International Journal of Human Capital in Urban Management

Volume 8, Number 1, Winter 2023

Indexed by
Scopus

International Journal of Human Capital in Urban Managemet (IJHCUM)

Urban Sustainability is Based on Human Capital

Aims and Scope

International Journal of Human Capital in Urban Management (IJHCUM) aims to offer an outlook on the utilization of human capital in urban management based on existing urban and metropolitan problems. The journal expects to eventually turn into a convergence point as a reference available to professionals, managers and researchers in the field of urban management. Topics of interest include but are not limited to the following disciplines: Human Capital in Urban Management; Urban architecture, design, development and planning; Urban communications and services; Urban civil engineering and related management issues; Urban economics, administrative and financial management; Urban transportation systems and traffic management; Urban social and cultural welfare; Urban ecology and related; environmental concerns; Urban Health, Safety and Environment; Sustainable urban infrastructure.

Vision and Mission

International Journal of Human Capital in Urban Management (IJHCUM) is an open access, peer-reviewed journal affiliated with Municipality of Tehran focusing on employment and allocation of human capital for urban management, including urban multidisciplinary themes. IJHCUM is an integral partner with the scientific and technical communities, delivering superior Information products and services that foster communication, build insights and enables individual and collective advancement in urban management. Providing human capital information to the general public administration with description of contemporary advances in urban issues to be used in improving protection and management.

OPEN ACCESS

IJHCUM

ISSN 2476-4698

Quarterly Publication

International Journal of Human Capital in Urban Management

CALL FOR PAPERS

Publication benefits in
International Journal of
Human Capital in Urban Management

- *Quarterly Publication journal*
- *Online submission and reviewing*
- *Online status inquiry*
- *Double blind peer reviewing*
- *Rapid evaluation and publication*
- *Immediate publication on the net*
- *Open access to all PDF full text of published articles*
- *No pay charge for publication*

Indexed by
Scopus

CONTENTS

Volume 8, Number 1, Winter 2023

(Serial # 29)

COVERING LETTER

Type of Manuscript (check one):

☐ Original research paper

☐ Case report

☐ Research note

☐ Short communication

☐ Review paper

Name:

Corresponding Author Signature:

Date:

International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: http://www.ijhcum.net/

Formation of the intelligent energy system based on digital technologies in urban management

S. Drobyazko[1,*], T. Hilorme[2], S. Nesterenko[3], Z. Shatskaya[4]

[1] The European Academy of Sciences Ltd, London, UK

[2] Scientific Research Institute of Energy Efficient Technologies and Materials Science, Oles Honchar Dnipro National University, Dnipro, Ukraine

[3] Department of Finance and Accounting, Open International University of Human Development, Kyiv, Ukraine

[4] Department of Smart Economics, Kyiv National University of Technologies and Design, Kyiv, Ukraine

ARTICLE INFO

ABSTRACT

BACKGROUND AND OBJECTIVES: The economic consequences of the introduction of digital technologies are projected both at the level of electricity market participants and at the level of the state as a whole. As a result of the introduction of intelligent electricity metering it is possible to achieve energy savings of 20 % and solve the problem of transparency of energy flows of the national economy (information asymmetry). The purpose of the work is to substantiate the organizational-economic management of the national integrated intelligent energy system of the country in the conditions of the digital economy.
METHODS: Statistical analysis for technical-economic analysis of the functioning of the national energy system, technological forecasting and foresight for assessment of future changes in the architecture of energy systems, economic-mathematical modeling and scenario analysis for comparative assessment of future development of separate energy technologies.
FINDINGS: Forecasting of development of macrotechnologies in the energy sector is carried out, points of bifurcation of competitiveness of various energy technologies are defined. Assessments of economic consequences of introduction of digital technologies in energy systems both at the level of energy market entities, and at the national level are carried out. In the presence of own generating capacity, the consumer becomes an active participant (producer) in the electricity market, which in turn reduces system technological losses and economic costs of suppliers in the expansion of energy grids.
CONCLUSION: For generation companies, the effect lies in reduction of operating costs of up to USD 2 billion annually by smoothing the load schedule in Slovakia. Significant results can be achieved in the electricity distribution sector, in particular by reducing electricity losses by 50 % and reducing equipment maintenance and repair costs by 10 %. It was suggested to consider the technological platform as a business model for the digital development of the infrastructural sectors of the economy, in particular, the digitalization of the energy infrastructure. The authors developed the structure and presented the opportunities of the technological platform for the introduction of an intelligent energy system in Slovakia. Proposals for the implementation of the concept of an intelligent energy network as part of the digital transformation of the economy of Slovakia were developed.

NUMBER OF REFERENCES

42

NUMBER OF FIGURES

4

NUMBER OF TABLES

3

*Corresponding Author:
Email: drobyazko.s.i@gmail.com
Phone: +440207134551235
ORCID: 0000-0003-2022-0126

INTRODUCTION

The rapid development of Information and Communication Technologies (ICT) leads to the gradual digitalization of many sectors of the national economy, including infrastructure, which includes the energy system of a country. Under these circumstances, the traditional methods of strategic planning and implementation of technological changes in the energy system of a country do not meet the modern requirements of an integrated combination of interests and efforts of the state and business. In network sectors of the economy, this in turn necessitates the expansion of scientific views on the processes of formation of supply and demand, as well as changes in existing approaches to market regulation of the monopoly type (Borlase *et al.,* 2017). The need for radical changes in the energy sector of a country is conditioned by new requirements to increasing the reliability and quality of the energy supply system of a country, increasing the level of its manageability under conditions of growing share of renewable energy sources (RES), growing level of cybersecurity of the energy system of a country (Sadeghi-Pouya *et al.,* 2017). The combination of these factors requires the development of an economic mechanism for the development of the intelligent energy system of a country. Directions and stages of the process of integration of information and communication technologies and electricity grids include conducting appropriate technological forecasting (energy foresight), determining the effects of technology implementation, determining bifurcation points, that is the terms of replacement of traditional energy technologies with alternative energy sources when the structure of the energy balance will change and the intellectual architecture of the energy system will develop (Cebulla and Fichter, 2017). The economies of the world leading countries are undergoing changes that affect the consumption of electricity (Ghodousi *et al.,* 2017). The problem arises as to the efficiency of energy production, supply, distribution and use (Cheng and Yu, 2018). Accordingly, a transformation of the energy sector is taking place, which is becoming global in nature, which should lead to significant changes in the energy sector and energy efficiency (Seljom and Tomasgard, 2017). The purpose of the work is to substantiate the organizational-economic management of the national integrated intelligent energy system of the country in the conditions of the digital economy. To achieve this goal, the following scientific tasks were set and solved: identify characteristics and areas of digital modernization of the national energy system; systematize possible threats, risks and evaluate the economic effects of digital modernization of the national energy system; suggest conceptual provisions for the management of the intelligent energy system of a country.

Literature Review

The following main trends in scientific and technological development can be identified (Bunn *et al.,* 2018): strengthening technology convergence; strengthening the diffusion of modern high technologies in medium-tech segments of the manufacturing sector; strengthening the impact of new technologies on management and organizational forms of business. Innovative technologies are being developed, which will largely determine both future markets and the competitiveness of countries (Filipović *et al.,* 2019). The key factor in the development of the technological paradigm 4.0 was the integration of information technology with technologies, which are basic for the development of the modern world in the field of energy, transport, biology, medicine, media, education and culture, defense and national security (Lund *et al.,* 2017). This paradigm fuels the design and development of new integrated energy and telecommunications technologies, biotechnology, nanotechnology, etc. The main result of the development of new technologies is the resource-saving potential of economic growth (Karjalainen and Heinonen, 2018). The identified trends and regularities prove that qualitatively new large-scale technologies are able to provide solutions to complex, unsolvable on the previous technological basis, economic, social and environmental problems (Richter *et al.,* 2018). The most promising areas of technology convergence are as follows (Solano Rodriguez *et al.,* 2017): nanotechnology and ICT; cognitive technologies and ICT; nanotechnology, materials science and ICT; energy technologies and ICT. In the future, these technologies will promote the emergence of new sectors of the economy and markets. The final formation of a complete set of converged technologies is expected no earlier than in 2020 (Saul and Gebauer, 2018). Currently, the level of uncertainty in the prospects for the development of the energy sector has increased significantly (Brown *et al.,* 2018). This is related to the fact that

global participants in the fuel and energy markets give different assessments of energy development. Accordingly, opposite development strategies are developed. Scientists identify two main options for answering questions about the development of energy supply in the future. The first option is known as "energy efficiency plus" (Ilieva and Gabriel, 2019). It provides for the modernization of existing energy systems, which are based on centralized energy supply grids, large-scale generation and "carbon energy" (Fan *et al.,* 2018). The second option is a paradigm that involves the development of new energy, which should be based on renewable energy sources, energy systems based on a decentralized intelligent grid and "smart" infrastructure of cities (Aineto *et al.,* 2019). It is also planned to move to buildings with

lower energy consumption and integrated technical solutions for autonomous energy supply. The leading countries already provided for the transition to a new type of real estate ("resource-producing") (Nerini and Strachan, 2017). In the existing studies in general the prospects of innovative development of electricity industry on the basis of digital technologies are proven, and it is determined that when using new methods of management of introduction of technologies, both consumers and energy companies will receive advantages (Wagner *et al.,* 2020). However, issues regarding possible risks, mechanisms for introduction of innovations in the industry in the context of the development of a competitive electricity market remain unresolved. The problems of balancing the interests and consolidating the efforts of stakeholders
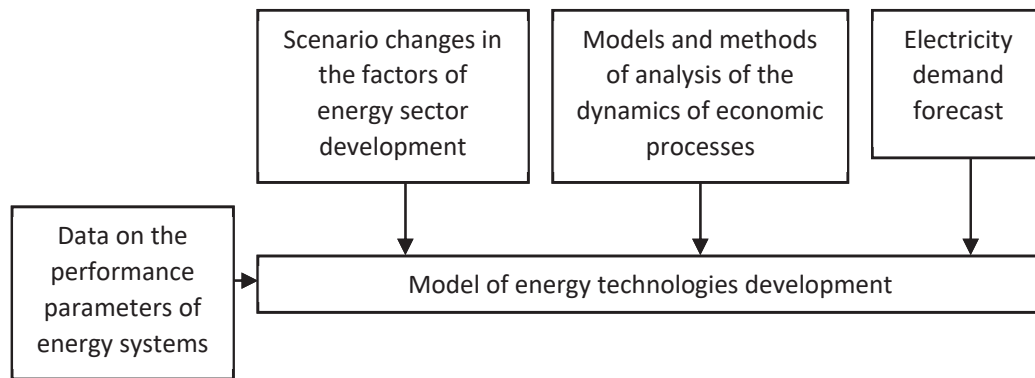

Fig. 1: Components of the process of model-scenario analysis of the development of energy technologies
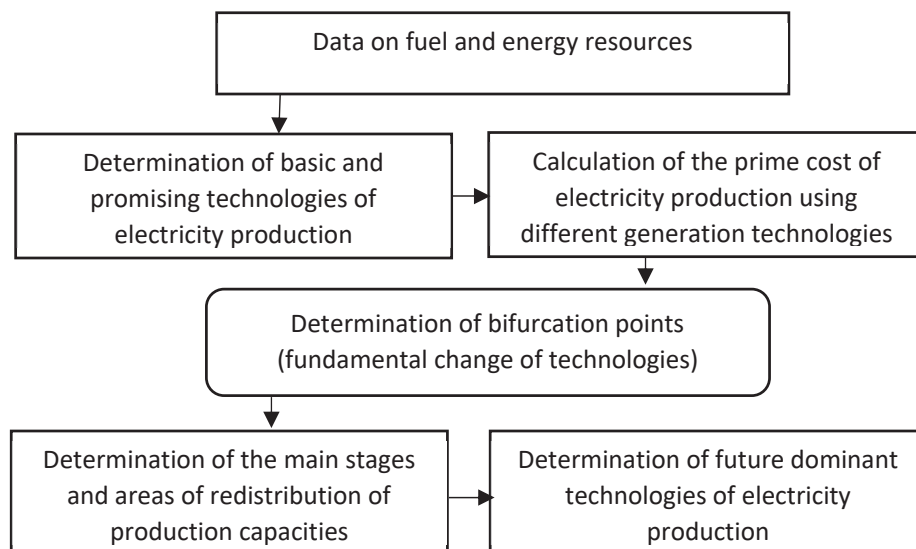

Fig. 2: Model for determination of the future dominant technologies of electricity production

in the process of developing the intelligent energy system of a country also remain insufficiently covered. Thus, further study is required in part of developing organizational and economic support for the process of innovative development of the energy system based on digital transformations. The current study have been conducted in Slovakia during 2015- 2021.

MATERIALS AND METHODS

The following scientific methods were used to achieve the set purpose: logical-historical method for the study of regularities of technological development of energy systems, structural and functional analysis for classification of the objectives of modernization of the energy system in the current conditions, factor analysis for systematization of economic threats and risks of fundamental changes in the architecture of future energy systems, statistical analysis for technical and economic analysis of the functioning of the national energy system, technological forecasting and foresight for assessment of future changes in the architecture of energy systems, economic-mathematical modeling and scenario analysis for comparative assessment of future development of separate energy technologies.

In the article, foresight is the main method of forecasting the formation of the energy system, which is a much more complex approach than traditional forecasting. With the help of technological forecasting, one gets information about the possibilities of new technologies, about their perfection and dynamics, about the possible terms of their transfer from laboratories to production (Al-Tarazi and Chang, 2019). It is a preparation for the decision-making process regarding the establishment of priorities in the field of science and innovation and provides for the involvement of informed participants from scientific, business circles and the public in technological analysis and dialogue. The forecast gravitates towards more specific and certain results based on the information available today. With the help of technological forecasting, one gets information about the possibilities of new technologies, about their perfection and dynamics, about the possible terms of their transfer from laboratories to production (Ashraf et al., 2020). It is a preparation for the decision-making process regarding the establishment of priorities in the field of science and innovation and provides for the involvement of informed participants from scientific, business circles and the public in technological

analysis and dialogue (Cai et al., 2019). The forecast gravitates towards more specific and certain results based on the information available today. In addition to the advantages, foresight research has certain disadvantages (Choi et al., 2018): the availability of financial resources and time (the larger the scale of the research, the greater the costs it involves); the necessary level of participation of experts and stakeholders (some methods, such as Delphi, allow for the interaction of large groups of participants, but such interaction will be rather fleeting; expert panels, on the contrary, allow for greater depth of discussion, but with a smaller number of participants; a combination of methods makes it possible to eliminate the indicated shortcomings, but requires large costs); combining a method with others as a basis or supplement to the main method (formal methods are rarely used alone, more often a combination of several methods is practiced). The existing model of calculation of prime cost and definition of development of macrotechnologies in the field of energy efficiency was adapted for modeling (Uniejewski et al., 2017). Since the introduction of methods for management of electricity demand particularly affects the activities of thermal power plants, the main effect lies in reducing the use of units with a capacity of 200 and 300 MW by 20-30 % and fuel savings of 40-60 million tons per year from smoothing the daily load schedule, as well as passing the heating season (DeCarolis et al., 2017). Model-scenario analysis of the development of energy technologies and assessment of their impact on the structure of electricity demand involves: representation of relevant aspects in world energy systems; formalization of models, data input; review of possible technology development using scenario analysis of built models. The components of the process of model-scenario analysis of the development of energy technologies are given in Fig. 1, and the conceptual diagram of the model, in Fig. 2.

To build an economic-mathematical parametric model, a number of assumptions are made. Namely: there is a set (vector) of technologies (Eq. 1):

$$v = V_f(f_{ii}; C_i; r_i; h; g) \tag{1}$$

where f_i — utilization factor; C_s — primary fuel price; r_i — installed power; h_i — unit cost; g_i — emissions CO_2.

The following technologies are selected for the

calculations:

$V_1(f_1; C_1; r_1; h_1; g_1)$ – TPP (Thermal Power Plant), steam turbine with subcritical steam parameters;

$V_2(f_2; C_2; r_2; h_2; g_2)$ – TPP, steam turbine with supercritical steam parameters;

$V_3(f_3; C_3; r_3; h_3; g_3)$ – NPP (Nuclear Power Plant);

$V_4(f_4; C_4; r_4; h_4; g_4)$ – HPP (Hydro Power Plant);

$V_5(f_5; C_5; r_5; h_5; g_5)$ – Solar Power Plants (silicon cells);

$V_6(f_6; C_6; r_6; h_6; g_6)$ – Solar Power Plants (thin film cells);

$V_7(f_7; C_7; r_7; h_7; g_7)$ – Solar Power Plants (hub);

$V_8(f_8; C_8; r_8; h_8; g_8)$ – wind power stations.

The objective function is as follows (Eq. 2):

$$F = \sum_{i=1}^{m} \left(S_i \sum_j Y_{ij} \right) \qquad (2)$$

where S_i — prime cost of electricity production using i-th technology, USD/kWh, which in turn is calculated by the formula (Eq. 3):

$$\begin{cases} S_{ij} = K_w + C_w + S_f + Z_w + S_{CO2_w} \\ O_a \sum_k \sum_i (Y_{ik}) \leq N_a \\ \sum_i \sum_j Y_{ij} \geq U_j \end{cases} \qquad (3)$$

where Y_{ij} - volume of electricity produced using i-th technology at j-th plant, $\cdot$ kWh; K_w - specific capital costs, USD/$\cdot$ kWh; C_w - operating costs and management, USD/$\cdot$ kWh; S_f - fuel costs, USD/tons of oil equivalent; z_w - waste disposal costs, USD/$\cdot$ kWh; S_{CO2_w} - emission permit costs, USD/$\cdot$ kWh; U - demand for electricity, $\cdot$ kWh; O_a - greenhouse gas emissions, t/$\cdot$ kWh; N_a - target level of greenhouse gas emissions, tons.

The study information base is analytical materials of the International Energy Agency. The assessment of the Integrated National Energy and Climate Plan of Slovakia made by the EU in 2020 generally indicates a low level of ambition of the state by a number of main indicators, such as the share of RES in final energy consumption in 2030, energy efficiency, energy security, research and innovation (Slovak National Energy and Climate Plan, 2022). According to the statistical data of the Regulatory Office for Network Industries of Slovakia as of June 2020, the consumed electricity from renewable sources was 17.48% in

2019, while its total specific weight in the electricity balance was 18.42% (Slovak National Energy and Climate Plan, 2022). Biomass processing (5%) and hydropower (8.1%) are the main renewable sources of generation. Solar energy accounts for only 1.8% of electricity, while nuclear power plants produce more than 55% of all consumed electricity (Slovak National Energy and Climate Plan, 2022). Among the positive aspects of the plan, the presence of good examples of the interconnectedness of climate change and energy efficiency issues is noted. Particular attention is focused on the formation of measures at the local level by creating a network of regional energy centers. The presence of the specified problems in the development of the methodology to study the management of the creation of the intellectual energy system of the country actualizes the need to define all the components of the methodological framework of such a study as viewed by the authors. The basis of the indicated methodology will be formed by a number of assumptions (hypotheses). Hypothesis of environmental complexity: changes and their implementation are determined by the action of factors of the external and internal environment. Hypothesis of chance: change management, as a management process, has in its arsenal a list of tools and techniques, the use of which depends on the type of problems and change situations that have arisen. Hypothesis of integrity: changes and their effectiveness depend on the coordination and interaction of various control elements (subject, object, subject of management). Hypothesis of balance: for each level of the combination of factors of the change environment, a combination of control elements can be determined that will ensure the achievement of the change goals. The use of the assumptions (hypotheses) specified in the methodology is possible in two aspects: theoretical and applied (practical).

RESULTS AND DISCUSSION

Digital transformation of energy sector is a natural stage of development of energy systems in developed countries. However, in each of these countries, the areas of implementation of digital technologies are conditioned by national characteristics of energy systems. The presence of excess, but physically obsolete generating capacities, shortage of switching capacities, imbalance of logistics of primary energy supply, imperfect tariff policy, non-transparency of

energy flows are the characteristic features of the energy system. At the same time, the use of RES (Renewable Energy Sources) is accelerated in the country. The introduction of a competitive electricity market provides for inclusion of qualified consumers in the system of market relations and significantly increases the requirements for information and software support of the energy management system. The diagrams for replacement of one equipment with another are presented by S-shaped curves. If it is not a case of replacing old equipment with new one, but a case of using new equipment performing the functions, which were not previously performed by it, the same type of growth curve is still used.

It seems most difficult to forecast the dynamics of operating capacity for thermal power plants. Considering the extremely wide variety of types and characteristics of existing Thermal Power Plant (TPP) equipment, as well as the high dependence of solutions on the dynamics of gas and coal prices, this problem has no clear solution and requires an integrated analysis of the following key factors (Drobyazko and Hilorme, 2021): age structure of existing equipment, most of which was introduced 30–50 years ago, and estimates of its physical wear; depreciation and non-competitiveness (unprofitability) of operation of existing capacities in the conditions of deep deregulation of the electricity market; comparative efficiency of investment solutions on reconstruction (modernization or replacement) of existing equipment or its dismantling with replacement by new, technologically advanced power plants taking into account the changing cost of fossil fuels. Analysis of the age structure of existing equipment and assessment of the dynamics of potential disposal of existing TPP capacities through natural physical wear allows to estimate the total amount of investment decisions on their reconstruction or replacement in the first approximation. The traditional criterion for assessing the scale of potential disposal is the "fleet life" of energy equipment, the value of which is determined by the operating life of the units of thermal power equipment of similar design, materials and operating conditions, which ensures their trouble-free operation in compliance with standard requirements for metal control, operation and repair (Henríquez *et al.*, 2017). In the general case, the concept of "fleet life" can be attributed to the power plant as a whole, separate units (boiler, turbine, steam pipeline) or their main elements.

