Nigeria.

3. Research methods

3.1 Data and Sample

The study area for this research was four randomly sampled Local Government Areas (LGAs) in Lagos metropolitan area, namely; Surulere, Lagos Island, Kosofe and Ikeja, all of which make up one-quarter of the sixteen administration areas in the Lagos metropolitan area of the Lagos State southwest Nigeria (see Figure 1).

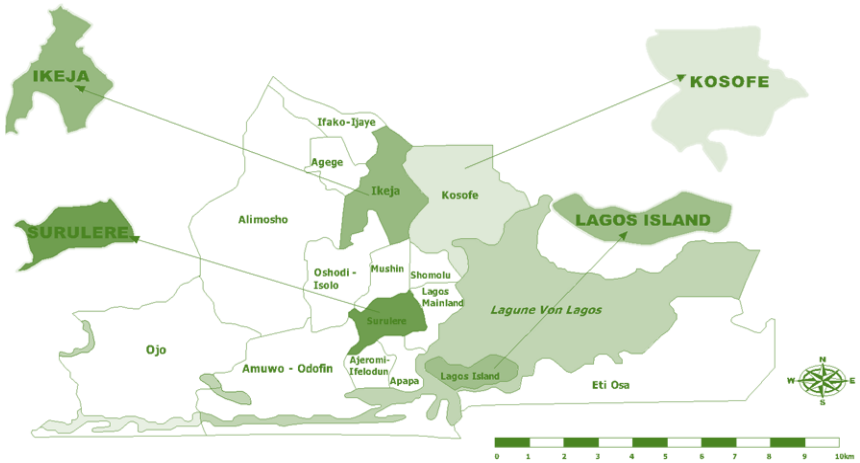

Figure 1. Map of Lagos Metropolis indicating selected Local Government Areas
Source: Lagos State Secretariat, Ikeja Lagos.

Although the research population comprised all residents in the earmarked communities, the high rate of population growth made it difficult to rely on the last population census figure of 2006 for an accurate determination of the population of residents in the Lagos metropolitan area. Consequent to this, the sample size (n) for this study was derived from the formula put forward by Turner (2003) and represented in the following equation.

$$n = \frac{(Z_\alpha)^2 r(1-r) fk}{phe^2}$$ ----------Equation 1

Where n represent the expected number of participants, *p* is part of the overall population representing the target population to factor parameter, *r*, and calculated as 0.03x18 =0.54. As explained by Turner (2003), 0.03 was recommended for each year of age included in the expected population and *h*= household size, which is 6 persons in developing nations) and *e* =0.05 for the allowed error margin set at 5% of *r*. In addition, Z_α=1.96, which stands for the critical value of normal distribution provided in the Standard Normal Distribution Table at a confidence level of 95%, *f* =4 is the design effect, $r = 50\%$, which is an estimate of part of the number of the expected respondents in the research and *k*=20% and represents the margin added to the sample size to take care of non-response rate. Using equation 1, the sample size was calculated by substituting the foregoing values and these parameters as shown in equation 2

$$n = \frac{(1.96^2 \times 0.5 \times 0.5 \times 4 \times 0.2)}{[0.54 \times 6 \times (0.05 \times 0.5)^2]} = 379.4 \approx 380$$ --

------Equation 2

The result obtained was 380 participants as the smallest number of informants to be selected from each of the four LGAs. This gives 1,520 overall minimum participants.

3.2 Measures

A semi-structured questionnaire specifically developed for this study with contents from existing literature was used to generate the required data. Contents of the questionnaire were arranged in three different sections: Sections I, II and III. Section I had questions on the socio-demographic profile of the survey participants, Section II contained information on the participants' understanding or interpretation of the quantity and quality of green infrastructure in their neighbourhoods, while Section III contained 15 items of the NEP scale. In collecting data in section II, the residential quality indicators as perceived by the residents (PRQI) scale previously invented by Bonaiuto et al. (2006) was adopted. Each participant in the survey is required to show the level of agreement or disagreement with

carefully structured statements on green infrastructure quality within a 5-point Likert type scale that ranges from '1' (Strongly Disagree) to '5' (Strongly Agree). The mean score for each statement was interpreted based on the framework previously proposed in the work of Akpa and Bamgboye (2015), which recommended that a mean score < 3.0 should be described as poor quality, mean score = 3.0 for average quality and mean score >3.0 for good quality was adopted.

Similarly, section III of the questionnaire was used to generate information on the respondent's perception of how the quality of green infrastructure in their neighbourhoods had influenced their endorsement of the NEP scale. The revised NEP scale investigated has 15 items, and these items are related to the notion that "humans have the right to modify the natural environment to suit their needs" or "the balance of nature is very delicate and easily upset". Participants were also expected to indicate the extent to which they agree or disagree with the selected statements on a 7-point Likert type scale ranging from '1' (Strongly Disagree) to '7' (Strongly Agree). However, this rating was done bearing in mind the key advantages of urban green infrastructure in shaping the man-nature interaction; thus, helping the respondents to indicate the extent to which the availability of urban green infrastructure can contribute to the environment and also determine if these were strong enough to elicit strong or weak endorsement of the statements. Notably, seven of the 15 NEP statements, including 6th, 7th, 8th, 11th, 13th - 15th stated in negative form (disagreement), and thus scored in reverse order. The remaining eight NEP statements: 1st - 5th,9th, 10th, and 12th items were stated in positive form(agreement). Notably, both the disagreement and agreement statements help to assess the respondents' concern for the ecological environment as previous authors had indicated (Dunlap, 2010; Kovács et al., 2014).

To enhance the validity of the study findings, the initial questionnaire was moderated by experienced researchers and pre-tested in Ojo Local Government Area in Lagos metropolitan area. Results from the pre-test assisted in adjusting the questionnaire for the main survey. Furthermore, the Cronbach's Alpha reliability test was conducted on the data to understand the reliability of the scale of measurement for the present study. The results yielded a value of 0.79 and 0.71 for the 15 and 10 items of NEP and the PQGI scale, respectively. These results are more than the 0.6 acceptance level Pallant (2020) and thus, the instruments were considered reliable in measuring the PQGI and endorsement of the NEP scale in this survey.

3.3 Data collection and analysis

As part of the initial preparation for the survey, the archive of the National Population Commission (NPC) office in Lagos State was visited to secure data on Enumeration Areas from where seventeen Enumeration Areas were identified in the selected four LGAs involved in this study. To select participants for the study, sampling intervals (n) were calculated for each EA by dividing the total of dwelling units by the estimated sample size proportionately allocated to each of the enumeration areas. Consequently, households were selected systematically using a list of numbered houses in the neighbourhoods. The first participants were randomly sampled in each EA, while the rest were selected in the order established by the sampling interval (n). Each household head or their representative was requested to complete a questionnaire in every dwelling unit selected. The fieldwork was carried out between April and May 2019 by the authors and trained field workers using 1600 copies of the questionnaire. At the end of the survey, 1560 (97.5%) copies were correctly filled and returned by the respondents

In line with the research questions stated in the introductory section of this paper, the data generated from the fieldwork were analysed using two main types of statistical tools. The first was descriptive analysis involving the use of descriptive statistics such as frequency and percentage distributions to describe the socio-demographics of the participants in the survey. The measure of central tendency (mean) and variation (standard deviation) were specifically employed in the analysis to see how participants perceived the green infrastructure quality (PGIQ) using the ten quality indicators and the overall rating of the green infrastructure quality collectively provided by all the 1560 participants in the survey. The second was the variant of multiple regression analysis is known as

Categorical Regression (CATREG) analysis, which meant to explore how the perceived quality of green infrastructure in the residential neighbourhoods influenced the participants' endorsement of the NEP. In the regression analysis, the NEP mean value serves as the dependent variable, while the mean values for each of the ten statements describing green infrastructure quality as perceived by the respondents were the independent variables. This specific analysis helped in the identification of the variance R2 accounted for, uncovering and comparing the contributions of the various green infrastructure characteristics in explaining the participants' endorsement of NEP in this research. The CATREG analysis was adopted in this research because the dataset is mainly ordinal as Shrestha (2009) had suggested that this variant of multiple regression was most suited for an ordinal dataset.

4. Results

4.1 Participants' description of attributes of green infrastructure

Results of the socio-demographics of those residents that took part in the survey reveal that a majority (58.6%) of them are married male household heads of over 29 years having a household size of between 2 persons and 4 persons (Table 1). The results also show that around 70.6 per cent and 87.4 per cent of the respondents are of Yoruba ethnic origin and attained at least a post-primary education and that about 73.2 per cent of them were employed (Table 1). These results generally show that the respondents are indeed literate, which is typical of the Lagos urban population; and thus, they are considered qualified to provide valid responses to the questions on the questionnaire.

Table 1. Demographics of the participants.

Variables	Frequency	Percentage (%)
Sex		
Female	646	41.4
Male	914	58.6
Age Groupings in years		
Less than 30 years	587	37.6
Between 30 years and 49 years	752	48.2
50 years and above	189	12.1
No Response	32	2.1
Marital Status		
Never been marriage relationship	592	37.9
Currently in a marriage relationship	896	57.4
No longer married	62	4.0
No Response	10	0.6
Number of persons in the household		
1	166	10.6
2-4	731	46.9
4 +	654	41.9
No Response	9	0.6
Ethnic origin		
Yoruba	1102	70.6
Others	457	29.3
No Response	1	0.1
Highest level of educational attainment		
No formal education	89	5.7
Primary education	108	6.9
Post primary education	395	25.3
Post-secondary education	968	62.1
Employment status		
Not employed	417	26.7
Self employed	704	45.1
Private/public sector employee	439	28.1

The results (from Table 2) of the participants' understanding and interpretation of the features of green infrastructure in the Lagos metropolis reveal the range for the mean scores to be 2.05±1.11 to 3.57±1.26. The respondents further asserted that there is a minimum of one

garden or park for residents' inter-personal relationships and that green areas were comparatively small in quantity and not enough and were fast disappearing in their neighbourhoods. In addition, the residents strongly disagreed with the following a) there was a dearth of parks where young people can freely play; b) the majority of green spaces in their estates are in proximity to the people; c) the green areas within their neighbourhoods have adequate equipment; d) residents in this neighbourhood usually visit more parks located outside the neighbourhoods in the city, and e) that their neighbourhoods have green areas that are in good condition. Their levels of agreement/disagreement are reflected in the mean score for each of the 10 items as presented in Table 2.

Table 2. Residents' rating of the features of Green Infrastructure.

Specific Features	Mean	S.D
Green areas are in small quantity in our neighbourhood	3.57	1.26
We are confronted with the fast depletion of green spaces in this neighbourhood	3.47	1.28
We have in this neighbourhood minimum of one garden or park for residents' interaction	3.28	1.27
We do not lack green areas for recreational activities in our neighbourhood	3.10	1.33
There are no parks in our neighbourhood where young people freely can play	2.82	1.40
People stay close to a majority of green areas in this neighbourhood	2.68	1.26
Green spaces in our neighbourhood are adequately equipped	2.54	1.27
Residents in this neighbourhood usually visit more parks located outside the neighbourhoods in the city	2.53	1.29
Green spaces in this neighbourhood are in good condition	2.46	1.24
The green spaces in this neighbourhood are adequate	2.05	1.11

4.2 Endorsement of the NEP by residents in the survey

NEP scale in the study area, the mean scores for the influence of GI quality on their endorsement of the NEP ranged from 4.12±1.93 to 5.62±1.45 (Table 3). A cursory look at the result reveals that the participants felt that green infrastructure had a positive influence on their endorsement of the 15 aspects of the NEP statements investigated in this study. This was informed by the mean score above 3.5 for each of the 15 variables related to NEP statements investigated (see Table 3).

Table 3. Respondents' rating of influence of green infrastructure in endorsement of the NEP.

Green Infrastructure versus New Ecological Paradigm	Mean Score	S.D
Helps to sustain and develop the earth 's natural resources	5.62	1.45
Ensures that human beings are not seriously abusing the environment	5.47	2.35
The availability of green infrastructure can help to avert ecological catastrophe	5.44	1.50
Assists people understand activities of nature and putting such activities under control	5.42	1.46
People can take advantage of green infrastructure to subdue nature	5.37	1.55
Helps to create habitats for plants and animals	5.35	1.51
Helps to balance the delicate nature of the earth	5.28	1.57
Enhances human special abilities to cope well with the laws of nature	5.25	1.56
Helps to modify the natural environment to meet human demands	5.16	1.69
Helps to balance nature and the impacts of modern industries.	5.13	1.51
Human destruction of green infrastructure often led to disastrous consequences	5.11	1.72
Human ingenuity without green infrastructure will make the earth unliveable	5.09	2.02
Green infrastructure helps to maintain the earth with its limited spaces	4.84	1.84
Enhances expansion of the earth's human carrying capacity	4.71	1.88
Helps to resolve the ecological crisis facing humankind	4.12	1.93

4.3 *Influence of Green Infrastructure on the Participants' endorsement of the NEP*

The descriptive analysis revealed that of the 15 items used to investigate the participants' endorsement of The regression model of the influence of green infrastructure on the endorsement of the NEP scale produced F (385.077, 1174.923) =12.135, p<0.000 and R2=0.247, suggesting 25% of the variance in the influence of the features of green infrastructure on the participants' endorsement of the NEP was accounted for in the regression model used in the study. The regression coefficients also show that based on the p-values, only one out

of the 10 characteristics investigated in this research, that is the condition of green spaces/areas in the neighbourhoods (p=0.161) did not come up as a significant predictor of the participants' endorsement of the NEP (Table 4). This means that nine features of green infrastructure significantly influenced participants' endorsement of the NEP in the study area.

Table 4. Regression analysis of Green Infrastructure features on the endorsement of the NEP.

Features of Green Infrastructure	Standardized Coefficients		df	f	p
	Beta	Estimate of Standard Error			
Green areas are small in quantity in this neighbourhood	0.065	0.039	4	2.791	0.025*
In this neighbourhood, there are green areas for relaxation	0.223	0.052	4	18.533	0.000*
We have a minimum of one garden or park in our neighbourhood where people can interact	0.074	0.040	4	3.381	0.009*
Green spaces in this neighbourhood are in good condition	0.058	0.045	4	1.644	0.161
There are no parks in this neighbourhood where children can freely play	0.126	0.046	5	7.448	0.000*
Residents in this neighbourhood usually enjoy the services of parks located in other neighbourhoods in this city	0.062	0.037	4	2.769	0.026*
The green areas in our neighbourhood are small	0.254	0.056	4	20.641	0.000*
Many green areas in our neighbourhood are rapidly been depleted	-0.133	0.045	4	8.569	0.000*
Green spaces in this neighbourhood are adequately equipped	0.132	0.044	4	9.003	0.000*
People stay close to a majority of green areas in our neighbourhood	0.200	0.045	4	20.013	0.000*

Dependent Variable: Mean Score of New Ecological Paradigm
**significant predictors*

Considering the Beta (β)coefficients as presented in Table 4 in the ascending order of value, the small number of green areas in this neighbourhood having a beta coefficient of 0.254 is the most noticeable feature of green infrastructure that influenced residents' endorsement of the NEP. This indicates that the size of available green spaces contributed most to explaining residents' endorsement of the NEP scale in the study area. Closely follow is the existence of green areas for relaxation (β = 0.223), the closeness of a majority of the green areas to the people (β= 0.200), fast depletion of the green areas (β = 0.133), level of equipment of the green areas in the neighbourhoods (β =0.132), availability of parks in the neighbourhoods where children can freely play (β= 0.126) and others. These results mean that residents' endorsement of the NEP scale will change by 0.254, 0.223, 0.200,0.133, 0.132 and 0.126 times for 1 unit addition in standard deviation in the number of green areas, the existence of green areas for relaxation, people stay close to a majority of green areas in the neighbourhood, reduction in the rate depletion of the green areas, level of equipment of the green areas and availability of parks in the neighbourhoods where children can freely play neighbourhoods, respectively.

5. Discussion of Findings

In this research, the influence of green infrastructure on residents' endorsement of the new ecological paradigm was investigated. Overall, there are some key issues which have emerged that require further discussion. First, is the finding of how the residents felt about the general attributes/characteristics of green infrastructure in neighbourhoods sampled. Generally, the participants felt that the available green areas were relatively too small, being depleted at a very fast rate, not adequately equipped and thus were considered not to be in good condition. This shows that the residents felt that the green spaces in the residential neighbourhoods sampled were not enough both in quantity and quality. This implies that the current efforts by the Lagos State Parks and Gardens agency in upgrading the green areas in Lagos metropolitan area are yet to produce the desired results as expected by the people. Considering the evidence in the literature on the role of green areas in enhancing ecological balance (Kim et al., 2013; Zhang et al., 2017), promoting environmental sustainability (Dipeolu & Ibem, 2020), community attachment and social cohesion (Dipeolu et al., 2020), the perceived inadequacies of green spaces in the neighbourhoods can contribute to inhibiting the rate at which the residents can imbibe environmentally-friendly behaviours and

denying the city of the several ecological benefits associated with green infrastructure, especially in the area of enhancing its capacity to cope with the challenges associated with climate change.

Secondly, regarding the extent to which the existence of green infrastructure has influenced the respondents' endorsement of the NEP in the neighbourhoods sampled, the survey data also show that the participants believe that the quality of existing green infrastructure was generally poor, but the fact that it was available had a positive influence on their endorsement of the 15 different aspects of the NEP investigated. With each of the 15 items used to investigate endorsement of the NEP having a mean score above 4.01 (Table 3), it is obvious that the residents were certain that the existence of green infrastructure in the neighbourhoods contributed positively to their endorsement of the NEP. In support of previous studies (Liu et al., 2015; Wolch et al., 2014), the respondents generally agreed that green infrastructure can help to sustain and develop the earth's natural resources, create habitats for plants and animals and balance the delicate nature of the earth. In addition, the results further revealed that the participants felt that the presence of green infrastructure in their surroundings contributed to enhancing the capacity of the natural environment to meet human needs; balance nature and the impacts of modern industries and also assist in resolving ecological crisis confronting humankind, especially, in town and cities. These are no doubt basic ecological benefits of green infrastructure that previous authors (Lee & Maheswaran, 2011; Ogunbode, 2013) had a link to the new ecological paradigm.

Lastly, this study also identified nine features of green infrastructure that influenced the participants' endorsement of the NEP. Notably, the size of green spaces, the existence of green spaces for relaxation and the closeness of the green spaces to the residents, respectively, had the greatest positive influence, while the availability of green areas for relaxation in the neighbourhoods had the least influence on the endorsement of NEP. These results seem to provide support to the existing studies (Austin, 2014; Barthel et al., 2013; Benedict et al., 2012) linking green infrastructure and ecological benefits in urban neighbourhoods. Further, the discovery of the size of green spaces in the neighbourhoods as one of the leading factors influencing the participants' endorsement of the NEP in this research is well-rooted in previous literature. In fact, according to Ignatieva et al. (2011), large green spaces promote biodiversity by providing habitat for plants and animals in the terrestrial and aquatic environment, especially in a place like Lagos State, Nigeria, which has a massive aquatic environment. In addition, several authors (Naumann et al., 2011) have also reported that the availability of green spaces helps residents to have a wider perspective of the functions of nature, including conservation, and social and environmental regeneration, especially in large cities like Lagos.

Similarly, the identification of the existence of green areas for relaxation as the next in the order of influence of green infrastructure characteristics on the residents' endorsement of the NEP is also incongruent with the findings of previous studies (Dipeolu et al., 2021; Kim & Song, 2019; Mansor et al., 2012), indicating that green gardens in urban centres are made up of diverse components of green infrastructure, including street trees, fountains, open spaces, horticulture, urban forests, streams and other water bodies capable of providing the urban population with the opportunities to engage in social interactions and recreational activities in the natural environment. (Mansor et al., 2012) in particular observed that these categories of green infrastructure encourage city residents to engage in various activities such as relaxation, walking and other forms of mental and physical activities that promote mental and physical health and well-being. They are also known to provide the opportunity for people to gain access to nature, unlike the situation where green areas have been completely depleted and replaced with grey infrastructure and there is little or no access to elements of nature for recreation and leisure in towns and cities.

The result shows that the closeness of the green areas to the residents as the next green infrastructure feature with a high influence on residents' endorsement of NEP was also expected. This is because the presence of green infrastructure in urban neighbourhoods has been linked with a positive influence on social interactions by previous studies (Dipeolu et al., 2021; Zhang et al., 2017). The existing studies have also confirmed that having access to

green infrastructure, which is a function of the location of such elements of nature to close to the people can also engender regular contact with nature (Mansor et al., 2012) and that natural environments, such as gardens, parks, community forests, river views, fountains and open spaces have been reported to contribute greatly to improved health (Zijlema et al., 2020). Indeed, natural environments, have empirically been identified as avenues for promoting physical interactions, mental restoration and stress reduction (Markevych et al., 2017; Zhang et al., 2017). It was on this premise that Polat and Akay (2015) noted that the search for comfort in outdoor environments, in particular, was increasingly turning towards having contact with natural environments that green spaces offer to urban dwellers. For the residents of Lagos metropolis, Nigeria, having access to and living close to green infrastructure might mean that they do not need to go in search of green infrastructure and enjoy the benefits associated with adequate contact with nature and its restorative functions.

7. Conclusions and Recommendations

The findings of this study, which explored the influence of green infrastructure on the endorsement of the new ecological paradigm by residents of neighbourhood environments of Lagos metropolis in southwest Nigeria, have produced three major conclusions. The first conclusion is that the respondents in the study rated the quality of the green infrastructure in the studied neighbourhoods low. The second is that notwithstanding the perceived low quality of green infrastructure, the participants felt that the presence of this vital component of the built environment in their neighbourhoods had positively influenced their endorsement of the NEP. The last but not the least conclusion is that the three most important features of green infrastructure that significantly influenced the residents' endorsement of the NEP are the size and existence of green areas for relaxation and the closeness of the green areas to the residents in the neighbourhoods.

There are notable implications from the findings of this study. First, the study implies that residents in Lagos metropolis are confronted with challenges relating to poor quality of green infrastructure; suggesting that they are yet to enjoy the full benefits associated with green infrastructure, which could have contributed to their level of manifestation of pro-environmental behaviours. To address this situation, the LASPARK, other public institutions and non-state actors responsible for urban development and management need to scale up their activities and programmes to ensure that more green infrastructure, including green spaces, gardens, recreational parks, sports fields and street trees among others are adequately provided and properly maintained in the residential neighbourhoods, towns and cities within and outside Nigeria. Among other benefits, this will help improve the quality and quantity of green infrastructure and reverse the growing trend in the depletion of this vital component of the ecosystem in urban areas. In addition, it is also suggested that when planning and developing public resources such as green infrastructure, the opinions and views of the residents regarding such facilities should be sought and incorporated into the process. Notably, this will help to minimize any form of inconsistency between the need and expectations of users and what urban managers are providing.

Second, the research approach employed suggests that this research has some limitations. For example, the data used were gathered basically through questionnaire administration, and this makes the results to be limited to the participants' biases and moods, which are outside the control of the researchers. In addition, in terms of geographic scope, the survey was restricted to some selected neighbourhoods in the four Local Government Areas of Lagos metropolitan area; and as such the findings cannot be generalised to other residential neighbourhoods and LGAs in Lagos State, southwest Nigeria. To this end, future studies are required in other neighbourhoods and LGAs in this State and beyond. Finally, the regression analysis used in this research accounted for approximately 25% of the influence of green infrastructure on the endorsement of NEP. This implied that about 75% of the factors are not explained in this study. Therefore, other studies are recommended and such studies should include more variables to identify the remaining 75% of the predictors of urban population endorsement of the NEP.

Acknowledgements
The authors specially acknowledged the contributions of the Lagos State Government in approving this study (*MOE/OES/7250/52*) and also the residents of the study area for their voluntary participation.

Funding
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interest
The Author(s) declare(s) that there is no conflict of interest.

Data availability statement
The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Ethics statements
Studies involving animal subjects: *No animal studies are presented in this manuscript.*
Studies involving human subjects: No human studies are presented in this manuscript.
Inclusion of identifiable human data: No potentially identifiable human images or data is presented in this study.

CRediT author statement
Conceptualization: A.A, E.O. **Data curation:** A. A., O. A. **Formal analysis:** E.O., A.A. **Investigation:** O. A., A. A., E. O. **Methodology:** A.A., E.O., O.A. **Project administration:** O.A., A.A. **Writing—original draft:** E.O., A.A. **Writing—review and editing:** A.A., E.O., O.A. All authors have read and agreed to the published version of the manuscript.

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How to cite this article:
Dipeolu, A. A., Ibem, E. O., & Oriola, O. A. (2022). Influence of Green Infrastructure on Residents' Endorsement of the New Ecological Paradigm in Lagos, Nigeria. *Journal of Contemporary Urban Affairs, 6*(2), 159-173. https://doi.org/10.25034/ijcua.2022.v6n2-4

Journal of Contemporary Urban Affairs

2022, Volume 6, Number 2, pages 175–192

Original scientific paper

Smart Heritage for Urban Sustainability: A Review of Current Definitions and Future Developments

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ARTICLE INFO:

Article History:
Received: 24 June 2022
Revised: 25 August 2022
Accepted: 3 September 2022
Available online: 12 September 2022

Keywords:
Architectural heritage;
Smart heritage;
Urban sustainability;
Heritage;
Smart cities;
Integrative review approach.

ABSTRACT

Smart heritage is still novel in heritage discourse, with a few relevant review articles. In this regard, a specific interpretation of smart architectural heritage and a framework for instructing its development is lacking. This article reviews the literature on smart heritage in sustainable development to fill the knowledge gap. As a methodology for this study, the integrative review approach and thematic analysis are adopted to review references located at the crossroads of historic, smart, and sustainable disciplines. The review and interpretation draw on literature from relevant fields to understand implementations, current states, and support to interpret smart heritage. Review outcomes indicate that smart heritage is becoming dynamic as technologies are increasingly applied to more detailed heritage branches. This article lists the factors that heritage should possess to be defined as smart, and it provides a framework that might be followed to achieve the aims of this discourse by stating that smart heritage discussions are relevant to smart cities, as they may have a mutual effect and interact to promote each other.

JOURNAL OF CONTEMPORARY URBAN AFFAIRS (2022), ***6***(2), 175-192.
https://doi.org/10.25034/ijcua.2022.v6n2-5

www.ijcua.com

1. Introduction

Topics around sustainable development have been evolving for more than 30 years. Environmental concerns, energy decisions, social issues, and other aspects of urban development should be integrated (Rogers et al., 2012). With the involvement of smart concepts in sustainable development, environmental, sociological, and economic concerns are increasingly considered in the quest for a higher standard of living (Deakin, 2001). These factors are linked, and they are all necessary for individual and social well-being. In a specific system, such as a building, "smart" refers to an entity with sophisticated control systems and technologies that enable interconnected operability and the capacity to respond quickly to external and internal communications (Pipattanasomporn et al., 2009). Many studies have discussed smart concepts (e.g., smart grid, smart buildings, and smart cities) and their interactions.

Smart grid ideas advocate using modern information and communication technology (ICT) infrastructure to enhance grid (and grid-

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How to cite this article:
Song, H., Selim, G. (2022). Smart Heritage for Urban Sustainability: A Review of Current Definitions and Future Developments. *Journal of Contemporary Urban Affairs, 6*(2), 175-192. https://doi.org/10.25034/ijcua.2022.v6n2-5

edge, for example, consumer) monitoring and control and communication between them (Good et al., 2017). Definitions of smart buildings have been proposed and constantly evolved since 1980, and a structure's smartness is defined as a space with complete control over its surroundings (Wong et al., 2005). Frequent discussions exist among researchers, industry experts, communities, and higher government-level officials concerning smart buildings and smart cities since buildings and infrastructure must be developed and run in line with smart city features (Apanaviciene et al., 2020). Irrespective of what tools and applications are involved, the smart city definition is inclusive enough to cover all important initiatives. As an interdisciplinary topic, it must face increasing problems from various urban dimensions (Dameri & Rosenthal-Sabroux, 2014). The term "smart city" refers to using various information technologies or innovative concepts to connect and integrate urban systems and services to improve resource utilisation efficiency, optimise urban management and sources, and improve citizens' quality of life (Guo et al., 2016). A smart city connects various urban infrastructures to achieve urban intelligence (Harrison et al., 2010). This topic is a cutting-edge area for theoretical study and actual applications. Further research into smart cities is still developing (Dameri & Rosenthal-Sabroux, 2014).

Based on smart city research, new academic and industrial domains are emerging that mix technology and services, including policy discussions from other disciplines (Lim et al., 2021). However, understanding and describing smart cities from several viewpoints is difficult. Given the extensive use of this idea in various fields (for example, urban planning and administration), future studies should discuss smart city initiatives in more detail. Researchers agree that it is critical to interact with the past while considering the future (Sandford, 2019). Developments in heritage smartness are still novel, and some researchers have contributed to comprehensive heritage management and conservation through the digital domain. However, there are only a few review articles on smart heritage and sustainable development that exhibits lag in understanding and developing strategies for smart architectural heritage.

This article reviews literature relevant to smart heritage with a sustainable background. It aims to offer new insights into the architectural domain to develop a framework guiding implementations and applications. This paper does not review all academic publications on the topic but integrates views to construct novel interpretations. Section 2 describes the review methodology, including data collection and analysis methods. In Section 3, a review of smart heritage is conducted corresponding to different features. Section 4 categorises the key outcomes from selected publications and discusses the contributions of this review. Likewise, Section 5 presents the concluding remarks.

2. Methods and materials

A literature review is a method of gathering and analysing previous studies (Baumeister & Leary, 1997; Snyder, 2019; Tranfield et al., 2003). The literature associated with smart heritage covers various disciplines, which requires a creative data collection method. According to Snyder (2019), the integrative review approach can be adopted to understand smart heritage development. The authors reviewed literature from cultural heritage to different heritages extending into semantics, such as heritage monitoring, management, presentation, digitisation, and visualisation.

The article selection procedure cited by Tan et al. (2021) is specialised to correspond to the research aim of this study, and the review workflow is shown in Figure 1. Keyword searches in Science Direct and Scopus for "Smart Heritage", "Smart Cultural Heritage", and "Sustainability" support this review. In addition, highly relevant paper insights from selected articles are reviewed. This study untangles and structures pre-existing knowledge based on 44 highly relevant articles to smart heritage. The initial search included queries using a combination of "smart heritage" with "sustainability". Key concepts in cultural heritage are reviewed at the start to support keyword identification and narrow down the research scope. The keywords "smart cultural heritage" and "sustainability" are then adopted to conduct a review of publications on heritage smartness and cultural heritage domains. Two rules are set to filter the target literature: (a) identify cultural heritage in tangible domains, which excludes literature from intangible cultural heritage and (b) adopt concepts of smartness to promote architectural heritage protection and sustainable development.

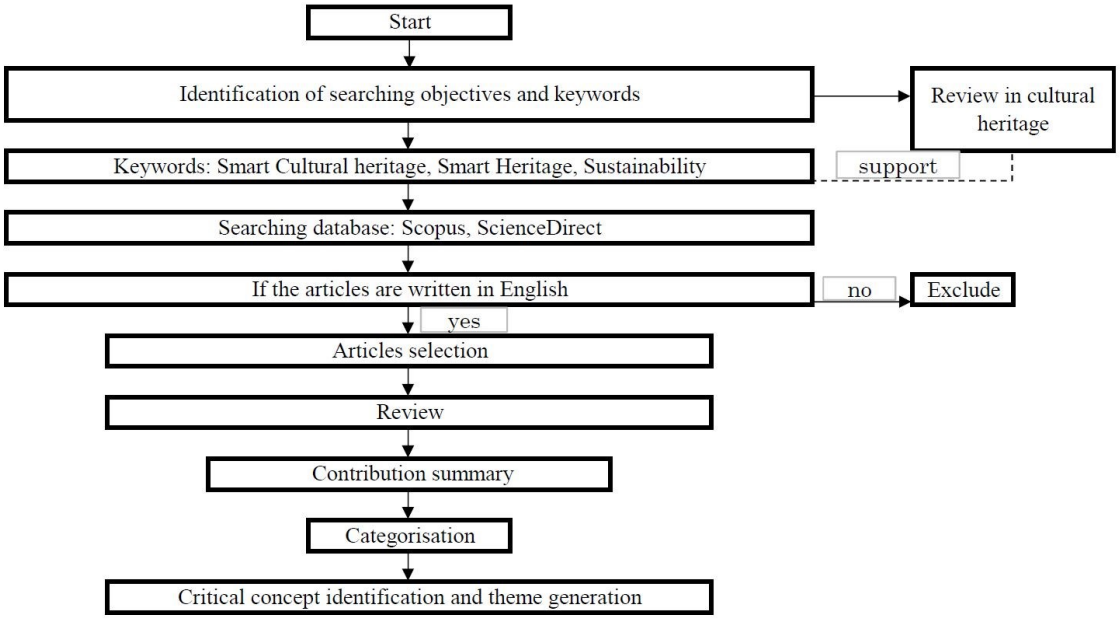

Figure 1. Article Selection Process.

Thematic analysis is used initially to identify common themes and ideas in data analysis. The authors use research topics and contributions from the selected articles to classify this review into three phases: 1) early discussion, 2) detailed discussion, and 3) particular discussions within specific discourse. Collected data were initially imported into Microsoft Excel to determine the general features of each document. After reviewing all selected publications, content analysis is conducted to identify the contributions from each study. The steps are as follows: one—summarising contributions based on the authors and years of publication; two—categorising them based on each contribution; and three—identifying critical concepts mentioned in the article and generating themes (Aktürk, 2022).

3. Results

3.1 Cultural heritage: key concepts

Cultural heritage includes tangible and intangible assets with historical, artistic, scientific, and cultural value (Ahmad, 2006; Vecco, 2010). It generally incorporates architectural works, works of monumental sculpture and paintings, archaeological sites, literary masterpieces, ethnological treasures, oral traditions, and unwritten languages (Bedate et al., 2004; Ferretti et al., 2014; Harvey, 1997). Cultural heritage is a crucial bridge linking humanity's past, present, and future. Over the years, its definition has been considered a dynamic category within constant social and cultural evolution (Li et al., 2020). In modern theory, cultural heritage definitions are constantly updated and reiterated; the whole is the result of continuous historical transformation and progress (Selim et al., 2022).

The UNESCO World Heritage 1972 Convention recognises cultural heritage monuments, groupings of structures and sites as having extraordinary historical, artistic, or scientific value (Cleere, 1996). Cultural heritage is essential to sustainable urban development in the New Urban Agenda. For instance, it can be used to protect and promote cultural infrastructures and sites, museums, indigenous cultures and languages, traditional knowledge, and arts in cities and human settlements (Agenda, 2016). Conflicts between preservation and development continue in urban development: traditional urban elements adapt to contemporary trends by incorporating tools and techniques enabling them to become smart (Koukopoulos et al., 2017). Heritage is an integral part of them.

3.2 Early research into smart heritage

When smart techniques are adopted in heritage fields, well-rounded and systematic conservation and management processes are involved. The exploration of new modes in different heritage discourses widens the knowledge of smart heritage. According to Adrian and Kurniawan (2020), INTACH Heritage Academy introduced smart

concepts into the heritage field in 2007 by addressing the challenges of cultural heritage conservation based on ICT.

Based on keyword searches in this study, discussions around smart heritage started in digital cultural heritage when Moustakas and Tzovaras (2010) proposed a virtual reality (VR) framework for heritage modelling and interactive simulation. In addition, Bearman (2011) mentioned smart objects in the museum discourse and highlighted that cutting-edge techniques help visitors have a more enjoyable visit. Tewfik and Mohamed (2013) suggested the use of smart aspects in heritage protection, and how integrating emerging construction and heritage environments needs to rely on measurable technologies and methods to meet the calls for sustainability.