The forecast of dynamics of operating capacity of TPP is made taking into account the recommended investment decisions on reconstruction by standard groups of equipment. According to calculations, by 2030 of the operating capacities (103 GW) reaching the maximum physical service life, only one tenth (10 GW) is subject to final dismantling (Lopion *et al.*, 2018). As for the other capacities, effective decisions on their reconstruction can be implemented, and with that more than a half (55 %) of existing equipment can be replaced by technologically progressive equipment. Along with a quantitative comparison of the efficiency of different fuels and waste generated, it is important to consider the relative costs associated with the use of a particular fuel. The cost of construction of nuclear power plants is much higher than the cost of existing coal- or gas-fired thermal power plants. But the cost of nuclear fuel, including its necessary preparation, is less than the cost of oil, coal and gas. The actual cost of electricity generated by nuclear power plants will be almost the same as that generated by thermal power plants. Regarding investment in new generating capacities, design and capital construction costs are a determining factor. If low gas prices are projected in any area today, it is the main reason for the non-competitiveness of nuclear energy there. The presence of areas of electricity consumption away from sources of cheap coal is the main condition for increasing the use of nuclear energy for many countries. An important aspect of the development of nuclear energy is its dependence on the solvency of a country in the international market. Therefore, in countries such as Japan or France, where the choice is between importing large quantities of fuel and high capital construction costs on own territory, the decision can be made simply on the basis of international exchange (Yang *et al.*, 2017). Buying a thermal power plant abroad, for example in Japan, would lead to higher electricity prices and significantly reduce the foreign exchange reserves of the country, which will not happen when using less expensive uranium fuel. An agreed policy on the prices of carbon fuel burned for electricity generation, or significant taxes on it, will change the economic status of nuclear energy. For example, the price of USD 37 per ton of regular coal, or USD 29 per ton of brown coal, will increase the cost of electricity by one cent per kilowatt hour at constant prices for nuclear electricity (Lane *et al.*, 2018). It was noted above that the cost of nuclear power plants

is higher than that of thermal power plants. Energy costs (that is the amount of energy invested in the manufacture of materials, fuel preparation, etc.) may also be higher. This is especially true for light water reactors, which require additional energy to enrich the fuel. Energy costs for manufacture of structures and initial loading of the fuel of the light-water reactor are approximately 1.5 % of the energy produced by the reactor, and taking into account subsequent fuel loads, this value will be less than one percent (Price and Keppo, 2017). In the worst case, when using expensive diffusion methods of uranium enrichment, it will be up to 4 percent. Although coal and uranium compete for the leading role in basic electricity production, some developed countries see their progress in their equal role. Also, it is necessary to take into account the fact that the cost of equipment is relatively constantly decreasing and solar energy has a high Levelized Cost of Energy (LCOE) value. At the same time, the quota cost is calculated. This indicator reflects a fixed tariff for electricity, which reflects the cost of its generation and at which the total discounted revenue from the sale of electricity to the final consumer is equal to the total discounted costs throughout the entire life cycle of the power-generating facility. It is the minimum price at which the electricity generated over the entire life of the power plant must be sold to reach its break-even point (NPV = 0). If the price of electricity is higher than the LCOE, it will give a higher return on invested capital (NPV > 0) than the adopted discount rate, while a lower price will not allow the project to pay off at the given discount rate (NPV < 0). Data for different fuel prices (for fossil fuels) or commissioning terms (for nuclear installations). 5 % discount factor taking into account the 30-year service life and an average load factor of 70 % (Drobyazko and Hilorme, 2022). The issue of fuel prices is a key factor for fossil fuels (Ketter *et al.,* 2018). Since in nuclear energy the ratio of fuel cost to total cost of electricity is low, the time of design and construction, and hence capital costs, is a key factor. Thus, increasing the load factor will be more advantageous for nuclear installations. In practice, the energy payback period is actually about six months. Hydropower is a clean source of energy. However, hydropower causes indirect greenhouse gas emissions, mainly during the construction and flooding of a water storage reservoir. This may be related to the decomposition of some part of flooded biomass (forests, peatlands and other types of soil) and the increase of aquatic wildlife and vegetation in the reservoir. Long-term socio-economic development of European countries provides for the concentration of efforts on the development of special tools allowing to combine science, production and state administration in various sectors of the economy and industry. Technology platforms are one of such tools. Ten years of experience in the creation and implementation of such EU platforms show their effectiveness in the context of accelerating innovative development at the level of separate sectors of the economy. In order to implement the mechanism for solving problems with regard to modern requirements for the functioning of the energy supply system on the basis of new advanced technologies, it is necessary to improve the system of forecasting, planning and consolidation of efforts.

Thus, it is substantiated that the development of integrated intelligent energy systems has a system nature of energy transformation and requires consolidation of efforts of all stakeholders: state institutions, energy business and research institutions. This form of cooperation in matters of technological development is called a "technological platform" (Drobyazko *et al.,* 2020). The corresponding organization plan of interaction of institutions in the course of digital modernization of energy systems is suggested in the paper (Fig. 3). The availability of these resources to the growing population of the world and the capacity of ecosystems for permanent and sustainable self-healing depend to a large extent on the efficient use of resources in the production and consumption of goods, services and technologies used in these processes. In these conditions, industrialized countries must find an adequate response to formulate their energy strategy in the medium and long term. Three pillars of energy policy, namely: competitiveness, sustainable development and security of energy supply should be the basis for planning future prospects. New participants from other sectors of the economy are entering the energy market. In particular, companies that are leaders in the field of information and communication technologies are becoming participants in energy markets and investing in the development of alternative energy. Based on these observations, it can be argued that the convergence of information technology with technologies that are basic for the development of the modern world is a key factor in the development of economic sectors. This paradigm fuels the design and
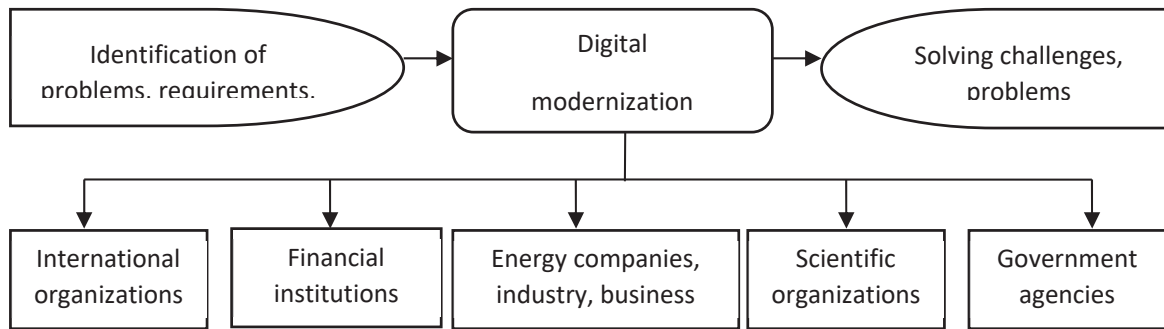
Fig. 3: Communications of institutions in the process of digital modernization of energy systems

development of new energy information technologies (Drobyazko *et al.*, 2021). The process of digital energy transformation is global in nature and is related with the convergence of information-communication technologies and energy technologies, which leads to the formation of integrated intelligent energy systems and synergy effects. The main result of the application of new technologies is the use of resource-saving potential of economic growth. Currently, the role of energy consumers, who can become its producers, is changing. Thus, consumers not only buy energy resources in the centralized energy system, but also buy capacities for energy production. This allows to increase the self-regulatory role of consumption, to mobilize the technologies of decentralized energy production, to increase the value of local resources, as well as to move to "smart consumption" in cities. It can be argued that the scenario of transition to new energy is already justified in the leading countries of the world. The following should be considered as preconditions for the introduction of intelligent energy system technologies: electrification of energy demand, increase of renewable energy sources in the energy balance, growth of demand for digital technologies in the field of energy supply, construction of real estate with much lower consumption of energy resources. This provides for maximum flexibility and informatization of energy systems, including generating capacities. The identified trends prove that qualitatively new, large-scale technologies can provide solutions to complex economic, social and environmental problems that cannot be overcome on the basis of the previous technological base and methods of technological forecasting and planning of development of energy supply systems. Therefore, new strategic planning

tools are gaining ground in the leading countries. These include: foresight, strategic technology plans, technology roadmaps, technology platforms, problem-oriented scenario analysis, methods of adaptive management and technological forecasting, etc. The results of studies are used to make decisions on promising areas and priorities of energy development. The use of energy foresight is caused by the following factors: crisis of existing relations in the energy supply system; consequences of financial and economic crises of recent decades; emergence of structural and functional imbalance, which leads to the accumulation of contradictions and new bifurcations; new system of design and production of equipment and materials with predetermined properties, which is a promising way of technological modernization of energy systems. To obtain results regarding the transition to a new quality conditions of the system operation, that is to determine the bifurcation points and to calculate the prime cost under different conditions of application of advanced technologies of intelligent metering and flexible transmission systems in the bulk electrical system for leveling the imbalance of generation and consumption of electricity modeling was carried out. Scenario conditions for the development of electricity production include prices for the following fuels: oil, natural gas, and coal. Natural gas will undoubtedly play a major role in meeting global energy needs for at least the next two and a half decades. Global demand for natural gas, which declined in 2009 due to the economic downturn, has been resuming its growth trajectory, characteristic of gas for a long period of time, since 2010. This is the only type of fossil fuel for which demand is higher in all scenarios in 2035 than in 2008, although growth rates are completely different.

With the long-term rise in oil and gas prices, interest in coal as an alternative energy source is only growing in the world. According to the US Department of Energy, after 2020, coal in general will become the fastest growing fuel for power plants, significantly outpacing gas. In Western European countries, where fuel costs and consumer properties are taken into account, the gas/coal/fuel oil price ratio is 2/1/2.8 (Lane *et al.,* 2018). Market pricing mechanisms should eliminate serious distortions of domestic gas prices and gradually bring the energy price ratio to the level formed in other countries. The key criteria for selecting the future structure of generating capacities are the efficiency of capital investments in various types of generation, which determines the minimum cost of electricity for the consumer (including reimbursement of capital and all other costs of generation and transmission), as well as energy security, general economic efficiency, existing constraints in terms of connections and environmental consequences. The comparative analysis of the economic efficiency of different types of generation will be primarily determined by the specific capital investments for the construction of different types of plants and fuel costs (Table 1).

Comparison of cost characteristics of energy generating technologies (Table 2). The expected reduction in the cost of alternative energy sources is fundamentally dependent not on time but on the cumulative effect of mass production, which in turn requires the development of the market for these technologies. Most technologies can reduce investment costs by 30–60 % of the actual level by 2024 and by 20–50 % in the period after 2040 reaching its peak development. Particular attention should be paid to bifurcation points. It can be assumed that after 2025 the cost of electricity produced using renewable energy sources, especially solar ones, will be significantly reduced.

Globally, in 2035, coal will be the leader among energy sources used for electricity generation, although its share in electricity generation will be reduced from the current 41 % to 32 %. Significant growth in coal-based electricity production in non-OECD countries will be partially offset by its lower production in OECD countries. Globally, the transition to nuclear energy, renewable energy and other low-carbon technologies is expected to reduce emissions per unit of electricity produced by one third by 2035. According to the scenarios of electricity industry development, the total electric capacity of nuclear power plants may increase significantly in the world by 2050. Although coal and uranium compete for a leading position in basic electricity generation, some developed countries see their progress in their equal role. Solar and wind energy will become the main competitors of nuclear energy by 2030. The rate of reduction of the cost of solar energy generation and the development of energy storage technologies suggest that in 20 years the capital costs for solar energy generation, even in the basic mode, will be lower than those for nuclear energy. Table 3 contains the results of scenario modeling regarding the motion of bifurcation points, and as a result of reducing the generation volumes for certain technologies Thermal Power Plant (TPP); Wind Power Plant (WPP); Hydro Power Plant (HPP); Nuclear Power Plant (NPP); Solar Power Plant (SPP) and replacing one technology with another.

According to modeling results, one can see that the increase in fuel costs affects the development of technologies for alternative sources of electricity, especially solar energy. Also, growing specific fuel consumption is a significant factor. This is especially true of outdated TPP technologies. So, an economic-mathematical model is developed that allows to perform scenario modeling of energy technology development, both in the world as a whole and for a separate country. Based on the modeling results, the bifurcation points were identified, which would allow you to determine the areas and stages of the development of macro-technologies in the field of energy and to outline further transformations in the field of energy and energy efficiency (Fig. 4). By the modeling results one can also trace the stability or insignificant growth of electricity generation from traditional sources and a significant increase in the amount of electricity generation using technologies based on alternative sources. The first stage involves the introduction of digital technologies in the existing energy systems. The second stage involves the creation of a decentralized energy system operating together with a centralized energy system. The world leading countries are currently undergoing this stage. Distributed generation and the energy system become equal in the process of providing a consumer with electricity. The organization of interaction between the main energy system and the distributed generation system is carried out in energy system management. Competition is beginning to take effect in the retail

Table 1: Basic energy technology parameters

Parameter	Parameter
Coal-fired power plants	
Discount rate, %	8
Efficiency, %	36.7
Annual operation time, hours	7446
Specific investments per kW of installed capacity, USD	1300
Service life, years	40
Project start period, months	48
Fuel price, US dollars/MMBtu	1.2–1.5
MW production cost, USD	42
Combined cycle power plants	
Discount rate, %	8
Efficiency, %	53
Annual operation time, hours	7446
Specific investments per kW of installed capacity, USD	500
Service life, years	40
Project start period, months	24
Fuel price, US dollars/MMBtu	4.42
MW production cost, USD	41
NPP	
Discount rate, %	8
Efficiency, %	32.8
Annual operation time, hours	7446
Specific investments per kW of installed capacity, USD	2000
Service life, years	40
Project start period, months	60
Fuel price, US dollars/MMBtu	-
MW production cost, USD	67

Made by the author based on data from (International Smart Grid Action Network, 2018)

electricity market. The third stage lies in creation of a hybrid energy system in which a significant amount of electricity is generated by decentralized power plants together with centralized generation. Therefore, it is advisable to develop a program for the introduction of new technologies in the electricity industry and the development of important facilities in this area. When modernizing the energy system, mutually beneficial and comprehensive interaction with innovative companies of small and medium business is one of the important areas of cooperation of electricity companies with the entities of the innovation environment. Partnership relations should be formed and developed within the framework of subjects and projects defined by the sector development strategy. For the electricity industry, the import substitution program is considered as the main mechanism for implementing certain goals of the energy strategy in the context of digital transformations. Implementation of the import substitution program allows to achieve a

Table 2: Estimated cost of new capacities and prime cost of electricity

Technology	Investment, US dollars/kW	Prime cost, cents/ kW · h
Coal-fired TPPs:		
steam turbines with chemical absorption of gases	1850	6.79
steam turbines with supercritical steam parameters	1675	5.70
integrated coal gasification combined cycle plant	2100	6.73
hybrid combined cycle units with integrated coal gasification and high-temperature solid oxide fuel cells	2100	6.00
with integrated coal gasification based on coal water mixture	1620	3.35
combined cycle units with circulating fluidized bed (pressurized fluidized bed) and desulfurization	1400	5.26
Gas-fired TPPs:		
Combine-cycle plants with chemical absorption of exhaust gases	800	5.73
Combine-cycle plants with chemical absorption of exhaust gases and combustion in oxygen	800	5.41
Hybrid TPPs based on a combination of CCGT and high-temperature solid oxide fuel cells	1200	5.39
Modernization of steam turbine TPPs based on gas turbine superstructure	300-550	5.00
NPP (with decommissioning inventory)	1200-2500	2.50-6.00
NPP (extension of service life)	250-390	2.50-6.00
Large-scale hydropower	1000-2500	1.00-8.00
Small-scale hydropower	800	6.00
Renewable power plants: Biomass power plants	226	7.60
Geothermal power plants	2500-5084	6.50-30.80
Solar power plants (photovoltaic)	5000	15.00-50.00
Wind power plants	1370	3.60

Calculated by the authors based on data from (International Smart Grid Action Network, 2018)

Table 3: Results of scenario modeling for the motion of bifurcation points

Scenario	TPP with supercritical steam parameters	WPP	HPP	NPP	SPP
Basic scenario	2012	2014	2011	2029	2045
+ 10 % of fuel cost	X	2011	X	2024	2041
+ 10 % of quota cost	X	X	X	2028	2044
Quota cost up to 50 $/t	X	X	X	2029	2040
Specific fuel costs + 5 %	X	X	X	2022	2033
TPP capital costs + 10 %	X	2013	X	2027	2044
SPP (silicon) capital costs $\pm$ 10 %	X	X	X	X	2042

Calculated by the authors based on data from (International Smart Grid Action Network, 2018)

Alternative energy
Renewable energy sources (RES)
Clean energy and RES

Centralized "passive energy systems"
Electrical grid distribution
Energy system architecture
"Intelligent active-adaptive" energy systems

Urbanization and development of
Local grids
Smart City

ICT
Smart
Development of "energy-producing real estate"

Liberalization and integration of national energy markets
Continental and intercontinental electrical grids

2020   2025   2030   2035   2040   2045   Year

Fig. 4: Development in the field of energy sector and energy efficiency based on digital technologies (author's forecast based on Foresight methodology)

set of goals that affect not only electricity companies, but also companies in the fields of mechanical engineering, instrument making, chemical and other industries.

This trend can give a powerful impetus to the economy of the country towards innovative development. The management of the import substitution process should have an integrated and system nature. It is necessary to take into account the different goals and interests of the parties involved, which give rise to different economic relations between the parties involved in the process. Therefore, it is necessary to consistently and carefully build a system of economic cooperation with them. A special place in the formation of the system of economic cooperation is occupied by methods of stimulating manufacturers and suppliers of equipment, which must be adequate

to the capabilities of energy companies and provide the necessary level of interest of contractors. It is necessary to use the developments of a system and integrated approach to building the systems of economic cooperation of electrical companies with equipment suppliers for the purpose of implementation of innovative programs based on import substitution and propose an effective system of benefits (preferences) to encourage economic cooperation.

Discussion

In pursuit of the goals and objectives of innovative investment programs, electrical companies place special demands on partners for product localization, its innovative component, as well as their general impact on the modernization of the country. In such an integral part of the institutional environment as

an ideological sphere, it is necessary to propose a scientific concept that would become an integral part of the national idea of creating and implementing intelligent energy systems, a kind of national doctrine of building a energy-efficient, energy-ecological and energy-saving society. There arises a need to form a stable consciousness and behavior of the government, institutions, organizations, people and other subjects in the new mode of energy use. Institutional changes should provide for: creation of new legal norms that set priorities for energy saving at all levels of their use; attracting investments for the implementation of new energy systems; planning both at the state level and at the enterprise level for the implementation of all elements of intelligent energy systems; change of organizational structure of management within firms and the organizations, which would meet new requirements of energy consumption; introduction of new forms of state-private partnership. Thus, institutional changes should contribute to the creation of a system of incentives for the introduction of norms of intelligent energy systems in every sphere of society. The following main trends in the development and implementation of new technologies can be identified:

➢ Wide use of methods of strategic planning and process management using methods of forecasting of innovation and technological development (Ghodousi *et al.,* 2017);

➢ Orientation to set long-term goals, in particular, reduction of energy and water consumption, greenhouse gas emissions and waste in production and consumption, etc. (Solano Rodriguez *et al.,* 2017);

➢ Proper organization of monitoring of results and evaluation of progress as a precondition for preventing the scattering of funds and reducing investment risks (Ilieva and Gabriel, 2019);

➢ Active involvement in the whole process of research and development of experience and funds of business associations as the main consumer of new technologies through the mechanisms of state-private partnership and the creation of technological platforms, joint technological initiatives (Wagner *et al.,* 2020);

➢ With that, the ratio between public and private funding changes in favor of private investors closer to the end of the innovation chain, that is to the stages of introduction and distribution of technologies (DeCarolis *et al.,* 2017).

European regions play a key role in developing innovative solutions, building new value chains and cultivating markets for sustainable energy solutions. Today, the EU is actively looking for additional ways to solve problems that may arise in the future. The EU actively promotes innovation and sustainable solutions by participating in research projects, testing new technologies or creating pilot projects. Thus, the EU forms the future of energy policy. The European Union develops innovative technologies that reduce energy consumption and the depletion of key finite resources and fuels such as coal, crude oil and natural gas (Dwijaksara *et al.,* 2019). It should be noted that by ensuring this, the EU will transform electricity into thermal energy and vice versa, and due to the implementation of the innovation and development program, new opportunities were created for the transformation of the energy sector. Europe is confident in promoting a common energy policy based on competitive, sustainable and safe components. Therefore, the largest EU countries play an important role in the development of the energy sector. The European Union helps member states finance energy efficiency plans through the EU budgets and financial institutions (Epoh and Mafini, 2018). Decarbonisation of building heating and industrial process heating policies will have important implications for future demand for natural gas. Reducing carbon emissions and achieving industrial sector targets by 2050 will largely depend on a combination of energy efficiency, thermal electrification and Carbon Capture and Storage (CCS) (Giama and Papadopoulos, 2018). Therefore, the EU is confident in the goals approved by its member states. The EU goals aimed at energy efficiency and the use of endogenous energy sources are also reflected in the programs and legislation of EU member states. The EU coordinates the policies of the countries of continental Europe, introducing programs aimed at the transition to renewable energy sources and increasing the competitiveness of the economy. The EU also emphasized the EU renewable energy needs and the importance of photovoltaic facilities for 100 percent decarbonisation of the energy sector (Kot, 2018). Therefore, the cost-effective means of achieving emission reductions and the transition to renewable energy are a combination of technologies and investments in R&D of renewable energy strategies, the implementation of existing projects and new ones related to environmentally sustainable economic growth. As mentioned above, the transition

to renewable energy is one of the main problems not only of the EU policy, but also of the whole world. Therefore, the energy sector is a guarantee of economic stability and growth of the countries of the European Union. The new Energy Sector Strategy (ESS) promotes secure, affordable and sustainable energy through the transition to a market-oriented energy sector. The main sense lies in the expansion of alternative energy sources (Lopes *et al.,* 2019). Therefore, the issue of energy is central to the long-term energy strategy of Europe, as it contributes to reducing greenhouse gas emissions, reducing the energy imports of Europe and making it more independent. This fast-moving economic sector provides the EU and the region with new 'green' jobs, opportunities to export energy with high added value and increased competitiveness in the production of goods and services, thereby helping to contribute to technological leadership. The European Union is on the "green" pass. Europe is going from a fossil fuel-based energy system to a low-carbon, fully digital and complex system.

CONCLUSION

Areas for improving the methods of managing the demand for electricity using digital technologies were suggested. A systematization of possible threats, risks and an assessment of the economic effects of the digital modernization of the national energy system were carried out. It was proven that progress in the creation of the intelligent energy supply system of the national economy depends on a number of organizational-economic factors. A sectoral analysis of the features of the digital transformation process in solving separate tasks of the energy industry development of a country was carried out. The necessity of implementing a new mechanism for the effective development of promising sectors of the economy was identified.

The technology platform should provide a link between research and development, business, public and state interests to form a long-term development strategy. Important areas of project implementation and international scientific and technical cooperation should be dealt with by separate groups as the main components of the technological platform. It is also advisable to use the institution of business reputation in the process of joining new participants to the technology platform. The organizational and legal aspects of the creation of the technological platform and the regulation of its work as a communication tool of various program participants deserve special attention. The limitation of the study lies, first of all, in the use of the principles of foresight study. Also, this study is possible when taking into account the principle of ceteris paribus. This means that the coincidence of economic interests of the alpha stakeholders regarding the implementation of projects of energy saving technologies is required. Alpha stakeholders form their requirements in accordance with the goals and motivations and influence the project based on their interests, professional competencies and the degree of involvement in its implementation. Based on these assumptions, the prospects for further research are the development of strategies and measures to achieve energy efficiency and energy saving at all levels of the economy.

AUTHOR CONTRIBUTIONS

S. Drobyazko performed an experimental design and analyzed the data. T. Hilorme defined the concept and methodology of the research. S. Nesterenko ranked the data into tables and figures. Z. Shatskaya performed the literature survey.

ACKNOWLEDGEMENT

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

ABBREVIATIONS (NOMENCLATURE)

CCGT	Combined Cycle Gas Turbine
CCS	Carbon Capture and Storage
C_3	Primary fuel price
CO_2	Carbon dioxide
C_w	Operating costs and management, USD/kWh
EU	European Union
Eq.	equation
ESS	Energy Sector Strategy

f_i	Utilization ratio	V_i	vector i-th technology
Fig.	Figure	*WPP*	Wind Power Plant
g_i	Emissions CO_2	Y_{ij}	Amount of electricity produced using i-th technology at j-th plant, kWh
GW	Gigawatt		
h_i	Specific cost	Z_w	Waste disposal costs, USD/kWh
HPP	Hydro Power Plant	*$*	Dollars
ICT	Information and Communication Technologies	*%*	Percent
K_w	Specific capital costs, USD/kWh		
kW	Kilowatt		
LCOE	Levelized Cost of Energy		
MBTU	British Thermal Unit		
MW	Megawatt		
N_a	Target level of greenhouse gas emissions, tons		
NPP	Nuclear Power Plant		
NPV	Net Present Value		
O_a	Greenhouse gas emissions, t/kWh		
OECD	Organization for Economic Cooperation and Development		
RES	Renewable Energy Sources		
R&D	Research & Development		
r_i	Installed capacity		
S_{CO2_w}	Emission permit costs, USD/kWh		
S_i	Prime cost of electricity production using i-th technology, USD/kWh		
SPP	Solar Power Plants		
S_f	Fuel costs, USD/tons of oil equivalent		
t	tonne		
TPP	Thermal Power Plant		
U	Demand for electricity, kWh		
US Department of Energy	United States Department of Energy, DOE		
US dollars	United States dollars		
v	vector		

REFERENCES

Aineto, D.; Iranzo-Sánchez, J.; Lemus-Zúñiga, L.G.; Onaindia, E.; Urchueguía, J.F., (2019). On the influence of renewable energy sources in electricity price forecasting in the Iberian market. Energies, 12(11): 21-27 (**7 pages**).

Al-Tarazi, M.; Chang, J.M., (2019). Performance-aware energy saving for data center networks. IEEE Trans. Network Serv. Manage., 16(1): 206-219 (**14 pages**).

Ashraf, S.; Ahmed, T.; Saleem, S.; Aslam, Z., (2020). Diverging mysterious in green supply chain management. Oriental J. Comput. Sci. Technol., 13(1): 22-28 (**7 pages**).

Borlase, S.; Brandao, M.; Fine, J.D.; Kezunovic, M.; Wojszczyk, B.; Bossart, S.; Mirzatuny, M., (2017). Smart Grid Challenges and Transformations. Smart Grids, 17-66 (**50 pages**).

Brown, T.; Schlachtberger, D.; Kies, A., Schramm, S.; Greiner, M., (2018). Synergies of sector coupling and transmission reinforcement in a cost-optimised, highly renewable European energy system. Energy, 160: 720-739 (**20 pages**).

Bunn, D.W.; Gianfreda, A.; Kermer, S., (2018). A trading-based evaluation of density forecasts in a real-time electricity market. Energies, 11(10): 1-8 (**8 pages**).

Cai, W.; Lai, K.H.; Liu, C.; Wei, F.; Ma, M.; Jia, S.; Lv, L., (2019). Promoting sustainability of manufacturing industry through the lean energy-saving and emission-reduction strategy. Sci. Total Environ., 665: 23-32 (**10 pages**).

Cebulla, F., Fichter, T., (2017). Merit order or unit-commitment: How does thermal power plant modeling affect storage demand in energy system models?. J. Renewable Energy, 105: 117-132 (**16 pages**).

Cheng, L.; Yu, T., (2018). Nash equilibrium-based asymptotic stability analysis of multi-group asymmetric evolutionary games in typical scenario of electricity market. IEEE Access, 6: 32064-32086 (**23 pages**).

Choi, C.; Esposito, C.; Wang, H.; Liu, Z.; Choi, J., (2018). Intelligent power equipment management based on distributed context-aware inference in smart cities. IEEE Commun. Magazine, 56(7): 212-217 (**7 pages**).

DeCarolis, J.; Daly, H.; Dodds, P.; Keppo, I.; Li, F.; McDowall, W.; Winning, M., (2017). Formalizing best practice for energy system optimization modelling. Appl. Energy, 194: 184-198 (**15 pages**).

Drobyazko, S.; Hilorme, T., (2021). Influence of Sustainable Development of Space Activities on Earth Ecology. IOP Conf. Ser.: Earth Environ. Sci, 1-8 (**8 pages**).

Drobyazko, S.; Hilorme, T., (2022). Methods for evaluating technical innovations in the implementation of energy-saving measures in enterprises. MethodsX, 9: 101658.

Drobyazko, S.; Hilorme, T.; Solokha, D.; Bieliakova, O., (2020). Strategic policy of companies in the area of social responsibility: Covid-19 challenges. E3S Web Conf., 211 (2020) 04011.

Drobyazko, S.; Wijaya, S.; Blecharz, P.; Bogachov, S.; Pinskaya, M., (2021). Modeling of Prospects for the Development of Regional Renewable Energy. Energies, 14, 2221.

Dwijaksara, M. H.; Jeon, W. S.; Jeong, D. G., (2019). User association for load balancing and energy saving in enterprise WLANs. IEEE Syst. J., 13(3): 2700-2711 (**12 pages**).

Epoh, L.R.; Mafini, C., (2018). Green supply chain management in small and medium enterprises: Further empirical thoughts from South Africa. J. Transport Supply Manage., 12: 12-24 (**13 pages**).

Fan, T.; He, Q.; Nie, E.; Chen, S., (2018). A study of pricing and trading model of Blockchain & Big data-based Energy-Internet electricity. In IOP Confer.Series: Earth and Environ. Sci., 108(5): 83-92 (**10 pages**).

Filipović, S.; Radovanović, M.; Lior, N., (2019). What does the sharing economy mean for electric market transitions? A review with sustainability perspectives. Energy Res. Social Sci., 58: 1-15 (**15 pages**).

Giama, E.; Papadopoulos, A.M.; (2018). Carbon footprint analysis as a tool for energy and environmental management in small and medium-sized enterprises. Int. J. Clean Product., 37(1): 21-29 (**9 pages**).

Ghodousi, M.; Atabi, F.; Nouri, J.; Gharagozlou, A., (2017). Air quality management in Tehran using a multi-dimensional decision support system. Pol. J. Env. Stud, 26: 593-603 (**11 pages**).

Henríquez, R.; Wenzel, G.; Olivares, D.E.; Negrete-Pincetic, M., (2017). Participation of demand response aggregators in electricity markets: Optimal portfolio management. IEEE Trans. Smart Grid, 9(5): 4861-4871 (**11 pages**).

Ilieva, I.; Gabriel, S., (2019). The Impact of End-User Market Integration and the Smart Grid on Electricity Retailers in the Nordic Region, J. Energy Market Forthcoming: 1-25 (**25 pages**).

International Smart Grid Action Network (2018).

Karjalainen, J.; Heinonen, S., (2018). Using deliberative foresight to envision a neo-carbon energy innovation ecosystem–a case study of Kenya. Afr. J. Sci. Innov. Dev., 10(5): 625-641 (**17 pages**).

Ketter, W.; Collins, J.; Saar-Tschansky, M.; Marom, O., (2018). Information systems for a smart electricity grid: Emerging challenges and opportunities. ACM Transactions on Manage. Inform. Syst., 9(3), 1-22 (**22 pages**).

Kot, S., (2018). Sustainable supply chain management in small and medium enterprises. Sustainability, 10(4): 1143-1151 (9 pages).

Lane, D.; Maxfield, R., (2018). Foresight, complexity, and strategy. The economy as an evolving complex system II, CRC Press: 169-198 (**30 pages**).

Lopes, J.; de Araújo Kalid, R.; Rodríguez, J.; Ávila Filho, S., (2019). A new model for assessing industrial worker behavior regarding energy saving considering the theory of planned behavior, norm activation model and human reliability. Resour. Conserv. Recycl., 145: 268-278 (**11 pages**).

Lopion, P.; Markewitz, P.; Robinius, M.; Stolten, D., (2018). A review of current challenges and trends in energy systems modeling. Renew. Sustain. Energy Rev., 96: 156-166 (**11 pages**).

Lund, H.; Arler, F.; Østergaard, P.A.; Hvelplund, F.; Connolly, D.; Mathiesen, B.V.; Karnøe, P, (2017). Simulation versus optimisation: Theoretical positions in energy system modelling. Energies, 10(7): 1-13 (**13 pages**).

Nerini, F.F.; Keppo, I.; Strachan, N., (2017). Myopic decision making in energy system decarbonisation pathways. A UK case study. Energy Strategy Rev., 17: 19-26 (**8 pages**).

Price, J.; Keppo, I., (2017). Modelling to generate alternatives: A technique to explore uncertainty in energy-environment-economy models. Appl. Energy, 195: 356-369 (**14 pages**).

Richter, B.; Mengelkamp, E.; Weinhardt, C., (2018). Maturity of blockchain technology in local electricity markets. In 2018 15th International Conf. on the European Energy Market (EEM): 1-6 (**6 pages**).

Sadeghi-Pouya, A.; Nouri, J.; Mansouri, N.; Kia-Lashaki, A., (2017). Developing an index model for flood risk assessment in the western coastal region of Mazandaran. Iran. J. Hydrol. Hydromech., 65(2): 134-145 (**12 pages**).

Saul, C.J.; Gebauer, H., (2018). Digital transformation as an enabler for advanced services in the sanitation sector. Sustainability, 10(3): 1-18 (**18 pages**).

Seljom, P.; Tomasgard, A., (2017). The impact of policy actions and future energy prices on the cost-optimal development of the energy system in Norway and Sweden. Energy Policy, 106: 85-102 (**18 pages**).

Slovak National Energy and Climate Plan (2022).

Solano Rodriguez, B.; Drummond, P.; Ekins, P., (2017). Decarbonizing the EU energy system by 2050: an important role for BECCS. Clim. Policy, 17(1): 93-110 (**18 pages**).

Uniejewski, B.; Weron, R.; Ziel, F., (2017). Variance stabilizing transformations for electricity spot price forecasting. IEEE Trans. Power Syst., 33(2): 2219-2229 (**11 pages**).

Wagner, O.; Adisorn, T.; Tholen, L.; Kiyar, D., (2020). Surviving the Energy Transition: Development of a Proposal for Evaluating Sustainable Business Models for Incumbents in Germany's Electricity Market. Energies, 13(3): 730-740 (**11 pages**).

Yang, J.; Zhao, J.; Luo, F.; Wen, F.; Dong, Z.Y., (2017). Decision-making for electricity retailers: A brief survey. IEEE Trans. Smart Grid, 9(5): 4140-4153 (**14 pages**).

International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: http://www.ijhcum.net/

The effect of team performance on the internationalization of Digital Startups: the mediating role of entrepreneurship

M. Tajpour *, SM. Razavi

Department of Industrial Management, Faculty of Management, University of Tehran, Iran

ARTICLE INFO

ABSTRACT

BACKGROUND AND OBJECTIVES: Team performance is one of the ways to deal with successive changes from the point of view of experts. Therefore, continuous changes in the work environment and daily work activities require sharing ideas and the need for continuous learning and entrepreneurship. Neglecting entrepreneurship has a negative effect on companies and by neglecting entrepreneurship, it is impossible to operate effectively in a dynamic environment. Therefore, in today's competitive world, companies will lose their competitiveness. Thus, the purpose of this study is to investigate the effect of team performance on the internationalization of digital startups through mediating role of entrepreneurship.

METHODS: In terms of the purpose, it is applied and quantitative research. The research population is estimated to be 375 employees of 101 Iranian international digital startups in the field of technology and city services, which accounted for 10% of exports between 2021 and 2022. The sample size is estimated through Cochran's formula of 190 people. To collect data, a standard 5- point Likert scale questionnaire with 22 items was used. Finally, the data were analyzed by using Smart PLS 3 software.

FINDINGS: The results showed that emotional commitment, creating an environment of innovation, and knowledge sharing through mediating role of entrepreneurship have a positive and significant effect on the internationalization of digital startups. The results of the research indicate positive relationships among Emotional Commitment (2.671) and with entrepreneurship mediating (2.927), Innovative environment (2.478) and with entrepreneurship mediating (2.697), and Knowledge sharing (2.707) and with entrepreneurship mediating (3.333) concerning the internationalization of digital startups. Therefore, these hypotheses were confirmed.

CONCLUSION: The team performance of employees plays an important role in the survival and success of companies in the international sector. The knowledge that companies gain from other companies, especially during internationalization, can escalate their competitiveness in the global market. The performance of the team as the primary factor of learning and innovation facilitates trust among the company's employees.

NUMBER OF REFERENCES

67

NUMBER OF FIGURES

3

NUMBER OF TABLES

4

*Corresponding Author:
Email: tajpour@ut.ac.ir
Phone: +989127947802
ORCID: 0000-0001-8951-9711

INTRODUCTION

Companies of all sizes have commenced expanding their activities beyond national markets due to globalization and its relevant changes. Therefore, the competition in businesses has been improved, and internationalization has been universally one of the principal components of business strategies as a result of the extended volume of global trade and the related changes in the economic environment of countries (Onkelinx *et al.,* 2016). Furthermore, the internationalization of companies has recently attracted the attention of many researchers as a topic. Accordingly, such companies in many developing countries have started their activities in international markets and have participated more in the markets of developed countries (Liu *et al.,* 2019). Since these companies are principally placed in the category of small and medium companies, they play an essential role in the economic development of the country in the world economy. Therefore, such companies are regarded as the engine of economic development (Cela *et al.,* 2022). According to the statistics provided by the Small Industries Investment Support Fund in 2018, it is seen that small and medium enterprises constitute a 10% share of the total export of Iran. Moreover, according to the report provided by the United Nations Development Fund, Iranian digital startups using advanced technology have d export share of less than 1.5% of non-oil exports; therefore, Iran's rank in this area is lower than countries in the region including Saudi Arabia and Turkey (Vashdi et al., 2007). Internationalization enables digital startups to increase their capabilities needed to compete and succeed in the global arena; so while achieving some degree of internationalization is important for all businesses, it is especially important for digital startups that have fewer resources and experience to compete in international markets (Arghashi *et al.,* 2020). As a result, the conformity of the statistics current position with the determined lofty aims shows that there is high-performance gap and the national economic drivers are in inferior. Moreover, digital startups should accomplish their knowledge and research based on international innovation to develop a strategic approach (Purkayastha *et al.,* 2022); accordingly, international organizations such as UNIDO, UNDP which are in the process of trying to integrate the global economy through economic liberalization and reducing laws and regulations has emphasized the promotion of such activities as the best method for economic development and eliminating inequality in developing countries (Neupane, 2019; Jehan *et al.,* 2020). The significant benefits of internationalization of companies include sustainable competitive advantages, greater performance and higher growth (Bagheri *et al.,* 2019); because the companies working at the international level have normally started their business in national markets and the expanded their activities in global markets after a few years with a cautious approach (Cela *et al*., 2022). Accordingly, the present study investigates the effect of team performance on the internationalization of digital startups with the mediating role of entrepreneurship, because digital startups are considered as essential components of the development and growth of a society; moreover, entrepreneurship is one of the reasons for success in digital startups because entrepreneurship is created in companies when management and employees have creative and innovative ideas. It can be said that no study has been conducted in this field in Iran so far, and therefore it is an innovative research. Therefore, they are sent study aims the effect of team performance on the internationalization of digital startups with the mediating role of entrepreneurship.

Theoretical Foundation

Successful companies, especially digital startups, are those which continuously create new knowledge, distribute it broadly throughout the organization and quickly use it in new technologies and products. Such companies conduct research and development and their growth and development greatly depends on the development of new knowledge and technology (Salamzadeh *et al*., 2021). Also, Knowledge is considered as a combination of documented experience, values and defined information that facilitates a framework to collect and evaluate the new experience and information (Sabokro *et al*., 2018; Tajpour *et al.,* 2022). Furthermore, digital startups, especially in developing societies, are the axis of economy development and transformation. In these companies, the employees are the principal capital and it can be valuable if the knowledge of employees is shared with members inside and outside the company (Hosseini *et al*., 2020); because the knowledge acquired by the companies from the other companies, especially during internationalization, can

improve their competitiveness in the global market (Liu *et al.,* 2019). Also, business managers figured out that achieving information and knowledge cannot be ignored for the organization survivals as efficiency and effectiveness. Foreign market knowledge is a type of knowledge that is considered a greatly favored motive for the internationalization of businesses and can distinguish it from competitors. Therefore, companies with more knowledge about foreign markets make more informed decisions (Casillas *et al.,* 2019). As a result, identifying international entrepreneurial opportunities is considered as an essential element in understanding the internationalization behavior of businesses and identification of opportunities is undoubtedly associated with the success in international markets and the internationalization speed (Soetanto, and van Geenhuizen, 2019). Many studies have been conducted to explain team performance as companies are increasingly becoming team-oriented and use the team as the principal unit. Consequently, effective teams are considered as an essential factor for digital startups in dynamic environments (Yang, 2011). In addition, many employees in digital startups perform cognitive and intellectual responsibilities in a team environment, and team-oriented performance has become a challenge for human resource management researchers (Vashdi *et al.,* 2007). Furthermore, Coveri and Zanfei (2022) showed that the determining factors of utilizing the internationalization capability of research and development has directed the increasing attention to companies' efforts to improve the knowledge base of domestic production and take advantage of technological overload (Coveri and Zanfei, 2022). Also, internationalization refers to the process of increasing involvement in international operations (Hosseini *et al.,* 2021). The main hypothesis of the study is as follows:

H0: Team performance with the mediating role of entrepreneurship has a significant effect on the internationalization of digital startups.