Husain et al. (2013) indicated that integrated multidisciplinary information (for instance, geographic data) using smart tools not only documents the past and current status of heritage sites but also supports decision-making in the future. They considered how smartness may benefit sustainable development plans by reviewing and discussing the ways combined technology applications can potentially model a real web-based heritage scene. Thwaites (2013) discussed digital heritage and what occurs when heritage contents are digitised, pointing out that smart heritage and cultural futures refer to software that combines pictures and sound collected at heritage sites. Tools, such as animation and film, should be used to build complete hybrid virtual-reality environments as far as possible. Smart heritage research is promising because it aims to produce new experiences and ensures that the cultural future is intact (Thwaites, 2013).

Kenderdine (2013) used captured images combined with methods, such as narrative techniques, to create immersive panoramas of the Dunhuang Mogao cave site with rich details, which involved tourists and created an interactive scene. History and culture can be inherited. Chianese and Piccialli (2014) developed an Internet of Things (IoT) architecture that assisted the creation of a static cultural environment. Even though they did not directly mention smart heritage, they stated that modern technology, such as sensors, sought to turn cultural items into smart objects that could communicate with one another, visitors, and networks. This acquired characteristic is critical for cultural spaces' smartness. By adopting the IoT paradigm consisting of sensor nodes capable of transforming cultural spaces, stakeholders can develop strategies to support heritage smartness.

Other technology paths suggest a different direction for heritage smartness. Garau (2014) has discussed the current state of augmented reality (AR) in cultural heritage. A simulated case study in a historical neighbourhood proves that AR on mobile devices can dynamically offer smart and interactive solutions for the cultural heritage conservation scenario. Likewise, Chung et al. (2015) investigated how AR affects people's desire to visit historical places. Besides IoT, AR brings opportunities for heritage digitisation and visualisation (Selim et al., 2021), but smart heritage might consist of more than a single context or application. Chianese et al. (2015) used IoT to address complex links between transmitting historical knowledge and visitors' experiences in heritage environments through smart design. The development of smart objects supported the progress of this research with the aim of stimulating visitors' interest and enjoyment.

3.3 Technologies for developing smart heritage

Technologies play a crucial role in smart heritage development, highlighting the latter's potential to turn cultural institutions like heritage sites into current assets (Selim et al., 2022). Della Corte et al. (2017) described smart concepts being applied to museums and historical sites with smartness entailing ICT, as evidenced by deploying AR and 3D modelling during producing phases of cultural materials and using cloud environments during modelling and display phases (Della Corte et al., 2017). According to this study, smart heritage can be defined as an ICT-enabled virtual environment that satisfies the requirements of different stakeholders, such as online heritage touring, heritage protection, and sustainable cultural promotion. Borda and Bowen (2017) assessed cultural heritage in several cases across different countries using smart platforms and visualisation technologies. They found that the cities and cultural heritages' smartness needs require contextualised services, which can be made feasible by a shared set of fundamental technologies. With the implementation of smart advancements, those technologies are becoming pervasive and inextricably linked. Borda and Bowen

introduced visualisation technologies, such as simple infographics for 3D modelling and AR combined with technologies, such as IoT, which were applied to every project.

However, only some of the projects can be considered an achievement of smart heritage. For example, by aiming the devices' camera toward the object, an AR application named Skin & Bones created a virtual environment on real objects in the Smithsonian National Museum of Natural History in the United States. Visitors could use an app to test their natural history knowledge by participating in activities, such as identifying a bat by its characteristic sound. The app is available on mobile devices so that visitors can visit exhibitions virtually (Borda & Bowen, 2017). According to Chianese and Piccialli (2016), technological involvement is insufficient to deem a place smart because smartness must be developed by a collection of applications and services with integrated use of shared and created data. To that end, smart heritage should consider the extensive use of various cutting-edge technologies to achieve smartness across multiple aspects and serve stakeholders.

Riganti (2017) attempted to construct a smart heritage agenda for sustainable and inclusive communities with a model based on a previously established smart environment based on a geographic information system (GIS) to support decision-making in long-term cultural heritage management. Riganti's core point was that it is vital to comprehend the value placed on heritage products by diverse stakeholders, particularly local people, to develop full and deep management of cultural heritage. She further suggested that the environment can address most cultural preservation problems. Smart solutions, ranging from customised apps to sensors that provide real-time data, should be included in these categories: one—a user-friendly platform, two—an open heritage-mapping platform, and three—a platform with a basic set of features, such as high-definition 3D visualisation and real-time data (Riganti, 2017). Wang et al. (2018) employed a device-to-device (D2D) communication method based on 5G mobile networks to develop conservation and management networks to address issues of low transmission rates and expandability between IoT and wireless sensor network (WSN). Compared with the study by Qiu et al. (2015) and reviewed in the following section, Wang's strategy brings attention to museum digitisation and visualisation, using "smart cultural heritage" and emphasising how smart city and heritage disciplines strengthened their practical convergence and materialised smart heritage itself.

In the other domain, Khoshelham (2018) overviewed tools and strategies for collecting geographical data for modelling heritage buildings. According to the study, the concept of smart heritage could be described as achieving more rational decision-making in heritage building conservation with the involvement of spatial data and building information modelling (BIM). The initial stage in the documentation and preservation of historic structures is frequently digitised. However, it is an insufficient basis for making educated decisions about the usage and maintenance of heritage structures (Khoshelham, 2018). According to the author, complex tasks, for example, structural health monitoring and assessing environmental impacts like weathering, need to combine enough semantic information from geographical data in historical records and topological relationships into the BIM.

A historic BIM streamlines the ongoing documentation of all preservation and restoration efforts and the administration and interchange of building data. In contrast to Khoshelham (2018), Pocobelli et al. (2018) reviewed BIM applications in historic building conservation projects, using BIM technology to model building components as smart objects with numerical parameters defining the parametric information of the components (e.g., dimensions) and embedding other types of information, such as building materials and attributes. Pocobelli et al. (2018) emphasised giving smartness to architectural components and focusing more on the microscopic level. Anwar (2019) elaborated on how people–place linkages might be used to determine a cultural heritage area's smart implication. The smart city trend has led to using smart technology in heritage conservation. By employing tools such as photogrammetry, reality-based 3D documentation, and permanent digitisation, smart approaches of archiving and genuine digital surrogates represent two heritage restoration strategies. Social networking, 3D visualisation, and VR technologies are among the interactive features that deem the physicality of a heritage virtual. Virtual heritage has thus become a popular concept in culture and history preservation,

conservation, and interpretation (Abdelmonem et al., 2017).

Suwardhi et al. (2022) discussed the creation of a prototype for a multipurpose land management system for an urban cultural heritage region. The first step would be creating a 3D map for documentation of cultural heritage locations. This step would further support heritage protection. In addition, using laser scanners and photogrammetry, a model of a historic building could be visualised at various levels of detail and used in heritage building information modelling (HBIM) for building maintenance. 3D models can be saved as a 3D GIS, BIM, or a combination of the two (the so-called GeoBIM) based on data from the mapping process. Constructing a multipurpose land administration system prototype for the cultural heritage region contributed to Suwardhi's research, and this system included many advantages, including area planning, monitoring, and management.

Mitro et al. (2022) drew on cutting-edge IoT tools to empower smart heritage ideas with a proposed approach that was autonomous, efficient, and non-intrusive. Their article represented using advanced technology to bring smartness into heritage, using smart tag devices to achieve low power consumption and long operational life. The data collected deviated little from the weather station (Mitro et al., 2022). However, one of the disadvantages was that the smart tags functionality was limited to the sensor-monitor level. In terms of a comprehensive system, the smart tag needed to be considered further in terms of giving heritage a deeper level of smartness.

3.4 Smart heritage implementations and applications

Many scholars have focused on developing paths and serving scenarios of smart heritage. Qiu et al. (2015) proposed a novel service system named "one platform—three systems" to address challenges in archaeological site data analysis and site management operations. It consisted of an online-offline-onsite service system and a digital explanation system, also called a smart-heritage management system. The presented platform achieved bidirectional engagement between heritage site management units and tourists, with visitors able to benefit from explanation and illustration of the sites' cultural and economic values. Based on this study, smart heritage in the archaeological domain can be understood as a comprehensive system capable of operating and managing heritage data and providing heritage presentation.

Piccialli and Chianese (2018) attempted to recognise the connections between history and smart technology, characterising the smart cultural environment as a new idea that blends objects, sensors, services, and apps into cultural sites, such as museums, monuments, and exhibitions. Vassilakis et al. (2018) developed a smart method capable of achieving specific heritage displays from an enlarged cultural collection database controlled by users' data. Compared to Piccialli and Chianese, who highlighted the originality and connectivity of cultural objects, Vassilakis et al. focused on smart technologies, as they fulfil significant roles in heritage presentation and communication.

Ardito et al. (2018) offered a strategy for end-user development for integrating smart device services. Fourteen professional guides from various cultural heritage sites in Southern Italy were involved in this study. Using a visual composition paradigm, end-user approaches provided opportunities to customise systems for diverse users' situational demands. Balducci et al. (2020) considered visitors' interests and feelings by improving smart interactive experiences, focusing on an interactive paradigm based on IoT technologies for managers and operators to synchronise different smart objects into a specific environment to satisfy visitors' needs.

It is worth noting that Ardito et al. (2018) aimed to develop interactive methods in which end-users without programming abilities might have smart experiences through the interoperable management of smart objects. Some resources, such as smart objects or web services, were required for the smart experience, but Balducci et al. (2020) focused more on the visitors' interactive experiences. Heritage smartness should become a system aggregating advanced technological tools and satisfying the stakeholders. Therefore, holistic considerations in the technological level of platforms and serving objectives are crucial to developing a smart heritage. It is also a beneficial exploration of organically combining art, technology, and humanities. According to Lerario and Varasano (2020), smartness in architectural heritage should be regarded as a holistic approach that not only brings the systematic opportunity with

monitoring and protecting function into heritage but also links heritage with urban data processing, environmental monitoring, economic growth, and public services. Cultural heritage smartness is highly likely to affect the promotion of social cohesion and push innovation, especially when combined with smart city initiatives (Borda & Bowen, 2017).

Visan and Ciurea (2020) provided a functional system for the digital transformation of cultural heritage and actual procedures for realising virtual displays. Collaborations with IoT and mobile technologies are indispensable when looking to facilitate smart cultural heritage development. In parallel, digitalisation efforts efficiently disseminate key historical data sources and help to preserve the past. Digital cultural heritage is brought to life through innovative visual analysis, interpretation, and engagement methods.

Cultural factors influence the progression towards more sustainable options and acceptance and implementation of circular economy ideas (Stanojev & Gustafsson, 2021). Different urban development stakeholders notice clear economic factors in future sustainable development. Therefore, smartness in cultural heritage should not be neglected. According to Borda and Bowen (2017), integrating heritage and advanced technologies benefits the economy and culture by attracting more tourists, protecting heritage, and creating more jobs. Carrying out theoretical and practical innovation in heritage protection and management is vital to building a modern public cultural service system.

3.5 Smart heritage within smart cities

With a more detailed and profound discussion of smart heritage in different fields and layers, as the previous authors (Borda & Bowen, 2017; Sindhu & Reshmi, 2020) mentioned, heritage smartness is directly or indirectly affected by the development of smart cities, and these two concepts tend to be inseparable and are worth discussing together. Cultural heritage is an invaluable global resource, and its relevance to a smart city grows as it is integrated into the digital ecosystem, especially when considering urban history and civilisation in the construction of the system (Amato et al., 2013). Sindhu and Reshmi (2020) stated that cultural infrastructure, including notable heritage structures, is an essential feature of cities, which should be included in smart city programmes, and that smart city applications can help with heritage monitoring and maintenance.

Angelidou et al. (2017) discovered that cultural heritage management could be implemented through many smart city strategic areas, reflecting various points of view and supporting several aims. The authors found that smart city approaches could strategically underpin smartness. They added that considerations of specific tools and applications for meeting urban developing trends, such as liveability and sustainability, can support the objectives of cultural heritage preservation and promotion in the context of a smart city. Three years later, Angelidou and Stylianidis (2020) revisited the progress achieved, focusing on whether the inadequate substantiation of heritage in smart city policies mentioned in 2017 had been improved. Tarragona (Spain), Budapest (Hungary), and Karlsruhe (Germany) were smart city examples chosen in this study, which found that cultural heritage smartness was not addressed sufficiently within these smart city initiatives. Their conclusion can be regarded as an interpretation of smart heritage, highlighting adopting sensors and other advanced hardware and software as the way to achieve the following goals: one, improving visitors' experiences; two, raising public awareness of a specific cultural heritage; three, preserving cultural heritage; and four, better managing conditions and utilities in heritage sites. The importance of cultural heritage in smart urban initiatives is rising, driving the emergence of a trend that links cultural heritage with sustainable urban development.

Mar et al. (2018) introduced an application in which different stakeholders of historical sites could share a visit itinerary with detailed real-time information tailored to their interests. The authors committed themselves to extending a smart city idea into a Smart Historical City project (SHCity), which took on an unprecedented challenge of producing an open-source tool to connect urban heritage centres. The SHCity was characterised as a system that processes information from urban 3D maps and data from sensor networks to monitor various heritage sites. This study combined digital sensors with historical sites to collect data and made it accessible to management and tourists, presenting a great example of achieving smart heritage.

According to Allam and Newman (2018), smart cities often reflect the ICT industry, ignoring the cultural and historical characteristics that certain cities have inherited. Neve (2018) indicated that prevalent notions about the nature of cities' smartness, cultural heritage, and the popular topic of smart cities do not appear to be a good fit. Neve emphasised the critical need for multidisciplinary research projects examining the interrelationships between all city aspects. Placing heritage at the cities' core, smart heritage should be understood as a coevolving assemblage of the built environment and people. Heritage's smartness research is critical for sustainable urban development. Adrian and Kurniawan (2020) discussed whether smart heritage were relevant to cultural sustainability when smart city development became a hot topic in the 2000s. According to previous research (e.g., Chianese & Piccialli, 2014; Della Corte et al., 2017), as people moved toward an ICT-equipped smart era, INTACH developed solutions to support visitors' experiences, archaeological work, and management of cultural heritage based on shared interests and decisions that engaged people and experts and aimed at developing heritage conservation, management, archaeology, interpretation, and experience. However, Adrian and Kurniawan (2020) indicated that smart heritage was still novel and yet to be completely implemented in any city. The role of smart heritage development is to help in decision-making in cultural heritage protection and create new prospects for economic growth while satisfying the public need for knowing, researching, and preserving (Adrian & Kurniawan, 2020).

Brusaporci (2020) analysed tangible heritage definitions, discussed difficulties in heritage digitisation, and underlined new linkages between actual dimensions and digital heritage. As a vital element of cities, architectural heritage studies have exceeded mere modelling and visualisation. In contrast to previous outcomes developed by other scholars, Brusaporci did not regard smart heritage and smart cities as two entirely different concepts; instead, the smart city approach was directly adopted to process a multitude of inputs, stakeholders, and outputs in the urban heritage context. The author employed a comprehensive smart city approach to defining smart heritage, which included seamless interactions between smart technology and heritage in various ways. Brusaporci mentioned that the ICT's involvement in cultural heritage promotes a cultural shift, resulting in a sustainable inheritance of culture and history in smart city contexts. With AR and IoT, information matches real objects with displays on screens, such as VR goggles, and heritage becomes more than mere digital objects; they transform into cyber objects. Although the author did not detail how smart heritage might promote sustainability, this study broke traditional boundaries between smart heritage and smart cities, tending to integrate architectural heritage databases and smart city construction.

Gandhi et al. (2021) studied the missing links between heritage site protection and smart city development planning by identifying museums and heritage sites in Pune, India, as cultural markers and using GIS to examine metro development plans to see if the present geography of museums and historical sites needed to be aligned with Pune's smart city objectives. This study demonstrated that urban upgrades and modernisation cause conflicts in preserving crucial historical and cultural sites. Heritage needs to update in real-time to cope with urban changes.

When cultural heritage evolves, Snis et al. (2021) pointed out, that some complicated issues, such as innovative procedures and heritage digitalisation, should be contemplated during the transformation from traditional to smart initiatives. Smart city solutions offer new ways to manage and promote immovable physical facilities, such as, historic buildings and monuments. This study highlights the role of stakeholder collaboration in cultural heritage management when making an old town smart. The authors stated that it was feasible to address and include a variety of stakeholders' interests by using a participative, interactive digital platform that manages and transmits cultural heritage content. Minh et al. (2021) used smart cultural heritage while developing heritage site management in France. By using smart technology, they found that smart heritage could help maintain heritage sites' tangible and intangible characteristics. It points out that to make heritage smart, an urban cultural heritage framework is required. The framework should consist of cultural indicators regarded as vital components of community infrastructure. To achieve the goal of smart governance, smart heritage indicators must be standardised, consistent, aggregated,

and updated throughout time and space, highlighting cultural and architectural elements. This study team devised a smart cultural heritage management strategy made up of five steps to becoming a smart community: one, data supply management and smart survey programme; two, smart classification criteria; three, heritage management regulations; four, community management; and five, enhanced heritage understanding. Therefore, these efforts towards cultural heritage must fulfil the following criteria: one, long-term development of activities to give heritage preservation information; two, smart and receptive administration of heritage and the community; and three, restructuring citizen-authority interactions with transparency and clarity (Minh et al., 2021).

4. Discussions

4.1 Contribution classification of reviewed articles

Based on articles searched and reviewed in this study, the critical contributions from each article are categorised into five parts. Digital heritage was increasingly discussed by researchers (e.g., Moustakas and Tzovaras, 2010) when a hot discussion wave rolled up in smart heritage. The worth-noting contributions using different technologies are presented in Table 1. The authors of this article believe that heritage digitisation is a foundation for developing smart heritage.

Table 1. Contributions to Digital Heritage.

Authors	Year	Contributions	Adopted technologies
Moustakas & Tzovaras	2010	VR framework for heritage modelling and interactive simulation.	
Husain et al.	2013	Integrated multidisciplinary information not only documents the past and current status of heritage sites but also supports decision-making in the future.	Geographic technology
Thwaites	2013	Software that combines pictures and sound collected at heritage sites.	Tools such as animation and films
Kenderdine	2013	Captured images are combined with narrative techniques to create immersive panoramas of Dunhuang Mogao cave site with rich details.	
Chung et al.	2015	Digitisation affects people's desire to visit historical places.	
Abdelmonem et al.	2017	Virtual heritage has become a popular concept in culture and history preservation, conservation, and interpretation.	3D visualisation and VR
Wang et al.	2018	The proposed strategy brings the interaction into museum digitisation and visualisation.	Device-to-device communication method based on 5G mobile networks, IoT, and WSN
Suwardhi et al.	2022	3D map for documentation of the cultural heritage location would further support heritage protection.	3D GIS, HBIM

Following digital heritage, some researchers are devoted to bringing smart ideas into different fields of cultural heritage. These are summarised as paths and methods of making heritage smart in different layers and scales, as shown in Table 2. Tools adopted in the selected articles are presented in Figure 2. This chart shows that more tools (e.g., AR, 3D modelling, and network) are involved in heritage conservation and documentation as smart heritage discussions increase. Some core theories (Table 3) contributed by scholars are regarded as significant guidance in the smart heritage discourse. A solid theoretical foundation is indispensable to support the discussion and construction of smart heritage. Smart heritage ideas present more interactive and collaborative technologies in academic and application fields of heritage for various purposes, including protection, management, education, and inheritance.

Table 2. Key Contributions in Smart Heritage Developing Paths and Methods.

Authors	Year	Key contributions	Adopted technologies/tools
Chianese & Piccialli	2014	The employment of modern technology sought to turn cultural things into smart objects that can now communicate with one another, visitors, and the network.	IoT paradigm consisting of sensor nodes
Garau	2014	AR on mobile devices dynamically offers smart and interactive solutions in the cultural heritage conservation scenario.	AR and mobile devices
Chianese et al.	2015	Address the complex link between transmitting historical knowledge and visitors' experiences in heritage environments through smart design.	IoT and smart objects
Pocobelli et al.	2018	Make architectural components smart.	BIM
Ardito et al.	2018	Develop interactive methods in which end-users without programming abilities can have smart experiences through the management of interoperable smart objects.	Smart objects or web services are required for the smart experience
Mar et al.	2018	Combine digital sensors with historic sites to collect data and make it accessible to managers and tourists.	Photogrammetry, 3D documentation,
Anwar	2019	People-place linkages might be used to determine a cultural heritage area's smart implication.	Photogrammetry, reality-based 3D documentation, and permanent digitisation
Mitro et al.	2022	The use of advanced technology to bring smartness into heritage.	

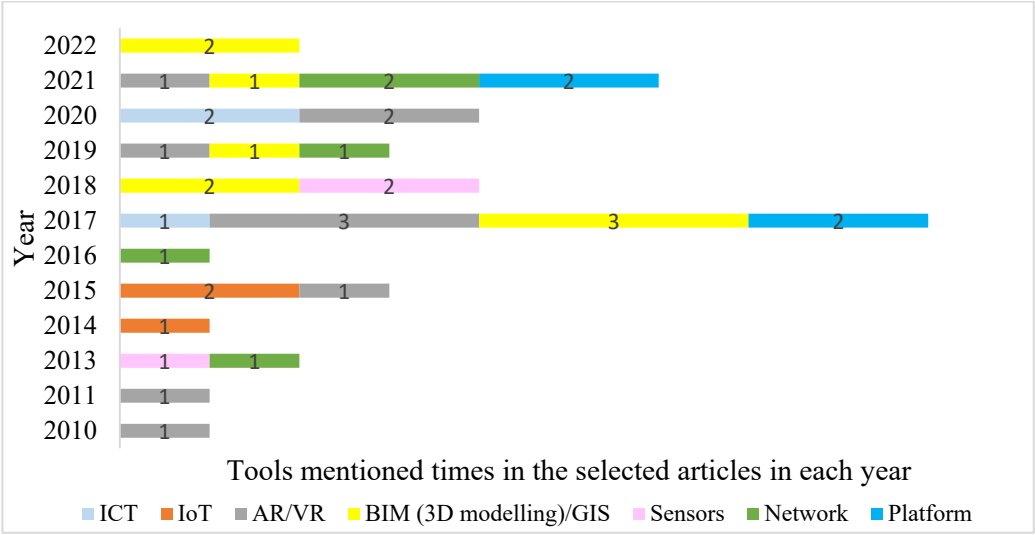

Figure 2. Key Methods or Tools for Developing Smart Heritage Mentioned Times in the Selected Articles in Each Year.

Table 3. Core Theories Contributed by Scholars.

Authors	Year	Mentioned key theories
Bearman	2011	Smart objects in the museum help visitors have a more enjoyable visit.
Chianese & Piccialli	2016	The simple involvement of technologies is insufficient to define a place as smart.
Riganti	2017	Smart solutions should be included in these categories: one, a user-friendly platform; two, an open heritage-mapping platform; and three, platform with a basic set of features, such as high-definition 3D visualisation and real-time data.
rda & Bowen	2017	The smartness needs of cities and cultural heritages require the achievement of contextualised services, which can be made feasible by a shared set of fundamental technologies.
Piccialli & Chianese	2018	Smart cultural environment as a new idea that blends objects, sensors, services, and apps into cultural sites, such as museums, monuments, and exhibitions.
Vassilakis et al.	2018	Smart technologies play significant roles in heritage presentation and communication.
Allam & Newman	2018	Smart cities often reflect the ICT industry, ignoring the cultural and historical characteristics that certain cities have inherited.
Adrian & Kurniawan	2020	Smart heritage development is to help decision-making in cultural heritage protection and create new prospects for economic growth while satisfying public needs of knowing, researching, and preserving.
san & Ciurea	2020	Collaborations with IoT and mobile technologies are indispensable when looking to facilitate smart cultural heritage development, and digitalisation efforts efficiently disseminate key historical data sources and help preserve the past.
Selim et al.	2021	AR brings opportunities for heritage digitisation and visualization.
Stanojev & Gustafsson	2021	Cultural factors influence the progression toward more sustainable options and acceptance and implementation of circular economy ideas.
Gandhi et al.	2021	Urban upgrades and modernisation are causing conflicts in preserving crucial historical and cultural sites.

The more advanced technologies are applied in heritage and urban protection and regeneration, the closer the connection between smart heritage and smart cities. A great deal of previous work corroborates this finding. For example, various ICT tools and knowledge across different heritage areas can extend smart city ideas into a smart heritage concept (Mar et al., 2018). Table 4 lists the crucial theories that involve smart heritage and smart cities based on this review.

Table 4. Key Theories Involve Smart Heritage and Smart Cities.

Authors	Year	Key theories between smart heritage and smart cities
Amato et al.	2013	Cultural heritage is an invaluable global resource, and its relevance with a smart city grows as it is integrated into the digital ecosystem.
Angelidou et al.	2017	Cultural heritage management can be implemented through many smart city strategic areas.
Sindhu & Reshmi	2020	Cultural infrastructure, including notable heritage structures, is an essential feature of cities, which should be included in smart city programmes.
Brusaporci	2020	The smart city approach is directly adopted to process various inputs, stakeholders, and outputs in urban heritage aspects.
Snis et al.	2021	Smart city solutions offer new ways to manage and promote immovable physical facilities, such as historic buildings and monuments.

Smart cities are inextricably linked when defining smart heritage, regardless of the perspective. In each heritage domain, smart heritage has its respective features and definitions: for example, in an exhibition, a virtual cultural exhibiting space is developed with sensors, networks, and applications to provide different services. In the historic building domain, smart heritage regulates and accesses data connected to historic buildings and their surrounding regions, preventing existing danger factors. Based on this review, the interpretations of smart heritage from reviewed articles are summarised in Table 5. Following this, a timeline of milestones in defining and developing smart heritage is presented in Figure 3.

Smart heritage is still a novel concept. The popularity of this topic began about ten years ago, covering fields ranging from archaeology, tourism, and architecture to information, technology, and the Internet. Research from 2013 to the present significantly defined smart heritage and formulated its indicators. Following this review, the authors of this article believe that smart heritage should be developed in smart cities, and they can be regarded as two interacting concepts. Developing indicators to define smart heritage seems a necessary step as a broad concept.

Table 5. Interpretations of Smart Heritage from Reviewed Articles.

Authors	Year	Smart heritage interpretations
Qiu et al.	2015	Smart heritage in the archaeological domain can be understood as a comprehensive system capable of operating and managing heritage data and providing heritage presentation.
Della Corte et al.	2016	A virtual environment established by employing ICT to satisfy requirements of different stakeholders, such as online heritage touring, heritage protection, and sustainable cultural promotion.
Khoshelham	2018	Smart heritage can be described as achieving more rational decision-making in heritage building conservation with the involvement of spatial data and BIM.
Neve	2018	Placing the idea of heritage at the cities' core, smart heritage should be understood as a coevolving assemblage of built environment and people, and heritage smartness research is claimed to be critical for sustainable urban development.
Balducci et al.	2020	Heritage smartness should become a system aggregating advanced technological tools and satisfying the stakeholders.
Lerario & Varasano	2020	Smart architectural heritage should not only bring systematic opportunities with monitoring and protecting function into heritage but also link heritage with urban data processing, environmental monitoring, economic growth, and public services.
Angelidou & Stylianidis	2020	Smart heritage to achieve the following various goals: one, improving visitors experiences; two, raising public awareness of a specific cultural heritage; three, preserving cultural heritage, and four, better managing conditions and utilities in heritage sites.
Minh et al.	2021	Smart cultural heritage management strategies are listed as follows: data supply management and smart survey programme; two, smart classification criteria; three, heritage management regulations; four, community management; five, enhanced heritage understanding.

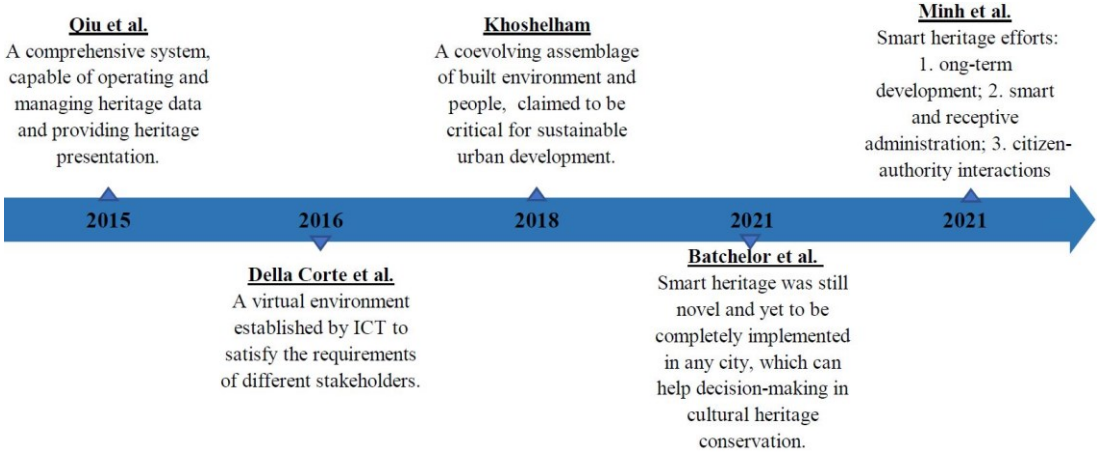

Figure 3. Timeline of Milestones in Defining and Developing Smart Heritage.

4.2 Smart heritage indicators and novel understanding

According to the above-mentioned tables and figures, based on standard systems developed by Riganti (2017), Adrian and Kurniawan (2020), and Minh et al. (2021), smart heritage from theory to tailored application and service objectives, should be incorporated into the following indicators (Table 6).

Table 6. Indicators and Effect Factors.

Indicators	Effect factors
Heritage digitisation	Cost Technology
، user-friendly platform	Data collection Data integration Data analysis
Service objectives	Requirements Benefits
Application optimisation	Users feedback New reuse

Finally, based on this review, the framework for developing smart heritage should comprise the following stages:

- heritage digitisation and visualisation using technologies, such as photogrammetry and 3D scanning, to form digital base plates
- with presentation through BIM, GIS, or both, or other types of models, a user-friendly platform construction through adopting techniques, such as WSN and IoT, to generate real-time interactive data
- identification of service objectives to develop different applications with the help of heritage models and data—for example, developing an app to enable virtual touring on users' smartphones and establishing a safety monitoring system for heritage buildings
- collection of user feedback to enhance and optimise applications

The authors of this article provide a new understanding of smart architectural heritage as architectural heritage is visualised through 3D modelling technologies and connected with numerous urban components through techniques like IoT to reach different goals in sustainability. These goals include heritage modelling for protection, developing virtual museums for touring, educating the following generations in history, and structural health monitoring of historic buildings.

5. Conclusions

This article conducts a holistic review of smart heritage to address its definitions within sustainable development and present its definition in the architectural field. Meanwhile, a few review articles cover smart heritage in academia, which provides a reference for scholars from different disciplines to interpret and develop heritage smartness. Smart heritage as a concept broadly covers various aspects of heritage and technology. Digitisation and visualisation support informative and interpretive applications in different contexts. Different applications follow in the footsteps of earlier discussions and extend to detailed research by adopting more advanced technology. As a broad concept, smart heritage definitions should be refined into different sub-research areas, as each represents a different application and contribution, even though they are interoperable. This article presents indicators for smart heritage definition and a framework for its development, including criteria and technology adoption for different purposes. They are novel outcomes which pave the way for more relevant studies. As another novelty, smart architectural heritage from a new perspective is interpreted as using technologies, such as 3D modelling and IoT, to manage architectural heritage to satisfy various requirements, including documentation, virtual tour, and adaptive reuse. Smart city solutions apply to heritage smartness, and smart heritage development contributes to the progress of smart cities. Therefore, the concept of a smart city should also come into play regarding smart heritage. The authors believe that the ways to make historic buildings smart within the smart city context will come to the fore in future research, bridging smart cities and heritage fields. This review has some limitations: 1) the search is limited to articles in English, and 2) phrases used in different studies may not be covered by the keywords used for the search. Further research is needed to consider more influence. Nevertheless, the authors of this article contend that a continued evolution exists in standard system establishment and further expansion in smart heritage understanding. Detailed subdivisions might include integration between different disciplines, approaches considering citizens and communities, deepening sustainable future urban development, and optimising smart heritage outcomes and their practical applications.

Acknowledgement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interest

The Author(s) declare(s) that there is no conflict of interest.

Data availability statement
The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Ethics statements
Studies involving animal subjects: No animal studies are presented in this manuscript.
Studies involving human subjects: No human studies are presented in this manuscript.
Inclusion of identifiable human data: No potentially identifiable human images or data is presented in this study.

Credit author statement
Conceptualization: H.S., G.S. **Data curation:** H.S., G.S. **Formal analysis:** H.S., G.S. **Investigation:** H.S. **Methodology:** H.S., G.S. **Writing—original draft:** H.S. **Writing—review and editing:** H.S., G.S. All authors have read and agreed to the published version of the manuscript.

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How to cite this article:
Song, H., Selim, G. (2022). Smart Heritage for Urban Sustainability: A Review of Current Definitions and Future Developments. *Journal of Contemporary Urban Affairs, 6*(2), 175-192. https://doi.org/10.25034/ijcua.2022.v6n2-5

Journal of Contemporary Urban Affairs

2022, Volume 6, Number 2, pages 193–205

Original scientific paper

A Proposal to Mitigate Energy Consumption through the Sustainable Design Process in Tunis

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ARTICLE INFO:

Article History:
Received: 12 June 2022
Revised: 26 August 2022
Accepted: 5 September 2022
Available online: 18 September 2022

Keywords:
Energy consumption;
Thermal comfort;
Built environment;
Sustainable design process;
Urban design;
Numerical simulations.

ABSTRACT

The main objective of this paper is to assess the energy efficiency of residential buildings in Tunis. To this end, three complementary studies were carried out at different levels. Initially, a diagnosis of the building's adaptability to climate change at urban and architectural scales was established. The methodology adopted was based on indicators obtained following a cross-reference of environmental assessment tools. This made it possible to highlight the lacunary factors related to thermal comfort. According to this finding, the second research was set up to focus on outdoor thermal comfort. The methodology adopted is based on numerical simulations and calculations of comfort indices. The results demonstrated the importance of specific morphological indicators at the urban scale. Finally, the third research is interested in the architectural scale to assess the building's thermal comfort and energy consumption. It was performed through numerical simulations. The results demonstrated the impact of specific physical indicators on buildings' thermal comfort and energy behavior. Ultimately, this research highlighted the gap factors in urban and architectural design in Tunis. It detected the most significant physical and morphological indicators to be considered for sustainable urban design.

JOURNAL OF CONTEMPORARY URBAN AFFAIRS (2022), ***6***(2), 193-205.
https://doi.org/10.25034/ijcua.2022.v6n2-6

www.ijcua.com

1. Introduction

The climate writes the history of peoples and civilizations, it influences our way of being, our way of life, our cities, and our homes (Song & Ye, C., 2017). Men have always been in harmony with their climate and ecosystem until the industrial revolution when this balance was broken, and nature was challenged (Goudie, 2018). The population explosion and pollution have caused unprecedented global warming. Indeed, during this decade, all countries recorded exceptionally high temperatures never experienced before (Carter, et al., 2015) This global warming is increasingly felt and threatens the environment in various aspects: depletion of energy, food, hydraulic resources, and pollution (Viguié, 2020; Wang, Chen, & Ren, 2011). In August 2021, the Intergovernmental Panel on Climate Change published a report focusing on the state of

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How to cite this article:
Achour-Younsi, S., Chabchoub, A., Jouini, N. E. H., Kharrat, F. (2022). A Proposal to Mitigate Energy Consumption through the Sustainable Design Process in Tunis. *Journal of Contemporary Urban Affairs, 6*(2), 193-205. https://doi.org/10.25034/ijcua.2022.v6n2-6

emergency and the increased risk of climate change in the Mediterranean region. Indeed, this region is considered a hot spot for climate change due to its many vulnerability factors (Climate Change , 2022). Thus, Mediterranean cities are heavily impacted by this climate change, and it is time to make the necessary decisions to preserve them. These agglomerations are not only the critical centers of energy consumption but also the most important centers of decision-making and the creation of adaptive solutions. It will thus be necessary to implement all the efforts to control energy consumption to adapt as much as possible to the current circumstances.