Emotional commitment

Committed human resources play an important role in the survival and success of the organization (Jayabalan *et al.,* 2016); Because commitment develops a sense of comprehensive identity among the people of the organization and it eventually leads to social behaviors including sharing ideas and voluntary opinions (Allen *et al.,* 2016); Therefore, organizational commitment is the positive or negative attitudes of employees towards the whole organization not towards the job. Based on organizational commitment, an individual has a strong sense of loyalty towards the organization and identifies his organization through that sense (Tough and Popoola, 2009); In other words, organizational commitment is an attitude about the loyalty of employees towards the organization as a constant process that leads to organizational success through the participation of people in organizational decisions and their care for the organization. Commitment consists of three dimensions: emotional, normative and continuous, and the present study deals with the emotional dimension (Anyango *et al.,* 2015). Emotional commitment is the emotional tendency of employees to the organization, which is identified by satisfaction with the organization and the inclination to stay in it (McKenna, 2005). Emotional commitment is defined as the emotional dependence of the person to the organization, and more precisely, emotional commitment is described as the emotional dependence of employees to determine their identity by means of organization (Arghashi *et al.,* 2020). Furthermore, emotional commitment refers to the extent of the individual's belonging to the organization, the expression of their identity with the organization and the degree of their active participation in organizational processes (Kim *et al.,* 2018); Therefore, emotional commitment is developed by employees' inclination to commit and indicates employees' subjective assessment of their possibilities at a particular time (Gonlo *et al.,* 2010). In this kind of commitment, people consider it their responsibility to proceed working in the organization. Emotional commitment causes employees to stay in the organization due to a sense of loyalty or responsibility and to feel that they are doing the appropriate job (Petty and Hill, 2005). Moreover, the process of internationalization consists of the relationships governing knowledge and awareness about the market, decisions relevant to the level of commitments to a market, and the current activities of academic and entrepreneurial companies (Mtigwe, 2006). Accordingly, organizations must be sensitive to the needs of employees at work and care for their views to achieve employee commitment

(Park and Nawakitphaitoon, 2018); therefore, it can be said that increase in job satisfaction increases the emotional commitment. Furthermore, the entrepreneurial approach and the capacity to absorb knowledge can play an effective role in the success of companies. However, researchers believe that the entrepreneurial approach is an organizational phenomenon that reflects the management ability by which organizations transform the competition based on their interests using innovation and an aggressive approach. Also, according to the internationalization literature, knowledge about foreign markets is a basic concept that explains the behavior and commitment of international companies (Mlinaric, 2016; Mirzapour *et al.,* 2019); therefore, internationalization is performed in digital startups as a strategic orientation to obtain commitment and participation in international markets (Tuppura *et al.,* 2008). According to the contents mentioned above, the first hypothesis of the research is as follows:

H1a: Emotional commitment has a significant effect on the internationalization of digital startups.

H1b: Emotional commitment has a significant effect on the internationalization of digital startups with the mediating role of entrepreneurship.

Innovative environment

Organizations require new and innovative ideas to survive. Organizations can associate with the dynamic environment outside and reach a competitive advantage through the creation of new ideas and processes (Tsai, 2011). As a result, the management should always be open to new ideas from everyone in the company and not just wait for new opinions to be expressed; Therefore, there are many obstacles and challenges to develop innovation in organizations and managers must solve them and support creative and innovative employees to develop a suitable environment for the development of innovation in the organization (Martínez-Román *et al.,* 2020). Furthermore, entrepreneurship is currently known as the principal motive for the development of innovation, and the appropriate solution to be successful in chaotic and unpredictable markets (Cunningham *et al.,* 2019). Therefore, large companies have recently been trying to cooperate with small companies due to the competitive business environment. In fact, due to problems including organizational problems and risk aversion, large

companies frequently encounter a lack of dynamism and lack of flexibility to develop innovation (Jang *et al.,* 2017). Thus, despite the competition in various fields, managers are trying to pay attention to the innovative production by identifying and creating an environment where proper understanding exists so that the creativity and productivity growth becomes possible (Mahdavi Mazde *et al.,* 2022). Environment is often defined as people's perception of the environment. In addition, Innovative environment is defined as the general financial, economic, technological, social and cultural environment of companies (Lawal *et al.,* 2018). Innovative environment includes the shared understanding of team members and the organization in respect of activities, methods and behaviors that promote the new generation of knowledge (Moolenaar *et al.,* 2010). Also, internationalization motivations and competitive advantages that are pursued during internationalization are useful for emerging economic companies (Ahsan and Sinha, 2022).Therefore, based on the conditions and Innovative environment, when team members face particular challenges and problems in the company, they take part in team work seriously and communicate to find appropriate solutions (Tsai, 2011). Because the created innovation is a collection of frequent cooperation, mutual learning and interaction. Thus, various activities of digital startups, regardless of what they produce, are performed based on innovation (Cela *et al.,* 2022). With the purpose of turning knowledge into power and by establishing knowledge-based business, these companies perform their economic activities according to research and development activities and assist in promoting the knowledge-based economy in society (Du *et al,* 2020); Since knowledge and innovation are considered as the main assets of digital startups based on technology in international markets, public support is essential for success in this field as the available resources are limited (Mahdavi Mazde *et al.,* 2022); Therefore, it is worth mentioning that the more digital startups are equipped with instruments to support the Innovative environment and entrepreneurship and provide an appropriate condition for the commercialization of ideas and the transfer of produced technologies, the more successful they will be in achieving their goals (Du *et al,* 2020). In this respect, Jang *et al.* (2017) stated in their study that the international business of

digital startups is greatly important for their growth, Innovative environment and survival. They also believe that the numerous restrictions experienced by small and medium-sized companies in the process of internationalization clarifies the importance of acquiring knowledge and continuous learning (Jang *et al.*, 2017). Martínez-Román *et al.* (2020) have shown in their study that entrepreneurship and innovation in the production leads to the development of the company's business and supports its export operations, however it is associated with a non-linear relationship and a regression in performance with an increase in the level of innovation (Martínez-Román *et al.*, 2020). Therefore, it can be said that the relationship between the company internationalization and the Innovative environment is influenced by many factors, and the strategy of internationalization changes the company's income and also reduces the company's risk and it is beneficial for investment in the development and research and innovation sector (Du *et al,* 2020). Accordingly, the second hypothesis of the research is as follows:

H2a: Innovative environment has a significant effect on the internationalization of digital startups.

H2b: Innovative environment has a significant effect on the internationalization of digital startups with the mediating role of entrepreneurship.

Knowledge Sharing

Organizations are required to react appropriately to the continuous changes in the process of competition in the business environment otherwise they will be destroyed (Hosseini *et al.*, 2020). Therefore, knowledge sharing is one of the factors influencing the competitive advantage of businesses in the international environment, and it is also an essential instrument for organizations to manage information and knowledge to a higher standard. Furthermore, entrepreneurial culture facilitates the entrepreneurial activities of international businesses through knowledge (Zahra, 2005). This leads to the identification of international opportunities (Dimitratos *et al.*, 2012). According to international entrepreneurship, internationalization means searching, knowing, evaluating and utilizing opportunities beyond national borders in order to produce goods and provide services, a process in which the company's engagement in international markets increases (Schillo, 2018) ; Therefore,

internationalization is the product of the combination of uncertain market conditions that generate measures, entrepreneurial insights, knowledge sharing and it is performed by decisions made on strategic entry mode in foreign markets (Martínez-Román *et al.*, 2020). As a result, collaborative agents in designing innovation and entrepreneurship take part in sharing knowledge, resources, and risks among participants (Chen *et al.*, 2020). Thus, knowledge sharing is known as one of the important components of business so that the competitive advantages of companies remain and are maintained in their business (Razak *et al,* 2016). In fact, it is worth mentioning that if organizations intend to achieve their goals including survival, growth and development through the international environment, they should provide the conditions for the development of entrepreneurial behaviors by managing knowledge (Chitsaz *et al.,* 2019). Subsequently, the business world is transforming the capital dominance into knowledge sharing (Korimbocus *et al.*, 2020). Therefore, sharing knowledge as a complex but valuable and basic activity is the foundation of many management strategies in the organization (Singh *et al,* 2019). Thus, in today's knowledge-based societies, knowledge assets serve a vital function in the growth, survival and better performance in the economy of organizations (Yasir and Abdul Majid, 2017); Because when people share their knowledge, skills and expertise among members of an organization, performance improves and organizations become more innovative (Tajpour *et al.*, 2022); Therefore, it can be stated that sharing knowledge effectively and efficiently is essential for the success of companies, especially digital startups that work in international environments (Al-Kurdi *et al.*, 2020; Tajpour *et al.,* 2022). In other words, knowledge sharing consists of sharing ideas, needs, successes and problems in the organization. As a result, the competitive advantages of any organization can be improved by sharing employees' knowledge. Accordingly, since knowledge sharing has an important and special position in the process of knowledge management, it is necessary for the success process of an organization to investigate the position of knowledge sharing in the international environment. Therefore, according to the contents mentioned above, the third hypothesis of the research is as follows:

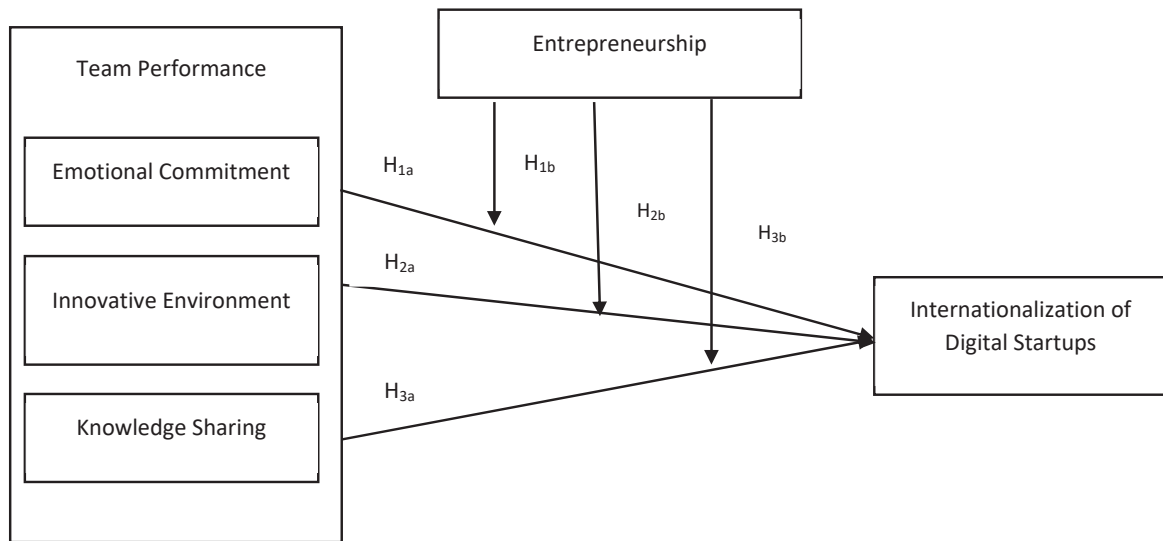*H3a: Knowledge sharing has a significant effect*

Fig.1: Conceptual model

on the internationalization of digital startups.

H3b: Knowledge sharing with the mediating role of entrepreneurship has a significant effect on the internationalization of digital startups.

The present study and the conceptual model are designed based on scientific sources and previous studies with a new arrangement; hence, according to the studies so far, no study has been conducted in Iran on team performance, internationalization of digital startups with mediating role of entrepreneurship as discussed in the present study. Therefore, the conceptual model of the research has been selected (Fig. 1) according to the research literature. The current study have been carried out in Tehran in 2022.

MATERIALS AND METHODS
Sample Methodology

The present study is applied in terms of the purpose and it is a quantitative research in terms of method. The population of the study is estimated to be 375 employees from 101 international digital startups in the field of technology and urban services that constitute 10% of exports during the past two years (2021-2022). For data collection, a standard questionnaire instrument has been used to measure the variables of the conceptual model. It includes 22 closed-ended questions and 12 team performance

questions including (emotional commitment (Allen and Mayer, 1990), Innovative environment (Sigel and Kimer, 1978) and knowledge sharing (Wang and Wang, 2012), 4 questions on entrepreneurship (Murphy *et al.,* 1996) and 4 questions on the internationalization of digital startups (Cahen, 2019) with a 5-point Likert scale (1- absolutely disagree, 2- disagree, 3- no opinion, 4- agree and 5- absolutely agree). The present study has investigated the relationships between variables using PLS3 software and structural equation modeling. This software has been used because the distribution is not required to be normal compared to other available software (Kline, 2015).

Measurement, reliability and validity

In the present study, the constructs are considered as follows: team performance is an independent variable, internationalization of digital startups is a dependent variable, and entrepreneurship is a mediating variable. In order to ensure the accuracy and precision of the results, the technical characteristics of the questionnaire were evaluated in two sections, validity and reliability, using different criteria. The validity of the questionnaire has been evaluated and confirmed through content and construct validity. To measure the content validity of

the instrument, the ideas of relevant professors and experts on the topic were used, and to measure the construct validity, the structural equation modeling of convergent and divergent validity was used. In order to determine the convergent validity, the average Variance Extracted (AVE) index was used and for the divergent measurement, the square root of average variance extracted index was used (Mobaraki *et al,* 2021). The average standard deviation extracted for the variables is higher than 0.5 and indicates its high validity. Moreover, the reliability of the questionnaire instrument was measured using Cronbach's alpha coefficient and composite reliability. Furthermore, as Cronbach's alpha of all variables is higher than 0.70 and the overall alpha of the questionnaire was calculated as 0.83, it can be concluded that the study instrumentation used has an accepted level of reliability (Table 1).

As can be seen in Table, the values for square root of the average variance extracted are higher than the acceptable minimum of 0.5; therefore, the variables have divergent validity. Furthermore, since the square root values for the average variance extracted are higher than the correlation of the variable with other variables, divergent validity is acceptable if the numbers mentioned in the main diameter are greater than their underlying values (Fornell and Larcker, 1981). So, it can be concluded that the variables have validity and their divergent validity is also confirmed.

According to the contents mentioned above and the results achieved from the SmartPLS3 software output in Tables 1 and 2, the measurement models have accepted validity (convergent and divergent) and

reliability (reliability, composite reliability coefficient and Cronbach's alpha).

RESULTS AND DISCUSSION

The fit of the model was examined at three measurement levels, structural and general. Some indexes are applied to examine the fit of the structural model of the study using the partial least-squares method, which is the first and most principal index of significant coefficients or t-statistic values. The fit of the structural model using t coefficients is such that these coefficients must be greater than 1.96 to confirm their significance at the 95% confidence level (Thomas, 2003). The results obtained from the investigation of this index revealed that the obtained values whose critical value is higher than the critical value (1.96) at the 95% confidence level have been confirmed (Fig. 2).

Coefficient of Determination (R^2)

The second index for examining the fit of the structural model in a study is the R2 coefficients related to the endogenous hidden variables of the model. R^2 is an index that displays the effect of exogenous variables on an endogenous variable and three values of 0.19, 0.33 and 0.67 are taken into consideration for weak, medium and strong values of R^2 (Salamzadeh *et al.,* 2021). In the present study, the index considered for the entrepreneurship is (0.721) and internationalization of digital startups is (0.215), so the structural model has a desired fit at a strong level based on this index. Furthermore, the results have been shown according to Fig. 3.

Table1. Variables, the Number of Questions and Reliability

No	Variables	Questions	Cronbach's alpha	Shared Reliability	Confidence Level	AVE
1	Emotional Commitment	1-5	0.847	0.884	0.943	0.632
2	Innovative environment	6-10	0.838	0.801	0.823	0.514
3	Knowledge Sharing	11-15	0.863	0.718	0.713	0.552
4	Entrepreneurship	16-19	0.777	0.712	0.726	0.875
5	Internationalization of digital startups	20-24	0.812	0.822	0.869	0.571

Table 2: Divergent validity

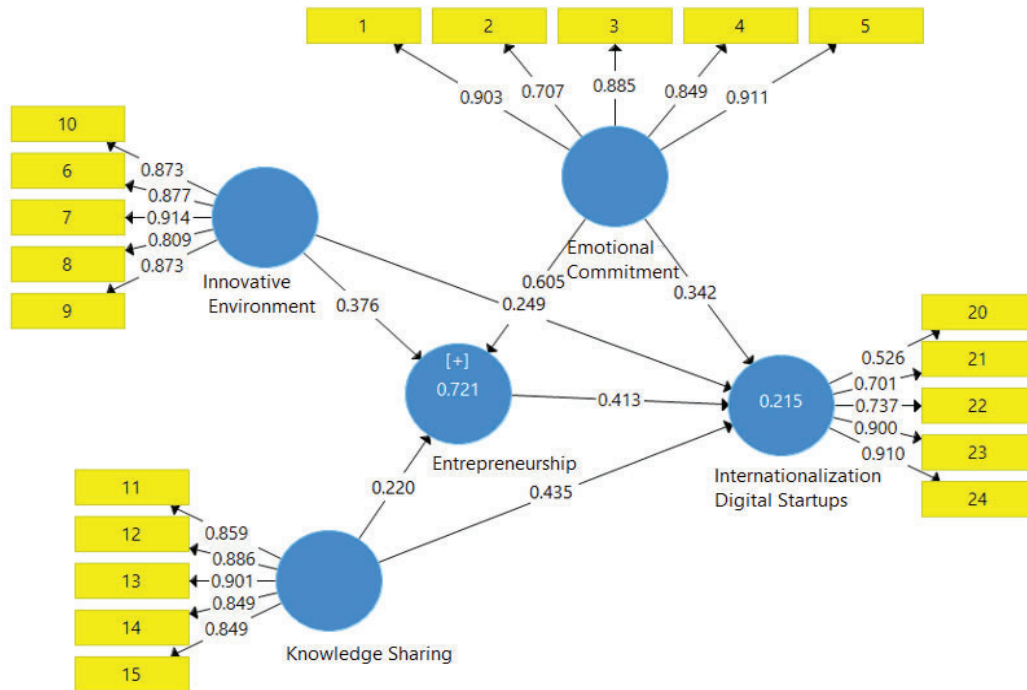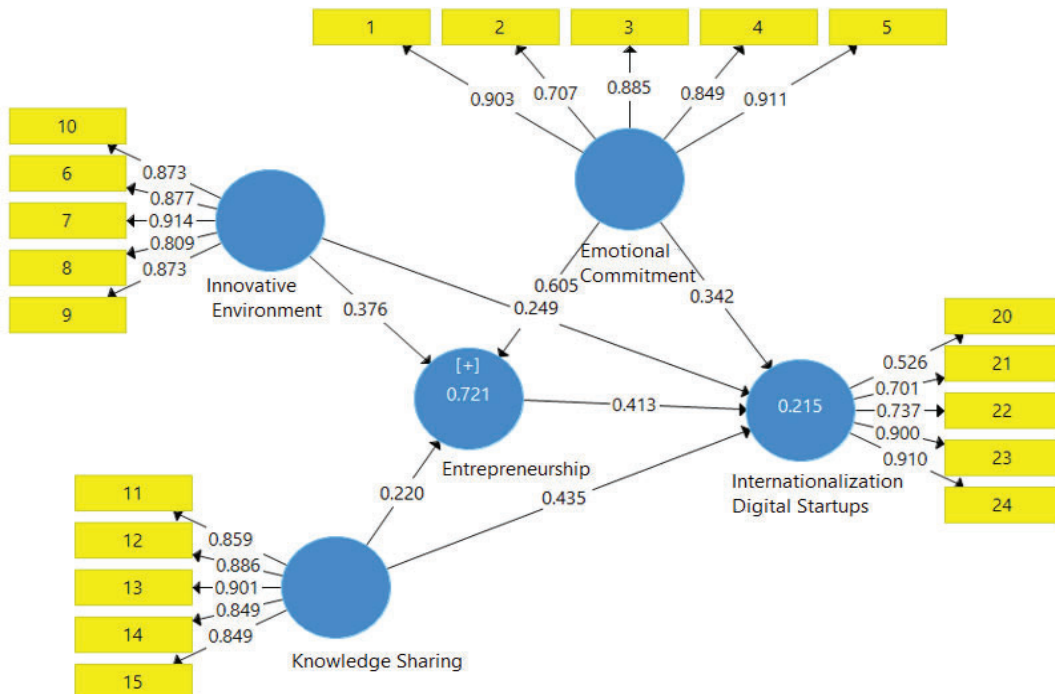| Variables	1	2	3	4	5
Innovative environment	0.383				
Emotional Commitment	0.89	0.795			
Entrepreneurship	0.241	0.481	0.534		
Internationalization	0.304	0.144	0.653	0.756	
Knowledge Sharing	0.367	0.408	0.165	0.500	0.689

Fig.2: T-statistic values

Fig. 3: Model in the case of standard factor loading coefficients

The Q2 index

The Q2 index is calculated for all dependent constructs and represents the product of the combined values of the study constructs by the values of their respective coefficients of determination. The value should be 0.2, 0.15 and 0.35 for all endogenous structures as low, medium and strong predictive power (Kline, 2015). This index in the present study is for entrepreneurship (0.513) and internationalization of digital startups is (0.177). This result shows the high and desired fit of the structural model of the study.