Tunisia, a country in the south of the Mediterranean basin, is classified as an ecological debtor. The United Nations ranks it among the 15 African countries most vulnerable to climate change (UNEP, 2018). The situation is alarming because the annual temperature will increase by about 2.1 °C and could reach +3.5 °C in 2050. It has also increased the number of heatwave days and extreme precipitation events (M.A.L.E, 2020). Therefore, Tunis, the capital, does not escape the problem of cities, which is to try to control its energy consumption. And like any city, the most energy-intensive sector turns out to be buildings. Thus, the real estate sector represented 36% of total energy and 39% of energy consumption and process-related emissions in 2017 (UNEP, 2018). It then seems essential for us, as designers, to rethink our designs, whether on an urban or architectural scale, in a more resilient way to limit the energy consumption associated with buildings. Unfortunately, the usage of air conditioning systems to enhance the thermal quality of places is mostly to blame (Degelman, 2002). These air conditioning devices release anthropogenic energy which, in turn, raises temperatures at street level (Girgis, Elariane, & Abd Elrazik , 2016). We are therefore facing an infinite loop, a vicious circle that it is important to break to help enhance the standard of living in our cities.

In this article, three complementary research works are presented. They tend toward the same objective: the mitigation of energy consumption, and this, through the highlighting of the levers of action at the urban and architectural scale. The research process, explained in Figure 1, follows three stages. The first stage of this study focuses on the environmental diagnosis which targets urban design and architectural conception. The main objective is to identify the deficient factors and the actors concerned according to the environmental diagnosis. Based on the results of the most lacunary factors, the second step is to deepen the outdoor thermal comfort at the urban scale. It studies the influence of urban morphology on outdoor thermal comfort conditions. Finally, the third stage is interested in the architectural scale, by assessing indoor thermal comfort and how it affects a building's energy use.

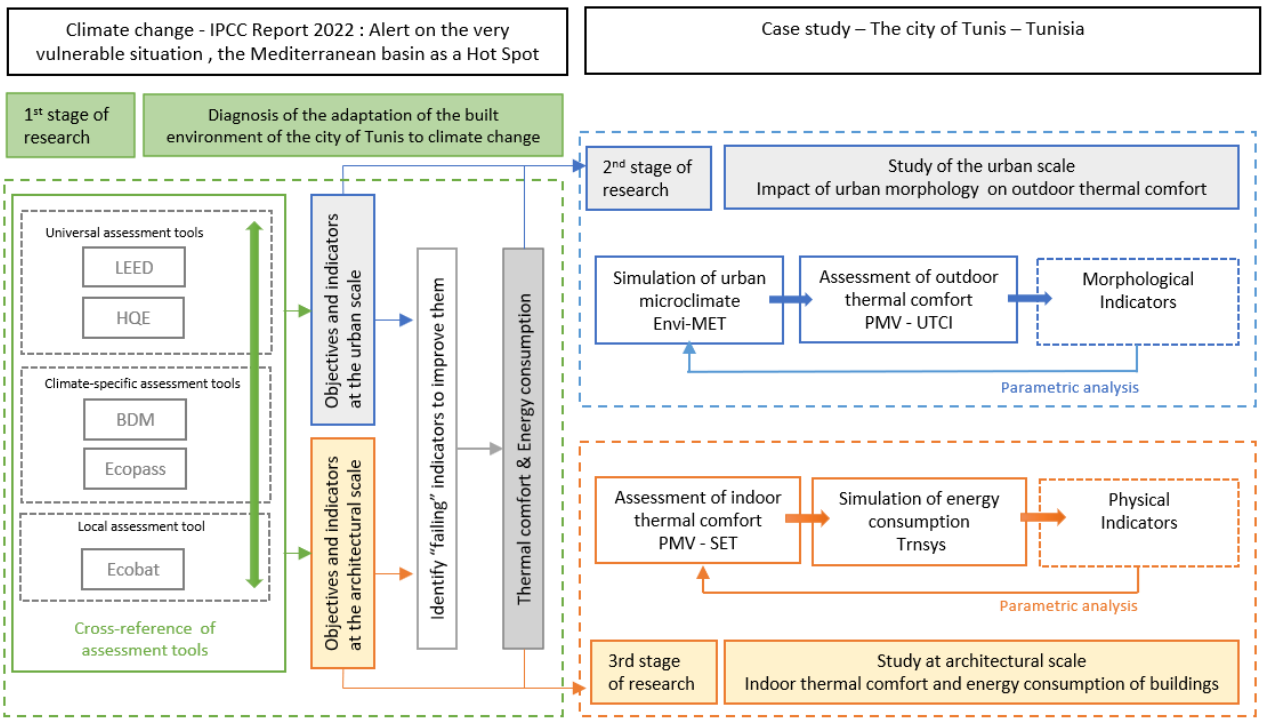

Figure 1. The research process.

2. Materials and Methods

Since the main objective of this study is to evaluate the energy efficiency of buildings in Tunis, the methodology adopted begins with a diagnosis of the adaptability of buildings to climate change in the city, based on a mix of environmental assessment tools on the urban and architectural scales. This diagnosis identifies the most deficient factors that need to be treated. Then, the second stage deepens the urban scale by studying the impact of urban morphology on outdoor thermal comfort. Finally, the last phase focuses on the architectural scale in more detail by studying thermal comfort and its effect on the energy consumption of buildings. These last two steps are based on two analyses, a first comparative followed by a parametric one. They are performed via numerical simulations, calculating different indices of thermal comfort and energy consumption. In the following sections, the three steps are explained in detail.

2.1 Methodology for a diagnosis of the environmental quality of neighborhoods and buildings in Tunis

In the environmental studies of the cities, three scales are studied: the territory, the district, and the building. It should be noted that the interlocking of the scales is essential. The methodology adopted in this step is a multi-criteria approach. It aims to diagnose environmental quality at the urban level of the neighborhood and the architectural level.

The methodology was developed using five global environmental assessment tools:

- Two "universal" assessment tools: LEED (Matisoff, Noonan, & Mazzolini, 2014) and HQE (Madec, 2002)
- Two climate and region-specific assessment tools, BDM (Envirobat, 2012) and ECO PASS (Gauzin-Müller, 2009)
- One local assessment tool under development ECOBAT (A.N.M.E, 2005)

Cross-checking allowed it to retain the objectives present in at least three tools. These objectives are consistent with the mitigation and adaptation measures of the national strategy.

Furthermore, two types of indicators are distinguished:

- Qualitative indicators that will be assessed on two to three scales (yes, few, no)
- Quantitative indicators that will be calculated using mathematical formulas and reference values. Citizen surveys and numerical simulations on Revit Architecture with the Insight 360° Plugin will also be used.

2.1.1 Case study applied to the diagnosis

This study is interested in collective housing in Tunis. To do this, a representative sample of five residential complexes was chosen: The Ennour - Jaafer residence, The Pin-Lac II residence, The Omrane - El Ghazela residence, and the two Palmeraie - Aouina residences. The choice was made so that there is a varied sample to have buildings of different standings and from public and private developers.

2.1.2 Environmental diagnosis at the urban scale of the district

This section presents the objectives selected from cross-referencing of assessment tools and their respective indicators in the following table. They will serve as an analysis grid for the corpus cited above.

Table 1. Objectives of the urban scale diagnosis.

	Objectives and Indicators	Type of Indicator	Analysis tool
1	Preliminary studies	Qualitative	Two-scale assessment (yes/no)
2.	Context of the site and integration into the natural and urban environment	Qualitative	Two-scale assessment (yes/no)
3.	Ecological continuity and preservation of plant cover		
	Respect for the topography of the land and reuse of excavated soil	Qualitative	Two-scale assessment (yes/no)
	Increase in Plant Density	Quantitative	Calculation of Plant Density
	Increased plant density of roofs	Quantitative	Calculation of Roof Plant Density
	Plantations of local species	Qualitative	Two-scale assessment (yes/no)
4.	Preservation of water resources and stormwater management		
	Increased soil permeability rate	Quantitative	Calculation of permeability rate
	Stormwater collection and reuse system	Qualitative	Two-scale assessment (yes/no)
5.	Reduced car trips		
	Connection to public transport within 1 km	Qualitative	Three-scale assessment (yes/few/no)
	Vehicle parking	Qualitative	Two-scale assessment (yes/no)
	Soft transport modes (cycle paths and pedestrian streets)	Qualitative	Three-scale assessment (yes/few/no)
	Functional diversity within a perimeter of 1Km	Qualitative	Three-scale assessment (yes/few/no)
6.	Limitation of urban sprawl and optimization of solar gains		
	Optimization of built urban density	Quantitative	Calculation of urban density
	Optimization of urban roughness	Quantitative	Calculation of urban roughness
	Optimization of solar gains through the envelope and shading of facades and streets	Qualitative	Numerical simulation of shading and average cumulative insolation

2.1.3 Environmental diagnosis at the architectural scale

The objectives and indicators are summarized in the following table by going to the architectural scale, and by the same crossing of tools. They serve as a grid of analysis on the buildings of the corpus.

Table 2. Objectives of the architectural scale diagnosis.

	Objectives and Indicators	Type of Indicator	Analysis tool
1.	Preliminary architectural and thermal studies		
	Architectural studies	Qualitative	Two-scale assessment (yes/no)
	Thermal studies	Qualitative	Two-scale assessment (yes/no)
2.	Propose a bioclimatic architecture		
	Optimize solar gains by envelope, shape, and orientation of the building	Qualitative	Two-scale assessment (yes/no)
	Reduce heat loss by increasing the compactness of the building	Quantitative	Form Factor Calculation
	Optimize the size and orientation of glass openings	Quantitative	Calculation of overall bay window rates (%) and relative bay window rates (%)
	Prioritize natural ventilation	Qualitative	Two-scale assessment (yes/no)
3.	Optimize the thermal quality of the envelope	Quantitative	thermal resistance R transmission coefficient U phase shift D
4.	Use construction materials with a high environmental index	Quantitative	environmental index of materials (high, medium, low)
5.	Reducing the use of fossil fuels		
	Give preference to types of renewable heating, air conditioning, and domestic hot water systems	Qualitative	Two-scale assessment (yes/no)
	Use energy monitoring equipment	Qualitative	Two-scale assessment (yes/no)
6.	Building resistance to climatic conditions and maintenance	Qualitative	Two-scale assessment (yes/no)
7.	Water management by shut-off valves and economical equipment	Qualitative	Two-scale assessment (yes/no)

2.2 Methodology for the assessment of outdoor thermal comfort conditions in the city of Tunis

This second stage of the study focused on the urban scale regarding outdoor thermal comfort, which is the primary impact of the Urban Heat Island effect (UHI). To do this, it is first necessary to study the impact of urban morphology on the urban microclimate (Jin, Cui, Wong, & Ignatius , 2018; Jansen, Martinez, & Devillers, 2021). Then, through the urban microclimate data, the outdoor thermal comfort can be assessed. Concerning the urban morphology component, this study is done on two levels, for each of them, the indicators which have been deemed to be the most influential on the urban microclimate according to the research of (Ait-Ameur, 2002) are listed below:

- At the district level:
  - Built density
  - Urban roughness
  - Plant density
  - Urban porosity
- At street level
  - Ratio Height to Width of streets H/W
  - Sky View Factor SVF
  - Albedo

2.2.1 Case study of the outdoor thermal comfort

This study conducted a comparative analysis of the three fabrics representative of the city of Tunis. The first one is a fabric from the Medina of Tunis, with a dense fabric composed of houses with patios assembled in clusters and thus generating narrow and sinuous streets. The second one is a sample of the European colonial fabric characterized by an orthogonal grid and buildings aligned with equal heights. And finally, the third one is a regulated fabric that is part of a subdivision governed by urban rules, specifications, and imposed withdrawals. This differentiation of fabrics will allow us to highlight the adaptation of new fabrics to climate change essentially on outdoor thermal comfort.

2.2.2 Comparative analysis of the fabrics

This first analysis aims to compare the outdoor thermal comfort conditions in the different fabrics of Tunis over time. Thus, to begin with, it was first necessary to carry out an in-situ measurement campaign to identify the microclimatic parameters involved in the evaluation of outdoor thermal comfort, namely, the air temperature (Ta), Mean Radiant

Temperature (Tmrt), relative humidity (RH) and wind speed (Va).

Then, a numerical simulation via the Envi-met model (v4.0) (Hutner & Bruse , 2009) was carried out to obtain the microclimatic data on the duration necessary for the analysis. The data thus obtained were compared with those measured to verify the correct parameterization of the simulation. Furthermore, statistical validation was done. Finally, the output data allowed us to calculate the comfort indices PMV: Predicted Mean Vote (A.F.N.O.R, 1995) and the UTCI: Universal Thermal Climate Index (Bröde , et al., 2013).

2.2.3 Parametric analysis of morphological indicators

After carrying out this first analysis, which allowed a first reading of the results, and to confirm them, a parametric analysis was performed, in which a single indicator was modified each time. This allowed verifying the influence of each indicator on outdoor thermal comfort.

2.3 Methodology for the assessment of indoor thermal comfort in collective buildings and their energy consumption

This third stage of the research, which is closely related to the previous one because of the effect of the Urban Heat Island (UHI) on the quality of life inside buildings, attempts to assess the degree of adaptation of the contemporary "new" building to the climate. The methodological approach is based on several analytical techniques resulting in a specific protocol. This is deployed on two approaches: the first comparative and the second parametric.

2.3.1 Study case of collective buildings

The research step is interested in downtown Tunis which has undergone many changes. Indeed, local authorities tend to demolish dilapidated colonial buildings and replace them with contemporary ones. Thus, the current urban landscape of the city center is composed of a mix of colonial and contemporary buildings. The study compares the adaptation of this new building to climate change. The corpus of study then contains four buildings; two colonial and two contemporaries located in the Lafayette district of Tunis.

2.3.2 Comparative study of colonial and contemporary buildings

This stage compared the interior spaces' thermal quality and the buildings' energy behaviour. A measurement campaign of the parameters involved in evaluating indoor thermal comfort was done. Then, a numerical simulation on the TNSYS model (version 16) was carried out.

To deal with the physical aspect of thermal comfort, the buildings were studied according to the two analytical indices of thermal comfort: PMV: Predicted Mean Vote and SET: Standard Effective Temperature (Ye, Yang , Chen, & Li , 2003). First, the PMV index was calculated using the numerical simulation on the TNSYS model (Magnier & Haghighat, 2010). Then, for the SET index, the results collected from the numerical simulation were entered into the calculation tool (CBE Thermal Comfort Tool) to calculate the SET comfort index and validate the PMV results given by TRNSYS.

To deal with the energy component, the study's results were based on adaptive comfort in Tunis, undertaken by (Bouden & Ghrab , 2005) . From the two formulas, relating to the calculation of the comfort temperature (TC-Griffiths and TC-Brager), proposed by Bouden and Ghrab and adapted to Tunisian conditions, the comfort temperature was calculated from that based on TC-Brager since it is the most suitable for high outdoor temperatures. Then, this temperature was entered in TRNSYS as the setpoint temperature so that the software could simulate the energy needed by the buildings studied to reach it.

2.3.3 Parametric analysis of physical indicators

Intending to propose the outline of a design adapted to the climate of Tunis, an experimental study on one of the two contemporary buildings studied was conducted.

To this end, it was first necessary to recognize and identify the physical architectural variables that could influence indoor thermal comfort and energy consumption. Then, new numerical simulations were performed, assigning the characteristics of colonial buildings to one of the contemporary buildings. Next, the intervention concerned the envelope composition by studying four envelope scenarios (Mourid , El Alami , & Kuznik, 2018) Then, the impact of the addition of solar protection on thermal and energy levels was studied. There were also changes affecting the glazing rate and type. For the last parameter, the contemporary building studied was manipulated by changing its orientation according to the four cardinal points each time.

3 Main Results

3.1 Diagnosis of the city of Tunis: a need to rethink the design of cities at all stages of the process

At the end of the diagnosis of the residential complexes, the results demonstrated that, their environmental potential remains low despite some differences, especially at the urban scale. To interpret the results, a rating system was created. The scoring system assessed the indicators and classified the objectives into four categories: achieved, partially achieved, flawed, and missing.

It has been deduced that the collective complexes of Tunis are not very respectful of the environment and are therefore very vulnerable to the present and future effects of climate change. Indeed, overall, 100% of the collective complexes analyzed have a rating below the average, 50% have a rating below the average for the urban scale and 75% have a rating below the average for the architectural scale.

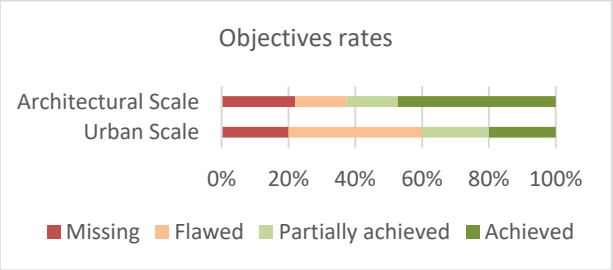

Figure 2. Objectives rates of the environmental diagnosis of the city of Tunis.

These results were mainly used to detect deficiencies or missing factors.

Thus, at the urban level of the district, which turns out to be the most lacking, the missing objectives are:

- Stormwater management
- Urban morphology

For the architectural component of the building, the most flawed objectives are:

- The thermal study
- Bioclimatic architecture
- Building materials

This study has also shown that adaptation goes through all the stages from the studies to the exploitation and requires the intervention and the awareness of all the actors of the building and even the user. Only by working together will it be feasible to redesign the built environment to accommodate both the immediate and long-term implications of global warming.

Action levers have therefore been identified and summarized in the table below.

Table 3. Proposals for possible improvements throughout the sustainable design process In Tunis.

Stage	Actors	Action levers
Urban Planning	Authorities Architects Urban planners Engineers Industrial	- Improve the transport network - Avoid the isolated housing type and limit urban sprawl - Thermal study on an urban scale - Rethinking construction and materials
District Planning	A public or private developer	- Provide interior courtyards - Increase the revegetation of floors and roofs - Reduce asphalt and provide pedestrian streets and cycle paths - Provide a water management system
Building Architecture	Real estate developer Architect	- Use bioclimatic architecture - Prioritize sun protection - Consider the orientation and reduce the openings - Integrate renewable energies - Improve the quality of the envelope
Exploitation	Users	- Awareness of the use of active systems of air conditioning - Choose energy-efficient equipment

3.2 Assessment of outdoor thermal comfort in Tunis: towards an urban morphology based on canyons-type streets

The results of the physical aspect of thermal comfort allowed us to classify the different fabrics according to their degree of adaptation to climate change, through the thermal comfort indices UTCI and PMV, as well as the percentage of comfort zones over a day. Furthermore, the results show the morphological characteristics of the medial fabric classify it as being the best thermally, followed by the regulated one and to finish the colonial fabric.

Table 4. Thermal classification of urban fabrics studied.

		Medina fabric	Regulated fabric	Colonial fabric
Indicators at the Neighborhood scale	Built Density	0.71	0.19	0.49
	Plant Density	0.03	0.22	0.03
	Urban Porosity	0.03	0.08	0.05
	Urban Roughness (m)	6.87	2.48	9.8
Indicators at street level	H/W average	3,51	0,49	1,59
	SVF average	0,16	0,49	0,20
	Albedo average	0,54	0,32	0,38
Outdoor thermal comfort	Percentage of comfort zones	61	58	53
	UTCI average (°C)	23.50 Comfortable	26.58 Moderate heat stress	30.06 High heat stress
	PMV average	0,8 Comfortable	1,6 Slightly warm	2,7 Warm

Then, the study looked for correlations with morphological indicators to better understand these differences in outdoor thermal comfort, by carrying out new parametric simulations on the Envi-met model. To confirm the first readings, and at the end of the parametric analysis, it has been possible to identify the following results.

Table 5. Correlations between morphological indicators and outdoor thermal comfort components.

Scale of analysis	**Neighborhood level**				**Street-level**		
Morphological indicators	Built Density	Urban Roughness	Urban Porosity	Plant Density	Ratio H/W	SVF	Albedo
Outdoor Thermal Comfort	**+++**	**+**	**+**	**++++**	**++++**	**++++**	**++**
Solar radiation	**+++**			**+++**	**+++**	**+++**	
Ta	**++**		**+**	**+**	**+++**	**+++**	
Tmrt							**++++**
HR				**+++**			
Va	**++**	**+++**	**++**	**+**	**+**	**+**	

++++ High impact
+++ Significant impact
++ Moderate impact
+ Low impact
No apparent impact

3.3 Assessment of the thermal quality of indoor spaces: a deterioration of the situation for new buildings

At the end of the analysis, the findings concerning the PMV index demonstrated a clear distinction between colonial and modern structures. This difference favors colonial buildings. The results relating to the SET index, also show a considerable difference (3°C at 6 pm) between the two types of buildings.

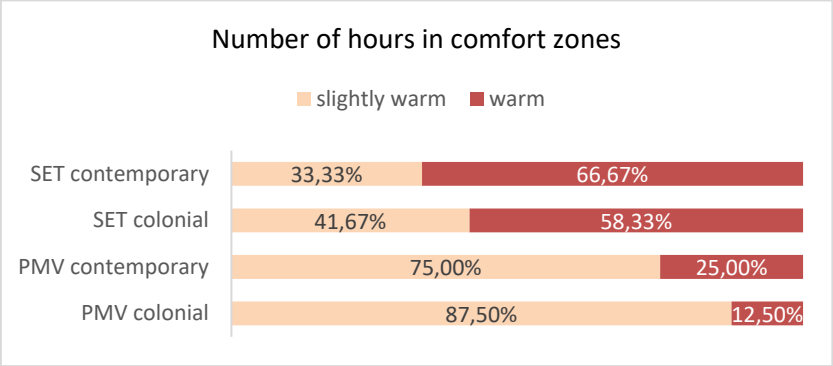

Figure 3. Comparison between thermal comfort in colonial and contemporary buildings.

Energetically, the numerical simulation results show that the colonial buildings consume 1902.40 kWh, during August 2018, half less than their contemporary's counterparts (which consume 4351.36 kWh).

At the end of this comparative study, the results clearly show differences between the two types of buildings studied. Whether thermally or energetically, colonial buildings are widely favored. Indeed, contemporary buildings of the colonial fabric of Tunis display a thermal failure explaining their energy-consuming side. This is probably due to the very high level of glazed surfaces present in contemporary buildings (compared to colonial buildings which have 25% less glazing) regardless of the orientation of the facade. Indeed, these glazed surfaces being in direct relation with the outside, and without the presence of any kind of sun protection, certainly cause overheating inside the building and discomfort due to direct sunlight thus decreasing the thermal quality of contemporary buildings, thus increasing their energy bill (by excessive use of cooling systems).

The following results were obtained in a second step, and after carrying out the experimental analysis, in which simulations were performed by changing each parameter.

Table 6. Results of the parametric analysis and the impact of each physical indicator.

		PMV	Number of hours in Hot zones of PMV	SET (°C)	Number of hours in Hot/ Unacceptable zones of SET	Energy Consumption (KW.H)
Original situation		1,59	8h30	30,79	13h	2442,87
Composition of the envelope Simulation						
Rubble	Floor on vaults	1,32	2h	30,05	11h	1672,13
	Hollow body floor	1,46	4h	30,47	12h	1808,23
Solid bricks	Floor on vaults	1,29	2h	29,95	10h	1577,35
	Hollow body floor	1,43	4h	30,38	11h30	1690,18
Solar Protections Simulation						
Projections	50 cm	1,49	5h30	30,58	12h30	1911,02
	80 cm	1,49	5h30	30,56	12h30	1888,18
Balcony	150 cm	1,48	5h30	30,54	12h	1861,46
Rates and Type of glazing		1,54	7h30	30,72	13h	1909,59
Orientation						
North		1.56	7h	30.79	15h	2290.12
East		1.66	8h	31.07	15h	2596.70
South		1.64	8h	31.01	15h	2791.63
West		1.57	8h	30.81	14h	2227.26

Concerning the first parameter, in relation to the composition of the envelope, it can be noticed that it is the most influential parameter both in the evaluation of interior thermal comfort and in terms of energy consumption (Chabchoub & Kharrat, 2020). The second parameter, relating to the addition of solar protection, strongly correlates with ambient temperatures (risk of

overheating) due to the excessive use of glazed surfaces in contemporary buildings. The results show that solar protection improves comfort and reduces energy consumption. The wider the sun protection, the less energy the building consumes. The results of the third parameter (modification of the rate and type of glazing) show that even if this parameter weakly influences interior thermal comfort, it shows an average impact on the energy level. Finally, it has been demonstrated that the modification of orientations does not significantly affect the thermal quality of the contemporary building studied. However, the East and South orientations in buildings location increase energy consumption since they are the two orientations that are the least advantageous from a thermal point of view. However, this parameter remains strongly linked to the previous ones insofar as the openings (rate and type of glazing) in addition to the absence of solar protection can play a major role even in the best orientations.

4. Discussions

This trilogy of complementary research has the common objective of adapting Tunis's built environment to climate change. Recall that, initially, a diagnosis of this adaptation for the city of Tunis was carried out, using a specific methodology: a cross-referenced five assessment tools to identify objectives and indicators used to draw up an inventory. At the end of this analysis, it turns out that at the urban level, only 20% of the objectives are achieved. This score shows that there are many gaps in urban planning, which will have to be considered to improve urban conditions. Regarding the architectural scale, and given the regulations in force in our country, the score is slightly better with 43% of objectives achieved (Jouini, Kharrat, & Achour-Younsi, 2019). However, it is possible, even fundamental, to correct these shortcomings to improve urban resilience (Stagrum, Andenaes , Kvande, & Lohne , 2020).

In a second phase and view of the importance of energy consumption challenges in cities, the two other studies complete this work by deepening the urban and architectural scales. Indeed, the interlocking of scales is essential to understanding the phenomenon of global warming and its impact on comfort within cities and their buildings. The research is interested in the degree of adaptation of the new built environment to this scourge that threatens our planet.

The more thermally comfortable a city is, the more its buildings will be, and the less energy they will consume. For this reason, the first step was to assess the impact of urban morphology on the outdoor thermal comfort of cities. Indeed, as designers, we have the heavy task of conditioning the thermal quality of our cities. Thus, upstream of the architectural design, it is essential to plan in an environmentally conscious way.

To do this, this second study was interested in the impact of various morphological indicators at the neighborhood and street level on outdoor thermal comfort. The results showed a strong correlation between built and plant densities at the district level. Indeed, by limiting urban sprawl and opting for a higher built density, the effect of the urban heat island, which is an alarming indicator of the poor thermal quality of our cities, can be reduced. As far as vegetation is concerned, its role is no longer to be demonstrated and its impact on the cooling of the thermal environment. At the street level, it turns out that the higher the H/W ratios, the more the street is thermally comfortable (Achour - Younsi & Kharrat, 2016). This is due to the reduction of solar radiation which affects the surfaces of the streets, and subsequently avoids the radiative trapping phenomena, which causes the overheating of space.

Moreover, being that the H/W and SVF have a high link, the latter is an equally significant indicator of outdoor thermal comfort (Svensson , 2004). It is also noted that albedo is a crucial component of outdoor thermal comfort in that it determines the mean radiant temperature value which strongly correlates with comfort (Schrijvers, Jonker, De Roode, & Kenjeres, 2016). These main morphological characteristics prove to be those of the urban planning of yesteryear, and our new cities, with their urban regulation, are not efficient from a thermal point of view. Thus, if designers master outdoor thermal comfort, the immediate environment of the buildings will be more lenient for them, who will not consume a lot of energy.

From this perspective, the third and last part of this research is to close the problem, by analyzing the thermal comfort conditions inside the buildings and by evaluating their energy consumption. The results showed that the newly built environment of the city of Tunis is not adapted to climate change and that the old buildings are more thermally comfortable. As a result, the oldest buildings consume less energy for air conditioning than new buildings.

Furthermore, it has been shown that energy consumption is strongly linked to air conditioning and thermal comfort regulation.

5. Conclusions

Climate change is one of the most worrying issues of the 21st century, given the environmental, socio-economic, and health risks it can cause. Adapting to this climate change in cities has become a necessity or a priority. Architects, urban planners, and all stakeholders are responsible for mobilizing to mitigate the risks associated with the building sector. From gas emissions to the most frightening energy consumption, the building is an essential chapter in the current crisis. To this end, this research was interested, in the first stage, in evaluating the situation in the city of Tunis, with the aim, first, establishing a diagnosis of the adaptability of buildings to climate change, then determining the shortcomings that need to be remedied. The results showed that more than half of the indicators are incomplete at urban and architectural scale. Then it appears that thermal comfort and energy consumption are the two most deficient factors in the environmental diagnosis in Tunis.

Moreover, the results showed that at all stages, there are actors who are responsible for this poor score. It was, therefore, possible to list possible action levers to improve the situation. Thus, avoiding isolated housing types and limiting urban sprawl, in urban and district planning is recommended. Furthermore, it is important to perform thermal studies and rethink the materials used, like reducing asphalt and increasing the vegetation of roofs and floors. Concerning the architectural scale, it appears essential to consider a bioclimatic conception using solar protection, integrating renewable energies, and improving the envelope quality. The following two stages of the research went deeper into these factors by looking for the most influential morphological and physical indicators of thermal comfort first, then on the impact of energy consumption. It appeared that at the urban and architectural scale, it is essential to consider these indicators which directly impact the quality of life of city dwellers.

For the specific context of the city of Tunis, and its climate classified as the subtropical Mediterranean,

the results showed that it is recommended to limit urban sprawl by increasing the built density and the H/W ratio. Furthermore, it is also recommended to consider the envelope's composition by using suitable materials and installing solar protection.

Thus, these morphological and physical indicators that are the most significant indicators in thermal comfort and energy consumption can be categorized into three main classes:

- Forms: urban density, building compactness, shape coefficients, street shapes, orientations, solar protections, etc.
- Materials: ground surface materials, surface albedo, building envelope, insulation, etc.
- Minerality: plant density, bodies of water

This modest work is only the beginning of a tedious research project that sounds the alarm and tends to attract decision-makers attention. Future research will therefore have to go deeper into these three categories by including in-depth analyses concerning the most suitable urban settlements for the climate and the construction materials most suited to the local context. The results will thus be able to draw up guidelines for designers to consider urban planning that is more respectful of the environment and buildings that consume less energy.

Acknowledgment

This research received no specific grant from public, commercial, or not-for-profit funding agencies.

Conflict of Interests

The authors declare no conflict of interest.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Ethics statements

Studies involving animal subjects: No animal studies are presented in this manuscript.

Studies involving human subjects: No human studies are presented in this manuscript.

CRediT author statement:

Conceptualization: S.A.Y., F.K., Data curation: S.A.Y., A.C., N.E.H.J, Formal analysis: S.A.Y., A.C., N.E.H.J, Investigation: S.A.Y., A.C., N.E.H.J, Methodology: S.A.Y., A.C., N.E.H.J, F.K., Project administration: S.A.Y, Writing—original draft: S.A., A.C., N.E.H.J., Writing—review and editing: S.A.Y. All authors have read and agreed to the published version of the manuscript.

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How to cite this article:
Achour-Younsi, S., Chabchoub, A., Jouini, N. E. H., Kharrat, F. (2022). A Proposal to Mitigate Energy Consumption through the Sustainable Design Process in Tunis. *Journal of Contemporary Urban Affairs, 6*(2), 193-205. https://doi.org/10.25034/ijcua.2022.v6n2-6

Journal of Contemporary Urban Affairs

2022, Volume 6, Number 2, pages 207–215

Original scientific paper

Informal Use of "Marginal Open Space" Along Residential Streets in a Nigerian City

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ARTICLE INFO:

Article History:
Received: 18 March 2022
Revised: 26 September 2022
Accepted: 15 October 2022
Available online: 27 October 2022

Keywords:
Marginal open space;
Sustainable urban development;
Residential area;
Planning implications;
Nigeria.

ABSTRACT

In today's highly regulated cities, a conspicuous pattern of marginal open space has emerged between buildings and streets. With rapid population growth, different activities are also emerging in the open spaces, particularly in the cities of developing countries. This study explores the informal use of the marginal open spaces along residential streets in Ile-Ife, Nigeria, to identify the physical planning implications. The data for this study were mainly collected through a questionnaire survey and open space measurements. Findings established that the major activities in the open space were necessary (earning income), socio-cultural and leisure pursuits. Land-use problem occurrence index (LPOI) showed that the significant challenges associated with the use of the space were an increase in travel time to destinations (LPOI = 4.33), open space littering (LPOI = 4.17), traffic and pedestrian congestion (LPOI = 4.17), and degradation of aesthetics (LPOI = 3.99). It is therefore concluded that the use of marginal open space has both positive and negative effects on the residential environments of the Nigerian city. The study adds to the body of knowledge in urban studies by empirically investigating the physical planning implications of the everyday use of marginal open space in a developing country.

JOURNAL OF CONTEMPORARY URBAN AFFAIRS (2022), ***6***(2), 193-215.
https://doi.org/10.25034/ijcua.2022.v6n2-7

www.ijcua.com

1. Introduction

Open space can be described as an area of land not covered by any building or structure within and around urban centres (Woolley, 2005). It may be formally planned and designed for a specific purpose or incidental (Stanley et al., 2012). Formal open spaces include parks, gardens, plazas, playgrounds, golf courses, polo fields, stadiums, and other outdoor recreation grounds (Jurkovic, 2014). Incidental open spaces, on the other hand, are "left-over" areas that are by-products of the processes of urban development (Trancik, 1986; Garde, 1999; Khalid et al., 2018). They are areas on the edges of buildings and other structures. They are often not meant for anything other than physical

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How to cite this article:
Adebara, T. M., Adebara, O, B., & Badiora, A, I. (2022). Informal Use of "Marginal Open Space" Along Residential Streets in a Nigerian City. *Journal of Contemporary Urban Affairs, 6*(2), 207-215. https://doi.org/10.25034/ijcua.2022.v6n2-7

separation, amenities, and safety. These may include open spaces along urban streets and streams, as well as areas around buildings.

Marginal open spaces can significantly contribute to sustainable urban development if properly managed and maintained in cities. They can be found almost everywhere and account for a significant portion of urban land (Garde, 1999). As is typical of formal open spaces such as parks and gardens, marginal spaces may encompass environmental, economic, and social aspects, which are fundamental approaches to sustainable urban development. In other words, like sustainable urban development, open space also has mutually interacted social, economic, and environmental dimensions (See Figure 1). For instance, the marginal open spaces along urban streets promote safety and prevent traffic hazards. They also allow for future street expansion, tree planting, and installing utilities like piped water, telephone, and electricity lines. Planning agencies usually stipulate the minimum requirements for marginal spaces along the streets, which may vary from place to place (Adebara, 2017).

In Nigeria, like in many developing countries, marginal open spaces in urban areas are used for various activities despite the strict official regulations governing the spaces (Basorun & Ayeni, 2013; Afon & Adebara, 2022). These manifest in the indiscriminate occupation of the open spaces and non-compliance with planning regulations governing the spaces. According to Adedeji and Fadamiro (2015), the use of open spaces for informal sector activities has put a significant strain on the physical appearance of most cities and significantly negatively influenced life quality. Furthermore, the encroachment of diverse activities into any accessible open space has resulted in several land-use problems, such as defacing urban aesthetics and open space littering (Adedeji et al., 2014; Adebara, 2021). These land-use problems are likely to have physical planning implications. Besides, the significant problems of marginal open space use in Nigerian cities may be ascribed to a lack of good physical planning and weak regulation of informal activities in urban open spaces. Many cities are not well-designed in terms of contemporary physical planning and are characterized by poor quality and utilization of open spaces (Falade, 1985; Adebara & Adebara, 2019). Policymakers and professionals engaged in urban planning and administration should be concerned about this.

Previous studies have examined how people use open space in urban areas (Garde, 1999; Magalhaes, 2010; Gehl, 2011; Kilnarova & Wittmann, 2017; Askari & Soltani, 2019; Afon & Adebara, 2022). Gehl (2011), an urban theorist, identified three forms of activity in open areas along urban streets and other public spaces. These are necessary, optional, and social activities. People's everyday tasks that are more or less mandatory, such as shopping, are referred to as necessary activities. The occurrence of necessary activities is usually unaffected by the character or quality of the open spaces. While necessary outdoor activities can take place regardless of the quality of spaces, the incidence of optional activities is significantly dependent on the physical condition of the spaces. Thus, the better the physical quality of open spaces, the more urban residents will participate in optional activities such as sitting out to enjoy the fresh air and other leisure activities. Gehl (2011) further described social activities as "resultant pursuits". Essentially, they are activities that can emerge from necessary and optional pursuits. In this category are greeting and conversation, passive contact, and communal functions of different kinds. The literature further shows that people have different perceptions of open spaces and use them for different purposes (Yilmaz, Zengin & Yildiz, 2007; Sanesi & Chiarello, 2006). Some scholars have established that people use open spaces differently because of gender, age, educational status, income, and race/ethnicity (Sanesi & Chiarello, 2006; McWhorter, 2013).

Although studies have looked into the uses of marginal open spaces in cities (Garde, 1999; Madanipour, 2010; Gehl, 2011), the planning implications of using these spaces, especially along urban streets, have not been well researched. This study aims to document this in the residential neighbourhoods of Ile-Ife, a traditional Nigerian city. In this study, "informal use of marginal open space" is defined as using an open area between the edge of a street and the adjoining buildings in a way that is against the laws or regulations governing such an area. The study is significant for many reasons. First, it adds to the body of knowledge in urban studies by empirically investigating the physical planning implications of the informal use of marginal open spaces in a developing country. Second, it provides information that could assist urban planners in developing appropriate policies for open space management. Third, the study's outcome reveals the extent of compliance with the planning laws governing the marginal open space. Lastly, the study's findings could serve as

a tool for developing educational programs and creating urban awareness regarding the appropriate use of marginal open spaces in residential environments.

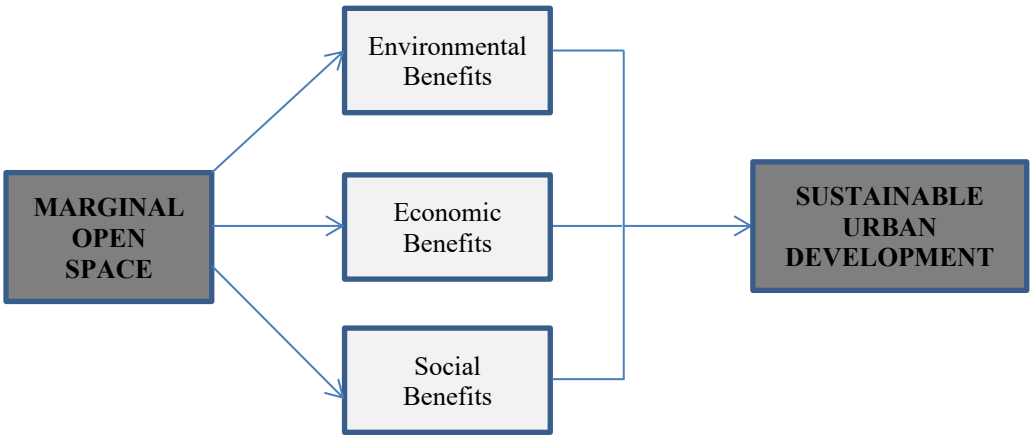

Figure 1. Framework for benefits of marginal open space and sustainable urban development.

2. Study Area

This study takes place in the traditional city of Ile-Ife, Nigeria. The city is known to be the "cradle of Yoruba culture." Ile-Ife occupies a unique place in the Yoruba people's mythology and history. The residents of Ile-Ife are also deeply rooted in culture and tradition (Afon & Adebara, 2022). The town is located at 7° 28′ N, 7° 45′ N, and 4° 30′ E, 4° 34′ E. The population of Ile-Ife was about 502,952 people when the 2006 Nigerian population census was conducted (Adebara, 2017). Based on a 2.5% annual growth rate, the population was projected to be 541,642 in 2010. With the rapid population growth of Ile-Ife, there is an increasing demand for open spaces where people may engage in their daily routine activities. This has resulted in the indiscriminate occupation of marginal open space along the streets in residential areas.

There are four types of residential areas that can be identified in Ile-Ife. These are the core, post-crisis, transition (middle-income), and sub-urban (high-income) residential zones, as presented in Figure 2. The physical planning of the core residential zone (pre-colonial development) is primarily rooted in the culture of the people. The core residential zone is set up like the traditional core area of other Yoruba towns, with the royal palace, town square, sacred groves, and the king's market (*Oja-Oba*) at the heart of the area.

Figure 2. A map of Ile-Ife and its residential zones.
Source: Ife Central Local Government.

The post-crisis zone was initially part of the core area and sub-urban zone. The present physical and social status of the zone is a result of the communal crisis in the city. Presently, the post-crisis area consists of free-standing homes, vacant lots, and many abandoned buildings, with some waste sites, bushes, and overgrown trees in between buildings. Most people who live in the area after the communal crisis are immigrants, low-income families, and those who do not work in the formal sector. The transition zone covers the areas developed to some extent through modern-day planning regulations. The sub-urban zone includes areas

that are designed through a good layout plan. The majority of people who live there have white-collar jobs. This study examines the everyday use of marginal open space along residential streets in Ile-Ife.

3. Methodology

A questionnaire survey and open space measurements were conducted to obtain data for the study. Ile-Ife was stratified into the core, post-crisis, transition and suburban residential areas to obtain the data. Through a reconnaissance survey and Google Earth, 391 streets were identified in the four residential areas. This comprised 85, 79, 182, and 45 streets in the core, post-crisis, transition, and sub-urban zones. One of every five streets (20%) in each zone was selected using systematic sampling. Along the selected streets, 561 houses were identified in the four residential zones, consisting of 118, 141, 180, and 121, respectively. After the first house was chosen randomly, every fifth house was selected using systematic sampling to determine where the questionnaire would be administered to obtain information on the use of marginal space and associated land-use problems, among other things. In this technique, 113 questionnaires were distributed to the household heads in the sampled houses. Household heads are providers and users of marginal open spaces around their homes. So, they are thought to be in the best position to give information about how the space is being used.

A list of land-use problems identified through the literature review was presented to the respondents. They were asked to rate the occurrence of the land-use problems on a five-point Likert scale of *never, almost never, occasionally/sometimes, almost every time and every time*. The data analysis using this procedure later evolved into the land-use problem occurrence index (*LPOI*) index. Each of the ratings mentioned above was given the corresponding values of 5, 4, 3, 2, and 1, respectively, to compute the index. The Total Weight Value (TWV) for each attribute is calculated by summing the product of the number of responses for each rating of an attribute and the respective weight value. This is mathematically represented as:

$$TWV = \sum_{i=1}^{5} PiVi \quad \text{..... (i)}$$

Where: *TWV* is the Total weight value,

Pi is the number of respondents to rating *i*,

Vi is the weight assigned to attribute *i*

i is the value of the Likert point response

The *LPOI* was computed by dividing the TWV by the total number of respondents for each of the five ratings. This is expressed mathematically as:

$$LPOI = \frac{TWV}{\sum_{i=1}^{5} Pi} \quad \text{.....(ii)}$$

Furthermore, open space measurements were conducted to determine the width of the space along the streets. To do this, the trained research assistants measured the distance between the lines of the selected houses for the questionnaire survey and the edges of the abutting streets in metres (m). In addition, interview guides were administered to town planning officials in Ile-Ife to obtain information on the planning standards for open space along the residential streets. Finally, descriptive and inferential analytical methods were employed to analyse the data obtained.

4. Results and Discussion of Findings

The results of this research are discussed in the section. Unless otherwise specified, all tables and plates in this section were products of the survey carried out in 2020. The findings are discussed under four sub-headings as follows:

4.1 Size of the marginal open space along the residential streets

Information from the town planning agencies indicated a minimum requirement for space along the streets in the different residential areas (see Table 1). The space should not be less than 6.5 metres in the core residential area, while the minimum requirement is 8.5 metres in each post-crisis, transition, and sub-urban zone. Thus, it is considered necessary to determine the actual width of the space to establish the average, minimum, and maximum sizes in the different residential areas.

As in Table 1, the minimum and maximum sizes of the marginal space varied directly along the line of residential areas. In other words, the farther one travels from the core to suburban areas, the bigger the size of marginal space along the streets. It was also shown that the mean size of marginal spaces was 5.2 m in the core area, 6.7 m in the post-crisis, 8.5 m in the transition and 10.3 m in the suburban residential

areas. These results indicated that the average size of the marginal spaces in the core and post-crisis residential zones was less than the planning requirements. This could be because many areas in the core and post-crisis zones were built long before the British colonialists introduced modern physical planning. The implication is that the marginal spaces in such areas might not be large enough for the visual amenity and safety of the occupants of buildings along the streets.

4.2 Socioeconomic characteristics of respondents in the different residential areas

The socio-economic status of people may influence how they perceive and use space in an urban environment (Ceccato & Bamzar, 2016; Yung et al., 2016; Adebara & Adebara, 2020; Agboola, 2022). Thus, this study examined the respondents' socio-economic characteristics in the study area. As stated earlier in this study, the household heads in the selected houses were the respondents for this study. This is because they are users and usually the providers of open spaces around the house. Therefore, they are considered the appropriate respondents for the questionnaire survey. The variables considered essential to the central focus of the study were: age, educational status, and income.

Table 1. The width of the marginal space in the different residential zones (in metres).

Residential Area	Planning requirements	Field measurement		
		Minimum Size	Maximum Size	Mean Size
Core	6.5	3.4	7.3	5.2
Post-crisis	8.5	3.5	10.8	6.7
Transition	8.5	4.1	13.7	8.5
Sub-Urban	8.5	4.6	16.1	10.3
Ile-Ife		**3.4**	**16.1**	**7.1**

The age of the household heads was divided into three categories: over 60 years (adult), 31-60 years (young adult), and 18-30 years (youth). These classes were adopted for ease of analysis and followed the classification of Adebara (2017). Through Table 2, it could be established that the bulk of the household heads in Ile-Ife were young adults. This group represented 80.5% of the sampled respondents in the whole of Ile-Ife. It was the dominant age group in each of the residential areas. This study confirmed that the active age group could perform different activities in open spaces. It was also shown that respondents above 60 accounted for 12.5% and 6.7% of the users in the core and post-crisis areas, respectively. None of the respondents in the other two residential zones was in this age bracket. Thus, the average age of the users decreased as one moved outward from the core area. The difference in users' age across the residential areas was statistically significant ($F = 5.751$; $p = 0.001$). Therefore, different age groups are associated with different residential zones in Ile-Ife. The implication is that the use of the marginal open space might differ across the residential areas according to the needs of the different age groups.

Educational status is essential to this study. Four levels of education were identified: primary, secondary, tertiary, and no formal education. As shown in Table 2, the most significant percentage of users without formal education qualifications (37.5%) was concentrated in the core area. In comparison, the sub-urban area accounted for the highest percentage (95.7%) of those with tertiary education. As in Table 2, it could be seen that the proportion of users and providers without formal education qualifications varied directly with residential zones. It was therefore implied that the educational status of users and providers increased as distance increased from the core to the sub-urban area. The result of $\chi 2$ value of 80.841; p= 0.000 confirmed that education qualification varied significantly from one residential area to another in Ile-Ife. This implies that if education status tends to influence the use of open space, this may vary across residential areas.

Directly related to the education status of the users and providers is the income status. For ease of analysis, three income groups were determined using the Osun State Civil Service income grade levels during the study period. These were the low, middle, and high. Open

space users on salary grade levels 01–06 were categorized as low-income earners (LI), while those on grade levels 07–10 were middle-income earners (MI), and high-income earners (HI) were those on salary grade levels 13–17. The low-income monthly salary was ₦24,500 or less, the medium-income monthly salary was between ₦25,501 and ₦54,000, and the high-income monthly salary was greater than ₦54,000.

From Table 2, users' income varied directly with increasing distance from the core area outwards. This pattern is further explained by the fact that none of the users in the core area was in the high-income group, while 6.5%, 16.7%, and 82.6% of the users in the post-crisis, transition, and sub-urban areas were in this group, respectively. This pattern of income could influence how users perceive the marginal open space along the streets in various residential areas. This result supported prior research by Afon and Adebara (2022), which showed that the majority of people in the traditional residential setting (core region) of Ile-Ife belonged to the low-income group, whereas the high-income earners primarily clustered in the sub-urban area. The Analysis of Variance ($F = 34.997$ and $p = 0.000$) indicated that the difference in the monthly income of open space users across the four residential zones was statistically significant at 0.05.

Table 2. Socioeconomic characteristics of the respondents (household heads).

Socio-economic Characteristics	Residential Areas				Total (Ile-Ife)
	Core f (%)	Post-Crisis f (%)	Transition f (%)	Sub-Urban f (%)	f (%)
Age Group					
18-30 years	7 (29.2%)	4 (13.3%)	5 (13.9%)	1 (4.3%)	17 (15.0%)
31-60 years	14 (58.3%)	24 (80.0%)	31 (86.1%)	22 (95.7%)	91 (80.5%)
Above 60 years	3 (12.5%)	2 (6.7%)	--- (0.0%)	--- (0.0%)	5 (4.4%)
Total	**24 (100.0%)**	**30 (100.0%)**	**36 (100.0%)**	**23 (100.0%)**	**113 (100.0%)**
Level of Education					
No formal Education	9 (37.5%)	5 (16.7%)	5 (13.9%)	--- (0.0%)	19 (16.8%)
Primary	6 (25.0%)	16 (53.3%)	10 (27.8%)	--- (0.0%)	32 (28.3%)
Secondary	8 (33.3%)	7 (23.3%)	14 (38.9%)	1 (4.3%)	30 (26.5%)
Tertiary	1 (4.2%)	2 (6.7%)	7 (19.4%)	22 (95.7%)	32 (28.3%)
Total	**24 (100.0%)**	**30 (100.0%)**	**36 (100.0%)**	**23 (100.0%)**	**113 (100.0%)**
Income Group					
Low (≤ ₦ 24,500.00)	17 (70.8%)	13 (43.3%)	20 (55.6%)	1 (4.3%)	51 (45.1%)
Middle (₦ 24,501- 54,000)	7 (29.2%)	15 (50.0%)	10 (27.8%)	3 (13.0%)	35 (31.0%)
High (> ₦ 54,000.00)	--- (0.0%)	2 (6.5%)	6 (16.7%)	19 (82.6%)	27 (23.9%)
Total	**24 (100.0%)**	**30 (100.0%)**	**36 (100.0%)**	**23 (100.0%)**	**113 (100.0)**

As established earlier in this study, the level of compliance with planning regulations concerning the marginal open spaces followed the educational and income statuses pattern.

Therefore, it can be inferred that the level of education and income of open space users and providers might influence their level of compliance with planning regulations regarding the space along the streets. This corroborated the findings of Awuah and Hammond (2014) that there is a direct relationship between the educational status of people and their compliance with planning regulations.

4.3 Utilization of marginal open space along the streets in the different residential areas

After assessing the sizes and socioeconomic attributes of the providers and users (household heads) of the marginal open space along the streets, this section focuses on examining the uses of the spaces. In order to achieve the above, the household heads were instructed to identify the different uses of the marginal space. Respondents were permitted to identify several activities they recognized. This resulted in multiple responses. The respondents' activities were broadly grouped into three: necessary, optional, and socio-cultural.

As presented in Table 3, it could be seen that the marginal open space along the streets was mostly used for activities that were more or less necessary. Such necessary activities are what people do to survive in their daily lives. These were: trading, artisanship, household cooking, and washing/drying of clothes, respectively, which accounted for 14.0%, 9.8%, 6.9%, and 10.5% of the activities in marginal space in the entire study area. Findings also showed that the necessary pursuits accounted for the highest frequency of activities in the post-crisis (44.2%), transition (40.0%), and sub-urban areas (47.9%).

Next to the necessary pursuits in order of frequency were the socio-cultural activities. Such activities are inextricably linked to the culture and traditions of the people of Ile-Ife. They are what the residents do to fulfil their cultural and religious obligations to departed ancestors and fortify social ties among relatives. Socio-cultural activities accounted for 33.8% of all the uses in Ile-Ife. This category includes ceremonies, burying departed ancestors in open spaces, family gatherings, ancestral worship, and cultural festivals. The study further established through Table 3 that the frequency at which socio-cultural activities occurred in marginal spaces along the streets increased from the sub-urban to the core area. In other words, socio-cultural activities were most common in the core residential area. This could be because people who live in the traditional residential areas of traditional African cities like Ile-Ife are known to be very rooted in their cultural beliefs and traditions (Adebara, 2017).

The optional activities accounted for 26.4% of all the uses. These activities are what people do when the conditions of open space are optimal and pleasant for them (Gehl, 2011). In other words, the occurrence of such activities is highly dependent on the physical conditions of open spaces. The optional activities were sitting/relaxing outside to enjoy fresh air, children's play, playing Ayo/Draft games, spending time with friends and neighbours, and storytelling. The low occurrence of these activities could be ascribed to the lack of basic auxiliary facilities that could support them along the streets. Such facilities include a well-designed sidewalk, ample outdoor seating area, tree cover and other landscape elements. This finding supports the theory of Gehl (2011) that the incidence of optional and leisure activities is strongly related to the landscape quality of open spaces. Despite the poor quality of the marginal space along the streets, people continue to engage in economic and socio-cultural activities. These are necessary activities in people's daily lives. Given the preceding, this study suggests that marginal open space plays a significant role in people's lives by serving as a place for income-generating and cultural activities. While the utilization of marginal open space enhances life quality, it generates diverse land-use problems in the residential areas of Ile-Ife.

4.4 Land-use problems emanating from marginal space utilisation

As summarised in Table 4, the three most prevalent land-use challenges associated with the marginal space in the core residential area were: traffic and pedestrian congestion, increase in travel time to destinations and conflicts among users with LPOI of 4.68, 4.33 and 4.24, respectively. On the other hand, the vandalisation of government properties with an LPOI of 2.97 was the least ranked problem associated with utilising marginal open space along the streets in the area.

In the post-crisis area, the three most highly rated land-use problems were: lack of safety along the streets (*LPOI* = 4.80), increase in the crime rate (*LPOI* = 4.35), and open space littering (*LPOI* = 4.26), respectively. On the other hand, with an index of 2.66, water

contamination was the least perceived land-use problem in the post-crisis area. The study further showed through Table 4 that the respondents in the transition area of Ile-Ife considered the increase in travel time (4.78) to be the most severe land-use problem emanating from space utilisation in their neighbourhoods. Next to this, in order of ranking, were degradation of aesthetics and open space littering, with LPOI of 4.15 and 4.12, respectively.

Table 3. Uses of marginal open space along the streets in the different residential areas.

Activities	**Core f (%)**	**Post-Crisis f (%)**	**Transition f (%)**	**Sub-Urban f (%)**	**Total (Ile-Ife) f (%)**
Necessary					
Trading	25 (12.4)	16 (11.6)	16 (11.0)	22 (22.9)	79 (13.6)
Artisanship	18 (8.9)	16 (11.6)	12 (8.3)	9 (9.4)	55 (9.5)
Household cooking	13 (6.4)	15 (10.9)	9 (6.2)	2 (2.1)	39 (6.7)
Washing/drying clothes	11 (5.4)	14 (10.1)	21 (14.5)	13 (13.5)	59 (10.2)
Sub-total	**67 (33.1)**	**61 (44.2)**	**58 (40.0)**	**46 (47.9)**	**232 (40.0)**
Socio-cultural					
Ceremonies	21 (10.4)	13 (9.4)	29 (20.0)	18 (18.8)	81(13.9)
Burying of Departed Ancestors	16 (7.9)	9 (6.5)	13 (9.0)	6 (6.3)	44 (7.6)
Family meetings	23 (11.4)	14 (10.1)	--- (0.0)	--- (0.0)	37 (6.4)
Ancestral worship	14 (6.9)	7 (5.1)	2 (1.4)	--- (0.0)	23 (4.0)
Cultural festivals	8 (4.0)	3 (2.2)	--- (0.0)	---- (0.0)	11 (1.9)
Sub-total	**82 (40.6)**	**46 (33.3)**	**44 (30.4)**	**24 (25.1)**	**196 (33.8)**
Optional					
Sitting/relaxing outside to enjoy the fresh air	12 (5.9)	9 (6.5)	18 (12.4)	9 (9.4)	48 (8.3)
Children's play	18 (8.9)	11 (8.0)	6 (4.1)	14 (14.6)	49 (8.4)
Playing Ayo/Draft games	11 (5.4)	7 (5.1)	14 (9.7)	2 (2.1)	34 (5.9)
Spending time with friends/neighbours	7 (3.5)	4 (2.9)	5 (3.4)	1 (1.0)	17 (2.9)
Story-telling	5 (2.5)	--- (0.0)	--- (0.0)	--- (0.0)	5 (0.9)
Sub-total	**53 (26.2)**	**31 (22.5)**	**43 (29.6)**	**26 (27.1)**	**153 (26.4)**
Grand Total	**202 (100.0)**	**138 (100.0)**	**145 (100.0)**	**96 (100.0)**	**581 (100.0)**

***** Note: The total exceeded the number of household heads surveyed since multiple responses were allowed.

Table 4. Land-use challenges associated with marginal space.

Land-use problems	**Core**	**Post-Crisis**	**Transition**	**Sub-Urban**	**Ile-Ife**
	LPOI	**LPOI**	**LPOI**	**LPOI**	**LPOI**
Odour from uncollected waste/filthy drain	3.77	3.79	4.11	3.87	3.89
Noise pollution	3.52	4.13	4.03	3.88	3.89
Lack of safety along the streets	3.99	4.80	3.08	4.02	3.97
Blockage of drainage by wastes	3.84	3.52	2.05	3.24	3.16
Degradation of the aesthetics	4.01	4.21	4.15	3.59	3.99
Water contamination	3.01	2.66	2.41	3.24	2.83
Traffic and pedestrian congestion	4.68	4.01	4.09	3.89	4.17
Open space littering	4.18	4.26	4.12	4.12	4.17
Road accidents	3.89	3.91	3.50	3.04	3.59
Vandalisation of government properties	2.97	3.10	3.00	2.57	2.91
Conflicts among users of open space	4.24	4.17	3.45	3.99	3.96
Increase in travel time to destinations	4.33	4.11	4.78	4.09	4.33
Increase in crime rate	3.99	4.35	3.61	2.44	3.60

Mean LPOI	**3.88**	**3.92**	**3.57**	**3.54**	**3.73**

Note: the acronym LPOI stands for Land-Use Problem Occurrence Index

Similarly, the most prevalent land-use problem perceived by the respondents in the sub-urban area was open space littering (4.12). Other significant land-use problems identified in the sub-urban zone included: an increase in travel time (4.09), lack of safety along the streets (4.02), conflict among users of open space (3.99) and traffic and pedestrian congestion (3.89). Each above had an index higher than the mean LPOI for the sub-urban zone (3.54). Overall, the study showed that the four significant challenges associated with the use of the space in Ile-Ife were an increase in travel time to destinations (4.33), open space littering (4.17), traffic and pedestrian congestion (4.17), and degradation of aesthetics (3.99).

5. Conclusion

Based on the above findings, the study concluded that the use of the marginal open space along the streets varied across the residential zones of a Nigerian city, reflecting people's socio-economic status. In essence, the study established that the use of open space has a spatial dimension. This should be taken into consideration for effective regulation of open space activities. While the everyday use of marginal space is essential in people's daily lives as a place for economic, socio-cultural, and leisure activities, it causes various land-use problems in residential areas. Therefore, using open spaces has both positive and negative effects in residential environments.

In light of the preceding, urban residents should be informed and educated on the values of marginal open space in the built environment and the consequences of disobeying town planning regulations. The planning agencies should also prevent the haphazard location of activities in open spaces to avoid breeding land-use problems. The everyday use of space is not necessarily the problem, but rather the haphazard location and poor management of activities through inappropriate policies and weak enforcement of regulations governing marginal open spaces.

Additionally, policymakers should respond to people's needs in regulating marginal open spaces. The planning regulations should be reviewed to reflect reality so that open space may become more valuable when planning requirements are met. While the supply of formal open spaces such as parks and gardens is decreasing in cities, the marginal spaces can be made more useful by encouraging various social and cultural activities in addition to the necessary activities (such as earning income). In essence, marginal space should be seen as a valuable asset contributing to sustainable urban development. The use of open space for social purposes should be encouraged by providing a well-designed sidewalk, an ample outdoor seating area, tree cover and other landscape elements along some major streets in residential neighbourhoods. This will assist in achieving a more lively and sustainable urban living pattern.

Although this study adds to the body of knowledge in urban studies by empirically investigating the physical planning implications of everyday use of marginal open space along residential streets in a developing country, further research is still needed. Further studies should determine the specific factors influencing how people use different types of marginal open spaces in different countries. This is because people may act differently in various open spaces depending on the type of the spaces and people's culture and norms.

Acknowledgements

This research received no specific grant from public, commercial, or not-for-profit funding agencies.

Conflict of Interests

The authors declare no conflict of interest.

Data availability statement

The data that support the findings of this study are available from the corresponding author, [T. M.], upon reasonable request.

Ethics statements

Studies involving animal subjects: No animal studies are presented in this manuscript.

Studies involving human subjects: No human studies are presented in this manuscript.

CRediT author statement:

- **Conceptualization:** T. M. **Data curation:** T. M., O. B., A. I. **Formal analysis:** T. M., O. B., A. I.

Investigation: T.M., O. B., A. I. **Methodology:** T. M., O. B., A. I. **Project administration:** T.M., O.B. **Writing—original draft:** T.M., O.B. **Writing—review and editing:** T.M., A. I. All authors have read and agreed to the published version of the manuscript.

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How to cite this article:
Adebara, T. M., Adebara, O, B., & Badiora, A, I. (2022). Informal Use of "Marginal Open Space" Along Residential Streets in a Nigerian City. *Journal of Contemporary Urban Affairs, 6*(2), 207-215. https://doi.org/10.25034/ijcua.2022.v6n2-7

Journal of Contemporary Urban Affairs

2022, Volume 6, Number 2, pages 217–231

Original scientific paper

Correlation between Socio-Economic Characteristics and Housing Quality of Residential Neighbourhoods in Akure, Southwest Nigeria

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ARTICLE INFO:

Article History:
Received: 10 August 2022
Revised: 15 September 2022
Accepted: 28 October 2022
Available online: 8 November 2022

Keywords:
housing quality;
socio-economic characteristics;
residential neighbourhood;
sustainable housing delivery system;
quality of life in Nigerian;

ABSTRACT

There is a general paucity of explanations for the emerging social and spatial changes in the pattern and socio-economic traits of urban residential housing units in Nigeria. Hence, this study examined the spatial pattern of residential neighbourhoods; assessed the quality of residential housing units; and evaluated the correlation between the socio-economic position of respondents and housing quality in Akure, Nigeria. Data were derived from the household questionnaire, remotely sensed data (Landsat 8 OLI/TIR, 2021), a Google Earth map, a Street Map of Akure Township, and personal observations. The study adopted a step-wise sampling technique to select 383 samples from 139,069 heads of households in Akure in 2021. Data were analysed using percentage distribution, Pearson Correlation Coefficient, and t-test. Results indicated varying housing qualities across three residential zones in Akure, Nigeria; houses in the low-density residential areas were of better quality than the other residential zones. The quality of houses occupied was influenced by the type of occupation, level of education and average annual income of residents. The study concluded that inadequate housing facilities are fundamental to the observed deteriorating housing qualities in the study area. Therefore, the study suggested improvement of the existing infrastructures and the provision of new ones in the study area. The main contribution of this study is to proffer solutions for a sustainable housing delivery system to facilitate a better quality of life in Nigerian urban centres.

JOURNAL OF CONTEMPORARY URBAN AFFAIRS (2022), ***6***(2), 217-231.
https://doi.org/10.25034/ijcua.2022.v6n2-8

www.ijcua.com

1. Introduction

Housing is consumed with some other items which appear to have no relationship with the land and its uses; one tends to be independent of another. The importance of providing adequate and quality housing in any country cannot be overstressed (Jiboye, 2010; Zainal *et al.*, 2012; Adeleye *et al.*, 2014; Haque *et al.*, 2020). However, the re-current quality of housing requirements and the interminable craving for good housing appears to confirm the impression that there may be to cope satisfactorily with housing requirements (Hsu & Guo, 2006; Owoeye & Ogundiran, 2014; Page & Gordon, 2017; Jochem *et al.*, 2018). Thus, to satisfactorily appraise the quality and evaluate the characteristics of a house, it is important to assess the sociocultural heterogeneity and economic status of the individual property owner.

For this study, housing is regarded as dwelling units occupied by households. From this perspective, three types of housing can be recognised in urban centres: self-built housing development, private developer-led housing and public housing

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How to cite this article:
Olayiwola, A. M., & Ajala, O. A. (2022). Correlation between Socio-Economic Characteristics and Housing Quality of Residential Neighbourhoods in Akure, Southwest Nigeria. *Journal of Contemporary Urban Affairs, 6*(2), 217-231. https://doi.org/10.25034/ijcua.2022.v6n2-8

development. Whereas self-built housing is a single-family property, the other two types are owned by corporate organisations, which could be private or government. Self-built housing units are the most predominant type of housing units in developing countries (Gough & Yankson, 2000; Coker *et al*., 2008; Brkanic, 2017). However, they vary greatly both in characteristics and qualities.

Housing quality can be described as the standard of the residential environment that provides residents with sustainable accessibility, healthy, safe and beautiful accommodation. Housing quality embraces many factors such as the physical condition of the building and other facilities and services that make living in a particular area conducive. Fakunle *et al*. (2018) corroborated by Wimalasena *et al*. (2022) submitted that the quality of housing within any neighbourhood should be such that satisfies minimum health and good living standards. Such houses are also required to be affordable to all categories of households. Studies have found that there exists a direct relationship between housing quality and quality of life (Zhonghua & Xuejun, 2015; Fakunle *et al*., 2018). Therefore, good housing quality is a basic requirement to guarantee stable communities and social inclusion (Konadu-Agyemang, 2001; Wimalasena *et al*., 2022).

Housing is regarded as one of the major factors determining the form of cities. Hence, a major concern in spatial analysis is the geographical distribution and pattern of housing within cities. Residential housing pattern has been the subject of considerable research for many years. The spatial arrangement of housing units in urban environments has been explained in some theoretical frameworks (Burgess, 1925; Hoyt, 1939; Harris & Ullman, 1945). Burgess (1925) developed the concentric zone model as the first theory to describe the internal structure of a city. The central thesis embedded in Burgess's model is that urban residence conforms to a zonal pattern. Hoyt (1939) proposed the sector theory wherein he considered direction and distance to explain the outward extension of the residential areas along district radii with new growths on the outer arc of the sector. Harris & Ullmann (1945) provided an innovative description that analyses the spatial structure of urban areas in the multiple-nuclei theory.

Many studies have been carried out on urban housing in both the developed and developing worlds. For instance, in recent times there has been an extraordinary revival of interest in the spatial preferences of households in choosing a residential location, especially in the urban area. In the more advanced countries of America, the United Kingdom and the eastern part of the world, several studies have examined the changes in the pattern of residential houses (Kearney, 2006; Kurniati & Erlambang, 2015; Gnatiuk & Kryvets, 2018; Premier, 2021). Also, studies have been conducted to unravel the spatial dimensions of neighbourhood housing quality (Myung-Jin, 2013; Haque *et al*., 2020). Furthermore, some studies have been conducted to examine the factors influencing housing quality (Sweis *et al*., 2014; Rajaei & Mansourian, 2017; Ren *et al*., 2019). Besides, there are quite ample studies on liveability in residential neighbourhoods (Streimikiene, 2015; Zhonghua & Xuejun, 2015; Satu & Chiu, 2019).

In the developing world, particularly, Nigeria, several studies have been carried out on urban housing (Gough, 2000; Arku *et al*., 2011; Filali, 2012; Baer, 2014; Adedire & Adegbile, 2017; Ezeanah, 2020). In recent times, there is a revitalisation of interest in the spatial preferences of households in choosing residential locations within an urban environment (Fakunle *et al*., 2018). Moreover, studies have shown that residential neighbourhoods exist in different patterns (Fasakin, 2018). Furthermore, studies have revealed that there are gross inequalities in the quality of residential housing units (Ogu, 2002; Morenikeji *et al*., 2017; Thomas & Hassan, 2018; Ezeanah, 2020). There are many studies on the poor environmental and health condition of slum areas and squatter settlements (Fadairo & Ganiyu, 2010; Omole, 2010; Babalola *et al*., 2016). In addition, studies have been conducted on factors influencing housing quality (Yoade *et al*., 2015; Yoade *et al*., 2018). Also, several efforts have been made at documenting the characteristics and conditions of residential housing units in Nigerian urban centres (Salami, 2016). There are scanty studies on urban housing in Akure, where the present study was conducted. Omole (2010) assessed housing conditions and socio-economic lifestyles of slum dwellers in Akure, Nigeria. In another study, Fasakin *et al*. (2018) focused on the impacts of land pricing on the pattern of residential density in Akure.

From the foregoing, it is obvious that while most of these studies only provided general views on housing, some others focused on just one particular aspect of urban housing. In other words, none of the existing studies on Akure has combined themes of urban housing quality and characteristics with the pattern of the residential neighbourhood. Yet, this is a major policy issue that should not be underemphasised. Therefore, this study seeks to fill the gap in the emerging social-spatial transformations by advancing knowledge on the physical structure and socio-economic characteristics of urban residential housing units in developing countries using Akure, Ondo State, Nigeria as a case study. Thus, this study assessed the relationship between housing quality and the socio-economic characteristics of residents in the study area. Also, the study examined environmental issues

associated with people living in the study area. Furthermore, the study evaluated the resulting pattern of the residential neighbourhood in the study area. These were with the view of offering explanations for sustainable housing delivery systems to improve living conditions in Nigerian urban centres.

2. The Study Area

The study was carried out in Akure, Ondo State, Nigeria. It lies between latitudes 7°07'N and 7°37'N and longitudes 5°06'E and 5°38'E (Figure 1). Akure, with a land area of approximately 991km², is the capital city of Ondo State with two Local Government Areas (LGA); Akure South and Akure North LGAs (Ibitoye *et al.*, 2017). The aboriginal people are of the Yoruba tribe, though there are other tribes such as Igbira, Igbo, Edo and Hausa, among others. Major economic activities include farming, trading, tourism, and civil service. Also, the inhabitants of Akure engage in scale indigenous industrial works such as cloth weaving, *gaari* production, block and bakery activities (Eades, 1980; Daniel, 2015; Ondo State Ministry of Agriculture and Natural Resources, OSMANR, 2015; Ibitoye *et al.*, 2017).