General fit of the model

The general model includes both measurement and structural model parts, and when its fit is confirmed, the fit check in a model is complete. Thus, the general fit of the model is possible with the help of GOF goodness of fit index. According to three values of 0.01, 0.25 and 0.36, weak, medium and strong values for GOF have been introduced. The value of 0.607 for this index shows the strong fit of the general study model.

GOF = √average (Commonality) × average (R²)

Another index is the Standardized Root Mean Square Residual (SRMR). According to Byrne (1998) view, the value of 0.05, according to Hu and Bentler's view (1999), the value of 0.08, and according to Ringel

et al. (2016) view, the value of SRMR is less than 0.10, showing an acceptable fit of the general model. According to Table 3, this index is also at its acceptable threshold, so it can be claimed that the present study model has a desired fit. Normed Fit Index (NFI) has also been used to measure fit. The acceptance range of this index is between 0 and 1 and the NFI should be larger than 0.9 (Kline, 2015). Therefore, as shown in Table 3, this value is 0.920, and this index is also confirmed. In addition, the VAF statistic indicates that the intensity of entrepreneurship mediation is equal to 0.326, which means that the mediation effect is partial.

Testing Hypotheses

Finally, t-statistic has been applied to examine the presumed relationships between the variables. To test the main hypothesis, six sub-hypotheses have been used, and according to Table 4, the T-coefficient of the six existing relationships has been confirmed. To determine the impact of the predictor variables on the dependent variables, the standardized factor loading coefficients relevant to the paths of each of the hypotheses have been investigated. These coefficients represent how many percent of the changes of the dependent variables are described by the independent variables.

Organizations have paid a great deal of attention to entrepreneurship considering today's disordered and

Table3: Fit Indexes

Model Fit	NFI	SRMR
Accepted Values	≥0.9	≤0.10
Calculated Values	0.920	0.07

Table 4. T-statistics and research impact factor

No	Path	T-statistics	Impact Factor	Test
1	Emotional Commitment-Internationalization of Digital startups	2.671	0.342	Hypothesis Confirmed
2	Emotional Commitment- Entrepreneurship -Internationalization of Digital startups	2.927	0.605	Hypothesis Confirmed
3	Innovative environment- Internationalization of Digital startups	2.478	0.249	Hypothesis Confirmed
4	Innovative environment- Entrepreneurship -Internationalization of Digital startups	2.697	0.376	Hypothesis Confirmed
5	Knowledge sharing- Internationalization of Digital startups	2.707	0.435	Hypothesis Confirmed
6	Knowledge sharing- Entrepreneurship -Internationalization of Digital startups	3.333	0.220	Hypothesis Confirmed

extremely competitive conditions. Therefore, the aim of the present study is to investigate the effect of team performance on the internationalization of digital startups with mediating role of entrepreneurship. The results of structural equation analysis using SmartPLS3 software demonstrated that the six hypotheses were confirmed. According to the first hypothesis i.e. the effect of emotional commitment on the internationalization of digital startups and its sub-hypothesis i.e. emotional commitment has a significant effect on the internationalization of digital startups with the mediating role of entrepreneurship, it can be said that organizations should identify the employees' goals and values and progress to connect these goals and values with the principal goals in order to improve the level of employees' emotional commitment, and they should explain the goals and values of the organization properly by establishing efficient and effective communication with the employees so that the employees can feel personally responsible for the success of the organization. Moreover, according to Oyewobi *et al*. (2019), the company should hire people who consider it an essential issue to stay in the company and they are emotionally attached to the company. Similarly, the results indicated that human resource is the most important and sensitive source to determine the success and failure of the organization. Therefore, managing people is one of the strategies that, if used in an appropriate and timely manner, can maintain and develop and proportionally improve the level of satisfaction of committed, hard-working and responsible employees based on objective performance measurement methods, and it can lead to the actualization of capabilities, capacities and the potential abilities of people, and the establishment of high motivation for employees entrepreneurship and it can also create a higher level of quality and organizational performance through the direct participation of capable entrepreneurial teams; Therefore, according to Kim *et al*. (2018), there is evidence of change in companies that feel committed to establishing entrepreneurial teams. In fact, they are moving towards a transformation or a revolution. Such risky activities are the new strategy for many companies. These teams are described as people who are their own managers and leaders and have great performance; it is also worth mentioning that in large organizations working

in the field of hierarchal technology and urban services, new ideas are shared among the groups while the environmental conditions are continuously changing, developing and transforming; The idea provider (entrepreneur), despite his interest and enthusiasm for the subject, gradually moves away from it and reduces his commitment and attraction to the subject. Furthermore, whenever the idea is transferred and exchanged, some information is missed and eventually the final result is very different from the original topic. Thus, in digital startups, the provider of a new idea can directly communicate with the principal decision-maker without observing the hierarchy and quickly gets informed about the work results. Consequently, they have a more successful performance in international environments. According to the second hypothesis i.e. Innovative environment has a significant effect on the internationalization of digital startups and its sub-hypothesis i.e. Innovative environment has a significant effect on the internationalization of digital startups with the mediating role of entrepreneurship, it can be said that it is necessary to focus on organizational culture and proceed towards arranging the values and norms of people, because innovative organizations have a common culture to move towards the internationalization of digital startups. They encourage experiencing, appreciate new experiences, and reward success and failure considering different situations, they also learn from mistakes and respond to environmental issues in the shortest time and in the best way according to the changes made. It is also worth mentioning that empowerment programs enable the company to perform in a creative and innovative way and provide its business plans in such a way that it always maintains excellently its position (Schillo, 2018). Therefore, managers are recommended to consider strategies such as innovative learning to solve problems, to prepare for change, to promote self-reliance and creativity development in digital startups regarding urban services and technology in order to improve the Innovative environment. They are suggested to facilitate the formation of an Innovative environment by creating a peaceful and informal work environment for staff, providing appropriate bonus and rewards to innovators, preparing people for change and supporting work bias. They should enhance the amount of

an Innovative environment by giving importance to entrepreneurial skills and providing relevant training among employees. They are also suggested to promote the development of digital startups regarding urban services and technology by applying the capabilities and innovative ideas presented by employees. Furthermore, managers should note that having information and communication technologies is the factor in achieving superiority and power in the company and it can influence various aspects of the company and it leads to important changes in the process of entrepreneurship, especially in internationalization. The results of this hypothesis are consistent with the statements made by Tajpour *et al.* (2020). According to the third hypothesis i.e. knowledge sharing has a significant effect on the internationalization of digital startups and its sub-hypothesis i.e. knowledge sharing with the mediating role of entrepreneurship has a significant effect on the internationalization of digital startups, it can be said that the lack of logical communication between managers and employees of digital startups in the development of executive rules and regulations reduces the motivation of people. Thus, informing employees through the publishing of extensive information leads to the production of constructive ideas to solve problems in digital startups in respect of urban services and technology. Furthermore, team spirit, self-efficacy, and self-confidence are improved through the behavioral honesty of the manager in presenting information. Teams for research, development, and support must be established senior managers to respond to environmental challenges in the internationalization of companies; therefore, using human resources efficiently provides knowledge and material resources and it makes it possible to perform at a greater level and to present their services and products in the customer's attitude by providing a proper condition and guiding the workforce; accordingly, entrepreneurs are able to efficiently face ambiguous, insufficient, inconclusive, disorganized and vague conditions and information to a moderate extent without feeling threatened or anxious by threats or failures, and they can use the ambiguities for their own interest and change the company in the international environment by resolving ambiguities using personal skills and efforts. The results of this hypothesis are consistent with the statements made by Kim *et al.* (2018).

CONCLUSION

Entrepreneurship is a significant phenomenon in digital startups, especially in Iran which is facing many challenges including sanctions and economic problems; therefore, managers should pay special attention to entrepreneurship because employees will express their creative and innovative ideas through suggestions if they ensure that their managers behave honestly. Thus, employees develop new and unique ideas to help digital startups in respect of urban services and technology to survive in the international competitive environment, support their colleagues and provide basic and quick suggestions for improvement to their leaders so that they can deal with the fundamental problems that arise in the industry. Furthermore, managers can set common goals, satisfy the social and group needs of members, create a two-way communication, develop the employees' skills and expertise, and establish group dynamics by collaborating and negotiating with team members. Creativity, innovation and entrepreneurship of employees are developed by participation and better responsiveness of employees to responsibilities and experiences. In fact, digital startups are developed in their specialized field by eliminating communication obstacles in the company. Company managers should also pay attention to the needs and demands expressed by their employees. Managers can create the opportunity to hear new opinions and ideas expressed by employees and clarify team and organizational goals by holding entrepreneurship courses so that they can perform well in the internationalization of their companies. Therefore, conditions for increasing the internationalization of digital startups in respect of urban services and technology will be provided through entrepreneurship.

Research Limitations

Even if a research is perfect, the researcher encounters some challenges and limitations. In present research, there are limitations in research data collection using questionnaire such as, the paper questionnaire naturally has limitation, it was impossible to investigate how careful the repliers were, there was a time limitation and the data collection was delayed because of online distribution of questions.

AUTHOR CONTRIBUTIONS

M. Tajpour and S.M. Razavi performed the conceptualization and literature review, compiled the data, manuscript preparation and editing references. M. Tajpour performed the Methodology, analyzed and prepared the manuscript text and manuscript preparation.

CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

PUBLISHER'S NOTE

IJHCUM Publisher remains neutral with regard to jurisdictional claims in published maps and institutional afflictions.

ABBREVIATIONS (NOMENCLATURE)

AVE	Average Variance Extracted
CR	Composite Reliability
R^2	R Square
Q2	Predictive Relevance
GOF	The Goodness of Fit
NFI	Normed Fit Index
SRMR	Standardised Root Mean Square Residual

REFERENCES

Ahsan, F.M.; Sinha, A.K., (2022). Internationalization motives, location advantages and performance: the case of Indian firms from knowledge-intensive industries. Cross. Culture. Strat. Manage. Ahead of print.

Al-Kurdi, O.F.; El-Haddadeh, R.; Eldabi, T., (2020). The role of organisational climate in managing knowledge sharing among academics in higher education. Int. J. Inform. Manage., 50: 217-227 (**11 pages**).

Allen, T.J.; Gloor, P.; Colladon, A.F.; Woerner, S.L.; Raz, O., (2016). The power of reciprocal knowledge sharing relationships for startup success. J. Small BUS. Ent. Dev., 23(3): 636-651 (**16 pages**).

Allen, N.J.; Meyer, J.P., (1990). The measurement and antecedents of affective, continuance and normative commitment to the organization. J. Occup. Psychol., 63(1): 1-18 (**18 pages**).

Arghashi, V.; Okumuş, A., (2022). Country-of-origin image; SMEs and emerging economies- evidence from a case study of manufacturing SMEs from Turkey. J. Isl. Mark., 13(4): 956-974 (**19 pages**).

Bagheri, M.; Mitchelmore, S.; Bamiatzi, V.; Nikolopoulos, K., (2019). Internationalization orientation in SMEs: The mediating role of technological innovation. J. Int. Manage., 25(1): 121-139 (**19 pages**).

Byrne, J.J., (1998). Teacher as hunger artist: Burnout: Its causes, effects, and remedies. Contem. Educ., 69(2): 86 (**1 pages**).

Casillas, J.C.; Moreno-Menéndez, A.M.; Barbero, J.L.; Clinton, E., (2019). Retrenchment strategies and family involvement: The role of survival risk. Fam. Bus. Rev., 32(1): 58-75 (**17 pages**).

Cahen, F.R., (2019). Internationalization of Brazilian high-tech startups. In Startups and innovation ecosystems in emerging markets. Palgrave Macmillan, Cham. 37-53 (**17 page**).

Cela, A.; Hysa, E.; Voica, M.C.; Panait, M.; Manta. O., (2021). Internationalization of Large Companies from Central and Eastern Europe or the Birth of New Stars. Sustainability., 14(1): 261 (**1 page**).

Chen, K; Zhang, Y; Zhu, G; Mu, R., (2020). Do research institutes benefit from their network positions in research collaboration networks with industries or/and universitos? Technovation, 94:102002-29(3): 94-95 (**2 page**).

Chitsaz, E; Tajpour, M; Hosseini, E; Khorram, H; Zorrieh, S., (2019). The effect of human and social capital on entrepreneurial activities: A case study of Iran and implications. Entr. Sustain., 6(3): 1393-1203 (**11 pages**).

Coveri, A; Zanfei, A., (2022). Who wins the race for knowledge-based competitiveness? Comparing European and North American FDI patterns. J. Tech. Trans, 1-39 (**39 pages**).

Covin, J.G; Miller, D., (2014). International entrepreneurial orientation: Conceptual considerations, research themes, measurement issues, and future research directions. Entrep. Theory. Pract., 38(1): 11-44 (**34 pages**).

Cunningham, J.A; Menter, M; Wirsching, K., (2019). Entrepreneurial

ecosystem governance: A principal investigator-centered governance framework. Small. Bus. Econ, 52(2): 545-562 (**18 pages**).

Dimitratos, P; Voudouris, I; Plakoyiannaki, E; Nakos, G., (2012). International entrepreneurial culture—Toward a comprehensive opportunity-based operationalization of international entrepreneurship. Int. Bus. Rev, 21(4): 708-721 (**14 pages**).

Du, H; Mitkova, L; Wang, N., (2020). The paths of internationalization of chinese innovative firms. Sustainability, 12(6): 1-27 (**27 pages**).

Fornell, C; Larcker, D.F., (1981). Structural equation models with unobservable variables and measurement error: Algebr. Stat., 382-388 (**7 pages**).

Hosseini, E; Ardekani, S.S.; Sabokro, M., (2020). Conceptual model of the voice of the members of the scientific board of public universities of Iran with the approach of interpretive structural modeling. J. Res. Manage. Teach. Mar. Sci., 7(4): 16-41 (**26 pages**). (In Persian)

Hosseini, E; Ardekani, S.S; Sabokro, M., Mahdi; S.; Almodarresi, A., (2021). Developing a model for knowledge employee voice: The case study of information technology enterprises. Org. Cult. Manage.,19(4): 655-682 (**27 pages**). (In Persian)

Hosseini, E; Tajpour, M; Lashkarbooluki, M., (2020). The impact of entrepreneurial skills on manager's job performance. Int. J. Hum. Capital Urban Manage., 5(4): 361-372 (**12 pages**).

Ipsmiller, E; Dikova, D; Brouthers, K.D., (2022). Digital Internationalization of Traditional Firms: Virtual Presence and Entrepreneurial Orientation. J. Int. Manage., 28(4): 100940 (**18 pages**).

Jang, H; Lee, K; Yoon, B., (2017). Development of an open innovation model for R&D collaboration between large firms and small-medium enterprises (SMES) in manufacturing industries. Int. J. Innov. Manag., 21(01): 1750002 (**16 pages**).

Jayabalan, J; Appannan, J.S; Low, M.P; Ming, K.S., (2016). Perception of employee on the relationship between internal corporate social responsibility (CSR) and organizational affective commitment. J. Prog. Res. Soc. Sci., 3(2): 168-175 (**8 pages**).

Jehan, Y; Hussain, D; Batool, M; Imran, M; Rasaizadi, A; Askari, M; Jonga, R. H., (2020). Effect of green human resource management practices on environmental sustainability. Int. J. Hum. Capital Urban Manage., 5(2): 153-164(**12 pages**).

Keser, S.; Duzgun, S.; Aksoy, A., (2012). Application of spatial and non-spatial data analysis in determination of the factors that impact municipal solid waste generation rates in Turkey. Waste Manage, 32(3): 359-371 (**13 pages**).

Kim, M; Choi, L; Borchgrevink, C.P; Knutson, B; Cha, J., (2018). Effects of Gen Y hotel employee's voice and team-member exchange on satisfaction and affective commitment between the US and China. Int. J. Contemp. Hosp. Manage., 30(5): 2230-2248 (**19 pages**).

Kline, R.B., (2015). Principles and practice of structural equation modeling: Guilford publications.

Korimbocus, M.A.; Towokul, T.; Nagowah, S.D., (2020). A Survey of knowledge capture and knowledge sharing techniques in Agile Software Companies. Springer, Singapore. Adv. Comp. Intell. Engn., 567-578 (**12 pages**).

Lawal, F.A; Iyiola, O.O; Adegbuyi, O.A; Ogunnaike, O.O; Taiwo, A.A.,

(2018). Modelling the relationship between entrepreneurial climate and venture performance: The moderating role of entrepreneurial competencies. Acad. Entr. Manage. J., 24(1): 1-16 (**16 pages**).

Liu, X; He, P; Chen, W; Gao, J., (2019). Improving multi-task deep neural networks via knowledge distillation for natural language understanding. 1904.09482 (**8 pages**).

Mahdavi Mazde, B; Zakery, A; Mirzamohammadi, S., (2022). A Model Presentation for the Role of Knowledge Types in the Internationalization of Knowledge Based Firms with its Policy Implications. Commer. Surv., 19(111): 85-106 (**22 pages**). Martínez-Román, J.A.; Gamero, J.; Tamayo, J.A.; Delgado-González, L., (2020). Empirical analysis of organizational archetypes based on generation and adoption of knowledge and technologies. Technovation, 96: p.102145.

McKenna, S., (2005). Organisational commitment in the small entrepreneurial business in Singapore. Cross Cult. Manage. Int. J., 12(2): 16-37 (**22 pages**).

Mirzapour, M; Toutian, S.S; Mehrara, A; Khorrampour, S., (2019). The strategic role of human resource management in crisis management considering the mediating role of organizational culture. Int. J. Hum. Capital Urban Manage, 4(1): 43-50 (**7 pages**).

Mlinaric, C.M., (2016). Foreign market knowledge and SME's international performance: Moderating effects of strategic intent and time-to internationalization. Entr. Bus. Econ Rev., 4(4): 51-66 (**16 pages**).

Mobarki, M; Ziyae, B; Rezvani, M; Tajpour, M., (2021). Conceptual model of internationalization of the entrepreneurial university with an interpretive structural modeling approach. J. Res. Manage. Teach. Mar. Sci., 8(4): 186-209 (**24 pages**). (In Persian)

Murphy, G.B.; Trailer, J.W.; Hill, R.C., (1996). Measuring performance in entrepreneurship research. J. Bus. Res, 36(1): 15-23 (**9 pages**).

Moolenaar, N.M; Daly, A.J; Sleegers, P.J., (2010). Occupying the principal position: Examining relationships between transformational leadership, social network position, and schools' innovative climate. Educ. Admin. Q., 46(5): 623-670 (**48 pages**).

Mtigwe, B., (2006). Theoretical milestones in international business: The journey to international entrepreneurship theory. J. Int. Entr., 4(1): 5-25 (**20 pages**).

Neupane, P.A., (2019). Networks and internationalization in higher education: A case study (Order No. 13808418). Available from ProQuest Dissertations and Theses Global. 1-31 (**32 pages**).

Onkelinx, J; Manolova, T.S; Edelman, L.F., (2016). The human factor: Investments in employee human capital, productivity, and SME internationalization. J. Int. Manage., 22(4): 351-364 (**14 pages**).

Ouakouak, M.L; Ouedraogo, N., (2019). Fostering knowledge sharing and knowledge utilization. Bus. Process. Mange. J., 757-779 (**23 pages**).

Oyewobi, L.O.; Oke, A.E.; Adeneye, T.D.; Jimoh, R.A., (2019). Influence of organizational commitment on work-life balance and organizational performance of female construction professionals. Eng. Constr. Archit. Manage., 26(10): 2243-2263 (**21 pages**).

Park, J.Y; Nawakitphaitoon, K., (2018). The cross-cultural study of LMX and individual employee voice: The moderating role

of conflict avoidance. Hum. Res. Manage. J, 28(1): 14-30 (**17 pages**).

Park, J; Chae, H; Choi, J.N., (2017). The need for status as a hidden motive of knowledge-sharing behavior: An application of costly signalling theory. Hum. Perform., 30(1): 21-37 (**17 pages**).

Petty, G.C; Hill, R.B., (2005). Work ethic characteristics: Perceived work ethics of supervisors and workers. J. Ind. Tech. Educ., 42(2): 5-20 (**15 pages)**.

Purkayastha, A.; Kumar, V.; Lovallo, D., (2022). How do business group affiliated firm in emerging markets outperform standalone firms? A knowledge-based view. J. Knowl. Manage.

Razak, N.A; Pangil, F; Zin, M.L. M; Yunus, N.A.M; Asnawi, N. H., (2016). Theories of knowledge sharing behavior in business strategy. Procedia Econ. Finance, 37(1): 545-553 (**9 pages**).

Ringel, M.; Schlomann, B.; Krail, M.; Rohde, C., (2016). Towards a green economy in Germany? The role of energy efficiency policies. Appl. Energy, 179: 1293-1303 (**11 pages**).

Sabokro, M.; Tajpour, M.; Hosseini, E., (2018). Investigating the knowledge management effect on managers' skills improvement. Int. J. Hum.Capital Urban.Manage., 3(2): 125-132 (**11 pages**).

Salamzadeh, A; Tajpour, M; Hosseini, E; Salembrahmi, M., (2021). Human capital and the performance of Iranian digital startups: the moderating role of knowledge sharing behaviour, Int. J. Public Sect. Perform. Manage. 2(1): 1-16. (**14 pages**).

Schillo, R.S., (2018). based spin-offs as agents in the entrepreneurial ecosystem. J. Technol. Trans., 43(1): 222-239 (**18 pages**).

Siegel, S.M.; Kaemmerer, W.F., (1978). Measuring the perceived support for innovation in organizations, J. Appl. Psychol., 63(5): 553-563 (**11 pages**).

Singh, S.K; Gupta, S.; Busso, D.; Kamboj, S., (2019). Top management knowledge value, knowledge sharing practices, open innovation and organizational performance. J. Bus. Res., 788-798 (**11 pages**).

Soetanto, D; van Geenhuizen, M., (2019). Life after incubation: The impact of entrepreneurial universities on the long-term performance of their spin-offs. Technol. Forecast. Soc. Change, 141: 263-276 (**14 pages**).

Tajpour, M., Hosseini, E., & Brahmi, M., (2022). Effect of international entrepreneurship indicators on innovative

performance: the mediating role of motivation. Int. J. Tech. Transfer. Commerc., 19(1): 142-162 (**21 pages**).

Tajpour, M; Mohammadi, M; Soleymanian, S. M; Yaghoubpour, M., (2022). spin-off and internationalization: the mediating role of entrepreneurial university. Acad. Strat. Manage. J., 21(5): 1-14(**14 pages**).

Tajpour, M; Ziyae, B; Mobaraki, M; Rezvani, M., (2022). Exploring the relationship between internationalization and entrepreneurial university: the mediating effect of education (University of Tehran, Sharif University of Technology, and Tarbiat Modares University). Iran. J. Manage. Stud. Ahead of print. (In Persian)

Thomas, K.W; Velthouse, B.A., (1990). Cognitive elements of empowerment: An interpretive model of intrinsic task motivation. Acad. Manage. Rev., 15(4): 666-681(**16 pages**).

Tough, A; Popoola, S.O., (2009). Organizational commitment of records management personnel in Nigerian private universities. Rec. Manage. J., 19 (3): 204-217(**14 pages**).

Tsai, C.H., (2011). Innovative behaviors between employment modes in knowledge intensive organizations. Int. J. Human. Soc. Sci., 1(6): 153-62 (**10 pages**).

Tuppura, A; Saarenketo, S; Puumalainen, K; Jantunen, A; Kyläheiko, K., (2008). Linking knowledge, entry timing and internationalization strategy. Int. Bus. Rev., 17: 473-487 (**15 pages).**

Vashdi, D., R; Bamberger, P., A; Erez, M; Weiss-Meilik, A., (2007). Briefing-debriefing: Using a reflexive organizational learning model from the military to enhance the performance of surgical teams. Hum. Res. Manag., 46(1): 115-142(**28 pages**).

Wang, Z; Wang, N., (2012). Knowledge sharing, innovation and firm performance. Expert systems with applications, 39(10), 8899-8908. (**10 pages).**

Yang, L. R; Huang, C.F; Wu, K.S., (2011). The association among project manager's leadership style, teamwork and project success. Int. J. Project. Manage. 29(3): 258-267 (**10 pages**).

Yasir, M; Majid, A., (2017). Impact of knowledge management enablers on knowledge sharing. World J. Entr. Manag. Sustain. Dev., 13(1): 16-33 (**18 pages**).

Zahra, S.A., (2005). Toward a theory of international new ventures: Reflections on a decade of research. J. Int. Bus. Study., 36: 29-41 (**13 pages**).

ORIGINAL RESEARCH ARTICLE

Environmental Worry Index-11: development, validity, and reliability

R. Oguntayo[1,*], S.F. Agberotim[2], P.O. Ajao[3], T.O. Olaitan[4], A.O. Olaseni[5], D.O. Ajibewa[6]

[1] Department of Psychology, Institue of Social sciences and Administration, Universidad Autonoma de Ciudad Juarez, Juarez, Mexico

[2] Department of Psychology, Chrisland University, Abeokuta, Nigeria

[3] Department of Psychology, University of Oye-Ekiti, Ekiti State, Nigeria

[4] Department of Psychiatry, Faculty of Clinical Sciences, College of Health Sciences, LAUTECH, Ogbomosho, Oyo State, Nigeria

[5] Department of Psychology, Faculty of Social Sciences, University of Ilorin, Ilorin, Nigeria

[6] Department of Psychology, Faculty of Social Sciences, University of Ibadan, Ibadan, Nigeria

ARTICLE INFO

ABSTRACT

BACKGROUND AND OBJECTIVES: Environmental worry involve primarily the thoughts of some hazardous immediate and long-run side effects of degradation that happened to our ecological system. Despite the side effects of this phenomenon, psychometrics measuring environmental worry from the African context are insufficient. Therefore, the Environmental Worry Index (EWI-11) was developed to assess proximal and personal experiences of worry about climate change and environmental degradation.
METHODS: This study used a qualitative method among environmental professionals and students (between the ages of 18 to 65) in a university to generate the themes and the pool of items that were used to determine the Environmental Worry Index (EWI-11). Thereafter, 925 participants were purposively selected and assessed from Ibadan city through a cross-sectional survey to ascertain the validity and reliability of this new scale. The participants were selected in Ibadan city, Nigeria. The software of the Statistical Package for Social Sciences (Version 26.0) was used for all analyses.
FINDINGS: Using exploratory factor analysis, the construct validity and Varimax rotation showed that the scale has two components (KMO = 0.892, df=91, p.00), thus showing a strong validity. The reliability dimensions and subscales have meritorious reliability (Proximal, α =.894, and Personal experience of worry, α =.671). The overall Cronbach's Alpha was 0.894.
CONCLUSION: The EWI-11 is adequate for measuring environmental worry and could be useful for experts in mental and environmental research and practice. EWI-11 is therefore recommended as a reliable and valid screening tool for environmental worry and may be acceptable across Africa and other countries as well.

NUMBER OF REFERENCES

32

NUMBER OF FIGURES

3

NUMBER OF TABLES

3

*Corresponding Author:
Email: rotimijoguntayo@gmail.com
Phone: +234 80607 48460
ORCID: 0000-0001-9926-5882

INTRODUCTION

Global environmental devaluation and climate change have made it more difficult for people to maintain good mental health. Trauma, anxiety, fear, concern, and sadness are a few of these difficulties that may come along with the immediate or long-term repercussions of environmental deterioration (Intergovernmental Panel on Climate Change (IPCC), 2014; Stewart, 2021; WHO, 2022). Studies have shown that being exposed to inclement weather might result in anxiety and stress (Steward, 2021). Additionally, the impacts of environmental devaluation on ecosystems and, consequently, human civilizations may create feelings of dread and fear about the potential climate-related uncertainties that lie ahead (Van der Linden, 2017). Concerns about environmental devaluation or climate change have been studied in several studies and related to the neglect of citizens, environmental scientists, and governments of all countries (Nisbet, 2017; Nisbet *et al*., 2017). Following changes brought about by the disrupted climate and environmental devaluation, people may react with feelings of grief, loss, and mourning; climate change may be the result of mourning (Cunsulo and Landman, 2017). Numerous other research has shown that being exposed to environmental dangers is bad for one's physical health as well as mental health problems like anxiety, depression, post-traumatic stress disorder (PTSD), and even suicidal thoughts. For instance, environmental deterioration has indirect effects on mental health that are linked to psychological stress, such as identity loss, relocation, interruptions in medical care, an increase in physical health problems, problems with physical health, an increase in community violence, food insecurity, malnutrition, and air pollution (Cianconi *et al.*, 2020; Kelly *et al.*, 2010). Environmental hazards worry and climate change anxiety is often used interchangeably but they are not the same environmental anxiety is a severe fear of doom that one has about climate or environmental degradation; even among those who have not personally encountered any direct effects of climate change, anxiety is more strongly correlated with perceptions about it (Clayton *et al.*, 2017). On the other hand, environment worry (EW) is the anxiety brought on by personal experience or contemplation of climate change, particularly in those who have personally

encountered any direct repercussions. A study characterized environment anxiety as verbal-linguistic concerns about the climatic changes that take place and their potential impacts. Such worry is one of the numerous potential psychological reactions (such as dread, anxiety, despair, and trauma) to environmental deterioration, which affects people more intrinsically than it does other people, whereas worry is more specific than anxiety and anxiety is more explicit than worry (Stwart, 2020). Several researchers in the western world have developed assessment tools for the neurotic implications of degraded natural environments as a whole. For instance, Worthington *et al.* (2006) designed a scale to measure environmental distress that individuals witnessed proximal to open places where mining is done in Australia. In a similar way, Bowler and Schwarzer (1991), investigated the distressing experiences of locals living close to hazardous waste sites in New Mexico and Texas that could expose them to environmental worries, like the researchers in Australia, they found signs of environmental worry and noted associations between it and signs of stress, anxiety, and depression. These researchers also developed a tool to measure environmental worry (Searle and Gow, 2010). The Eco-Anxiety Scale was also designed by other researchers (Hogg *et al.*, 2021). In contrast to the global focus on psychophysical and environmental health variables, the majority of African nations face unique social issues such as littering, open defecation, flooding, and species co-extinctions as a result of environmental change (Opayemi *et al.*, 2020; Strona and Brand, 2018; UNICEF, 2022). Also, heat, excess rain, and drought (United Nations Climate Change, 2022) among others, none of these studies take to cognizance the peculiarity effects of climatic change in sub-Saharan Africa. There are some observations to be noted from these referred studies related to climate change distress scales of measurement. The first is that climate change anxiety and its assessments (otherwise refers to as the environment concern scale) have been of interest to a number of researchers but none considered the worries that accompanied environmental degradation. Second, it is important for the present study, compared to all the cited studies to design a measure of EW considering that the alternative assessment tools

are from the western world and may not take into cognizance the peculiarity of the African context of EW. Also, those past studies that have been used in the African settings, lack cultural and contextual peculiarity if a question like adequate ecological validity were asked in those studies. Additionally, because those items evaluate personal worry about EWI across those domains of a psychological study of behavior, the items that focus on global or general societal worry about climate change may not relate to the current study, which is focused on personal experiences, psychological processes, behaviors, and cognitive/feelings that could be used to guide policy preferences, as reliably (Van der Linden, 2014). Given these considerations, researchers may gain from the development of a succinct, multi-item measure of individual concern with environmental degradation. The environmental worry may occur in an attempt to engage in mental problem-solving on an issue whose outcome is uncertain but contains the possibility of one or more negative outcomes; as a result, the environmental worry is closely related to the fear process. The concerns embedded in environmental destruction are typically described when examining the EWI constructs as being chained in thoughts and images, negatively affect-laden, and largely perceived as uncontrollable (Fetzek and Mazo, 2014). In addition, worry could be described as negative vocal-linguistic that uses thoughts and minimal amounts of imagery that accompanies fears about the negative effects of environmental degradation in the future (Barlow, 2004; Holaway *et al*., 2006 in Stewart, 2021). According to Szabo (2011), the emotional experience of worry is accompanied by stress-related symptoms such as tension, uneasiness, impatience, and difficulty controlling one's emotions. Normal worry differs from persistent, and acute worry in which an individual involves in worrying about a larger range of events, with more frequent occurrences over time and lasts longer episodes, and is felt as repetitive and uncontrollable one (Fetzek *et al.,* 2014; Stewart *et al.,* 2011). Furthermore, abnormal and adaptive worry involves attention to a threat in the environment and offers resources for doing so, whereas excessive and maladaptive worry may make it difficult to break free from repetitive thinking, which paradoxically impairs one's ability to think critically and solve problems in relation to the

threat (Godwin, Yiend and Hirsch, 2017). It has been asserted that EW could occur upon an increase in the severity of the weather hazards (Stewart, 2021). Alternately, EW may necessitate both coping and adaptive reactions, whose unpredictability may serve as a source of stress. People may also be concerned about how climate change will affect other people's ecosystems, lifestyles, livelihoods, health, and other factors (Clayton, 2020). Worry can help someone acclimatize to and adapt to an EW in moderation (Van der Linden, 2014). However, an excessive concern may prevent attempts at adapting and result in tension, distress, and diminished capacity for problem-solving Holaway *et al.*, 2001). Such excessive worry may also exacerbate other emotional problems like anxiety or depression (Godwin *et al*., 2017). According to the current study, determining the degree of worry that people may feel about environmental change was designed using a literature review to inform people's and experts' experiences while accounting for the frequency of worry that relates to the domain of a disrupted, changing, and the degraded environment from personal experience that resulted in worry rather than anxiety, fear, or depression. Based on the items, people are expected to self-report their worries about environmental damage. The study chose to concentrate on item content on potential near-term manifestations of environmental damage and climate change, such as severe weather outbreaks and their effects on the respondent's own life as well as the lives of others they care about, rather than on impacts like those on other nations, groups, and resource scarcity. This choice was made for two reasons. The first was that the authors wanted the measure to be simple and to concentrate on a single construct of individual environmental damage anxiety rather than anxiety over generic, societal, or global causes (Stewart, 2021). This was based on a deliberate choice, as learned from clinical experiences, because personal worry is an active emotional state that is frequently closely linked to behavioral changes intended to lessen a specific threat, as opposed to broad worry, which is not and can be expressed without any specific motivation or emotional content (Clayton, 2020; Van der Linden, 2014). The second justification for emphasizing individual concerns about the environment is consistent with research showing that people can

personally experience the proximal effects of environmental deterioration and that these experiences are reliable indicators of people's perceptions of the risk of the latter (Clayton, 2020; Diffenbaugh and Scherer, 2011; Stewart, 2021). As a result, only immediate and personal concerns about climate change and environmental degradation are included in the EWI items. As a result, the EWI serves as a scale for evaluating how worried people are about climate change. An inductive technique was utilized to design the scale's items; this method is particularly helpful when a construct's definition, operationally, or dimensions are unclear (Oguntayo *et al.,* 2020). In this situation, experts, professionals, and university lecturers were consulted to provide definitions of the construct, and such constructions are theorized and then derived; this could serve as the foundation for creating goods (Tay *et al.,* Stewart, 2017). The items and dimensions in a scale were precisely identified using a scientific technique called exploratory factor analysis (EFA), which is also the technique that is most frequently used to evaluate the validity of new scales. Factor analysis is a set of statistical structure analyzing techniques used to find correlations among observable variables in order to maximize data reduction of variables related to each dimension of the scale (i.e., factor) of the construct (Norris and Lecavalier, 2010). EFA examines the data and offers guidance regarding the number of factors loading. The number of factors and the related variables for each factor is carefully determined by researchers. EFA is essentially preferred over confirmatory factor analysis (CFA) for scale development since there is a chance that researchers' assumptions about the construct's dimensionality may be wrong. EFA is also recommended to determine the quality of the items (Kline, 2013; Stewart, 2021; Worthington *et al.,* 2006). The purpose of the current study is to develop and ascertain the validity and reliability of an indigenous African-based environmental worry assessment tool that focuses on the immediate and personal concerns about climate change and environmental degradation considering the paucity of literature on the psychometrics of this psychopathology, especially in Nigeria. The current study has been carried out in Ibadan, Oyo state, Nigeria in 2022.

MATERIALS AND METHODS

Qualitative design and data collection

This study utilized a mixed method (qualitative and qualitative methods). For the qualitative study where items were generated, those who participated in the Focus Group Discussions (FGD) that informed the themes generated were 30 from geography, agriculture, and social-related background in Ibadan, Oyo State, Nigeria, and one lecturer of geography and a lecturer of environmental psychology were granted a key informant interview in the same in the university of Ibadan, in Oyo state. The participants who consented to participate in the study were grouped thus; 10 participants were in FGD1, 9 participants were in FGD 2 and 9 participants were in FGD 3.

Items Generation and Selection

Firstly, the researcher reviewed the literature to examine the existing scales that measured EW and the factors influencing it. Secondly, the researcher conducted a qualitative study with a purposive sample of individuals with knowledge of climate change or environmental hazards. The participants were assessed using FGDs and in-depth interviews. This approach enhanced content validity (Nunnally, 1978) as the participants were considered experts in this area. The discussions in the FGD centered on both personal experiences, cognitive, and cultural worries about environmental degradation. The information gathered from the interviews was recorded, translated, and transcribed. From the thematic analysis of the FGD, three basis contents emerged: (i) emotional/cognitive factor, (ii) behavioral factor, and (iii) personal factor. Items were generated with these factors which resulted in 15 items. The themes generated were then pre-tested on the selected participants.

Face validation of the scale

The face validity was examined to see if the questionnaire included any pertinent questions for evaluating EW in the context of Africa, particularly Nigeria. The items were distributed to the chosen environmental Psychologist, geographer, and four psychology and geography students who are familiar with climate change in order to determine whether the measures accurately measure EW. They were

tasked with rating the questionnaire's items for relevancy, clarity, and conciseness. The respondents all agreed that the questions did in fact assess EW. All 15 things were kept after the initial evaluation.

Survey design, data collection procedure and settings

The study utilized a cross-sectional survey design. A face-to-face questionnaire administration was used to gather the data for the quantitative study between January and May 2022. In this study, proportionate stratified random sampling—which entails selecting random samples from stratified groupings, in proportion to the population—was used to better reflect the diversity of the city's population. In this method, the population size of the entire city was directly proportional to the sample size of each subgroup, which was categorized by the local administration. This indicates that the sampling fraction is the same for all local government samples. The next step was to select the respondents for this study phase using a methodical random sample. Therefore, 950 questionnaires were distributed to respondents across households in each of those five selected Local Government Areas (LGAs) in the main city of Ibadan, including the Ibadan North LGA, Ibadan North West LGA, Ibadan North East LGA, Ibadan South West LGA, and Ibadan Southeast LGA (Fig. 2) (Wahab and Popoola, 2018). Ibadan, with a population of 3,565,100 as of 2021 and more than 6 million residents in the metropolitan region, is the third-most populous city in Nigeria after Lagos and Kano (Statista, 2021). Ibadan, in south-western Nigeria, is a significant most big city between the coastal region and the regions in the country's interior. It is located 128 kilometers (80 km) inland from Lagos and 530 kilometers (330 mi) southwest of Abuja, the federal capital. (Statista, 2021). Ibadan was selected as the study region because the city government is determined to make it an environmentally friendly metropolis. As a result, this city appears to have a higher understanding of the effects of environmental dangers than other major cities in Nigeria. Furthermore, Ibadan city is home to nearly all of Nigeria's ethnic groups. As a result, this will aid in the national generalization of the study.

After removing the questionnaires not properly filled, a set of 925 qualified questionnaires was retained and used for further examination in the survey study. Participants ages ranged from 18 to 65years (60.0% males and 40.0% females; mean age =28.43, SD = 9.65). Individuals between 18-40years (youthful age) were 892(96.4%) while older individuals (between 41 to 65years) were 33(3.6%). For religion, Christians were 561(60.6%), while Muslims were 352(23.4%), and those practicing other religions were 12(1.3%). For tribe; Yorubas were 636(68.8%), Igbos were 138(14.9%), Hausa/Fulani were 66(7.1%) and other tribes were 85(9.2%). Educational status was; secondary school certificate 318(34.4%), diploma and equivalents 153(16.5%), Degree and equivalents 425(45.9%), while postgraduates were 29(3.1%). Marital status; single 409(44.2%), married 409(44.2%) and those separated/divorced were 107(11.6%). Lastly, Job-status; civil servants were 98 (10.6%), unemployed graduates were 96 (10.4), artisans/traders were 130 (14.1%), students were 444 (48.0%) and participants who were unemployed but not graduates were 157 (17.0%).

Analytical framework

In the current study, participants were asked to respond to the developed pool of questionnaire with this shown here; "I feel concerned when I think about the increase in air, water, land, and noise pollutions", "Concern on natural disasters and deterioration of earth's resources worry me", "Thoughts about the extinction of some animal species keep worrying me" etc. These seem to depict worry about ecological degradation. A choice of multiple responses using 4 Likert points response format was used thus; 0 = not at all, 1 = a few of the days, 2 = more than half the days, 3=almost every day. A descriptive statistic (mean, standard deviation, frequency, and percentage), EFA, Cronbach alpha reliability coefficient, and correlational analyses were utilized in this work to ascertain the validity and reliability of this index. The statistical package for social sciences (IBM SPSS 26.0) was used to examine the study's data.