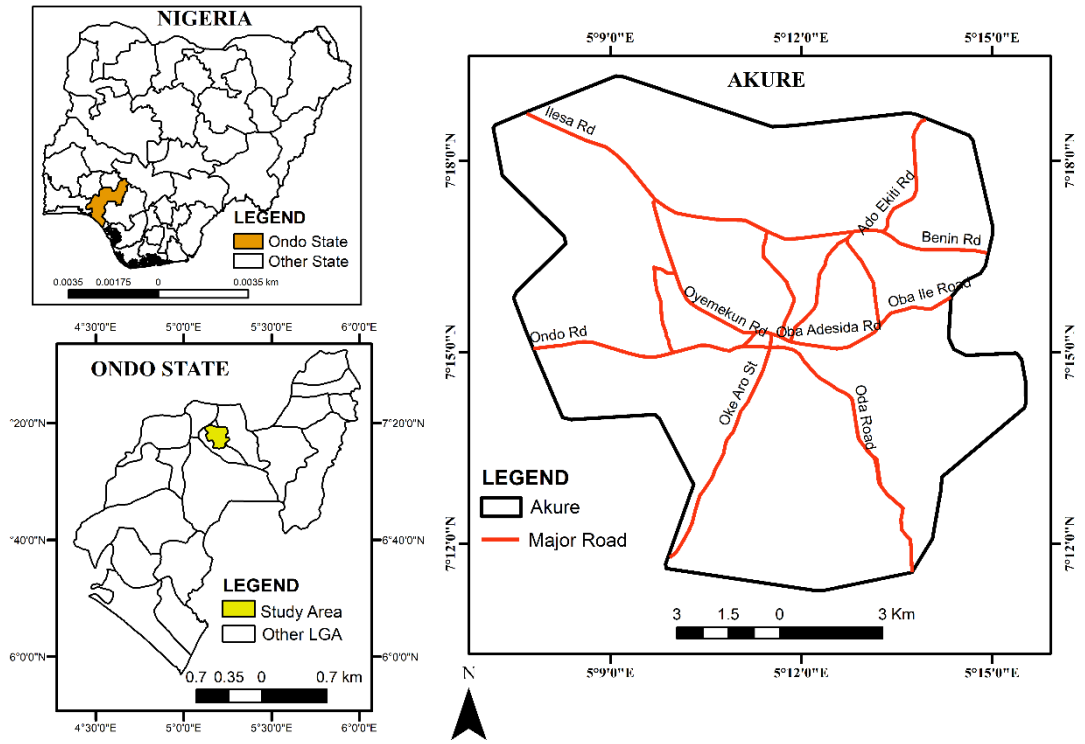

Figure 1. The Study Area.
Sources: Landsat 8 OLI/TIR, 2021; Google Earth map, 2021
Town Planning Division of Akure South Local Government Area.

According to the National Population Commission of Nigeria (NPC), the population of Akure in the last national headcount conducted in 2006 was 353,211 (NPC, 2006). Based on this census result, the population of the study area for the current year of study, 2021, was estimated using an official annual growth rate of 3.2% for urban centres in Nigeria (Nigeria Bureau of Statistics, NBS, 2021). However, because the population is compounded annually, the addition of annual growth rate (r) and 1 (a constant that denotes the inclusion of the current year in the calculation) was raised to a power of the number of years for which the population was projected (t) and multiplied by the population of the base year (P_o). The formula is given as follows (Equation 1):

$$P_1 = \frac{P_0(1+r)^t}{100} \qquad \text{(Eq. 1)}$$

Due to its latitudinal location, Akure experiences a tropical humid climate with two distinct seasons; wet and dry seasons. The wet season starts in April and ends in October, spanning over seven months. The total annual rainfall ranges between 1300mm and 1650mm (Asiwaju-Bello *et al*, 2013; OSMANR, 2015). Temperature is generally high during the day, especially in March and April. The annual mean temperature is 29°C. While evaporation is usually low from June to September (3.3mm to 4.0mm per day), relative humidity ranges between 5% and 90%, between the seasons (Asiwaju-Bello *et al*, 2013). The vegetation of Akure is rain forest consisting of valuable trees used for timber products such as Mahogany, *Obeche, Iroko,* and *Afara*. However, the area is fast becoming a derived forest zone due to persistent clearance of the vegetation. The study area contains lowlands and rugged hills (between 315m and 402m above the mean sea

level). While the northeastern part consists of basement complex rocks, the southern section comprises sand ridges, lagoons, swamps, and creeks. The soils are mostly tropical ferruginous with varied textures and gravel content (Ibitoye *et al.*, 2017).

3. Materials and Methods

3.1. Data Sources

Data for the study were extracted from Landsat 8 OLI/TIR, Google Earth map, Street Map of Akure, and household questionnaire (Table 1). Also, detailed personal observations were carried out using handheld GPS for recording the location attributes of major landmarks in the study area.

Table 1. Characteristics and Sources of Data.

Data	Year	Resolution	Path/Row	Source
Questionnaire	2021	N/A	N/A	Field Survey
Township Map of Akure	2016	N/A	N/A	Town Planning, Akure South LGA
Shapefiles of:				
Nigeria	2021	N/A	N/A	AFRIGIST, O.A.U. Ile-Ife
Ondo State	2021	N/A	N/A	AFRIGIST, O.A.U. Ile-Ife
Akure	2021	N/A	N/A	AFRIGIST, O.A.U. Ile-Ife
Landsat 8 OLI/TIR	March 6, 2021	28.5m	190/055	http://glcf.umiacs.umd.edu
GoogleEarth map, Akure	Accessed: September 10, 2021		N/A	
Population data	2006	N/A	N/A	NPC, Nigeria
GPS Coordinate	2021	N/A	N/A	Ground Truthing

Notes:
N/A: Not Applicable
AFRIGIST: African Regional Institute for Geospatial Information Science and Technology
O.A.U.: Obafemi Awolowo University, Ile-Ife

The sample frame for this study includes all heads of households in the study area. In 2006 there were 89,263 households in Akure (NPC, 2006). However, there has not been another national headcount in Nigeria since 2006, therefore, the study used an estimated number of households based on the official annual growth rate of 3% for urban centres in Nigeria (FBS, 2021). The compound interest formula was used to calculate the number of households for the current year of study, 2021, as contained in Equation 2.

$$A = P\left(1 + \frac{r}{n}\right)^{nt} \qquad \text{(Eq. 2)}$$

Where:
A = number of households for the current year, 2021.
P = number of households in the last headcount, 2006 (= 89,263).
r = annual rate of increase (FBS, 2021) = 3% (0.03).
n = number of times the increase is compounded per year (= 1).
t = number of years between the last headcount and the current year (=15 years)
Applying the formula, the number of households in Akure in 2021 was 139,069. The appropriate sample for this study was determined using an online calculator (Creative Research Systems - Sample Size Calculator). Thus, 383 out of the total 139,069 households in Akure in 2021 were selected for this study. A stratified sampling technique was adopted in the selection of residential housing units for the study. However, noting that there were variations in the quantity and concentration of buildings, the study area was categorised into three strata:

i. High-Density Residential Zone (HRZ)
ii. Medium-Density Residential Zone (MRZ)
iii. Low-Density Residential Zone (LRZ)

Furthermore, using the online calculator with particular consideration for the differences in building clusters, the 383 samples were distributed among the three residential zones (Table 2).

Table 2. Distribution of Samples in the Study Area.

S/N	Zone	Number of Households	Sample Size
1.	High (HRZ)	50,417	195
2.	Medium (MRZ)	45,021	119
3.	Low (LRZ)	39,581	69
Total		**135, 019**	**383**

3.2. Data Analysis

The study adopted a combined process of visual image interpretation and digital image processing to identify similar clusters of pixels that characterise the land use class of interest. Thus, following the supervised image classification procedure by adopting the maximum likelihood algorithm, the area was classified into two broad land uses/covers:

i. Built-up area: all areas containing building structures.
ii. Non-built-up area: this included vegetation, water body, and bare surfaces.

The spatial accuracy assessment utilised included producer accuracy (PA), user's accuracy (OA), and overall accuracy (OA) indices (Table 3). Also, KAPPA analysis was performed to ascertain the level of accuracy of image classification. Moreover, z statistics were calculated to validate the reliability of the imagery accuracy assessment (Sinha, 2016).

Table 3. Distribution of Validation Points (by LULC).

S/N	LULC Class	No. of Points		
		Topographical Map	GoogleEarth Map	Ground Points
1.	Built-up	28	46	55
2.	Non-built-up	35	55	60
	Total	**63**	**101**	**115**

To vividly describe the pattern of the residential neighbourhood in the study area, features of interest such as major roads and the built-up area were digitised in Google Earth and saved as *kml* files for further processing in ArcGIS. The converted layers were then overlaid on a Google Earth map of Akure where on-screen digitising was employed to extract the built-up area and streets. Using the Google Earth map complemented with the ground-truthing, the densities of the buildings were digitised to classify the study area into three residential zones: High-density, Medium-density, and Low-density residential zones.

The first step in the analysis of data obtained through the questionnaire involved the identification of parameters and variables for assessment. Two parameters were involved in the analysis; the socio-economic status of respondents and the quality of buildings (Table 4).

Table 4. Parameters and Variables for Assessment.

S/N	Parameters	Variables	Tag
1.	Socio-economic (n = 6)	Age	x_1
		Gender	x_2
		Marital Status	x_3
		Level of Education	x_4
		Occupation	x_5
		Average Income	x_6
2.	Housing Quality (n = 11)	House Type	y_1
		Floor	y_2
		Wall	y_3
		Painting	y_4
		Roof	y_5
		Ceiling	y_6
		Water	y_7
		Toilet	y_8
		Waste	y_9
		Electricity	y_{10}
		Fence	y_{11}

Data obtained through the questionnaire were analysed using percentages and mean which were used to assess the socio-economic characteristics of heads of households in Akure, and to evaluate the characteristics and quality of housing units in Akure. The relationship between socioeconomic status and the quality of buildings occupied by respondents in the study area was determined using Pearson Correlation Coefficient (Equation 3). The purpose of the Pearson correlation coefficient (denoted by r and also known as Pearson product-moment correlation coefficient) is to determine the relationship between two quantitative variables and the degree to which the two variables coincide with each another. In this study, the Pearson correlation coefficient was employed to measure the linear relationship between socioeconomic status and the quality of buildings in the study area.

$$r = \frac{\Sigma(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\Sigma(x_i-\bar{x})^2\sqrt{(y_i-\bar{y})^2}}} \qquad \text{(Eq. 3)}$$

Where:

x = socio-economic characteristics of respondents (x_{1-6}, Table 4)

y = the quality of the building (y_{1-11}, Table 4)

In Pearson Correlation Coefficient, the correlation is strong (or high) if r is ±0.50 ≤ ± 1; moderate degree if r r is ±0.30 ≤ ± 0.49, and low (or small) correlation when the value lies below +0.29.

Housing quality was derived by finding the average of the mean values of y_{1-11} (Equation 4).

$$y = \sum (\bar{y}_1 + \bar{y}_2 + \ldots\ldots \bar{y}_{11})/n \qquad \text{(Eq. 4)}$$

Therefore, the variance of housing quality was derived by finding the average of the variance values of y_{1-11} (Equation 5).

$$y = \sum (vy_1 + vy_2 + \ldots\ldots vy_{11})/n \quad \text{(Eq. 5)}$$

4. Results and Discussion

4.1. Image Analysis

This section contains the results of image analysis such as classification into land use/cover classes, area statistics calculation, accuracy assessment, and extraction of the built-up class.

4.1.1. General landcover of the study area

For this analysis, the land use and land cover (LULC) in the study area were classified into two broad classes; built-up and non-built-up areas (Table 5). While the non-built-up area covered just about a quarter of the total land area (26.9%), the built-up covered 73.1% (Table 5).

Table 5. Imagery classification.

Class Name	Area covered (km²)	% (of Total Land area)
Built-up	724.42	73.1
Non-built up	266.58	26.9
Total	**991**	**100**

Sources: Landsat OLI/TIRS 2021 (Path 190 Row 55).

Figure 2 shows the spatial occurrence and area extent of the two classified land covers in Akure in 2021. The built-up was found in almost every part of the study area. Although the built-up area has spread to almost every part of Akure, there were still patches of non-built-up portions in the city. At this stage, Akure can be described as a fully developed urban centre in 2021.

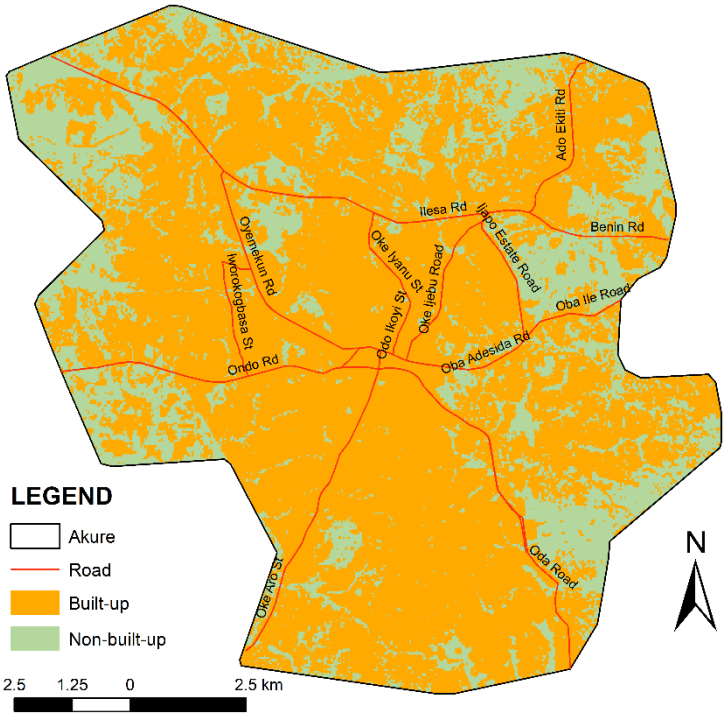

Figure 2. General landcover of Akure, 2021.

4.1.2. Results of accuracy assessment

Results of the image classification accuracy assessment indicate that the producer's accuracy (PA) = 97.66, the user's accuracy (UA) = 100.00, and the overall accuracy (OA) was 99.74% (Table 6). Kappa analysis was 0.9237 and z statistic yielded 44.08. These values indicate that there were significant agreements between the validation points and the extracted classes (Zanon *et al.*, 2019).

Table 6. Imagery classification and accuracy assessment.

Class Name	Land Area (km²)	% (of Total Land area)	PA	UA
Built-up	724.42	73.1	97.66	100.00
Non-built up	266.58	26.9	93.09	99.87
Total	991	100		
Overall Accuracy = 99.74%				
Kappa Statistics (k) = 0.9237				
Z statistics = 44.08				

Sources: Landsat OLI/TIRS 2021 (Path 190 Row 55)
Note: PA = producer's accuracy, UA = user's accuracy, OA = overall accuracy

4.2. The Built-up Area of Akure

The built-up area comprises residential quarters, business premises, and public utility buildings. Residential quarters provide accommodation for the human being; they are where man lives. Business premises are areas of commerce and economic activities. The business premises also include areas of industrial activities, whether local (indigenous) or modern. Public utility buildings are such areas that provide a common palace for community/township activities. Among such public buildings are the king's palace, town hall, places of worship (churches and mosques), all-day open market system, police station as well as educational and health institutions. Figure 3 shows the spatial occurrence and the extent of the built-up area of Akure in 2021. The built-up area occupied an area of 724.42 km² (73.11%) spread to every part of the study area.

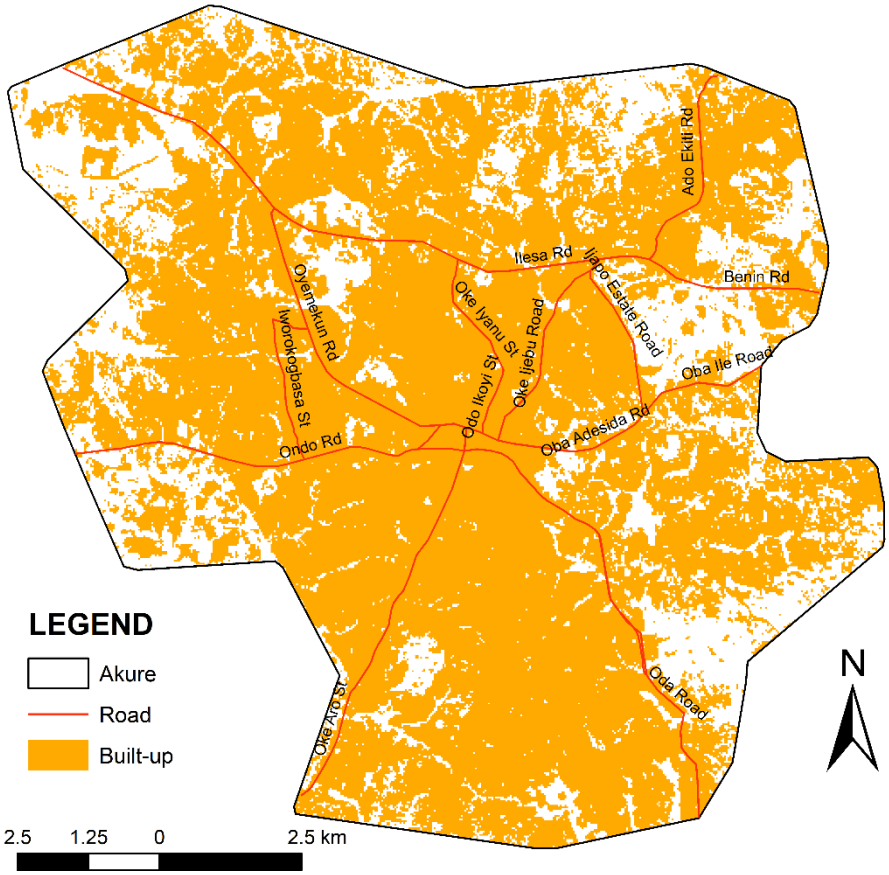

Figure 3. The Built-up Area of Akure, 2021.
Source: Landsat 8 OLI/TIR, 2021

4.2.1. Pattern of the Residential Neighbourhood

The residential neighbourhood includes all areas occupied by residential buildings. These buildings were found in every part of the study area; however, the heaviest density was in the central part of the study area where the development impulses were more concentrated. Public utility buildings like the palace, town hall, many places of worship (churches and mosques), all-day open market system and oldest buildings in the city were found to form circular rings around Arakale, Igisan, Oba-Adesida Road, and CMS areas of the settlement (Figure 4). Asides from this concentration, sporadic developments dotted some areas in the northern and eastern parts of the study area. The pattern exhibited by the built-up area in the central part was found to be following the Concentric Zonation pattern identified by Burgess in 1925 (Figure 4).

Housing developments were found to follow the axial corridors created by the roads. This is most noticeable along Akure – Benin, Akure – Ado Ekiti, Akure – Ondo, and Akure – Ilesa roads (Figure 4). Thus, this encouraged the development of a linear pattern of growth similar to Hoyt's sectorial pattern (Hoyt, 1939).

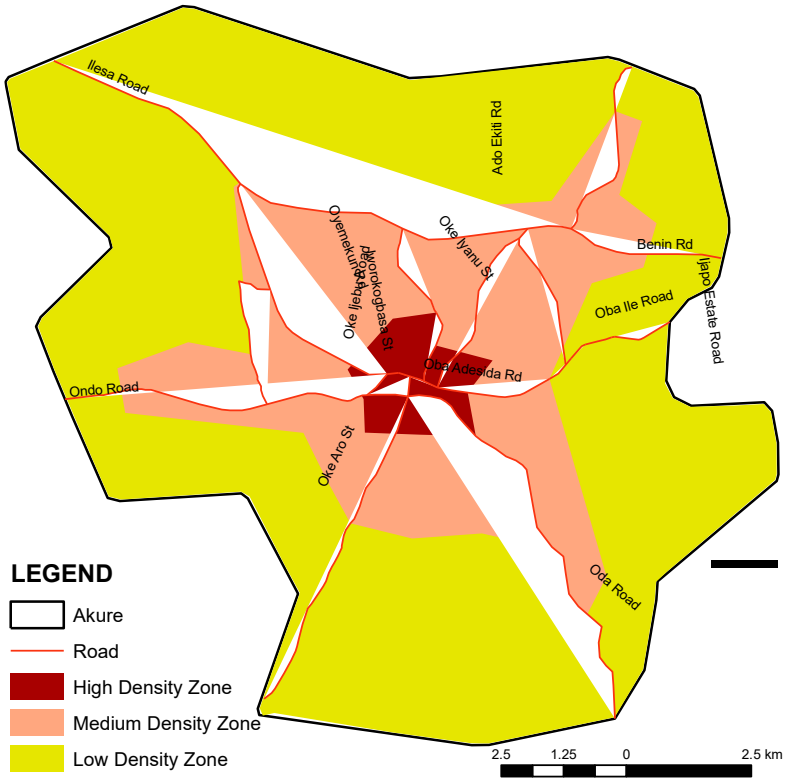

Figure 4. Pattern of Residential Neighbourhood in Akure.

4.3. Socio-Economic Characteristics of Respondents

The average monthly income of respondents was based on a threshold of ₦30,000 ($66.67) which was the minimum labour wage in the country at the time of this study. Respondents in the area were well-educated with only 13.8% without any formal education. Also, the majority of the respondents were gainfully employed; only 11.5% were either students or unemployed. However, at the zonal level of analysis, there were some internal disparities in the socio-economic characteristics of respondents. For instance, whereas primary and secondary education were mostly favoured in the HRZ, secondary and tertiary education were more prominent in the other zones. Also, in the HRZ and MRZ, trading and craftmanship were the major human occupations, while civil service and trading were the most attractive occupations in the LRZ. Though, income distribution appears to be similar across the three zones; the point of departure was in the spread of middle-high income (₦200,001; $444.44 - ₦500,000; $1,111.11); the majority of whom were found in the LRZ (Table 7).

Table 7. Socio-Economic Characteristics of Respondents.

Tag	Characteristics	Residential Zones						Total	
		High		Medium		Low			
		N	%	n	%	N	%	N	%
X1	**Age**								
	18 - 40 years	31	15.9	26	21.8	9	13.1	66	17.2
	41 – 65 years	86	44.1	54	45.4	23	33.3	163	42.6
	Above 65	78	40.0	39	32.8	37	53.6	154	40.2
	Total	**195**	**100**	**119**	**100**	**69**	**100**	**383**	**100**
X2	**Gender**								
	Male	122	62.6	78	65.5	51	73.9	251	65.5
	Female	73	37.4	41	34.5	18	26.1	132	34.5
	Total	**195**	**100**	**119**	**100**	**69**	**100**	**383**	**100**
X3	Marital Status								
	Married	88	45.1	76	63.9	36	52.2	200	52.2
	Single	36	18.5	20	16.8	27	39.1	83	21.7
	Divorced	24	12.3	8	6.7	4	5.8	36	9.4
	Widowed	47	24.1	15	12.6	2	2.9	64	16.7
	Total	**195**	**100**	**119**	**100**	**69**	**100**	**383**	**100**

X4	**Level of Education**								
	No Formal Education	32	16.4	13	10.9	8	11.6	53	13.8
	Primary Education	51	26.2	28	23.5	4	5.8	83	21.7
	Secondary Education	74	37.9	42	35.3	21	30.4	137	35.8
	Tertiary Education	38	19.5	36	30.3	36	52.2	110	28.7
	Total	**195**	**100**	**119**	**100**	**69**	**100**	**383**	**100**
X5	**Occupation**								
	Civil Service	14	7.2	21	17.6	31	44.9	66	17.2
	Self-employed/Craftsmanship	65	33.3	39	32.8	7	10.1	111	29.0
	Trading	72	36.9	30	25.2	12	17.4	114	29.8
	Others	21	10.8	16	13.4	11	15.9	48	12.5
	Unemployed	23	11.8	13	10.9	8	11.6	44	11.5
	Total	**195**	**100**	**119**	**100**	**69**	**100**	**383**	**100**
X6	**Average Monthly Income**								
	< ₦30,000* (< $66.67**)	48	24.6	34	28.6	10	14.5	92	24.0
	₦30,000 ($66.67) - ₦100,000 ($222.22)	82	42.1	31	26.0	8	11.6	121	31.6
	₦100,001 ($222.22) - ₦200,000 ($444.44)	34	17.4	22	18.5	21	30.4	77	20.1
	₦200,001 ($444.44) - ₦500,000 ($1,111.11)	28	14.4	23	19.3	24	34.8	75	19.6
	>₦500,000 (> $1,111.11)	3	1.5	9	7.6	6	8.7	19	4.7
	Total	**195**	**100**	**119**	**100**	**69**	**100**	**383**	**100**

Source: *Field Research, 2021*
Notes: **The official minimum wage in Nigeria was ₦30,000 (USD 66.67) per month.*
***Conversion was based on a conversion rate of ₦450 to $1 as of September 2021*

4.4. Quality and Characteristics of Residential Houses

The most common types of residential housing units in the study area were of the traditional type (50.1%). Modern flat buildings and duplexes were more common in the low residential area. Materials used for flooring indicated that modern techniques were not yet fully adopted in the study area; concrete or cement flooring styles still predominates in Akure at an average of 50.9% with the highest proportion found in the high-density residential zone (66.2%). Modern and fashionable flooring styles were not fully adopted; while only 44.6% were tilled, just 3.4% used terrazzo materials (Table 8). However, standard roofing and ceiling materials were being gradually accepted in the area (asbestos ceiling, 50.1%; plastic P. O. P. 24.5%; carved P. O. P 22.5%). Results indicated that 67.1% of the sampled houses were fully plastered. However, internal variations between the zones reveal that 75.9% in the high-density zone and 71.0% in the low-density zone were fully plastered. This contrasted the situation in the medium-density zone where only 50.4% were fully plastered; none of the buildings was with mud walls. (Table 8).

Table 8. Quality and Characteristics of Residential Buildings in Akure.

Tag	Materials Used for Construction	Residential Zones						Total	
		High		Medium		Low			
		n	%	n	%	n	%	N	%
Y1	**House Type**								
	Traditional compound (Bungalow)	84	43.1	16	13.4	7	10.1	107	27.9
	Traditional compound (Storey Building)	43	22.1	27	22.7	15	21.7	85	22.2
	Traditional compound (mixed)	9	4.6	5	4.2	0	0.0	14	3.7
	Bungalow (flat)	32	16.4	41	34.5	18	26.1	91	23.8
	Storey Building (Multi-flat)	21	10.8	16	13.4	6	8.7	43	11.2
	Duplex	6	3.1	14	11.8	23	33.3	43	11.2
	Total	195	100	119	100	69	100	383	100
Y2	**Flooring**								
	Mud or Earth	3	1.5	0	0.0	1	1.4	4	1.0
	Concrete/Cement	129	66.2	62	52.1	4	5.8	195	50.9
	Tiles	62	31.8	51	42.9	58	84.1	171	44.6
	Terrazzo/Granolithic	1	0.5	6	5.0	6	8.7	13	3.4
	Total	195	100	119	100	69	100	383	100
Y3	**Walling**								
	Mud only	3	1.5	0	0.0	1	1.4	4	1.0
	Plastered mud	16	8.2	9	7.6	2	2.9	27	7.0
	Clay bricks	7	3.6	16	13.4	12	17.4	35	9.1
	Concrete blocks	21	10.8	34	28.6	5	7.2	60	15.7
	Plastered concrete blocks	148	75.9	60	50.4	49	71.0	257	67.1
	Total	195	100	119	100	69	100	383	100

Y4	**Roofing**								
	Asbestos sheets (Addex)	10	5.1	2	1.7	2	2.9	14	3.7
	Concrete Deck	8	4.1	13	10.9	7	10.1	28	7.3
	Zinc	175	89.7	96	80.7	25	36.2	296	77.3
	Roofing Tiles	2	1.0	8	6.7	35	50.7	45	11.7
	Total	195	100	119	100	69	100	383	100
Y5	**Ceiling Materials**								
	Asbestos	110	56.4	59	49.6	23	33.3	192	50.1
	Concrete	8	4.1	3	2.5	0	0.0	11	2.9
	Carved P. O. P.	19	9.7	36	30.3	31	44.9	86	22.5
	Plastic P. O. P.	58	29.7	21	17.6	15	21.7	94	24.5
	Total	195	100	119	100	69	100	383	100
Y6	**Painting**								
	Entire Building	76	39.0	52	43.7	42	60.9	170	44.4
	Inside only	32	16.4	21	17.6	13	18.8	66	17.2
	Outside only	1	0.5	3	2.5	1	1.4	5	1.3
	Not painted	64	32.8	41	34.5	9	13.0	114	29.8
	Others	22	11.3	2	1.7	4	5.8	28	7.3
	Total	195	100	119	100	69	100	383	100
Y7	**Water Sources (main source)**								
	Borehole	39	20.0	37	31.1	43	62.3	119	31.1
	Well	103	52.8	64	53.8	19	27.5	186	48.6
	River/stream	0	0.0	1	0.8	1	1.4	2	0.5
	Public water service	53	27.2	17	14.3	6	8.7	76	19.8
	Total	195	100	119	100	69	100	383	100
Y8	**Toilet facility**								
	Water system	110	56.4	71	59.7	59	85.5	240	62.7
	Pit	29	14.9	31	26.0	4	5.8	64	16.7
	Bush	0	0.0	0	0.0	4	5.8	4	1.0
	River/stream	0	0.0	1	0.8	1	1.4	2	0.5
	Public toilet	56	28.7	16	13.4	1	1.4	73	19.1
	Total	195	100	119	100	69	100	383	100
Y9	**Electricity (main source)**								
	Public	14	7.2	12	10.1	10	14.5	36	9.4
	Generator	153	78.5	69	58.0	28	40.6	250	65.3
	Solar/inverter	22	11.3	36	30.3	29	42.0	87	22.7
	Others (candles, lanterns, rechargeable lamps)	6	3.1	2	1.7	2		10	2.6
	Total	195	100	119	100	69	100	383	100
Y9	**Security fence**								
	Full	61	31.3	68	57.1	49	71.0	178	46.5
	Part	14	7.2	23	19.3	13	18.8	50	13.1
	None	120	61.5	28	23.5	7	10.1	155	40.5
	Total	195	100	119	100	69	100	383	100
Y10	**Waste disposal**								
	Containers/bags	27	13.8	21	17.6	8	11.6	56	14.6
	Open dump site	33	16.9	12	10.1	1	1.4	46	12.0
	Gutter	7	3.6	1	0.8	2	2.9	10	2.6
	Public dust bin	72	36.9	59	49.6	21	30.4	152	39.7
	Private collector	31	15.9	14	11.8	27	39.1	72	18.8
	Burning	19	9.7	5	4.2	7	10.1	31	8.1
	Landfilling	4	2.1	7	5.9	2	2.9	13	3.4
	Stream	2	1.0	0	0.0	1	1.4	3	0.8
	Total	195	100	119	100	69	100	383	100

Source: Field Research, 2021

4.5. Correlation between Socio-Economic Characteristics and House Quality

Results of coefficients of correlation between socio-economic characteristics of respondents and house quality at the level of the residential zone in Akure, Nigeria indicated that there were high correlations between house quality and level of education (r = 0.99) in the high- and medium-density residential zones (Table 9). In the low-density residential zone, only occupation had a significant relationship with housing quality (r = 0.60). There were inverse correlations between housing quality and average monthly income (-0.454), and marital status (-0.689).

Table 9. Correlation between Socio-economic Characteristics and Housing Quality (by Zone).

	House Quality	Age	Gender	Level of Education	Occupation	Average Annual Income	Marital Status
High-Density Residential Zone							
Housing	1.000						
Age	0.613	1.000					
Gender	0.338	0.796	1.000				
Level of Education	0.993	0.871	0.678	1.000			
Occupation	0.428	0.813	0.769	0.813	1.000		
Average Annual Income	0.978	0.886	0.750	0.919	0.797	1.000	
Marital Status	0.868	0.909	0.926	0.805	0.077	0.952	1.000
Medium-Density Residential Zone							
Housing	1.000						
Age	0.736	1.000					
Gender	0.695	0.698	1.000				
Level of Education	0.900	0.901	0.767	1.000	0.334		
Occupation	0.313	0.924	0.879	0.334	1.000		
Average Annual Income	-0.454	0.906	0.805	-0.285	-0.904	1.000	
Marital Status	-0.689	0.898	0.967	-0.909	-0.573	0.374	1.000
Low-Density Residential Zone							
Housing	1.000						
Age	0.922	1.000					
Gender	0.426	0.817	1.000				
Level of Education	0.408	0.913	0.678	1.000			
Occupation	0.601	0.877	0.769	0.442	1.000		
Average Annual Income	0.470	0.968	0.750	0.129	0.508	1.000	
Marital Status	0.366	0.997	0.914	0.997	-0.464	-0.154	1.000

Source: Field Research, 2021

At the level of the entire city, results indicate that all the socio-economic characteristics considered have a high correlation with the quality of residential housing units occupied by the respondents. Level of education with a correlation coefficient of 0.588 has the weakest correlation with housing quality in the study area (Table 10).

Table 10. Aggregate Correlation of Housing Quality and Socio-Economic factors.

	House Quality	Age	Gender	Level of Education	Occupation	Average Annual Income	Marital Status
High-Density Residential Zone							
Housing	1.000						
Age	0.613	1.000					
Gender	0.338	0.796	1.000				
Level of Education	0.993	0.871	0.678	1.000			
Occupation	0.428	0.813	0.769	0.813	1.000		
Average Annual Income	0.978	0.886	0.750	0.919	0.797	1.000	
Marital Status	0.868	0.909	0.926	0.805	0.077	0.952	1.000

Source: Field Research, 2021

4.6. Discussion

The socioeconomic variables considered in this study spread across all works of life. The high similarity of some of the socio-economic characteristics considered among the three residential zones in the study area indicates that the population in the study was of homogeneous characteristics. Results of the general land use/cover analysis through Landsat imageries show that more than half (55.1%) of the total land in the study area had been built up. Though there were sporadic developments in other parts, there was a remarkable expansion of the built-up area in the central part. This corroborates the findings of other studies that residential land accounts for the largest proportion of total urban land uses in many African

cities (Coker *et al*., 2008; Arku *et al*., 2011; Ezeanah, 2020).

Like Ogu (2002), this study identified three residential zones in the study area based on building densities (high-density, medium-density, and high-density zones). The high-density zone is the core area of the city where the oldest buildings are found; this is where the settlement started. The zone lacks planning controls and there was a very little touch of modern technology in the housing standards. However, some of the buildings have been either renovated or reconstructed, particularly along the major roads. This zone houses the largest share of the business and economic activities in the city; therefore, the area was swarming with a large population, and of course the attendant noisy environment.

In the medium-density residential zone, there were traces of the introduction of new waves of development. The houses were of better quality than in the old core of the city. The majority of the inhabitants of this zone were average-income earners who were able to own a house or afford to pay the house rent. This zone contains more roads, most of which lead outwards from the city. Thus, in place of the concentric pattern formed in the high-density zone, foundations for the sectorial pattern were laid in the medium-density area. The low-density residential zone was a bit more orderly with sophisticated building materials than other zones. In agreement with Jiboye (2010), housing facilities in this zone were found to be better and more sufficient than in the other zones. Residential houses in this zone agree with the description of some earlier studies that housing is not just a shelter because it includes all the social services and utilities that make a neighbourhood a habitable setting (Kearney, 2006; Adeleye *et al*., 2014; Brkanic, 2017).

The observed variations in the quality and characteristics across the different residential zones in Akure might not be unconnected with the educational levels and type of occupation of the inhabitants (see Table 7). Considering the settlement at large, though mud walls and earth-surfaced floors are fast disappearings in the study area, the result indicates that the level of technology of building construction in the area was still at a rudimentary level.

5. Conclusion

This study has shed some light on the quality and condition of residential housing in Akure, especially in terms of adequacy of basic housing utilities as well as relationships between the socio-economic characteristics of residents and the quality of buildings occupied in Akure, Nigeria. Results of the study have revealed that there were differential relationships between house quality and the socio-economic characteristics of respondents across the three residential zones in Akure, Nigeria. For instance, there were high correlations between house quality and level of education in the high- and medium-density residential zones. In the low-density residential zone, only occupation had a noteworthy relationship with housing quality. However, there were inverse correlations between housing quality and an average monthly income as well as marital status in all the zones. Moreover, the study observed that inadequate housing facilities are fundamental to the observed deteriorating housing qualities in the study area. Therefore, the study recommends as follows.

First, for sustainable housing delivery in the study area, house owners should be educated on the relationship between essential housing facilities and the health of the inhabitants. This will encourage property owners to accept any byelaws that may be enacted to induce housing providers to provide certain basic services in their houses. Second, noting that poor housing quality is linked with low income, poverty alleviation programmes should be improved to reduce the unemployment rate in the country which will enhance the provision for basic household facilities and proper maintenance of buildings. Moreover, there is a need for a renewal programme through a renovation approach and the construction of more roads to open the devastated areas.