RESULTS AND DISCUSSION

Descriptive statistics and factor analysis for variables entering the analysis

Fig. 3 and Table 1, 2, and 3 explain the study's findings. There are 925 respondents who are valid instances for this set of variables, which have to be reduced from a big set of Likert-scale variables (15 items of EWI factors). The suitability of the data for factor analysis was assessed using Bartlett's test

Fig. 1: Map of Nigeria showing Oyo state (Borokini *et al*., 2013)
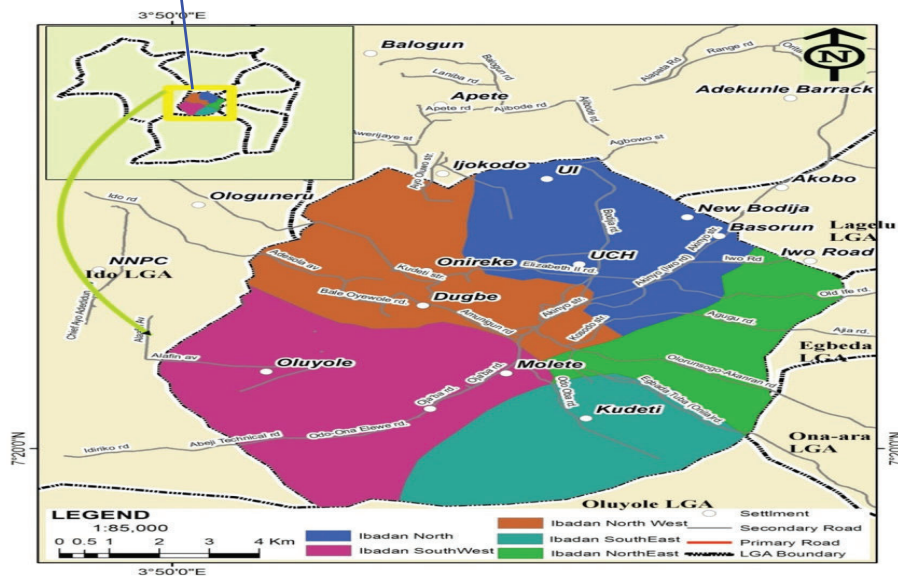
Fig. 2: Geographic location of the study region in Oyo State, Nigeria

of sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sample adequacy. The percentage of variance among variables that may have underlying causes or relevancy was also examined using the KMO test. The value of KMO increases as the data is more appropriate (near 1). When a matrix is put through the Bartlett sphericity test, it can be seen if it deviates significantly from an identity matrix. Therefore,

if Bartlett's test of sphericity yields a significant result, component analysis may be useful for the data (p 0.05) (Shrestha, 2021). The study's findings revealed that the KMO value was 0.892, which was higher than the threshold limit of 0.8 (Shrestha, 2021), and Bartlett's test was significant at p-value < 0.001, approving that the factor analysis is useful and applicable. According to the performance of the

factor analysis, two components were recovered, and the explained variance was 59.059%. As a result of these procedures, this scale has two subcomponents as indicated in Table 1. Items 2, 5, 7, and 10 with factor loadings less than 0.5 were eliminated, leaving 11 items as valid. However, for the new scale, the original scale's items 1, 3, 4, 6, 8, 9, 11, 12, 13, and 11 were kept. Additionally, as each original variable's variation is explained by the factor solution to at least a certain extent, the communality value was sufficient for all items because it was greater than 0.50 for all of them (Oguntayo *et al.*, 2020).

The dimensionality of EWI

Fig. 3 showed the scree plot that revealed the two subscales; items 1, 8, 9, 12, 13, 14, and 15 were retained for "Proximal", while items 3, 4, 6, and 11 were retained for "Personal worry experience". Table 1 shows factors loadings and communalities for the

EFA of the EWI. A total of 11-item out of the 15 items were retained while the final 11 items with unique factor loadings range from .56 to .77. The scree plot of the 2 factors (Fig. 3) showed optimal solutions and relationships of the items loading that are relevant to the EW of the participants.

From Table 2, evidence of convergent and discriminant validity of the new scale of EWI was supported through bivariate analyses resulting in statistically significant positive correlations between the measure of psychological distress called Clinical Outcomes in Routine Evaluation-Outcome (CORE-10) (Barkham *et al.*, 2013) and EWI (r = .073, n = 937, p = .001) though in a very low way, there was no association between the measure of Infectious Diseases Preventive Health Behavior Scale (ID-PHBS-12) (Ayandele *et al.*, 2020) and EWI (r = .040, n = 937, p = .269) (Table 2). With respect to EWI scores, the CORE showed statistically significant correlations.

Table 1: Rotated Component Matrix with Principal Component Analysis as Extraction Method and Varimax Rotation with Kaiser Normalization and Reliability Coefficient for the new EWI

| Items		Factors			Reliability		
		Component 1	Component 2	Communalities	KMO	Bartlett test	α
S/N	Items Retained						
1	I feel concerned when I think about the increase in air, water, land, and noise pollution	.797		.636			
3	I worry about flood disasters in my environment		.707	.509			
4	I feel concerned about the littering of the environment and open defecation		.681	.543			
6	Thoughts about traffic and congestion in my areas cause me to have worries		.765	.591			
8	Concern on natural disasters and deterioration of earth's resources worry me	.744		.707	0.892	χ2=5.18	0.771
9	Thoughts about the extinction of some animal species keep worrying me	.777		.614			
11	I tend to worry when I hear about food and water scarcity in my location		.563	.445			
12	I feel concerned about opposing low rainfall and excessive rainfall reports globally	.722		.593			
13	I feel concerned about earthquakes, tornados, and other environmental hazards	.771		.638			
14	Whenever I hear about the weakness of ozone layers my heart beats faster	.701		.596			
15	Bush burning and exposure to carbon dioxide give me concerns	.762		.626			
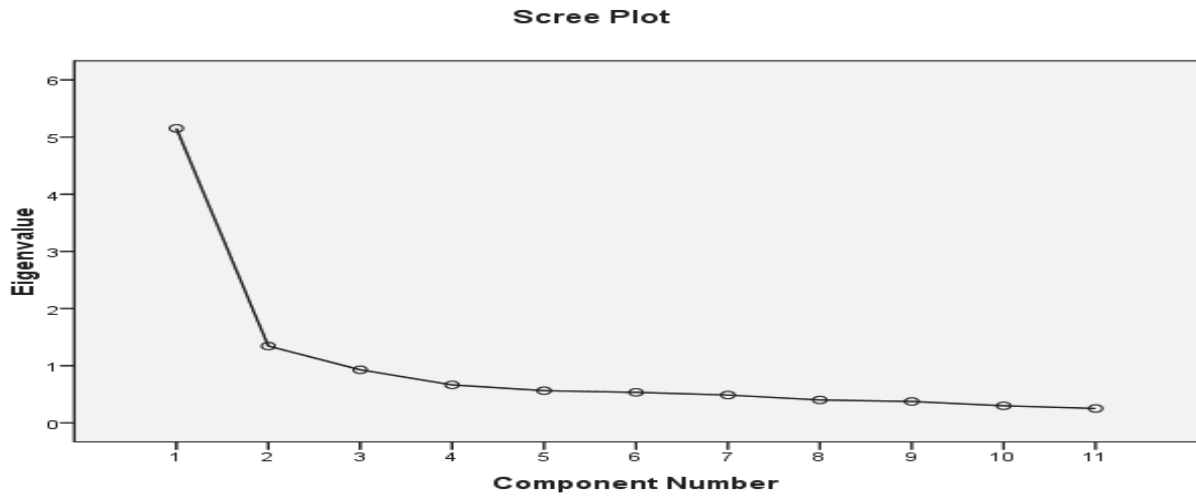
Scree Plot

Fig. 3: Scree Plot for Environmental Worry Index (EWI)

Table 2: Results of Inter-corelation analysis among study scales

Scale	1	2	3	M	SD
Clinical outcomes in routine evaluation	-			14.05	5.70
Infectious diseases preventive health behavior scale	.356[**]	-		48.24	14.67
Environmental Worry Index	.073[*]	.040	-	44.92	11.47

**. Correlation is significant at the 0.01 level (1-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

Table 3: Item-Total Statistics

Items	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
d1	29.1250	67.755	.611	.519	.873
d3	29.1238	73.573	.364	.259	.887
d4	29.1745	70.803	.506	.388	.879
d6	29.0165	73.561	.376	.304	.886
d8	29.6887	63.239	.780	.652	.861
d9	29.8998	63.847	.636	.515	.872
d11	29.1946	70.922	.515	.339	.879
d12	29.3667	66.778	.681	.529	.869
d13	29.7700	64.234	.693	.581	.867
d14	29.7252	64.414	.696	.530	.867
d15	29.6061	63.261	.690	.526	.868

Correlation research revealed an association between rising environmental worry and rising CORE scores (psychological distress) (Table 2). These findings revealed that environmental worry was more closely correlated with the emotional state of stress. A conclusion that supported the convergent validity of the EWI was the moderate degree of connection between psychological distress measures (CORE) and EW. These findings support the hypothesis that more severe psychological suffering may ensue from environmental deterioration and global climate system disruption (Lin *et al.,* 2018). People with past fears of environmental depletion may thus show increasing psychological distress when thinking of

environmental hazards. This could especially be the case if people have memories or recollections of severe environmental deterioration and have noted this trend over time such may exhibit greater severity in the measure of mental health in the long run. Also, the mean score according to this study is 44.10, SD=11.47 (Table 2).

The EWI reliability and its subcomponents were assessed using Cronbach's alpha test, the results showed the range of 0.861-0.886, which was greater than the minimum accepted value of 0.6 (Shrestha 2021), with an overall Cronbach alpha coefficient of .849 (Table 1 and 3). This examines how well these sets of items are related as a factor. For subscale; Proximal has a Cronbach's alpha value of 0.894, and personal worry experience has a Cronbach's alpha value of 0.671.

Comparing the Eco-Anxiety Scale to the results of this study, it can be shown that while the Eco-Anxiety Scale examines a more comprehensive evaluation of environmental anxiety (Hogg et al, 2021) the EWI assesses comprehensive environmental degradation worry. Recent empirical research by Clayton and Karazsia (2020) has given the first exception to this limiting focus on affective symptoms, providing support for the multidimensionality of climate change worry. The present study's findings on the cognitive-emotional and functional impairments of environmental change worry are novel and convincing, especially because it is compatible with the African setting rather than the Western context. In addition, it distinguishes between anxiety and worry in accordance with research on clinical anxiety disorders (APA, 2013). Similar to the authors of eco-anxiety, we adopted a mixed-methods approach to build a comprehensive measure of worry. However, we utilized EFA and discriminant validity in the validation of this new scale, whereas Hogg *et al.* (2020) utilized both EFA and CFA. EFA is fundamentally recommended over CFA for this scale construction because of the possibility that researchers' assumptions regarding the dimensionality of the new scale construct may be incorrect (Kline, 2013; Worthington *et al.*, 2006). However, future research may use analysis to corroborate the validity and dimensionality established in the present study. This study's focus is unique compared to the other studies interests

in global world environmental threats, because it focuses on African regions have distinct concerns combined with climate change worry, such as littering, open defecation, flooding, heat, excess rainfall, and drought (Opayemi *et al.*, 2020: UNICEF, 2022; United Nation Climate Change, 2020). Therefore, unlike other comparable historical metrics, the EWI possesses cultural and contextual characteristics of the African context. In addition, unlike other comparable scales, the current study focuses on personal experiences, psychological processes, actions, and cognitive/emotional states that could be utilized to drive policy preferences (Van der Linden, 2014). Therefore, the development of a concise, multi-item measure of individual worry with environmental deterioration will benefit professionals and clinicians interested in mental health and environmental hazards. EWI describes and analyzes the concerns embedded in environmental destruction constructs that are derived from negatively affect-laden thoughts and perceptions that are widely regarded to be uncontrollable (Fetzek *et al.*, 2014).

CONCLUSION

The Environmental Worry Index (EWI-11), an eleven-item self-report measure created to gauge how much worry people feel about environmental risks, is developed, described, and its psychometric development is established by the authors in this article. This article starts out by talking about concern and how it is fundamentally different from the related concepts of anxiety and dread. The construct of environmental degradation worries and the methods utilized to create the EWI is then described by the authors. The author goes into detail about the EWI's psychometric development in the single research that follows. The study evaluates the internal reliability of the factor analysis of the items and offers the findings. Through its pattern of correlations with a number of well-established clinical and weather-related measures, this study also looks at the invariance of the latent structure of the measure with respect to results about the convergent and divergent validity of the EWI. This research work provides an insight into the distinguishing environmental worry measure between Africans and the western world as well as ascertains the development, validity,

and reliability of a new scale of environmental worry (EWI). It was designed to clinically assess the environmental worry among the African population and the global world over time. Consequent analysis of the result shows that out of the developed 15 items of (EWI), 11 items were proven reliable and valid. The study suggests that the new scale can be used among other populations, tribes, races, and nations to ascertain its generalizability. Therefore, future studies should take into consideration using this new scale appropriately and especially in other regions to harmonize external validity. The structure of the single factor indicating the distress that worry could produce was constant for both the sample's male and female participants and the items of the new environmental worry scale showed good internal consistency. When this scale is used, it is expected to be for clinical practice of assessment and for academic inquiry for getting a better understanding of environmental worry or distress, which could help policy-makers, mental health stakeholders, and environmental professionals to design and improve effective means of managing the impacts of environmental hazard on humans. From a global point of view, this study contributes and adds value to the existing literature on the assessment of environmental hazard measures as related to mental health policy applied in the behavioral, social, cultural, and global world. Finally, worry over environmental depletion was linked to distressing feelings. The EWI and the Infectious Diseases Preventive Health Behavior Scale were unrelated (ID-PHBS). Readers should keep in mind that since CFA was not used in this study, it is crucial that CFA be performed on a different sample in order for future researchers to corroborate the scale's structure.

AUTHOR CONTRIBUTIONS

R. Oguntayo developed the idea of this study; designed, analyzed, and interpreted the data. While O. Oladele worked out the literature review and compiled the data and formatted the manuscript. O.A. Olaseni helped in the literature review. As for O.D. Ajibewa, P.O. Ajao, and S.F. Agberotimi contributed to the manuscript preparation and performed some of the remaining work like the formatting of the manuscript and placement of graphs.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

PUBLISHER'S NOTE

Tehran Urban Planning and Research Center remains neutral with regard to jurisdictional claims in published maps and institutional afflictions.

ABBREVIATIONS

CFA	Confirmatory factor analysis
CORE	Clinical Outcomes in Routine Evaluation
EFA	Exploratory factor analysis
EW	Environment worry
EWI	Environmental Worry Index
FGD	Focus Group Discussion

ID-PHBS	Infectious Diseases Preventive Health Behavior Scale
Km	Kilometers
KMO	Kaiser-Meyer-Olkin
LGAs	Local Government Areas
PTSD	Post-traumatic stress disorder

REFERENCES

American Psychological Association, (2013). Diagnostic and statistical manual of mental disorders, 5th ed. Author. Arlington, VA.

Ayandele, O.; Kolawole, S.K., Ramos-Vera, C.A.; Oguntayo, R.; Gandi, J.C.; Iorfa, S.K.; Ottu, I.F.A.; Dangiwa, A.L.; Olapegba, P.O., (2021). The Infectious Diseases Preventive Health Behavior Scale (ID-PHBS): Development and validation with an African Sample. SSRN (**17 Pages**).

Barlow, D.H., (2004). Anxiety and its disorders: The nature and treatment of anxiety and panic. Guilford press.

Bowler, R. M.; Schwarzer, R., (1991). Environmental anxiety: Assessing emotional distress and concerns after toxin exposure. Anxiety Res., 4(2): 167-180 (**14 Pages**).

Cianconi, P.; Betrò, S.; Janiri, L., (2020). The impact of climate change on mental health: a systematic descriptive review. Front. psychiat., 11: 74 (**15 Pages**).

Clayton, S.; Manning, C.; Krygsman, K.; Speiser, M., (2017). Mental health and our changing climate: Impacts, implications, and guidance. American Psychological Association and ecoAmerica. Washington, DC.

Clemens, V.; von Hirschhausen, E.; Fegert, J. M., (2020). Report of the intergovernmental panel on climate change: implications for the mental health policy of children and adolescents in Europe—a scoping review. Europ. Child Adolesc. psychiat., 1-13 (**13 Pages**).

Diffenbaugh, N.S.; Scherer, M., (2011). Observational and model evidence of the global emergence of permanent, unprecedented heat in the 20th and 21st centuries. Climatic Change, 107(3): 615-624 (**10 Pages**).

Fetzek, S.; Mazo, J., (2014). Climate, scarcity and conflict. Survival, 56(5): 143-170 (**28 Pages**).

Higginbotham, N.; Connor, L.; Albrecht, G.; Freeman, S.; Agho, K., (2006). Validation of an environmental distress scale. EcoHealth, 3(4): 245-254 (**10 Pages**).

Holaway, R.M.; Rodebaugh, T.L.; Heimberg, R.G.; Davey, G.; Wells, A., (2006). Worry and its Psychological Disorders: Theory, assessment and treatment. Wiley Library.

Hogg, T.L.; Stanley, S.K.; O'Brien, L.V.; Wilson, M.S.; Watsford, C.R., (2021). The Hogg Eco-Anxiety Scale: Development and validation of a multidimensional scale. Glob. Environ. Change., 1(71): 102391 (**34 Pages**).

Kelley, M.L.; Self-Brown, S., Le, B.; Bosson, J.V.; Hernandez, B.C.; Gordon, A.T., (2010).

Predicting posttraumatic stress symptoms in children following Hurricane Katrina: A prospective analysis of the effect of parental distress and parenting practices. J. Traum. Stress, 23(5): 582-590 (**9 Pages**).

Kline, P., (2013). Handbook of psychological testing. Routledge.

Intergovernmental Panel on Climate Change, (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectorial Aspects; Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press: New York, NY, USA.

Lin, H.; Chen, C.; Xirasagar, S.; Lee, H., (2018). Seasonality and climatic associations with violent and nonviolent suicide: a population-based study. Neuropsychobiology, 57(12): 32-7 (**6 Pages**).

Line, M.R.; Wolf, A.S.; Zhang, X.; Knutson, H.; Kammer, J.A.; Ellison, E.; Deroo, P., Crisp, D.; Yung, Y.L., (2013). A systematic retrieval analysis of secondary eclipse spectra. I. A comparison of atmospheric retrieval techniques. The Astrophysical J., 775(2): 137 (**22 Pages**).

Norris, M.; Lecavalier, L., (2010). Evaluating the use of exploratory factor analysis in developmental disability psychological research. J. Aut. Dev. Disorder., 40(1): 8-20 (**12 Pages**).

Oguntayo, R.; Olaseni A.O.; Kehinde, M.O.; Osinowo, H.O.; Yakubu, I.I., (2020). A Brief Propensity Index for Conduct Disorder (BPI-CD): Development, validity and reliability. J. Profess. Counsel. Psychother. Res., (3)1: 205-218 (**14 Pages**).

Opayemi, A.S.; Oguntayo R.; Popoola, A.O.; Alabi, A., (2020). Psychosocial factors as determinants of littering prevention behavior. Int. J. Hum. Capital Urban Manage., 5(1): 59-68 (**10 Pages**).

Searle, K.; Gow, K., (2010). Do concerns about climate change lead to distress? Int. J. Clim. Change Strat. Manage., (**17 Pages**).

Shrestha, N., (2021). Factor analysis as a tool for survey analysis. Am. J. Appl. Mathemat. Stat., 9(1): 4-11 (**8 pages**)

Stewart, A.E., (2021). Psychometric properties of the climate change worry scale. Int. J. Environ. Res. Pub. Health., 18: 494 (**22 Pages**).

Strona, G.; Bradshaw, C.J., (2018). Co-extinctions annihilate planetary life during extreme environmental change. Sci. Report., 8(1): 1-12 (**12 Pages**).

Worthington, R.L.; Whittaker, T.A., (2006). Scale development research: A content analysis and recommendations for best practices. Counsel. Psychol., 34(6): 806-838 (**32 Pages**).

UNICEF, (2022). Making Nigeria open defecation free by 2025: A national road map. The roadmap provides a guide towards achieving an open defecation-free country using different approaches. UNICEF Nigeria (**82 Pages**).

United Nation Climate Change. (2020). Climate Change Is an Increasing Threat to Africa. Nairobi Platform.

Van der Linden, S., (2017). Determinants and measurement of climate change risk perception, worry, and concern. The Oxford Encyclopedia of Climate Change Communication. Oxford University Press, Oxford, UK.

Van der Linden, S., (2014). On the relationship between personal experience, affect and risk. Perception: the case of climate change. Europ. J. Soc. Psych., 44(5): 430-440 (**11 pages**).

Wahab, B.; Popoola, A., (2018). Climate-Induced problems and adaptation strategies of urban farmers in Ibadan. Ethiop. J. Environ. Stud. Manage., 11(1): 31-42 (**12 pages**).

WHO, (2022). Why mental health is a priority for action on climate change. World Health Organization Geneva.