Although few concepts of housing quality were explored in this study, it makes some relevant contributions to the existing body of knowledge on housing research. It has shed some light on the opinions of residents on the quality and condition of housing in Akure, Nigeria. Also, the study has successfully employed Remote Sensing and Geographical Information System techniques to evaluate the pattern and quality of residential housing units which did previously not exist in the study area. In addition to this, the study has incorporated housing patterns and housing quality in just one research, which is very infrequent. Furthermore, the findings of the study, through the statistical analysis of the correlation between the socio-economic characteristics of respondents and house quality, have provided a set of specific factors influencing house quality and characteristics in the study area. Nonetheless, one major policy implication that can be drawn from the findings of this study is that adequate and effective measures to ensure residential land use development control should be introduced. Therefore, it is hoped that the findings of this study will provide a sufficient basis for policy attention on housing improvements in major urban centres in the country. The evaluated concepts can serve as a basis for further studies on housing quality assessment. Also, this study can be used as a

foundation for the evaluation of other sets of valuable criteria for analysing the characteristics and quality of residential housing.

Acknowledgements
The authors gratefully acknowledge the support from the African Regional Institute for Geospatial Information Science and Technology (AFRIGIST), Obafemi Awolowo University, Ile-Ife for providing relevant and necessary materials required for carrying out this study. Also, the author thanks the anonymous reviewers for their insightful comments and valuable suggestions.

Funding
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interests
The author declared that there was no conflict of interest relating to the conduct, outcome, and publication of this study.

Data availability statement
Raw data were generated from remotely sensed data. Derived data supporting the findings of this study are available from the corresponding author [A.M.] on request.

Ethics statements
Studies involving animal subjects: *No animal studies are presented in this manuscript.*
Studies involving human subjects: No human studies are presented in this manuscript.
Inclusion of identifiable human data: No potentially identifiable human images or data is presented in this study.

CRedit author statement
Conceptualization: A.M., O.A. Data curation: A.M., O.A. Formal analysis: A.M., O.A. Funding acquisition: No funding Investigation: A.M., O.A. Methodology: A.M., O.A. Project administration: A.M.. Writing—original draft: A.M. Writing—review and editing: A.M., O.A.. Both authors have read and agreed to the published version of the manuscript.

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How to cite this article:
Olayiwola, A. M., & Ajala, O. A. (2022). Correlation between Socio-Economic Characteristics and Housing Quality of Residential Neighbourhoods in Akure, Southwest Nigeria. *Journal of Contemporary Urban Affairs, 6*(2), 217-231. https://doi.org/10.25034/ijcua.2022.v6n2-8

Journal of Contemporary Urban Affairs

2022, Volume 6, Number 2, pages 233–248

Original scientific paper

The Role of Home Gardens in Developing Cities for Improving Workers' Psychological Conditions

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ARTICLE INFO:

Article History:
Received: 15 August 2022
Revised: 15 October 2022
Accepted: 11 November 2022
Available online: 18 November 2022

Keywords:
Home garden;
Green open spaces;
Psychological effects;
Stress level;
Java Island.

ABSTRACT

During the lockdown period, people were restricted from doing many things, particularly activities outside the home, putting strain on psychological circumstances. This study intends to demonstrate that providing a home garden to improve the psychological state of the workers' community may alleviate the challenges of access to green open space in city settings. This study investigates the psychological state of employees and the impact of home gardens on the psychological state of workers in numerous cities in Indonesia during the pandemic. The survey was carried out utilising the Snowball sampling approach by asking various questions and filling out a questionnaire on the participants' backgrounds and psychological problems using PSS-14 and WEMWBS. Data from participants were analysed using correlation and ANOVA. According to the findings of this study, the presence of a home garden utilised for activities has a substantial impact on the psychological condition of the working community. It is advised that the workers' community participate in activities in the home garden five days a week for at least one hour. On the other hand, it is suggested that urban housing developers pay more attention to the house garden and its constituent aspects.

JOURNAL OF CONTEMPORARY URBAN AFFAIRS (2022), ***6***(2), 233-248.
https://doi.org/10.25034/ijcua.2022.v6n2-9

www.ijcua.com

1. Introduction

Urbanization, which is expanding year after year, makes big cities in many countries more congested and disorganised (Houlden et al., 2018). The increased urbanisation adds to a reduction in the number of fields that may be utilised as green open spaces (GOS). This occurs in several major cities, particularly on Java Island, including Jakarta, Bandung, Semarang, Jogjakarta, and Surabaya (Budiman et al., 2014). In some cities, more than 20% of green open areas are removed in less than or more than ten years (Budiman et al., 2014). As previously stated, just 12.12% of Jakarta's land area is utilised for GOS. This reality contradicts the rule written in the Indonesian Republic No. 26 in 2007 about Space

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How to cite this article:
Lazuardi, S. N., Sulistyantara, B., & Pratiwi, P. I. (2022). The Role of Home Gardens in Developing Cities for Improving Workers' Psychological Conditions. *Journal of Contemporary Urban Affairs, 6*(2), 233-248. https://doi.org/10.25034/ijcua.2022.v6n2-9

Structuring (Article 29) and Government Regulation No. 15 in 2010 about The Implementation of Space Structuring (Article 36), which states that the ideal GOS is at least 30% of the city area width (20% public GOS and 10% private GOS).

The benefits of having GOS include offering a space for sports, social events, or nature-related activities, providing fresh air, and making the environment become physically (de Vries et al., 2003) and mentally (Douglas et al., 2017; Houlden et al., 2018) healthier. Maintaining their bodies' psychological and physiological health is critical for persons who live in densely populated cities and are serious about their employment. These circumstances compel everyone to take a break in order to return to work in good spirits and with a healthy body. Sports improve cardiac function, bodily flexibility, and emotional state greatly (Xie et al., 2020). Aside from that, social engagement is important for both types of wellness. People engage more when they interact with others around them. It will improve their psychological and bodily well-being indirectly (Kemperman & Timmermans, 2014; Pratiwi et al., 2019, 2020; Xie et al., 2020). Meanwhile, activities that may be done outside the house are prohibited during the pandemic. The limitation makes access to public green open spaces, which may be utilised as a facility to refresh the body, exceedingly limited.

During large-scale social restrictions (lockdown in a large region) in Indonesia, individuals are severely restricted in many ways, particularly the activities they can engage in outside the home. This case strains the psychological state and individual prosperity (Pfefferbaum & North, 2020). Citizens in some European countries opt to find green areas closer to their homes to address the issue of a shortage of activities outside the house. This situation leads to an increase in the number of persons visiting green spaces fewer than 200 metres from their homes (Ugolini et al., 2020). Subsequent research indicates that the increased infection risk is to blame for the decline in outside room activities, particularly visits to green spaces during the pandemic. Due to this risk, individuals are advised to attend to the nearest green space (Xie et al., 2020). The use of the home garden as the closest green area to the living space as a facility to stabilise the psychological state, such as lowering the degree of stress, becomes the subject of this study.

The difficulty of accessing green open spaces in metropolitan areas, as well as the increasing psychological health of the working community during the pandemic, prompted researchers to consider if these two issues might be addressed in one way, by providing appropriate land for home gardens. Furthermore, individuals in major cities, particularly in Indonesia, are losing sight of the importance of having a garden in their houses for physical and psychological well-being. As a result, this study generates the premise that having a home garden will alleviate these concerns. In this situation, a home garden is defined as a field that is large enough to give the ideal space for the individual or all family members and contains plants that help address psychological difficulties, particularly those caused by everyday life pressures.

As a result, this study will examine the psychological impacts of the availability of home gardens and the sorts of activities performed within the home to mitigate the effects of stress on employees. This study intends to examine the workers' psychological conditions, particularly their stress levels, and to discover the impacts of home gardens on the psychological conditions of the people who reside in the house, particularly employees who live in certain major cities in Indonesia. The benefit sought from this study is to share knowledge with society, particularly Indonesians. In this example, the knowledge is connected to the effect of a home garden on psychological conditions. This study argues that having a home garden might help avoid psychological disorders caused by work stress or stress during a pandemic that may return in the future.

2. Materials and Methods

2.1 Experiment Sites

The study was conducted across Java Island, located at 113°48'10" - 113°48'26" EL and 7°50'10" - 7°56'41" SL (Figure 1), which has a population number 56,10% of the total Indonesian People in 2020 and has productive age workers as big as 56,87% of the total productive age workers in Indonesia in 2022. Java Island has the highest proportion of productive-age employees among Indonesian islands (BPS-Statistics Indonesia, 2022). This study uses Java Island as a case study since its development and population growth rates are the fastest, allowing the main cities on this island to be compared to cities in other countries with similar rates. Java Island has 132.107 km^2 for its coverage mainland (Sholeh & Wibowo, 2015), and its geographical boundaries are as follows:

North Boundary: Java Sea
East Boundary: Bali Strait and Bali Island
South Boundary: Indian Ocean

West Boundary: Sunda Strait and Sumatera Island

This research was conducted online on Java Island from November 2021 to March 2022, with three phases of deployment. The first part consists of developing the research proposal and obtaining approval from November to December 2021. In January 2022, the second phase began with a preliminary survey and was expanded with the layout of questions focusing on the individual's psychological health and the condition of each home garden. The last phase is gathering qualitative and quantitative data about research subjects via questionnaires.

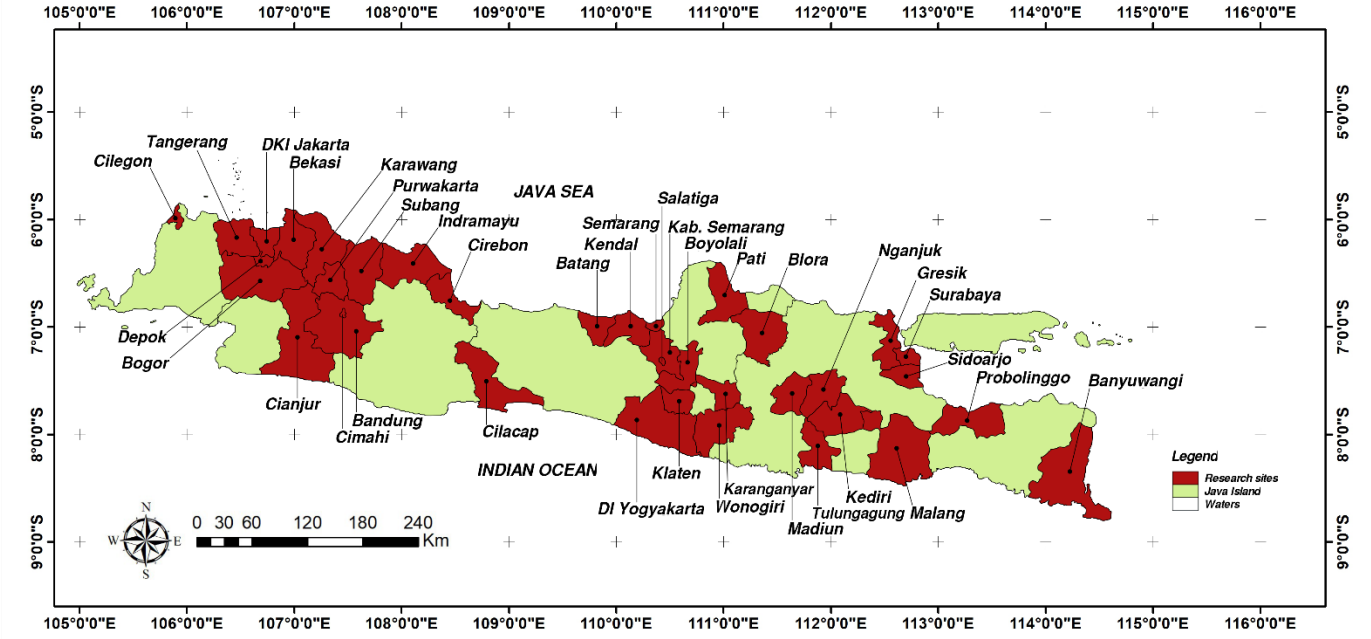

Figure 1. Study location map.

Note: Banten (Cilegon, Tangerang), DKI Jakarta, West Java (Bandung, Bekasi, Bogor, Cianjur, Cimahi, Cirebon, Depok, Indramayu, Karawang, Purwakarta, Subang), Central Java (Batang, Blora, Boyolali, Cilacap, Karanganyar, Kendal, Klaten, Pati, Semarang, Wonogiri), DI Yogyakarta, East Java (Banyuwangi, Gresik, Kediri, Madiun, Malang, Nganjuk, Probolinggo, Sidoarjo, Surabaya, Tulungagung)

2.2 Data Collection

The study makes use of both primary and secondary data. The primary data utilised was obtained via an online questionnaire, while secondary data was obtained from a literature review (Table 1).

Table 1. Types, forms, and sources of study data.

Data type	Data form	Data source
Geographical site	Map (location, border, and width)	Literature study
Participants' psychological condition	Descriptive	Questioner
The useful and influence of home garden	Descriptive	Questioner and literature study

The data was collected from the study participants by distributing questionnaires using online snowball sampling. Based on the findings of the shared questionnaires, the sample population was expanded as far as possible. The first questionnaire was sent at random to Java Island residents using social media platforms such as WhatsApp, Twitter, and Instagram. The research participants who had completed the questionnaires were re-evaluated to ensure that they met their requirements. The study began with a preliminary survey of the home gardens and the conditions of the participants. The survey on the participants' home gardens was exclusively performed online, using questionnaires that included questions about the garden's condition, total area, garden components, plant varieties, and the number of plants in the home garden. It was then expanded by conducting a poll of the participants. Some questions were asked via questionnaires in this poll. Those questions were relevant to the participants' backgrounds, particularly their employment, the health of psychological conditions (stress and mental health levels), and

the participants were required to respond using a Likert 5-point scale (such as very good, good, average, bad or very bad) (Corley et al., 2021). The level of stress is determined by the *Perceived Stress Scale* (PSS-14) (Cohen, S., Kamarck, T., Mermelstein, 1983; Huang et al., 2020; Jiang et al., 2017; Ribeiro Santiago et al., 2020), while the level of mental health is judged by *Warwick-Edinburgh Mental Well Being* Scale (WEMWBS) (Chalmin-Pui et al., 2020, 2021; Wicaksono et al., 2021).

The use of Indonesian PSS-14 questionnaires refers to the studies in Indonesia (Aris et al., 2019), while WEMWBS questionnaires used the version translated into Indonesian language (Wicaksono et al., 2021). Participants in the study were also invited to snap photos of their gardens and upload them to the surveys. This exercise was carried out by the study's participants. Product Moment Pearson's was used to conduct the validity test for the items and factors on the three measuring instruments (WEMWBS and PSS-14). Meanwhile, Cronbach's Alpha approach was utilised to assess the efficacy of both assessment systems (Table 2). WEMWBS has one dimension as a result of the Principal Component Analysis test and the directions for applying each measuring instrument, but PSS-14 has two dimensions. Table 3 contains the specifications for each measuring instrument.

2.3 Participants

Participants in the study originate from the study's area, which is in the cities of Java Island. Participants in the research range in age from 20 to 54 years old and are currently working (Law No. 13 of 2003), either within or outside the home, and not during their school or university studies.

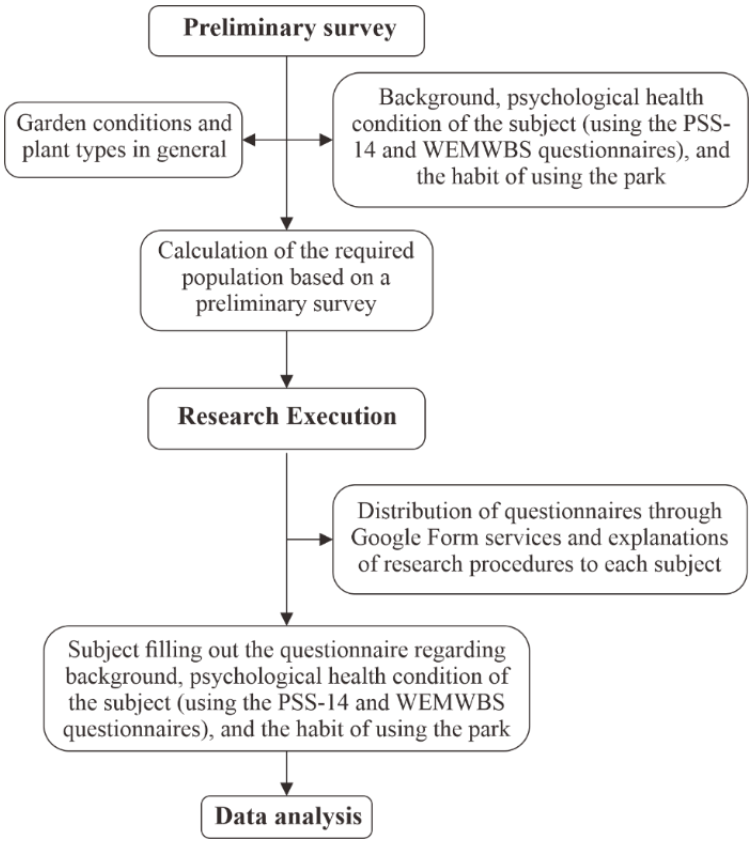

Figure 2. Research flow.

2.4 Analysis Methods

The first phase questionnaire results are assessed utilising the validity and reliability levels via the correlation of Product Moment Pearson's (validity) and Cronbach's alpha (reliability). The sample data is examined using Pearson correlation analysis as well as ANOVA with HSD-Turkey as the extension test on the results of mental well-being and stress level (PSS and WEMWBS) in the groups of individuals who do not have a garden and those who do have a garden. (Corley et al., 2021; Oka et al., 2008; Xie et al., 2020). The data processing application used in this study is IBM SPSS version 26 and RStudio version R-4.0.5.

Table 2. The result of the Validity dan Reliability of the three measurement tools (n=192).

Questionnaire	Factor	Total Item-Correlation (rcit)	Cronbach's a
WEMWBS	Positive	0,603 - 0,803	0,930
PSS-14	Positive	0,325 - 0,667	0,681
	Negative	0,004 - 0,708	0,728

Table 3. The specification of the three measurement tools according to each dimension .

Questionnaire	Dimension	Item	Item Example
WEMWBS	Positive	1 - 14	I feel optimist about my future
PSS-14	Positive	4, 5, 6, 7, 9, 10, 13	How often do you feel optimistic about your ability to handle your problems?
	Negative	1, 2, 3, 8, 11, 12, 14	How often do you feel nervous and stressed?

3. Result

3.1 The Characteristics of Sociodemographic

The total number of participants in both phases of the study is 206. In the first phase, fourteen participants reported that they did not meet the requirements for qualification. Only 107 of the 192 participants in the first phase indicated their ability to proceed to the second phase (second questionnaire), while the remaining seven did not meet the criteria. The following are descriptions of the participants' sociodemographic characteristics based on the questions on the initial questionnaire (Table 6). The average age of the research participants is about 35.5 ± 11.5, and the majority (n = 35) are between the ages of 20 and 24. The gender makeup of the study participants is 38.5% male (n = 74) and 61.5% female (n = 118). West Java Citizens account for 49.5% of participants (n = 95), Special Territory of Yogyakarta accounts for 12.5% (n = 24), DKI Jakarta accounts for 10.9% (n = 21), Central Java accounts for 10.4% (n = 20), East Java accounts for 10.4% (n = 20), and Banten accounts for 6.3% (n = 12). Private workers make up 62.5% (n = 120), public servants make up 13.5% (n = 26), and entrepreneurs make up 24% (n = 46) of the research participants. Aside from the participants' occupations, how they do their duties is also observed. According to the statistics, 41.7% (n = 80) of participants work offline, 21.9% (n = 42) work from home (WFH), and 36.5% (N = 70) work hybrid (a mix of online and offline work settings). As many as 83.3% (n = 160) of the participants do not have a chronic condition, whereas 16.7% (n=32) have one, one of which is bipolar. The study participants are divided into three groups: those who live in village areas as large as 26.6% (n = 51), those who live in housing 60.4% (n = 116), and those who live in cluster occupation 13% (n = 25). Their living arrangements are as follows: private house 55,7% (n = 107), family/relative house 28,6% (n = 55), and boarding/contract house/ 15,6% (n = 30). A garden is available in the homes of 92.7% (n = 178) of the survey participants, whereas 7.3% (n = 14) do not have one.

3.2 Sociodemographic Factors That Are Related to Workers' Psychological Condition

In this study, workers' psychological state refers to their level of mental well-being (as evaluated by WEMWBS) and their level of stress (measured by PSS-14). Figure 3 and Table 4 show the results of the correlation test. Because the state of mental well-being has a significant link to stress, as high as -0,56 ($p<0,01$), it may be inferred that the factor relating to one of the psychological conditions has a connection (indirectly) with other factors. The presence of a garden in the home correlates with stress levels by as much as 0.14 ($p<0,05$), albeit this link is weak. The other component is the age range, which is separated into seven categories. This component is strongly related to the level of mental well-being and stress, as high as 0,33 ($p<0,01$) for mental well-being and -0,31 ($p<0,01$) for mental stress.

The second component that becomes one of the study's focal points is the type of job that is related to stress levels as high as 0.16 ($p<0,05$). The work method factor has a p-value of 0.061, yet it is related to stress levels as high as -0,14. It signifies that there is currently insufficient information to conclude that the work approach is linked to stress levels. Another aspect is the participants' living situation, which is classified into three groups based on their prosperity and stress level, with values ranging

from -0,25 (p<0,05) to 0,21 (p<0,05). However, this figure is regarded as insignificant in terms of influence. The province is the final factor to consider, where the mental well-being level is as high as -0,15 (p<0,05) (Figure 3 & Table 4).

Table 4. The result of the p-value correlation test between psychological condition and sociodemographic factors.

Psychological Condition	Variable/Factor			
	Sex	Age	Health	
Mental Well-being Level (WEMWBS)	0,357	0,000**	0,824	
Stress Level (PSS)	0,653	0,000**	0,521	
	Profession	Work Type	Work Method	
Mental Well-being Level (WEMWBS)	0,982	0,519	0,0869	
Stress Level (PSS)	0,028*	0,508	0,061	
	Province	Environment	Living Status	Garden Existence
Mental Well-being Level (WEMWBS)	0,036*	0,445	0,000**	0,357
Stress Level (PSS)	0,317	0,314	0,003**	0,048*

Note: (*) p-value ≤0,05, (**) p-value ≤0,01; p-value the correlation between mental well-being level and stress level = 0,000**

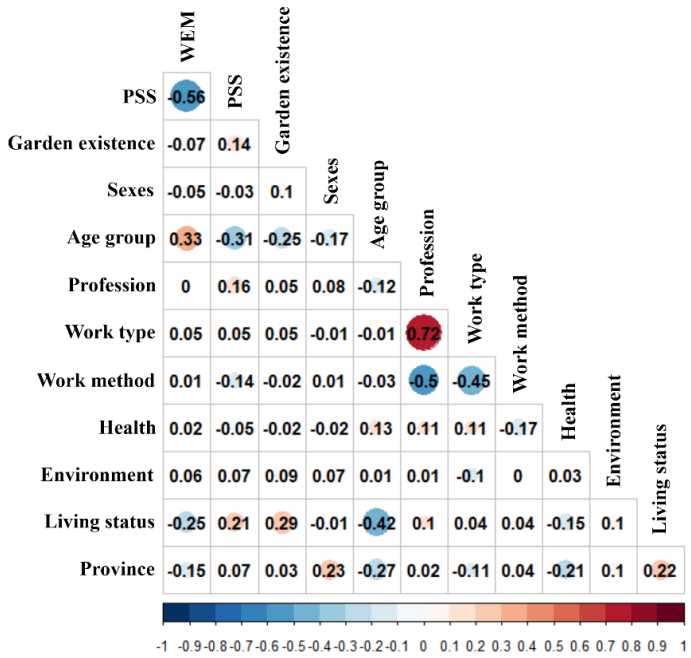

Figure 3. Heat map of psychological condition correlation matric with sociodemographic factor
Note: The number close to 1 and -1 shows a strong correlation.

3.3 Home Garden Condition Factor and the Habits that Have Connection with Psychological Condition.

Figure 4 and Table 5 show the results of the correlation study between psychological conditions and several factors related to the home garden. The variables of garden visiting frequency, length in the park (garden enjoying duration), garden acreage, and plant quantity all influence the level of mental well-being and stress. Only the mental well-being level variable in the water feature component exhibits the relationship. The sorts of activities done indoors and when the participants visit the garden have no associations and do not affect both psychological situations. It may be concluded that only by visiting and interacting with the home garden as a natural landscape, stress levels can be reduced and mental well-being is strengthened.

Table 5. The result of the p-value correlation test between psychological condition and some factors related to a home garden.

Psychological Condition	Variable/Faktor			
	Visiting Frequency	Visiting Duration	Activity Type	Visiting Time
Mental Well-being Level (WEM)	0,007**	0,000**	0,053	0,338
Stress Level (PSS)	0,009**	0,002**	0,198	0,220
	Garden Area	Number of Plants	Water Feature Existence	
Mental Well-being Level (WEM)	0,006**	0,026*	0,008**	
Stress Level (PSS)	0,03*	0,019*	0,164	

Note: (*) p-value ≤0,05, (**) p-value ≤0,01

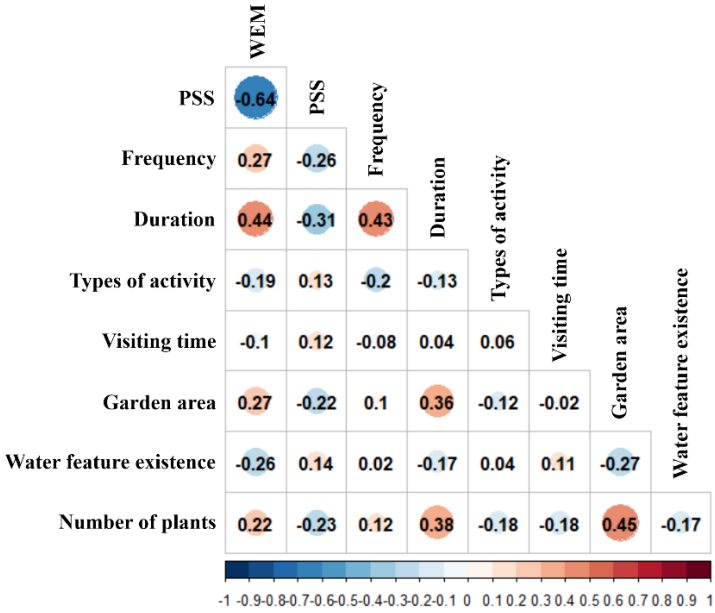

Figure 4. The heat map of psychological condition correlation matric with the factor that is related to a home garden.
Note: The number close to 1 and -1 shows a strong correlation.

4. Discussion

4.1 The Relationship of Age Group to Psychological Condition

Different ages had a strong association (p<0,01) (Table 4) with mental well-being and stress levels as high as 0,33 and -0,31. (Figure 3). If the advanced test using HSD-Tukey and ANOVA is used, the age factor affects the condition of mental well-being level and stress level (p<0,05). In this situation, the age groups 40-44 and 45-49 have the highest levels of mental well-being, while the ages 20-24 and 25-29 have the lowest levels of stress (Figure 5).

The findings back up prior research that claims that age difference affects the psychological condition (Chalmin-Pui et al., 2021; Lehberger et al., 2021; Priyantini et al., 2021; Theodorou et al., 2021). Each age group has its own set of psychological pressures, such as the range of old adult age, which has concerns about their pension time, which affects their psychological state. As they become older, their condition improves (Chalmin-Pui et al., 2021; Theodorou et al., 2021; WHO, 2017) (Figure 4).

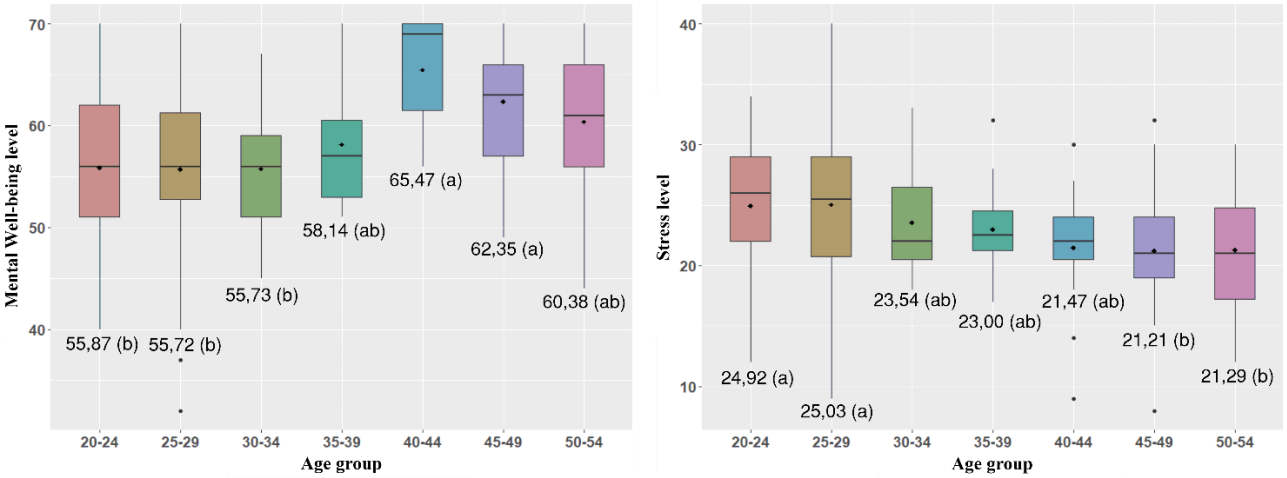

Figure 5. Box plot of age group factor with mental well-being level (left) and stress level (right).

4.2 The Relationship of Profession Types and Work Methods to Psychological Condition

The results demonstrate that there is a link between the types of occupations (p<0,05), however, it is weak to stress levels as low as 0.16. (Table 4 & Figure 3). In contrast, although having larger p-values than (p=0,061), the work approach lacks sufficient evidence to be stated to have a link with stress level (Table 6). The outcome in terms of profession kinds corresponds to what WHO describes. The workplace, according to WHO, is critical for intervening in mental and physical health disorders (WHO, 2017). This scenario can be linked to a change in someone's job load, which also has an impact on his mental health (Haoka et al., 2010). When the test is expanded to include the HSD-Tukey of occupation component, the results show that entrepreneurs and private workers had higher stress levels (23,8 ± 5,9 and 23,7 ± 5,4) than government officials (20,4 ± 5,1) (Figure 6).

The method of work under consideration has no association with stress levels and can nevertheless be determined to have varying averages. The work approach with the highest stress level is the work method performed online. It is reasonable to believe that the work approach has an indirect relationship with stress levels. It happens because there is no direct question on how frequently the research participants interact with the environment outside their residence (particularly during the Coved-19 period) that is specifically designed to address this topic. This notion is founded on past research, which shows that the less one interacts with the outside environment, the worse one's psychological state is (Corley et al., 2021; Pouso et al., 2020).

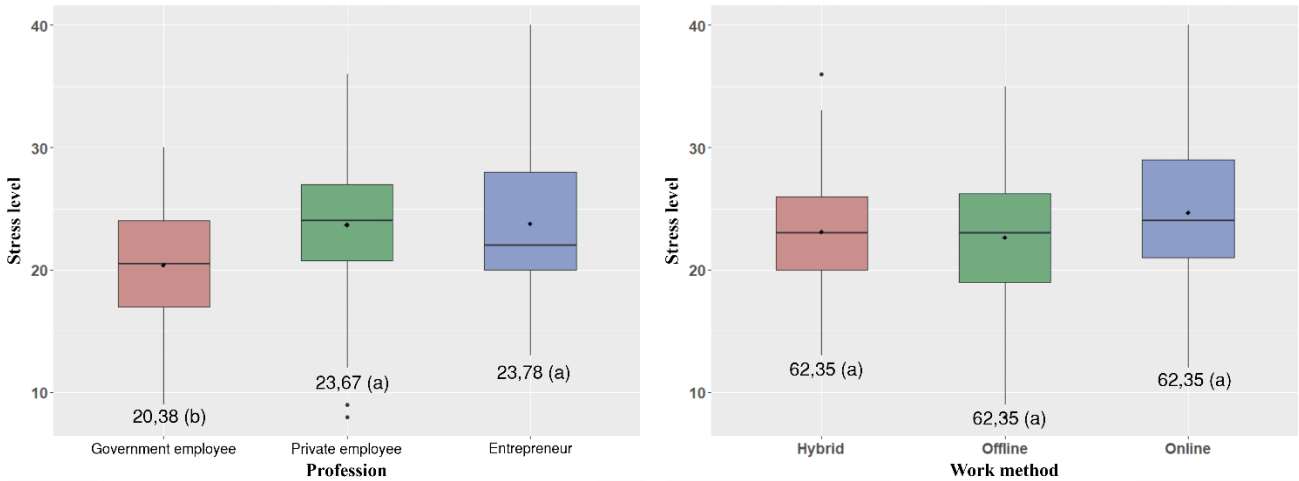

Figure 6. Box plot of profession factor with stress level (left) and work method factor with stress level (right).

4.3 The Relationship of Garden Existence in Place of Living to the Psychological Condition

One of the study's focal points is the impact of garden presence on living space/occupancy. The presence of a garden is related to stress ($p<0,05$), but not to mental well-being (Table 4). As previously stated, if a factor has a link with only one of the psychological states studied, it may be assumed that it also has a relationship with the other psychological conditions (indirectly). It happens because there is a significant connection between the two psychological disorders. Assuming the ANOVA test is used to expand the test. In that situation, the result shows that the garden existence factor has a strong influence on stress level ($p<0,05$), hence in the HSD-Tukey test, the living place/occupancy with a garden has a lower stress level (23,1 ± 5,4) than the living place/occupancy without a garden (26,0 ± 5,4). (Figure 7). Both have the same average stress level when seen via the stress level category, but the three-point difference in the score total has made a major difference. This is connected to certain research that shows that having a garden (in all senses) or plants (individually or in a group) has a favourable impact on psychological circumstances (mental health) (Chalmin-Pui et al., 2021; Corley et al., 2021; Elsadek et al., 2019; Lehberger et al., 2021; Luo et al., 2021; Xie et al., 2020).

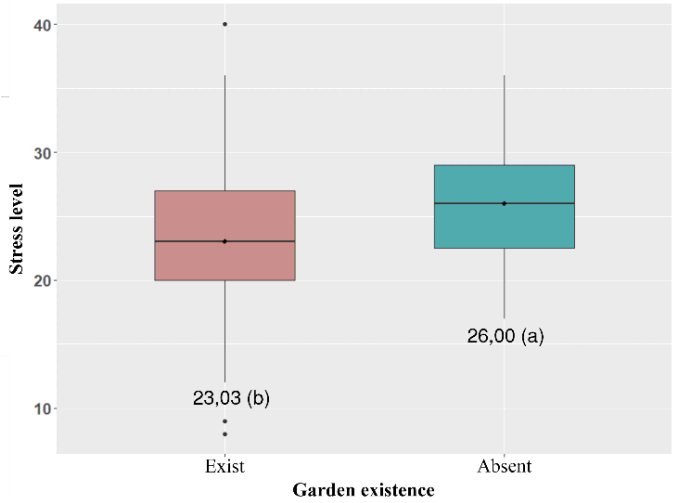

Figure 7. Box plot of garden existence factor with mental well-being level (left) and stress level (right).

Table 6. Sociodemographic characteristics and their relationship to psychological conditions.

Category	Sample (n = 192)	WEMWBS (range: 14-70)			PSS-14 (range: 0-56)	
		Mean ± SD	Category[2]	p-value[1]	Mean ± SD	p-value[1]
Age						
20-24	n = 53 (27,6%)	55,9 ± 8,1	Moderate	0,000**	24,9 ± 4,9	0,000**
25-29	n = 36 (18,8%)	55,7 ± 8,6	Moderate		25,0 ± 6,6	
30-34	n = 11 (5,7%)	55,7 ± 7,3	Moderate		23,5 ±4,7	
35-39	n = 14 (7,3%)	58,1 ± 6,1	Moderate		23,0 ± 3,8	
40-44	n = 15 (7,8%)	65,5 ± 5,5	High		21,5 ± 5,1	
45-49	n = 29 (15,1%)	62,3 ± 6,0	High		21,2 ± 4,9	
50-54	n = 34 (17,7%)	60,4 ± 6,9	Moderate		21,3 ± 4,9	
Sexes						
Man	n = 74 (38,5%)	59,1 ± 7,4	Moderate	0,466	23,5 ± 5,2	0,652
Woman	n = 118 (61,5%)	58,2 ± 8,3	Moderate		23,1 ± 5,6	
Province						
West Java	n = 95 (49,5%)	59,6 ± 7,7	Moderate	0,036*	23,1 ± 5,8	0,317
Central Java	n = 20 (10,4%)	57,6 ± 6,3	Moderate		22,4 ± 3,8	
East Java	n = 20 (10,4%)	59,8 ± 8,1	Moderate		22,9 ± 5,0	
Banten	n = 12 (6,3%)	54,5 ± 10,5	Moderate		23,7 ± 4,5	
DKI Jakarta	n = 21 (10,9%)	58,1 ± 7,7	Moderate		24,1 ± 4,4	
DI Yogyakarta	n = 24 (12,5%)	56,5 ± 8,3	Moderate		24,1 ± 6,8	
Profession						
Government employee	n = 26 (13,5%)	60,9 ± 6,9	Moderate	0,981	20,4 ± 5,1	0,028*
Private employee	n = 120 (62,5%)	57,5 ± 7,9	Moderate		23,7 ± 5,2	
Entrepreneur	n = 46 (24%)	59,8 ± 8,3	Moderate		23,8 ± 5,9	
Work method						
Offline	n = 80 (41,7%)	58,4 ± 7,9	Moderate	0,869	22,6 ± 5,4	0,061
Online	n = 42 (21,9%)	58,1 ± 8,2	Moderate		24,7 ± 5,8	
Hybrid	n = 70 (36,5%)	59,1 ± 7,8	Moderate		23,1 ± 5,2	
Suffer disease						
Yes	n = 32 (16,7%)	58,8 ± 8,1	Moderate	0,823	22,7 ± 6,2	0,521
No	n = 160 (83,3%)	58,5 ± 7,9	Moderate		23,4 ± 5,3	
Environment						
Rural area	n = 51 (26,6%)	58,6 ± 7,7	Moderate	0,445	22,4 ± 5,5	0,314
Urban area	n = 116 (60,4%)	58,1 ± 8,1	Moderate		23,6 ± 5,6	
Cluster housing	n = 25 (13%)	60,7 ± 7,7	Moderate		23,4 ± 4,3	
Living status						
Private house	n = 107 (55,7%)	60,6 ± 7,4	Moderate	0,000**	22,2 ± 5,5	0,003**
Relative's house	n = 55 (28,6%)	55,8 ± 8,4	Moderate		24,5 ± 5,2	
Rented house	n = 30 (15,6%)	56,2 ± 7,0	Moderate		24,9 ± 5,0	
Garden existence						
Exist	n = 178 (92,7%)	58,7 ± 7,9	Moderate	0,615	23,1 ± 5,4	0,040*
Absent	n = 14 (7,3%)	58,6 ± 8,5	Moderate		26,0 ± 5,3	

Note: (*) p-value ≤0,05, (**) p-value ≤0,01

[1] The significance level of Pearson correlation; the level of mental well-being (WEMWBS) and stress level (PSS-14) to some categories (free variables)

[2] The categories of prosperity levels: Low (≤42), Moderate (43-60), and High (≥61)

4.4 The Influence of Habit Factor on the Psychological Condition

Garden visits have a substantial correlation with mental well-being (as high as 0.27) and stress levels (as high as -0,26). This example makes a significant difference in both psychological states, so if an advanced test using HSD-Tukey is used, the visiting frequency of ≥5 days per week has the highest degree of mental well-being, as high as 60,93. In contrast, the frequency of visits on ≤1 day per week has the greatest stress level, as high as 25,79. (Figure 8). This conclusion is also shown in the duration component inside the garden, which has a very strong connection with mental well-being (as high as 0.44) and stress level (-0,31). According to the results of the advanced test conducted by HSD-Turkey, a duration of 1-2 hours and ≥2 hours spent within the garden has a strong association with mental well-being (as high as 0,44) and stress level (-0,31). According to the results of the advanced test conducted by HSD-Turkey, the durations of 1-2 hours and ≥2 hours spent within the garden have the greatest mental well-being levels, as high as 64,15 and 63,89, respectively, while the period of ≤30 minutes has the highest stress level, as high as 24,92. (Figure 9). The frequency and duration factors demonstrated that both factors, which were believed to be the habits of study subjects from two weeks to a month before the data were collected, had a significant impact on the levels of mental well-being and stress. Previous research has also shown that these aspects have an impact on someone's psychological state. The more a person visits his or her home garden and spends time in it, the better his or her mental well-being and stress level will be. (Shanahan et al., 2016; Xie et al., 2020; Yang et al., 2020).

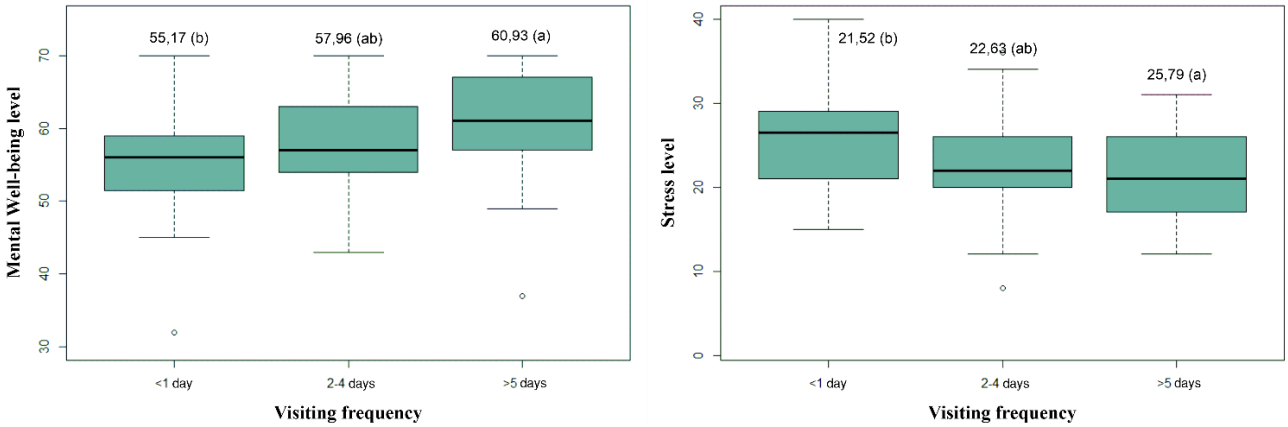

Figure 8. Box plot with the average factor of visiting frequency related to the level of mental well-being (left) and level of stress (right).

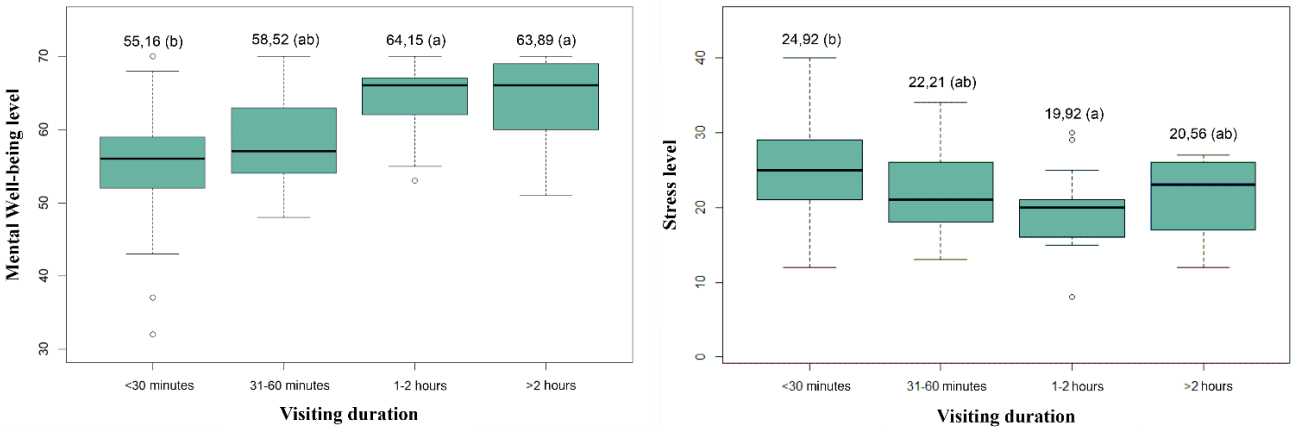

Figure 9. Box plot with the average factor of spending time duration in the garden in each visit related to the level of mental well-being (left) and level of stress (right).

4.5 The Influence of Home Garden Characteristics Factors on Psychological Condition

The size of the garden and the number of plants in it have a high correlation with both psychological disorders. It occurs because both parameters have a direct cause-and-effect relationship, revealing that the larger the garden space, the more plants there are inside it. The association between garden area and mental well-being level is as high as 0.27, and the relationship between garden area and stress level is as high as 0.22. An advanced HSD-Turkey test demonstrates that a garden of ≥20 m2 contributes the greatest mental well-being (the best) as large as 62,52, although the width of the garden area has no meaningful impact on the stress variable level (Figure 10). It is possible to deduce that the garden width area is related to stress levels, however, it does not influence it directly. The impact of the width of the garden space on the stress level is projected to be greater than the interaction with the number of plants. It is corroborated by the findings, which show that the plant number factor has a link with stress levels as high as -0,23 and mental well-being as high as 0,22. The advanced test results from HSD-Turkey demonstrate that the garden with 11-15 plants has the highest stress level, up to 26,14, while the garden with ≥20 has the highest mental well-being level, up to 60,43. (Figure 11). This finding presents an intriguing scenario in which research participants with 11-15 plants had the greatest stress level and the lowest metal prosperity level. The polynomial orthogonal (regression type test) test, on the other hand, demonstrates that the cause-and-effect connection associated with the number of plants and psychological states forms a linear line.

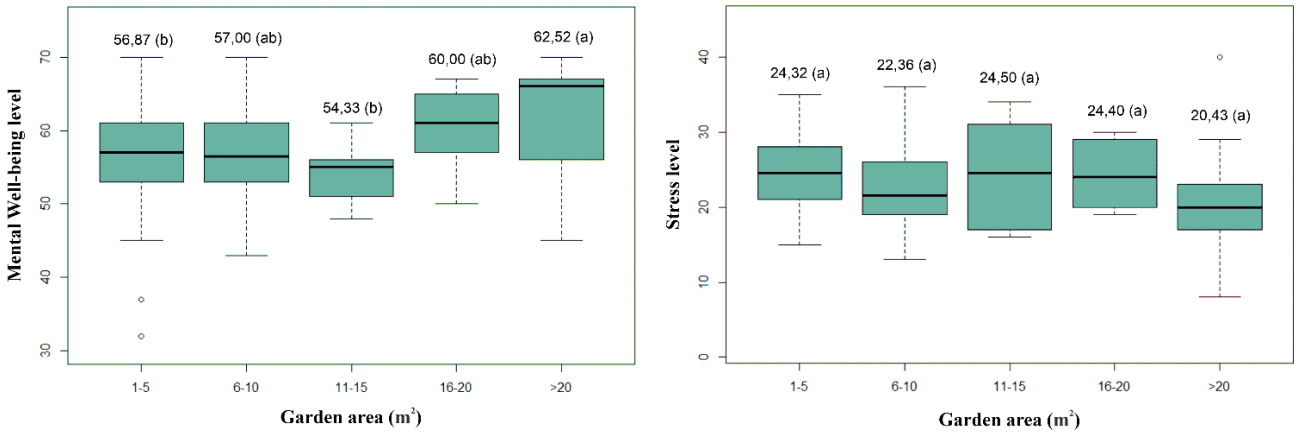

Figure 10. Box plot with the average factor of the garden area related to the level of mental well-being (left) and level of stress (right).

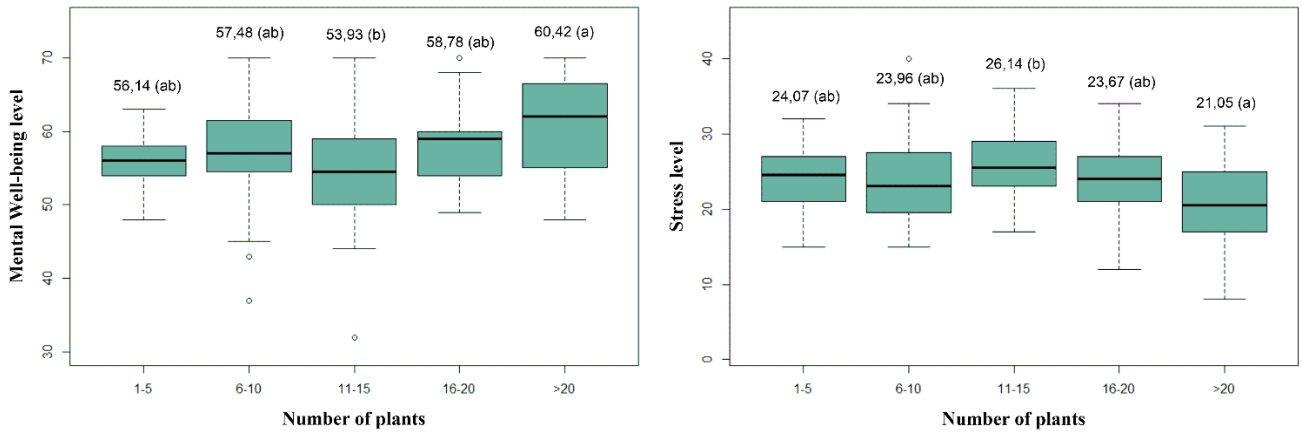

Figure 11. Box plot with the average factor of plant number related to the level of mental well-being (left) and level of stress (right).

The water feature in a home garden is the next thing to consider since it has a significant association with mental well-being levels as high as 0.26. The advanced test results suggest that a garden with a water feature raises the mental well-being level of research participants (as high as 59,71) compared to study participants who do not have a water feature in their garden (as high as 55,56). (Figure 12). The test results for the garden space, plant quantity, and water presence in the garden are identical to prior research. The more plants that are present in the garden, the greater the chance for biodiversity, which harnesses one's connection to nature (Cox et al., 2017; Hall & Knuth, 2019; Young et al., 2020; Zhang, Zhang, & Zhai, 2021). Aside from that, the more plants there are in the garden, the more oxygen there is, which relaxes someone's psyche. Keeping animals in the garden also improves their psychological state. Regarding the occurrence of water features, prior research shows that the availability of water bodies (particularly natural ones) has a good influence on psychological conditions such as mental health. It even happens when the socioeconomic element is taken into account (Pouso et al., 2020; White et al., 2010). Aside from that, listening to water sounds (together with visuals) may significantly reduce tension and improve psychological states (Thoma et al., 2018; Zhang, Zhang, Zhai, et al., 2021).

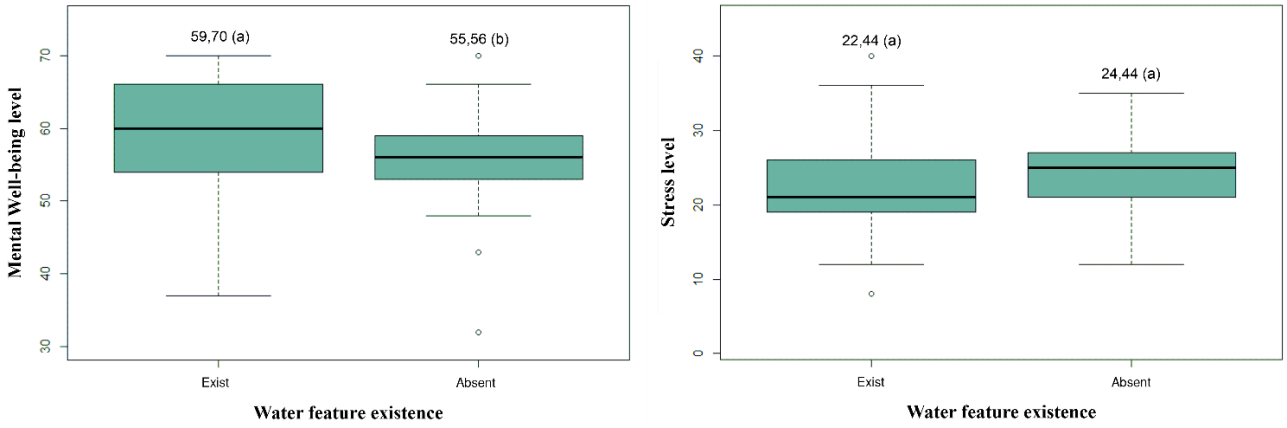

Figure 12. Box plot with average water feature existence factor related to mental well-being (left) and stress level (right).

5. Conclusion

This study was successful in expanding knowledge about the value of having a home garden to enhance psychological conditions during a pandemic, which has never occurred before. During the pandemic shift, various elements impact psychological circumstances connected to mental well-being and stress levels, according to this study. Age, employment type, provincial location, living quality, and the presence of a garden in the house are all contributing variables in this situation. In terms of Java Island society, the age range of 40-49 has the highest mental well-being (with an average of 62.35-65.47) and the lowest stress (with an average of 21.21-21.47), regardless of where they live in the province. Entrepreneurs (with an average of 23.78) and private workers have the greatest stress levels (with an average of 23.67). In terms of housing, a house with a home garden has the finest psychological state (with an average of 23.03). In addition, the habit of engaging in green space has a significant impact on psychological states. The frequency of visits, the length of time spent in the park, the breadth of the garden area, the number of plants, and the presence of water in the garden are all habitual elements that have a large influence. This study gives scientific evidence on the elements that influence psychological states. Someone who visits the home garden more than five days each week has the finest mental health (with a mean of 60.93) and the lowest stress level (with a mean of 25.79). Similarly, what happened to the time component in each park visit, when someone who attended for more than an hour had superior psychological condition results? It is advised that the workers' community participation in activities in the home garden five days a week for at least one hour. On the other hand, it is suggested that urban dwelling developers pay more attention to the house garden and its constituent aspects. The minimum time of each visit to the home garden,

which is also connected to the type of activity carried out, has to be examined further in a future study to optimise the influence of the home garden on mental well-being and stress levels.

Funding
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interests
The author declared that there was no conflict of interest relating to the conduct, outcome, and publication of this study.

Data availability statement
The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author/s.

Ethics statements
Studies involving animal subjects: *No animal studies are presented in this manuscript.*
Studies involving human subjects: The authors received a certificate of passing ethical review from the Human Ethics Commission of IPB University 615/IT3.KEPMSM-IPB/SK/2022 (11th Feb 22). No potentially identifiable human images or data are presented in this study.
Inclusion of identifiable human data: No potentially identifiable human images or data is presented in this study.

CRedit author statement
Conceptualization: S.N.L., B.S., P.I.P. Data curation: S.N.L. Formal analysis: S.N.L., B.S., P.I.P. Fundung acquisition: S.N.L. Investigation: S.N.L., Methodology: S.N.L. Writing-original draft: S.N.L. Writing-review & editing: S.N.L., B.S., P.I.P. All authors have read and agreed to the published version of the manuscript.

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How to cite this article:
Lazuardi, S. N., Sulistyantara, B., & Pratiwi, P. I. (2022). The Role of Home Gardens in Developing Cities for Improving Workers' Psychological Conditions. *Journal of Contemporary Urban Affairs, 6*(2), 233-248. https://doi.org/10.25034/ijcua.2022.v6n2-9

Journal of Contemporary Urban Affairs

2022, Volume 6, Number 2, pages 249–263

Original scientific paper

Exploring the Nexus between Political Risk and Financial Risk in the Balkan Countries: A Wavelet-Based NARDL Coherency analysis

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ARTICLE INFO:

Article History:
Received: 25 August 2022
Revised: 18 October 2022
Accepted: 19 November 2022
Available online: 24 November 2022

Keywords:
Political risk;
Financial risk;
Wavelet analysis;
NARDL coherency analysis;
Balkan countries;
Urban planning;
Inclusive growth.

ABSTRACT

The empirical investigation of which risk factor—political or financial—is the optimal driver of country risk in emerging economies in the twenty-first century has grown into a significant and volatile issue in recent decades. This paper investigates the linkages between political risk and financial risk in four Balkan economies (i.e., Greece, Albania, Bulgaria, and Romania) from 1984 Q3 to 2018 Q4, using non-linear autoregressive distributed lag co-integration (NARDL) and wavelet coherence approaches. As a result, findings from the links between political risk and financial risk are being used to provide significant insights into effective urban planning in Balkan cities. The outcomes of the NARDAL analysis indicate that there are short-term and long-term asymmetric links between political risk and financial risk in the Balkan countries except for Romania. The wavelet coherence study also revealed that there is significant vulnerability between political risk and financial risk at different frequencies in the region, also, political risk is a key for predicting financial risk over the selected study period at different frequencies in Albania and Bulgaria.

JOURNAL OF CONTEMPORARY URBAN AFFAIRS (2022), ***6***(2), 249-263.
https://doi.org/10.25034/ijcua.2022.v6n2-10

www.ijcua.com

1. Introduction

Country risk is an ancient global problem, while contagious diseases and cyber-attacks are considerably more recent occurrences threatening the world's economies. Regardless of how well-structured a nation's economy is, there is a chance that risk elements will exist (Hacker, 2019). Some risk factors can appear suddenly, while others might develop due to laws or regulations. Studies in recent years have indicated that factors related to bad governance, particularly after the 2008 global financial crisis, are linked to the fall of governing institutions, particularly in emerging economies (Humphrey & Michaelowa, 2019).

The dynamic relationship between political risk (PR) and financial risk (FR) is one of the issues that are mostly discussed in the macroeconomic literature. However, the methodology shows that the relation

How to cite this article:
Shuaibu, S. M., & Kirikkaleli, D. (2022). Exploring the Nexus between Political Risk and Financial Risk in the Balkan Countries: A Wavelet-Based NARDL Coherency analysis. *Journal of Contemporary Urban Affairs*, *6*(2), 249-263. https://doi.org/10.25034/ijcua.2022.v6n2-10

between PR and FR is unclear, especially concerning the direction of causality. Political factors are seen as a volatile source of financial stability. Although studies such as Barro (1991), Białkowski et al. (2008), Chan & John Wei (1996), Charfeddine & al Refai, (2019); Cutler et al., (1988); Hillier & Longan, (2019); Kirikkaleli, (2016), (2020); Li & Born, (2006); Pantzalis et al., (2000); Pástor & Veronesi, (2013) and Smales, (2015), were the papers that examined the linkages between political risk and financial risk. However, the findings are inconclusive. Studies by (Białkowski et al. (2008), Delavallade (2006), Pástor & Veronesi (2013), and Smales (2015) argue that political risk harms financial stability. Contrary to these findings, Cassette & Farvaque, (2014); Gyöngyösi & Verner, (2022) expressed that financial risk negatively influences political risk.

Unfortunately, most of the trending events in the Balkan countries are yet to be highlighted in the economics literature. Hence, the main aim of this research is to fill this gap by employing the NARDL and wavelet coherence techniques to examine the linkages between political risk and financial risk. Thus, using these modern econometric techniques, this paper's other contribution is to proffer answers to the following questions: (i) Is there a causal link between PR and FR in the Balkan countries? (ii) If yes, what is the direction of causality? (iii) Also employ the findings to explain urban planning in the Balkan countries.

To examine the linkage between PR and FR, we used the econometric tools of NARDL and wavelet coherence. The mother wavelet (t), which contains useful tools for determining both the short- and long-term correlations between political risk and financial risk, theoretically serves as the time-frequency domain (Bredin et al., 2015). As a result, it takes the time and frequency dimensions into account simultaneously. Although out-of-sample Granger causality analysis has been used in prior studies, its contribution to the literature remains unclear (Dees & Brinca, 2013) due to systemic alterations in the interplay concerning parameter uncertainty. In order to measure the sensitivity of the link between variables in the plot, we employed wavelet coherence, which allows us to comprehend the degree of interdependence within the analysis. The study's most significant contribution is its recommendation of an inclusive growth conceptual framework to lower PR and FR in the Balkan countries in particular and the world in general. The study will also recommend effective urban planning development to urban planners based on the political-financial risk outcomes. Finally, while previous research has yielded conflicting results, the new study's conclusions will be helpful to policymakers and allow for additional debate among those working to reduce risk and advance urbanization.

The average public debt-to-GDP ratio for the Balkan region is 46.4%, while that for Central Africa is 42.2%. Nevertheless, there are considerable differences between nations. In the case of Albania, the far-right or extreme right-wing has posed a significant threat to the country's financial system as a group of people who believe to be superior to the vast majority based on racial, ethnic, and religious criteria and regard others as inferior. Since 1991, when Albania was the least developed and most isolated nation in the Balkans, the country has been dependent on assistance from foreign organizations despite not yet being a member of the European Union. Corruption in Albania has increased over the years, as evidenced by the pyramid crisis in Albania caused by political institutions. The extractive political institutions are said to have started the scheme and utilized the proceeds for personal gain. Markets can efficiently create wealth when supported by robust governmental institutions. Therefore, the small, undeveloped economy was largely shielded from the global financial collapse during the world's financial meltdown. The global financial crisis did not affect Albanian financial markets but also on the resilience of Albanian banks because the markets were less developed and no institutions filed for bankruptcy during this crisis (Suraj, 2015).

Political instability caused by communist rule imposed on the people of Albania also impacted rural-urban migration, which cumulated in the early phases of urban growth (Lerch, 2014). Difficulties faced by the Albanian government in adopting a democratic system and free market economy have made urban planning in Albania rather static. The Communists imposed restrictions on leaving the countryside in Albania between 1960 and 1990, which resulted in economic transformation as a major driver of urban transition. Furthermore, the post-communist era saw a sharp increase in urban expansion, impacting urban labor markets (Pojani, 2009). The labor market situation has worsened in Tirana, the capital city, as more than 25% of the population revealed the rapid rate of urbanization.

In 1999, Romania was experiencing its worst economic crisis due to several factors, including the nation's declining GDP, high current account deficit, inability to obtain credit, failure to pay off foreign

debt, and the long-term cause of a lack of swift structural reform implementation. The country's apparent political instability was in the background of all of this (Hord, 2001). Nevertheless, the nation started its transition in 1990 with the advantages of not having any external debt and inhabitants who were enthusiastic about the end of communism. Moreso, Romania's urbanization level is far below the 52% target set by the European Union (EU) due to changes in the political system despite the declaration of new towns in 2002. Before 1989, there was socialist industrialization with a primary focus on developing industrial centers. Resulting in nationalizing residential buildings and eliminating the market's role in forming city structures (József, 2006).

Greece's situation was very different; being the tenth country to join the EU, it smoothly transitioned from a highly authoritarian to a liberal one. It was regarded as a model democracy that allowed a pluralist system. Due to the quality and capacity to guarantee rapid economic growth while engaging in borrowing, the fierce policy reforms carried out by its administration and its linkages to the EU recognized it future potential. However, the 2008 financial meltdown and the crisis brought on by the sovereign debt had a terrible impact on the country's financial and political systems. Beginning with its failure to pay its debt, which prompted the IMF's intervention and financing of the country's application for austerity measures and the government debt- to-GDP ratio increased from 109% in 2008 to 146% in 2010. On the political front, the nation faces instability that resulted in the downfall of the one-party system in favor of a multi-party system. In addition, institutional quality, corruption, and bureaucratic quality are significant obstacles to the nation's politics and economy (Butkiewicz & Yanikkaya, 2006).

It is widely acknowledged that financial stability can lead to the stable growth of a nation (Ozil, 2018). Frequent policy reforms could reduce financial risk; as a result, political risk causes the need for short-term macroeconomic policies. In addition, Pantzalis et al., (2000) examined the range of asset values in equity markets across a two-week election period for 33 different countries, and the results showed that stock prices rose within two weeks during the election. A similar conclusion was reached by Cutler et al. (1988) in their study, which found that political risk had an immediate negative effect on the US financial system. Pástor & Veronesi (2013) argued that changes in the Australian financial market negatively impacted political risk in Austria, while the Australian federal political elections, according to Smales (2015), harmed the financial market, which is consistent with Pástor & Veronesi (2013) findings. Political risk's impact on financial markets was also studied by Białkowski et al., (2008) in 27 OECD nations, and the results showed a favorable impact. Also, according to Ashraf & Prentice (2019), political strikes and labor unrest in Bangladesh harm 33 major production firms. Other studies, including Kirikkaleli, (2016) and Arcand et al., (2015), have highlighted the relationship between PR and FR in terms of economic risk.

More so, the impact of PR on FR is also seen in other empirical studies such as Mauro (1998), which utilizes OLS regression to investigate the effect of corruption on financial stability in 100 nations. The results demonstrate that corruption lowers government health sector spending, increasing public debt. After noticing this link in a survey of 64 nations using the 3SLS estimate from 1996 to 2001, Delavallade (2006) corroborated this viewpoint. Similarly, González-Fernández & González-Velasco, (2014) found that political risk due to corruption increased financial risk due to high public debt throughout the period 2000–2012 after investigating the Spanish autonomous communities. Additionally, left-wing governments are more likely to impose restrictions on capital flight than right-wing governments (Alesina & Tabellini, 1989). Therefore, elections or regime changes can affect exchange rate policies, considering their importance to investors concerning capital flight. This negative impact of political risk on financial risk was also confirmed by Siokis & Kapopoulos (2003) after investigating the impact of election cycles on the Greece exchange rates market using an E- GARCH model. Therefore, determining a suitable exchange rate depends on the government's political condition. Berdiev et al. (2012) conducted a panel investigation on the relationship between PR and FR in 180 countries using a data set spanning from 1974 to 2004. The results demonstrate that left-wing governments and democratic institutions determine the likelihood of choosing a flexible rate regime.

In addition, there has been limited study on the connection between populism and financial crisis. According to Funke et al. (2016)'s investigation into the financial crisis and its electoral consequences for 20 developed countries, far-right party vote shares increased by about 4% or 30%. However, no far-left party vote shares increased, and the outcome was statistically stronger for post-World War II periods. The study of Gyöngyösi & Verner (2022) research describes how the far-right Jobbik party in Hungary rose to prominence amid the 2008 global financial

meltdown. Several Hungarian families that had taken out loans in the Swiss franc (or other foreign currencies) were severely harmed by the steep devaluation of the Hungarian forint. The study by Cassette and Farvaque (2014) revealed the detrimental impact of financial risk on political stability. They stated that debts accumulated by incumbents before elections increase their likelihood of being reelected. They also added an increase of about 20% in the vote of the far-right populists, particularly in areas where the exposure to foreign currency debt was higher.

Just as political and financial risk affects every facet of life, it also harms urban planning by migrating people, companies, and investments between cities or regions. The 2008 global financial crisis and political swings in policies have undermined meaningful sets of guidance, investment, and policies in urban statutory planning and design. It can be stated that the built environment set up by the Commission for Architecture and the Built Environment (CABE) has dissolved since 2011 due to unstable political and financial situations (Roberts & Townshend, 2017). The field of urban planning in Albania has been quite static. The uncontrolled movement of people caused by political instability, primarily towards Tirana, corrupts the urban planning system.

Given that no study has focused on political and financial risks in these countries using the wavelet coherence technique and a nonlinear autoregressive distributed lag co-integration model, this paper set out to fill this gap. Hence, the remainder of this study is organized as follows: Section 2 provides the dataset source and methodologies used in analyzing the data. Section 3 includes a discussion and empirical results, and Section 4 presents a conclusion, policy recommendations, and an important future research direction.

2. Data Sources and Methodology

2.1. Data Sources

This study analyzed the relationship between PR and FR using the International Country Risk Guide (ICRG) data from the Political Risk Service Group for Albania, Romania, Bulgaria, and Greece from 1984 Q3 to 2018 Q4. In the ICRG, the PRS group has published political, economic, and financial data for 146 countries since 1984. A country's political risk is evaluated by six subcomponents, while its financial risk is evaluated by 5. Financial risk sub-components include exchange rate volatility, foreign debt as a percentage of GDP, current account as a percentage of exports, net international liquidity, and foreign debt service. In addition, there are six sub-components of political risk: external conflicts, corruption, religious involvement in politics, law and order, ethnic tensions, bureaucracy quality, and democracy (Howell, 2011). In addition, Stata and R-software tools are used to analyze the NARDL co-integration and wavelet, respectively. Table 1 presents the summary of the descriptive statistics of this study and it indicates that there are no outliers in the datasets.

Table 1: Summary of Descriptive Statistics.

Period:	**1984Q3 - 2018Q4**							
Source:	**Political Risk Group (PRS)**							
	PRRO	**PRGR**	**PRBU**	**PRAL**	**FRRO**	**FRGR**	**FRBU**	**FRAL**
Mean	65.18	70.90	69.38	63.90	29.44	31.84	31.82	27.30
Median	68.00	71.58	69.33	65.00	31.92	32.17	32.83	33.00
Maximum	78.00	84.00	77.00	69.67	42.50	37.00	41.00	46.17
Minimum	45.00	58.00	61.67	49.67	15.67	26.67	15.00	9.00
Std. Dev.	8.10	6.90	3.64	4.53	7.86	2.75	6.20	11.33
Skewness	-1.10	-0.17	-0.04	-1.32	-0.11	-0.01	-0.69	-0.45
Kurtosis	3.22	1.92	2.26	4.21	1.42	1.67	2.71	1.55
Jarque-Bera	28.36	7.33	3.18	48.26	14.69	10.19	11.54	16.76
Probability	0.00	0.03	0.20	0.00	0.00	0.01	0.00	0.00
bservations	138	138	138	138	138	138	138	138

Note: PRRO: political risk in Romania, PRGR: political risk in Greece, PRBU: political risk in Bulgaria, PRAL: political risk in Albania, and FRRO: financial risk in Romania, FRGR: financial risk in Greece, FRBU: financial risk in Bulgaria, and FRAL: financial risk in Albania.

2.2. Models Estimations

2.2.1. Unit Root Test

The initial estimation step in this study is to prevent spurious regression. In a recent study, some studies have criticized the analysis of unit root tests of time series data without structural breaks (Humphrey & Michaelowa, 2019; Ashraf & Prentice, 2019; Roberts & Townshend, 2017). The study employs the unit root test of Zivot & Andrews (2002) with a single structural breakpoint analysis and this primary step is important to know if the variables employed in this study are integrated at I (1) or I(0) but not at I(2) or higher. To estimate the unit roots for Zivot & Andrews with breaks point, the mathematical null hypothesis of the unit root is formulated as:

$$x_t = \mu + \rho x_{t-1} + e_t \quad (1)$$

Where x_t refers to interest variables; μ is the constant term, and e_t is the error term. By taking unit differencing, the equation becomes $\Delta x_t = \mu + e_t$; where Δ=(1−B); ρ is the parameter slopes for lagged variables; which becomes 1 if there is a unit root or the variable is not stationary (Zivot & Andrews, 2002). The alternative units' roots such as ADF and FADF with a break points are criticized (Humphrey & Michaelowa, 2019; Ashraf & Prentice, 2019) and are not used for this study.

2.2.2. NARDL bounds test

The study used the NARDL bounds test developed by Shin et al. (2014). This test helps to capture the long- and short-run asymmetric co-integration relationship between political risk and financial risk. Furthermore, this technique can be employed whether the repressors are stationary at first difference or level; however, they cannot take on regressors that are stationary at I (2). The econometric models are presented below in equations (2) and (3).

$$PR_t = \theta_0 + \theta_1^+ FR_t^+ + \theta_2^- FR_t^- \ , \quad (2)$$

$$PR_t = \theta_0 + \theta_1^+ FR_t^+ + \theta_2^- FR_t^- + \varepsilon_t \ , \quad (3)$$

The study illustrates separate estimation models for NARDL models in the following estimation equation shown below:

$$\Delta PR = \theta_0 + \theta_1 PR + \theta_2 FR + \sum_{k=1}^{s} \theta_3 \Delta PR + \sum_{k=1}^{s} \theta_4 \Delta FR + \varepsilon_t \ . \quad (4)$$

In the previous equation above, θ_0, θ_1 and θ_2 represent long-run parameters, while θ_3 and θ_4 denote short-run parameters. PR is the political risk, the dependent variable, while FR signifies financial risks, which are the regressors. Following the study of Ahmad et al. (2018), $\theta_0, \theta_1^+ \text{ and } \theta_2^-$ represent vectors of unknown long-run parameters.

$$FR_t^+ = \sum_{j=1}^{s} \Delta FR_j^+ = \sum_{k=1}^{s} \max(\Delta FR_j, 0), \quad FR_t^- = \sum_{k=1}^{s} \Delta FR_j^- = \sum_{k=1}^{s} \min(\Delta FR_j, 0), \quad (5)$$

The fifth equation models asymmetric co-integration in the nonlinear framework association of the Balkan countries' PR and FR. The equation also indicates the partial sums of the negative and positive changes in financial risk. Finally, as shown in equation (6), we convert conventional ARDL to NARDL.

$$\Delta PR_t = \delta_0 + \theta_1 PR_{t-1} + \theta_2^+ FR_{t-1}^+ + \theta_3^- FR_{t-1}^- + \sum_{i=1}^{p} \emptyset_i \Delta PR_{t-1} + \sum_{i=0}^{t} (\pi_i^+ \Delta FR_{t-1}^+ + \pi_i^- \Delta FR_{t-1}^-) + \varepsilon_t \ , \quad (6)$$

Where p and t are lag orders, $\pi_i^+ \Delta ER_{t-1}^+$ estimates the short-run effects of financial risk increases in political risk and $\pi_i^- \Delta ER_{t-1}^-$ measures the short-run impact of financial risk reduction on political risk.

$$\Delta PR_t = \sum_{i=1}^{p} V_i \Delta PR_{t-1} + \sum_{i=0}^{t} (K_i^+ \Delta FR_{t-1}^+ + K_i^- \Delta FR_{t-1}^-) + R_i ECT_{t-1} + \mu_t, \quad (7)$$

$$B_a^+ = \sum_{j=0}^{a} \frac{\rho PR_{t+j}}{\rho FR_{t-1}^+}, B_a^- = \sum_{j=0}^{a} \frac{\rho PR_{t+j}}{\rho FR_{t-1}^-}, a = 1, 2, \quad (8)$$

In equation (7), K_i^+ and K_i^- stand for short-run adjustment symmetry, V_i represents the short-run coefficient; and R_i is the coefficient of the error correction term. Finally, with equation (8) above, FR_{t-1}^+ and FR_{t-1}^- are computed, which is the asymmetric cumulative multiplier effects of a 1% variation.

2.2.3. The Wavelet Approach

The paper examines the linkage between PR and FR and follows the wavelet mathematical application postulated by (Goupillaud et al., 1984). This wavelet technique's innovation is that it decomposes a single time series into a bi-dimensional time-frequency domain. The mother wavelet's equation is shown below.

$\psi(t) = \pi^{-\frac{1}{4}} e^{-i\omega_0 t} e^{-\frac{1}{2}t^2}$, p(t), t=1, 2, 3…., T, where ψ is the mother wavelet (Kirikkaleli & Gokmenoglu, 2020). The transformed wavelet is indicated in the equation below by adding location and frequency.

$$\psi_{k,f}(t) = \frac{1}{\sqrt{h}} \mu\left(t - k/f\right), k, f \in R, f \neq 0. \quad (9)$$

The continuous wavelet function after adding p(t), which represents time series data, is depicted below:

$$W_p(k,f) = \int_{-\infty}^{\infty} p(t) \frac{1}{\sqrt{f}} \psi\left(\frac{t-k}{f}\right) dt, \quad (10)$$

Where k and f are determinants of time and frequency domains and they are represented by a modified p(t) equation with the ψ coefficient. After adding the coefficient of ψ to equation (10) above, equation (11) is generated:

$$p(t) = \frac{1}{C_\psi} \int_0^{\infty} \left[\int_{-\infty}^{\infty} |W_p(a,b)|^2 da\right] \frac{db}{b^2}, \quad (11)$$

This study utilizes the wavelet power spectrum (WPS), which enables us to capture the vulnerable frequencies and periods of the time series variables to obtain information about the political and financial vulnerability of the Balkan countries. The WPS function is shown below:

$$WPS_p(k,f) = |W_p(k,f)|^2, \quad (12)$$

One of the major benefits of WPS is that the approach reveals causal linkage between the PR and FR variables in a combined time-frequency-based causality, which makes it more advantageous than the traditional causality and correlation tests. The equation below shows the squared wavelet coherence (Kirikkaleli, 2020).

$$R^2(k,f) = \frac{\left|C\left(f^{-1} W_{pq}(k,f)\right)\right|^2}{C\left(f^{-1}|W_p(k,f)|^2\right) C\left(f^{-1}|W_q(k,f)|^2\right)} \quad (13)$$

Where C represents time and the smoothing process over time, and $0 \leq R^2(k,f) \leq 1$. Variables are correlated when $R^2(k,f)$ is close to 1 and is depicted in red color. Similarly, when it gets close to zero, variables are not correlated and are depicted in blue color. Torrence & Compo's (1998) strategy of examining differences in the wavelet coherence by employing deferrals in the wavering of two-time series is used to solve the challenge of $R^2(k,f)$, which does not provide insight into the negative and positive correlation. The

equation below shows the wavelet coherence phase difference:

$$\phi_{pq}(k,f) = tan^{-1}\left(\frac{L\{C(f^{-1}W_{pq}(k,f))\}}{O\{C(f^{-1}W_{pq}(k,f))\}}\right), \qquad (14)$$

In the wavelet coherence analysis, an imaginary operator is represented by L and O for the real portion operator. When arrows point to the right (left) in the thick black area of the wavelet coherence analysis, variables are said to be positively (or negatively) correlated. Arrows that point up and down are another sign of causality (Cai et al., 2017). When arrows point left-up or right-down, it implies that the first variable is leading the second, and when they point left-down or right-up, it means the second variable is leading the first. Since the first variable is financial risk and the second is political risk, arrows pointing left-up or right-down indicate that financial risk leads to political risk, while arrows pointing left-down or right-up indicate the opposite. Political risk is leading when arrows point straight up and lagging when arrows point straight down.

3. Empirical Findings and Interpretations

3.1 Unit Roots Test Outcomes

The preliminary step was to prevent spurious regression, hence this study employs a single structural break unit root test of Zivot & Andrews (2002). Table 2 presents the result of Zivot Andrews's unit root tests, which are analyzed categorically across all four Balkan countries. The Zivot-Andrews unit root results show that the PR and FR variables are integrated at both I(1) and I(0) and none of the variables were I(2) or higher.

Table 2: Summary of Unit Root Test outcomes.

Unit Root	**Greece**		**Albania**		**Bulgaria**		**Romania**	
Technique								
	PR	FR	PR	FR	PR	FR	PR	FR
Zivot-Andrew	I (0)**	I (0)***	I (1)***	I (1) *	I (0)**	I(0)**	I(0)*	I(0)*
BreakPoint	(1993Q3)	(2010Q2)	(2002Q2)	(1996Q2)	(1994Q3)	(1998Q1)	(1999Q1)	(1999Q4)

*Note: *, **, and *** denote statistically significant at the 10%, 5%, and 1% levels, respectively.*

3.2. NARDL Estimations Test Outcomes

3.2.1. NARDL Estimations Test Outcomes for Greece

The next step in the risk modeling procedure is to ascertain the long- and short-term asymmetric effects of the PR and FR linkages between the countries. The paper rejects the null hypothesis of no co-integration between political risk and financial risk in Greece because, as illustrated in figure 3 below, the calculated t-statistic and f-statistic are greater than the critical values of those developed and postulated by Banerjee et al. (1998) and Pesaran et al., (2001) at 1% and 5% significant values, respectively. According to the calculated long-run coefficients, the political risk in Greece is statistically impacted by both positive and negative financial risk. The positive coefficient for the positive portion of financial risk will cause a rise in PR of 0.129%, while the positive coefficient for the negative portion of financial risk will cause a rise in PR of 0.028%. This indicates that any shock in financial risk, whether positive or negative, contributes to an increase in political risk in Greece. In the short run, the estimated coefficient shows that a positive or negative shock to financial risk positively correlates with political risk. Any positive or negative shock to financial risk increases political risk by 0.069% (0.067%). Summarily, both positive and negative financial shocks in Greece increase its positive political risk, both in the short and long term.

Table 3: NARDL Estimation for the Balkan Countries where Financial Risk is the Regressor.

	Bulgaria			Albania			Greece		
Long-Run Estimates									
Regressors	**Coeff**	**T-stat**	**P-value**	**Coeff**	**T-stat**	**P-value**	**Coeff**	**T-stat**	**P-value**
FR_t^+	0.139	4.28	0.00	0.093	2.34	0.02	0.129	3.32	0.00
FR_t^-	-0.055	1.16	0.25	0.155	4.33	0.00	0.028	0.51	0.60
Short-Run Estimates									
ΔFR_t^+	-0.015	-0.37	0.71	0.006	0.25	0.80	0.069	0.93	0.35
ΔFR_t^-	-0.027	-0.49	0.63	0.161	2.89	0.00	0.067	1.18	0.24
	F-stat	P-Value		F-stat	P-Value		F-stat	P-Value	
Long-Run Asy	0.010	0.91		2.232	0.138		57.29	0.00	
Short-Run Asy	0.545	0.46		1.001	0.319		0.550	0.46	

The co-integration test statistics include Bulgaria (t BDM = -2.7757, F PSS = 4.0253), Albania (t_BDM = -5.3522, F_PSS = 6.5515), Romania (t_BDM = -2.7293, F_PSS = 2.0047), and Greece (t_BDM = -4.9555, F_PSS = 6.3306). The t-statistics' critical value is equivalent to -2.76, while the F-statistics' critical values are equal to 3.47, 4.01 and 5.17 at 1%, 5%, and 10%, respectively. Short-Run Asy = Short-Run Asymmetry and Long Run Asy = Long Run Asymmetry.

3.2.2. NARDL Estimations Test Outcomes for Bulgaria

With regards to Bulgaria, the null hypothesis is rejected also simply because the study's t-statistics (t BDM) is higher than the critical value using Banerjee et al., (1998) as a benchmark at a 5% significant level, indicating co-integration between the PR and FR variables in the country. The f- statistic exceeds Pesaran et al. (2001)'s the critical value by more than 1% at the 1% significant level. The study for the NARDL's estimated t-statistics and f-statistics (F PSS) shows co-integration between PR and FR, indicating that PR is linked to Bulgaria's FR.

The coefficients for the positive (negative) portions of financial risk indicate that over the long term, a positive (negative) shock to financial risk will cause an increase in the political risk of 0.139% and a decrease in political risk of (-0.055%), respectively. This study suggests that any positive shock to financial risk contributes to an increase in political risk, and any negative shock to financial risk contributes to a decrease in political risk in Bulgaria. In order words, every negative shock to Bulgaria's financial risk lowers the nation's long-term political risk. Moreover, any positive (negative) shock to Bulgaria's financial risk will, in the short run, cause a decrease in political risk of up to -0.015% (-0.027%), suggesting that any shock to financial risk, whether positive or negative, contributes to a short-term reduction in political risk in Bulgaria.

3.2.3. NARDL Estimations Test Outcomes for Albania

We adopt the alternative hypothesis because, in the case of Albania, the study's t-statistics (t BDM) is higher than the crucial value using Banerjee et al. (1998) as a benchmark at a 5% significant level. It indicates that Albania's political risk and financial risk indicators are co-integrated. Additionally, the f-statistics exceeds the Pesaran et al. (2001) 1% significant level crucial value. Therefore, the study for the NARDL's calculated t-statistics and f-statistics (F PSS) demonstrate a linkage between political risk and financial risk. In the long run, positive coefficients of financial risk demonstrate that a positive (negative) shock to financial risk has increased political risk by 0.093% (0.155%), which means that any positive ((negative) shock to financial risk contributes to an increase in political risk in Albania. In the short term, a positive (negative) shock to financial risk also raises the political risk by 0.006% (0.161%), according to the positive coefficients for both the positive and negative sections of financial risk. In conclusion, any positive or negative shock in political risk plays a role in increasing Albania's financial risk in both the short and long run.

3.3. Wavelet Approach Test Outcomes

As in figure 1 below, the red color indicates the high political risk activities. In Greece, high political risk activities occurred from 1989 to 2000 in the medium –run (on a scale of 8-16). During this period, several political events took place, including (i) protests against the government's plan to curtail the president's authority, (ii) an internal crisis brought on by opposition to the Republic of Macedonia's flag and name, (iii) tension between Greece and Turkey over the Aegean Isles dispute and (iv) tension

resulting from the killing of a British diplomat by a left-wing guerrilla group (BBC). Also, significant vulnerability is revealed from 1990 to 2002 in Albania in the long run (in the 16-32 scales). Some of the political events in Albania during this period include- (i) the conviction of corrupt politicians – Fatos Nano and Ramiz Alia, (ii) the Protest against the death of Azem Hajdari, (iii) internal conflicts from the succession of Pandeli Majko and (iv) fraud from general elections. More so, the result of Bulgaria shows that high political risk occurred from 1989 to 2005 in the medium run. The political events during this period include- (i) the collapse of the Bulgarian Socialist Party government in the face of mass demonstrations, (ii) the arrest of Todor for corruption, and (iii) elections as Zhan Videnov becomes prime minister. In addition, Romania's power spectrum indicates weak political risk vulnerability from 1989 to 1999 at different frequencies except from 1999 to 2003, and the political activities during this period include disputes resulting from the killing of Nicolae Ceausescu and his wife, ex-communist leadership protests, and miner riots, to name a few.

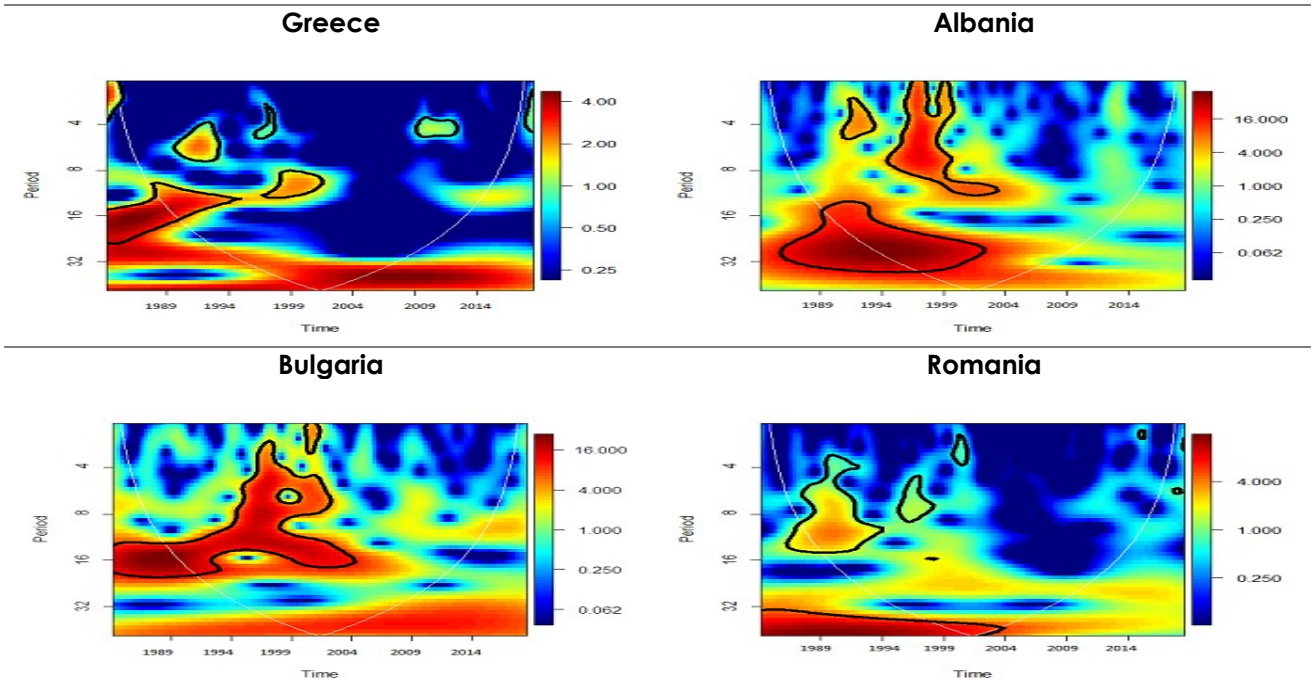

Figure 1. Wavelet Power Spectrum for Political Risk.
Source: Author using Political Risk Group (2019) data

Figure 2 shows the wavelet power spectrum of financial risk across the four Balkan countries. As previously indicated, the x-axis represents the wavelet location in time, while the y-axis represents the wavelet period in years. As seen in the figure, Greece experienced significant short- and medium-term financial risk vulnerability from 2008 to 2014 (at different scales) and 2004 and 2001 (at the 2-4 scale). The sovereign debt crisis prompted more austerity measures in exchange for debt the European Union had sanctioned. More austerity measures were also agreed upon, with a 50% debt write-off from the EU. The worldwide financial crisis and Greece's sovereign debt crisis are, therefore, represented by the financial risk in Greece from 2008 to 2014. So, when the Greek parliament was debating EU treaties and policies, the country's finances collapsed due to the adverse impact of the world financial crisis and long-term trends in current account imbalances and budget deficits.

In addition, Albania indicates significant financial activities in the short- and medium-terms (at different frequencies) from 1997 to 1999; this represents the collapse of Albania's pyramid investment schemes. In contrast, Bulgaria's wavelet power spectrum from 1994 to 1999 is statistically

significant in the medium- and long terms. The devaluation of the Bulgarian currency was a source of financial risk during this time. The financial risk was particularly susceptible in Romania between the 4-8 and 8-16 scales from 1999 to 2001. Therefore, whereas Greece's financial risk vulnerability is mainly in the '20s, it is dominant in the '90s in Bulgaria, Romania, and Albania. Any political risk shock, positive or negative, contributes to a rise in FR in Albania over the long and short run.

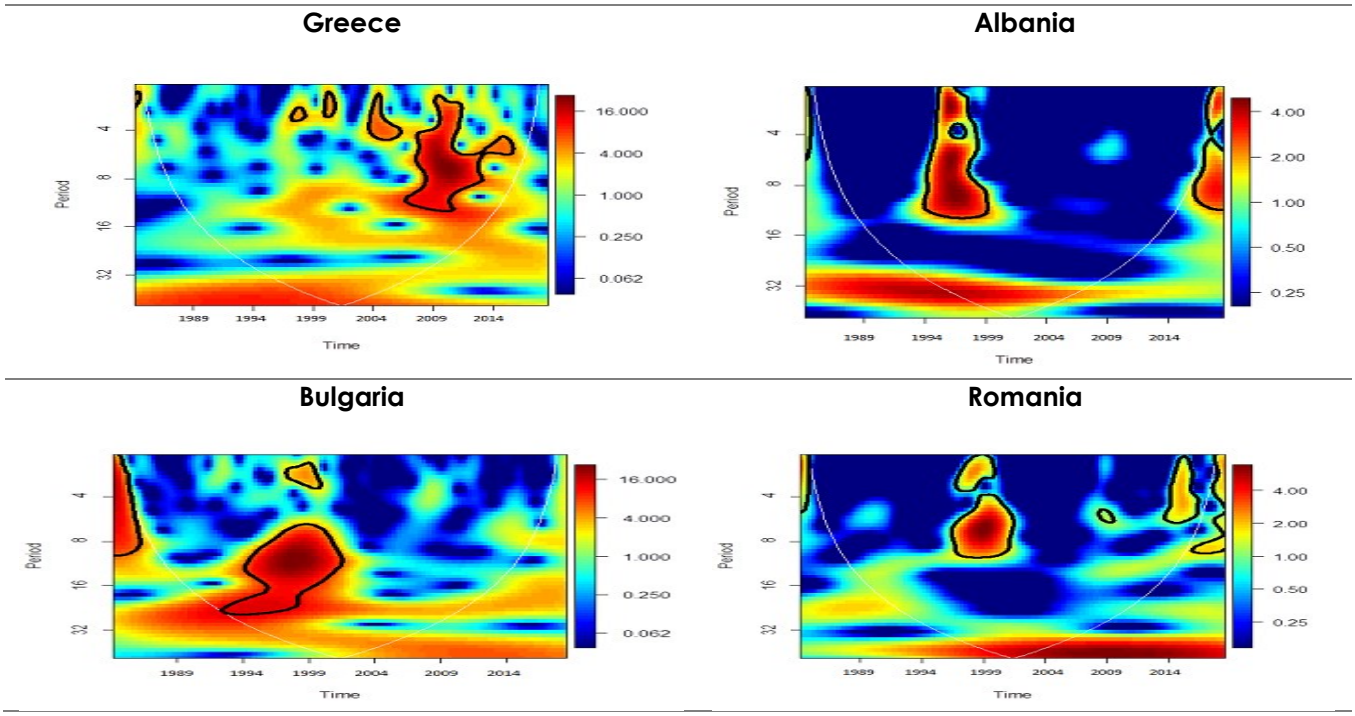

Figure 2. Wavelet Power Spectrum for Financial Risk.
Source: Author using Political Risk Group (2019) data

The wavelet coherence between PR and FR is shown in Figure 3 below; the couture lines represent wavelet squared coherence values of 0.0, 0.2, 0.4, 0.6, and 0.8. Curves with red colors and the black lines surrounding them are the more vulnerable regions. The arrows also depict co-movements between the two variables. In Greece, political risk and financial risk are statistically correlated. From 1995 to 2002, which corresponds to an eight-year cycle period, the primary region is in the medium-term between the 8 and 16 scales when FR is a good predictor of PR. This finding in Greece is consistent with research by (Pantzalis et al., 2000), which found that PR is a direct effect of FR. However, at high frequency, there was a negative correlation in 2004 and, in the short run, a positive correlation in 1988.

In contrast, lead-lag causality from PR to FR was shown in 2009. In the case of Albania, significant causality between 1991 and 2002 demonstrates that political risk leads to financial risk because the arrows between the 16 and 32 scales point directly upward, and a positive correlation between the two scales was seen in 1989 in the short run, in the 2 to 4 scales. Furthermore, a two-year cycle from 2003 to 2004 shows an opposite lead-lag association from financial to political risk. The 2009 global financial crisis had little impact on Albania since the country lacks standard financial markets, which can be considered a blessing in disguise.

Additionally, the main central region in Bulgaria is shown to have a highly significant coherence between 1996 and 1999. In the short run, changes in PR lead to FR on a scale of 2 to 4. The situation in Bulgaria is significantly different since, from 1996 to 1999, we saw that financial risk leads to political risk in the short run. Romania's most statistically significant area is the high-frequency region between the 2–4 and 4–8 scales, which has a positive connection between 2013 and 2015. More so, there was a positive correlation in 1988, which shows a positive association between PR and FR in the short run.

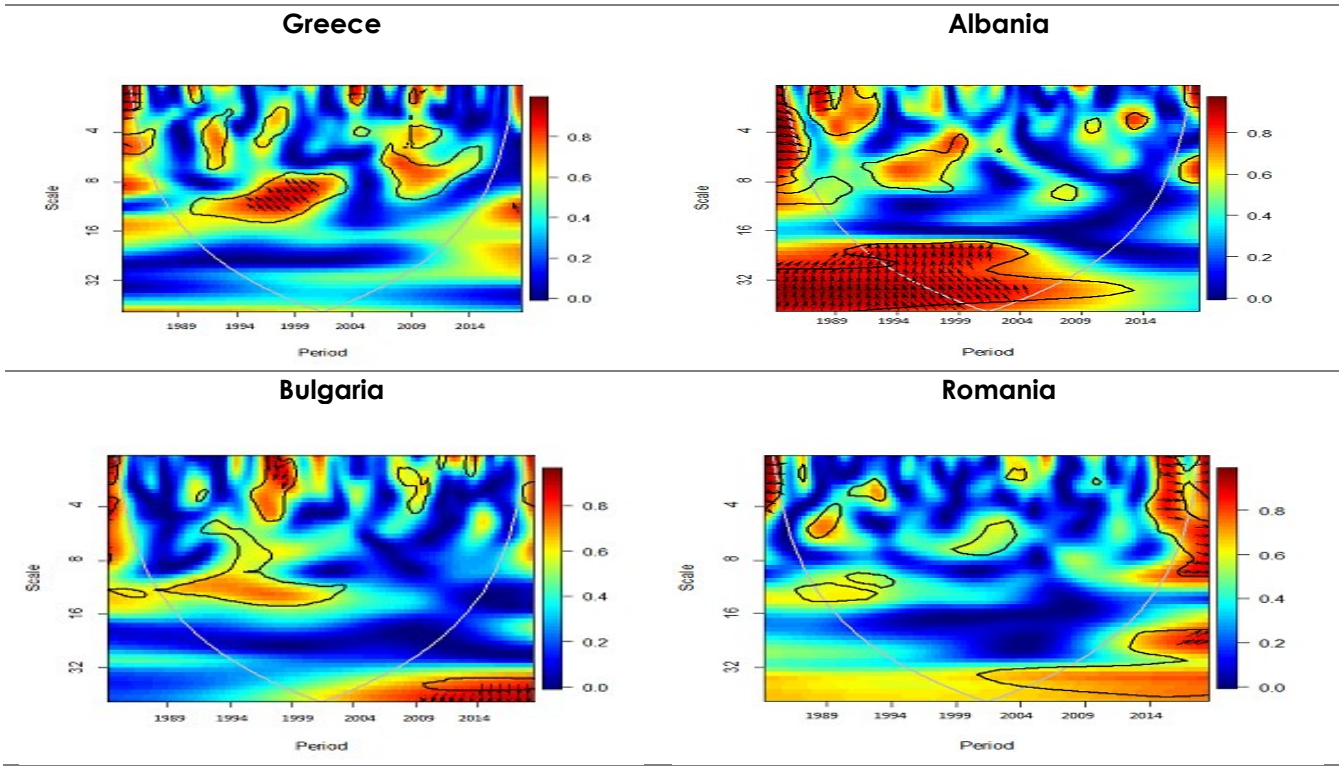

Figure 3. Wavelet Coherence between Political Risk and Financial Risk.
Source: Author using Political Risk Group (2019) data.

This study proposed a conceptual framework of inclusive growth to mitigate PR and FR in the countries, as shown in figure 4 below.

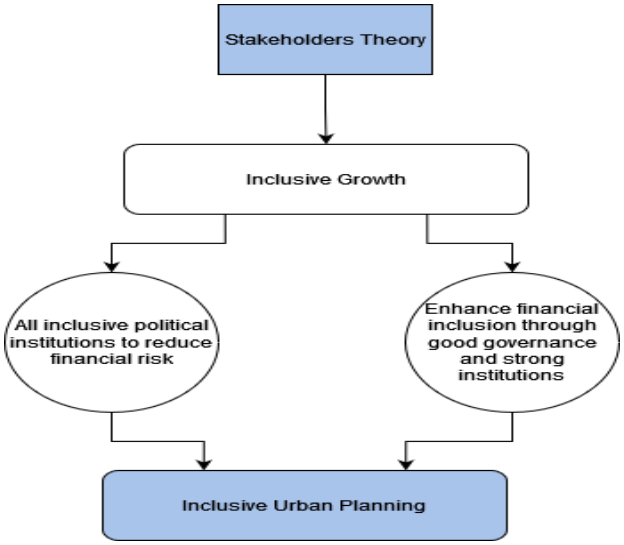

Figure 4. The figure proposed a conceptual framework for inclusive growth for countries.
Source: Author's computation

Political institutions are essential for a country's success because strong political institutions determine good economic institutions. An individual's property rights are assigned to them by the constitutional state, which also guarantees them. The promise of property rights serves as the

primary incentive for people and businesses to gather inputs for production and utilize them in manufacturing. When looking at inclusive growth from a political standpoint, it is important to have an impartial judiciary that will uphold law and order neutrality. Power should also not be concentrated within small individuals or elite groups. Better inclusive growth is facilitated by social capital, which includes public trust in leadership, the government, and civic involvement (Wilson, 1997). Political institutions are open to everyone, regardless of background, gender, or area. Inclusive political institutions' influence impacts a nation's income and production on economic processes like investment in factors of production (Porta et al., 2008).

By ensuring that all participants have access to the same level of services and opportunities as one another, inclusive urbanization aims to address difficulties with access to urban services and the equality of the socio-economic structure. Furthermore, effective political and financial institutions with the foresight of inclusive growth will ensure adequate decision-making. Inclusive urbanization that embraces well plan housing policy and less restrictive land use regulations where all stakeholders- such as women, children, migrant workers, and refugees, are taken into account can enhance better livelihood for all.

4. Conclusion and Recommendations

In order to assess the asymmetry and time-frequency relationship between political risk and financial risk in the Balkan countries, the paper used a quarterly dataset spanning from 1984Q3 to 2018Q4. The dataset in this study is broken down into time-frequency space using a wavelet, which makes it easy to determine the short-, medium-, and long-term interactions between the two variables. Our NARDL findings show an asymmetric relationship between political risk and financial risk in Albania, Greece, and Bulgaria, except Romania, which lacks co-integration. Additionally, our results from the wavelet coherence analysis demonstrated that political risk in Albania and Bulgaria is a good predictor of financial risk. While financial risk drives political risk in Greece, Romania's result shows a positive correlation between political risk and financial risk at different frequencies. Furthermore, in terms of the linkage between PR and FR, our findings support those of Pástor & Veronesi (2013) and Białkowski et al. (2008), who show how political risk affects financial development.

The study also brings to bare recommendations for urban planning development in the Balkan countries. First, we recommend that the Balkan countries' urbanization development becomes mature. The government of Albania, Bulgaria, Romania and Greece should focus on how to reduce political and financial instability to improve urbanization, which will consequently help urban planners develop cities, towns or regional planning. In addition, the government should enact urban planning laws that are amenable to the dynamics in the political and financial situations, as authoritarian leadership can either make static urban policies or slow down urban planning processes. Furthermore, reducing corruption can reduce the bureaucratic processes involved in implementing and executing urban planning policies. Hence, good governance via a good leadership style, effective handing over during regime change and a stable financial regime can enhance an effective urban planning system. Finally, to enhance the effective financial sector, the study recommends long-run financial policy reforms, increase public trust in the countries' financial system and credible all-inclusive political parties to attain all-inclusive financial systems. Future studies should consider other macroeconomic variables in the estimation of NARDL co-integration in a country-specific analysis.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interest

The Author(s) declares(s) that there is no conflict of interest.

Data availability statement

The data that supports the findings of this study can be purchased directly from Political Risk Service Group or available from the authors upon reasonable request

Ethics statements

Studies involving animal subjects: *No animal studies are presented in this manuscript.*

Studies involving human subjects: No human studies are presented in this manuscript.

Inclusion of identifiable human data: No potentially identifiable human images or data is presented in this study.

CRediT author statement

Conceptualization: The wavelet concept is by D. K. while the NARDL concept in the paper is by Sadat Shuaibu. Data curation: D. K. bought data from the Public Risk Service Group. Formal Analysis: Sadat used stata for the NARDL and did the analysis while D. K. used the R-software for wavelet analysis. Funding acquisition- This research did not receive any grant from funding agencies. Methodology- NARDL models are made available by S. M. S. while wavelet models are by D. K. Project administration: Coordination responsibility by D. K. Resources: Analysis tool, R-software provided by D. K. while stata was made available by S. M. S. Software: by S. M. S. and D. K. Supervision: Oversight responsibility for the research activity was done by D. K. Validation- Validated by S. M. S. Visualization- S. M. S. Roles/writing: S. M. S. wrote the draft. All authors have read and agreed to the published version of the manuscript.

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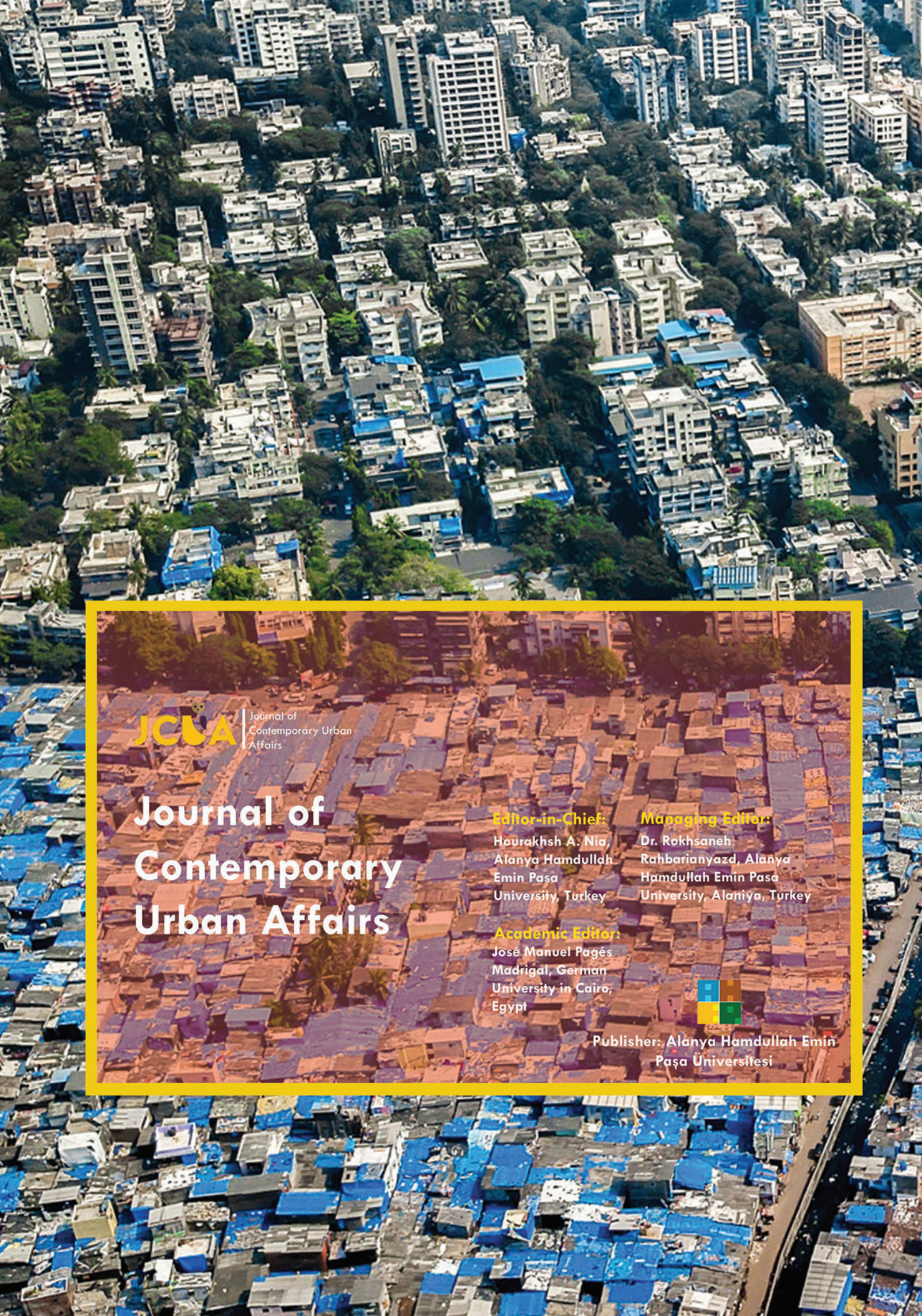
How to cite this article:
Shuaibu, S. M., & Kirikkaleli, D. (2022). Exploring the Nexus between Political Risk and Financial Risk in the Balkan Countries: A Wavelet-Based NARDL Coherency analysis. *Journal of Contemporary Urban Affairs, 6*(2), 249-263. https://doi.org/10.25034/ijcua.2022.v6n2-10



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