International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: http://www.ijhcum.net/

The effect of gamification on improving the performance of organizations by mediation of knowledge management

M.R. Bahadoran, H. Ghasemi*, A. Farahani, M. Hosaini

Department of Sports Management, Payame Noor University, Tehran, Iran

ARTICLE INFO

ABSTRACT

BACKGROUND AND OBJECTIVES: Knowledge is a key factor and strategic resource for gaining assets and non-functional organizational capabilities. Knowledge Management is the knowledgeable process of creating, validating, presenting, distributing and using the knowledge in an organization. Successful organizations consider human resource development as a fundamental principle. Many organization find their knowledge management process to be ignored by the employees. Gamification is a way of enhancing knowledge management with game design elements to increase employee's engagement, content creation and satisfaction.
METHODS: The research method was descriptive-survey and based on variance-based structural equation modeling. The statistical population included 384 employees of the sports organization of selected metropolises. The statistical sample size was determined by stratified random sampling method, 384 employees who answered the research tools: questionnaires of gamification, performance improvement and knowledge management. The validity of the instrument was confirmed by 5 professors of sports management and their reliability was calculated with Cronbach's alpha coefficient and combined reliability in the dimensions of the questionnaires, higher than 0.696 and 0.757, respectively. Data analysis was performed by descriptive and inferential statistics tests and sobel test in SPSS 22.0 and SmartPLS 2.0.
FINDINGS: The relationship between research constructs with their dimensions, gamification with performance improvement and knowledge management with performance improvement of positive and significant research model (T≥2.86) and research model fit (GOF = 0.589) was evaluated as strong. As a result, managers of metropolitan municipal sports organizations can play a mediating role in the relationship between gamification and performance improvement by implementing knowledge management in the organization.
CONCLUSION: According to the research results, although gamification is an effective factor in improving employee performance, but knowledge management plays a crucial role. Therefore, it is suggested that municipal sports managers pay special attention to knowledge management and gamification to improve employee performance.

NUMBER OF REFERENCES

56

NUMBER OF FIGURES

2

NUMBER OF TABLES

6

*Corresponding Author:
Email: h_ghasemi@pnu.ac.ir
Phone: +989125938839
ORCID: 0000-0001-5305-3331

INTRODUCTION

Organizations face many challenges throughout their life, and in most situations, contrary to expectations, it may be necessary to leave the organization to resolve these challenges. The sustainable use of the organization's resources is the key to the success of organizations (Riege, 2005). In addition to human, physical or financial resources, knowledge is a relatively abstract but no less important key resource than other resources of an organization. Knowledge gives the organization a decisive advantage over its competitors and ensures the flow of organizational processes now and in the future (Richter, 2009; Sawairnathan and Halimoon, 2017). With the maxim "Knowledge is power," one can express a desire for success and an edge over the competition. On the one hand, it's very important that organizations protect their knowledge well. On the other hand, they need to be able to use their knowledge freely in their internal processes (Helm *et al.*, 2007). The sustainable use of business resources is a key to corporate success. The notion of "knowledge is power" represents the struggle for success and competitive advantages in the world of business. While on the one hand, the adequate protection of the company's own knowledge is of great importance for companies, on the other hand, a free and open handling of knowledge is required in the internal process (Huerta, 2012). Organization can take advantage of the knowledge, ideas, experience and intellectual capital that their employees have as an inexhaustible capital to respond to a wide range of challenges. In order to achieve success and not fall behind competitors, organizations should use the knowledge available to their employees as one of the main factors of their success (Powell *etal.*, 2016). The lack of knowledge Management (KM) can have extensive consequences for the company's ability to function in the event of an employee's absence, such as losing the ability of organizations to perform work. In addition, the lack of knowledge can waste time and increase the cost of training and acquiring knowledge that was previously handled by colleagues. These cases make KM a competitive factor for organizations (Abila and Kantola, 2016). KM comprises the processes of creating, storing, transferring and applying knowledge within a company (Alavi *et al.*, 2001). Knowledge Management Systems (KMS) is a system for applying and using KM principles to typically enable employees and customers to create, share and find relevant information quickly (Fernandez *et al.*, 2014). A Knowledge Management System is a valuable tool for any business operating in our data-driven digital world, particularly those that sell products and provide services (Desouza *et al.*, 2005). Examples of KMS are Content Management Systems (CMS), Wikis, Blogs, Enterprise Social Networks (ESN), Groupware systems or Bug tracker (Chin *et al.*, 2015). They allow employees to create documents or other forms of knowledge artifacts (videos, instructions, tickets), to store and structure them. Creating and maintaining a shared and searchable knowledge base supports the re-usage of knowledge and, hereby, value-creation of the company. But a KMS alone cannot guarantee successful KM. The relevance of different contextual factors for Knowledge Sharing (KS) and KM such as relational models (Boer *et al.*, 2011), subjective norms (Chennamaneni *et al.*, 2012), corporate culture (Javernick-Will, 2012) but also barriers have been examined comprehensively (Hong *et al.*, 2011). Withholding of knowledge has a negative impact on KS behavior of the knowledge community as a whole like intra-organizational knowledge-hiding (Singh *et al.*, 2008) and may additionally lead to knowledge gaps. These can have far-reaching consequences for the company's operating capability in the event of an employee's absence like loss of the organizations' ability for task performance (Levy, 2011). In addition, the loss of knowledge can result in spending a lot of time and money on training and acquiring knowledge that is or has been in the hands of colleagues (Serenko *et al.*, 2016). This makes KM capability a competitive factor for organizations (Chuang, 2004). The lack of KM can have extensive consequences for the company's ability to function in the event of an employee's absence, such as losing the ability of organizations to perform work. These cases make KM a competitive factor for organizations (Cechanowicz *et al.*, 2013). Deterding *et al.* (2011) in research, lack of motivation, lack of trust, lack of promotion of positive attitudes towards KS and KMS, lack of effective processes for KMS and then, evaluating the success rate of these systems are the reasons why employees do not use the KMS. KMS usually have a proper structure and design, but nevertheless, these systems remain unused. Among the mentioned factors, lack of motivation of employees in using KMS is known as the main reason for the failure of

these systems (Deterding *et al.,* 2011). Ardichvili *et al.* (2003) provide a summary of the key issues that affect KMS used by employees:

1. Motivation to share knowledge

2. Lack of trust

3. Creating a positive attitude towards KS and KMS

4. Creating effective processes for sharing knowledge and evaluating the success of KMS

Applying information and communication technology to enrich knowledge exchanges will act as an organizational accelerator. There are many ways to increase employee motivation, improve their attitudes, and help them find meaning and enjoyment in sharing the knowledge they acquire. Video game designers use rewards, badges, medals and challenges and leaderboard (Friedrich *et al.,* 2020).

The phenomenon of creating gaming experiences is specially called gamification. To understand what gamification is, one must first understand the game. Games have existed since ancient times and are an integral part of all cultures throughout history (Friedrich *et al.,* 2020). They are one of the oldest forms of social interactions among humans and are defined as a formalized expression of play which allows practitioners to go beyond direct physical interaction and immediate imagination (Tajpour *et al.,* 2018). There are several important aspects of games beyond the immediate definition. Digital games have reached an incredible level of complexity as compared to classical games. Chess and similar games, like go board game, still retain a form of "nobility" status among games, since they are complex in the number of combinations of moves one can make on the board (Yamani, 2021; Ozcinar *et al.,* 2021). Computers being able to match the human brain in its capacity to accurately predict outcomes is a recent phenomenon. Since digital games provide an infinitely larger range of movements and freedom it also adds an additional layer of complexity, too complex some contend (Braga, 2022). For example, moving around in a game seems simple but there are many variables at play to achieve it. The feeling of games is also a high interesting area, with environmental physics and graphics and freedom of choice. However, some games that are quite far from meeting today's standard of graphical requirement, or diversity of choices, are still played by gamers

seeking compelling storylines (Schell, 2005). This shows the compelling power that the feel of a game holds over our interest and motivation, going beyond the simple visual needs of players (Ahmed, 2017).

Gamification elements:

Game elements were chosen to trigger the mentioned game mechanics.

Points and gifts can be earned by the order picker for good results in the process. Points give feedback about the rendered performance. Therefore, it is important that the user understands how points are measured. Besides feedback, points target the mechanics competition and result transparency (DaSilva Alcantara *et al.,* 2022). Badges are given to the staff member for outstanding performance and the fulfillment of certain goals. They trigger the game mechanics' concrete objectives, competition, and result transparency. Badges can also foster collaboration as order pickers with the same badges could feel a connection between each other. To support the game mechanics competition, it was chosen to use a high score list. As mentioned before, however, the high score list does not display the ranked results of each individual order picker, but the team's outcome. Hence, the game element can trigger collaboration as well. The game element, level, was chosen to target the mechanics, concrete objectives and result transparency. The level displays the result of the order picker in the categories of executed picks, required time per order, and errors per order. Thus, the staff member gets feedback about his performance and his improvement in the particular categories (Ikhide *et al.,* 2022). Another element that was chosen is a meaningful stories. The other elements are combined into a story that has been told during the use of the gamification application. As there are decisions to make within that story, it supports the game mechanic, freedom of choice (Suh *et al.,* 2022). Challenges and Contests can also be included in gamified KMS. These tasks are typically limited in time: users have a pre-set timeframe to fulfill them – two hours, a day or a week (Trees, 2015). Challenges are tasks that need to be fulfilled in the time given in order to receive a reward – a badge or a pre-defined amount of points. In contests, users compete for the best performance within a given timeframe. Challenges and contests put users under time pressure, which according to

Andrews and Farris (1972) increases several aspects of performance including usefulness, innovation and productivity. Turning a task into a time-constrained challenge renders it to be of higher priority. Users who decide to pursue the challenge allocate more resources to task-relevant activities and avoid distractions more (Baumann, 1998). Setting up challenges is not optimal for all kinds of tasks though. Time pressure increases performance, but at the same diminishes precision and output quality (Moore and Tenney, 2012). Users under time pressure rely more heavily on various heuristics and their focus scope is narrowed. Thus time-limited challenges and contests are not suitable for creative tasks or those that require great precision and analytical approach. On the other hand, they may prove beneficial for simple and repetitive tasks, such as "In the next hour, share your latest KMS contribution with 5 of your colleagues who might benefit from it". The last common gamification aspect is the use of achievements. Ironically, achievements actually came out of the gamification of playing games. Meta-goals that players could accomplish when playing a game or set of games within an established system. For example, Xbox achievements earned from playing various Xbox games all add together to give a player their gamer score, which is used in the community as an indication of overall gaming prowess (Werbach, 2014). The aim of gamification is to support and motivate the users to perform tasks promoted by the services (Caponetto, et al., 2014). This goal is pursued by providing affordances for gameful experiences and thus making the target activities more engaging. Gameful experiences Similar to those created by games, such as flow, a feeling of mastery, and intrinsic motivations (Ryan et al., 2006), have been at the core of the discussion of gamification as a means to motivate behavioral and psychological outcomes(Huotari et al., 2012). For instance, in the case of gamified exercise applications, the services at their core aim at increasing exercise, thus serving a utilitarian purpose. In addition to the main service, gamification features are implemented by adding a hedonic element to the activity, with the aim of motivating and supporting the user to increase exercise: for example, providing feedback, achievable goals, progress, and encouragement. The engaging elements of gameplay are employed to create more enjoyable exercise experiences. Werbach (2014),

define gamification as: the use of game design elements in non-game contexts, which is one of the most common definitions that is used in the literature. The term gamification is often used to cover other terms like serious games, games with a purpose or game-based learning (Krath, et al., 2021), these concepts relate to game-based applications and their definitions are not mutually exclusive, but they serve different purposes that distinguish them from each other. With the aim of enhancing the motivation of recipients, gamification has been applied to various contexts such as education and learning or business (Trees et al., 2015). Also for the context of KM, benefits of gamification have been addressed but predominantly not in a holistic way (Shpakova et al., 2019) but limited to selective measures such as points for content creation (Swacha et al., 2021). Paying attention to employees and above all their job performance as the biggest and most important asset of the organization is a phenomenon that has grown a lot in the last few decades. Many developments in recent years, in the form of decentralization of management systems, reduction of organizational classes, employee participation in the decision-making process, and things like that, are entirely due to the fact that the attitude of organizations towards the workforce has changed, and the organization's employees have a new definition (Šajeva, 2014). Nowadays, industrial, commercial and even service organizations have turned more than before to increase their level of productivity by increasing the expertise, satisfaction and attachment of their human resources and related productivity with improving their job performance (Endramanto et al., 2021; Mirzapour et al., 2019). This research is not commissioned by specific organization, which would normally narrow down the scope. But at the same time the performance improvements and KM in municipal metropolitans is initially very similar, raising the same kind of problems. This allows to make the final result of research concrete enough, so that it could be easily implemented in municipal metropolitans with minor or no changes. Even though gamification can be used in various KM functions, the research concentrates specifically on improvements performance of employee. This will help to narrow the scope and concentrate on explicit functions of gamification that can be helpful especially in this area of KM. The aim of this study was to identify the

effect of gamification on improving the performance of employees of organization of metropolitan cities of Iran through the mediation of knowledge management. The current study have been carried out in Tehran in 2021.

MATERIALS AND METHODS

Survey design and data collection

The present research, in terms of purpose, method of data collection, and, type, is applied, survey, and causal-descriptive, respectively and is specifically based on the structural equation modeling. The statistical population of the research was made up of employee of sport organization of Tehran, Tabriz, Mashhad and Shiraz municipal sports organization who were 126000 people according to the obtained information from the human resource departments. 384 employees completed the researcher-developed questionnaire. The first section of the questionnaire contains demographic variables and the second part, contains questions related to research variables Questionnaires of gamification, performance improvement and knowledge management. The validity of the instrument was confirmed by 5 professors of sports management and their reliability was calculated with Cronbach's alpha coefficient

and combined reliability in the dimensions of the questionnaires. The survey for the given research was designed with the online surveys and reporting tool. The survey was provided in Farsi language. It was distributed as a link through social media all data collected remained confidential. Before sharing the survey link, the questions were tested on 60 volunteers and the feedback was collected and slight changes on the order of questions and professional terms used were made. 419 people opened the survey, 405 started responding and finally 384 fully submitted their responses. Data analysis were performed by descriptive and inferential statistics tests and Sobel test in SPSS 22.0 and SmartPLS 2.0 software. Table 1 shows that Cronbach's Alpha Coefficient and the compound reliability of all variables are than the least acceptable number.

Table2 shows the dimensions of variables of the questionnaire.

RESULTS AND DISCUSSION

Descriptive statistics and factor analysis for variables entering the analysis

Demographic data showed 44% of the respondents were females and 56% were males. Also, the highest frequency of age was between 31

Table 1: Cronbach's alpha, combined reliability of variables

Variables	Questions	Cronbach's alpha	Combined reliability
Gamification	26	0.863	0.884
Improvement performance	23	0.754	0.806
Knowledge management	25	0.954	0.959

Table 2: Cronbach's alpha, combined reliability of variable

Dimensions	Variables	Questions	Cronbach's alpha	Combined reliability
Gamification	Point and gift	7	0.765	0.816
	Challenges	4	0.714	0.776
	Levels	2	0.706	0.802
	Budge	2	0.715	0.836
	Meaningful stories	4	0.758	0.846
	Achievements	7	0.736	0.815
Improvement performance	Efficiency	9	0.693	0.757
	Effectiveness	6	0.702	0.796
	Productivity	3	0.723	0.804
	Development	5	0.704	0.765
Knowledge management	Knowledge creation	7	0.820	0.767
	knowledge Shearing	6	0.850	0.890
	knowledge replication	5	0.833	0.883
	Knowledge storage and organization	7	0.898	0.992

and 41 years with 51% and highest frequency of experiences was between 5 to 10 years with 51%. Finally, in terms of education level, the highest number belonged to bachelor's degree 40%, and the lowest number belonged to doctoral education 20%. The demographic data are presented in Table 3.

Data Analysis

Exploratory Factor Analysis (EFA) showed 3 constructs: the results of the Kaiser-Mayer-Olkin (KMO) test and the significance of Bartlett's test (P < 0.05) and (KMO < 0.596) sample size and data are suitable for factor analysis. Also, the results of Bartlett's test were also indicative· There is a definite correlation between the items of each structure. Then, due to the standardization of these questionnaires and experts' consensus about the research items, Confirmatory Factor Analysis (CFA) was used and measures (items) were observed in all three structures of the research with factor loads higher than 0.5. Fitting index models: measurement models with (index reliability, convergent validity and discriminant validity) and a structural model that includes T value, coefficient of determination (R-squared values), and the effect size measure (F^2) was used. Evaluation of structural model fit: After assessing the validity and reliability of the measurement model, the structural model was examined.

T-values: The simplest criterion for measuring the relationship between variables in the structural part of the model is the significance of T-values. If the value of these numbers exceeds 1.96 and 2.58, it indicates the correctness of the relationship between the variables and, as a result, the confirmation of the research (the relationship between categories and structures) at the confidence level of 95 and 99

percent. In the present study, according to Table 4, it was (T≥2.860). Effect size criteria (F^2): Cohen (1988) introduced values of 0.02, 0.15 and 0.35 or more as indicators of small, medium and large effect size of one structure on another structure. According to Table 4, the results showed that effect size value (F2<0.293<9.264) was higher than middle and larger.

Results

The results of Table 4 showed that all the paths and relationships between the constructs whose significance coefficients of T values are greater than 2.58 are significant at the 99% confidence level. F^2 in the range of (0.293-9.264) have a more than middle and large effect on their structure.

Regarding the coefficient of determination (R^2), a measure of the model's predictive accuracy, squared correlation between a specific endogenous construct's actual and predicted values is calculated. R^2, as the most commonly used measure of structural model, represents the exogenous latent variables' combined effects on the endogenous latent variable. Its value ranges from 0 to 1, however, the values of 0.75, 0.50, or 0.25 for endogenous latent variables can be respectively described as substantial, moderate, or weak (Hair, *et al.*, 2014). In the current research, it was (0.403< R^2< 0.903), which was clear in Fig. 1. Researchers also examine Stone-Geisser's Q^2 value (Geisser, 1974; Stone, 1974), besides the coefficient of determination, to measure the model's predictive relevance. This is done by resampling procedure, also known as bootstrapping, and is applied just for reflective models not he formative ones. In the structural model, Q^2 values more than zero prove the path model's predictive relevance for a certain reflective endogenous latent variable. As provided in

Table3: The demographic data

Variables	Value	Frequency	Percentage
Gender	male	216	56%
	Female	164	44%
Age	20 to 30	100	26%
	31 to 41	196	51%
	More than 42	88	23%
Experience	Under 5	42	11%
	5 to 10	196	51%
	More than 10 year	146	38%
Education	Bachelor degree	156	40%
	Master degree	151	39%
	Doctorate degree	77	20%

Table 4: Result from model directions by structural equations

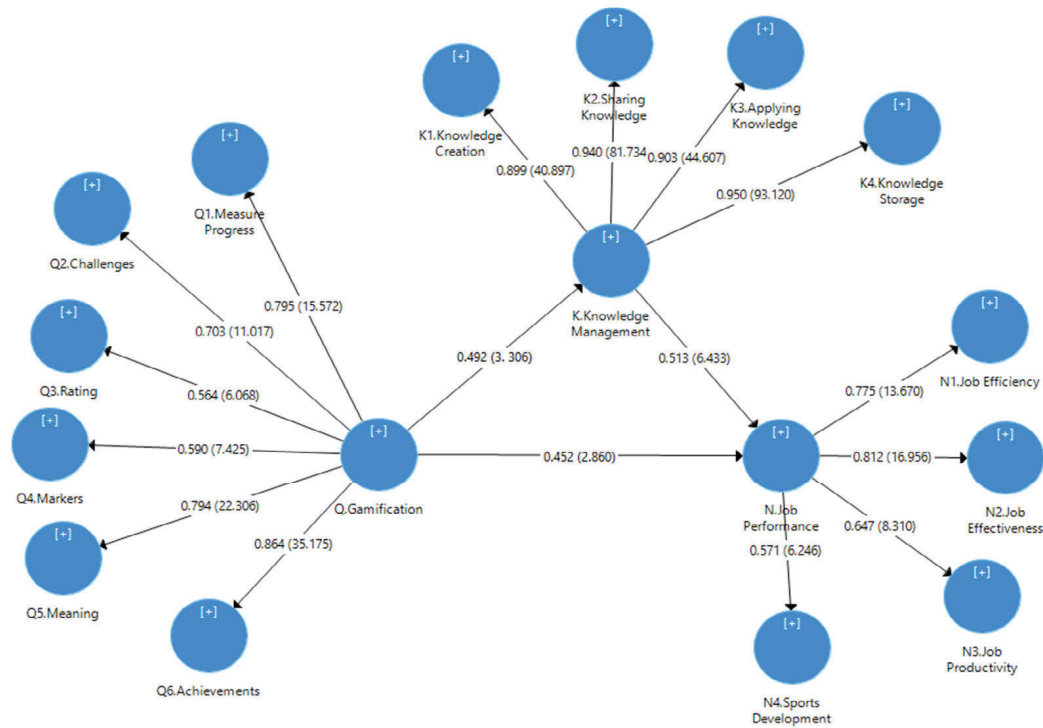| Dimensions	Variables	T-value	P value	Path coefficient	F²	Result
Gamification	Point and gift	7	0.765	0.795	0.816	Confirmed
	Challenges	4	0.714	0.703	0.776	Confirmed
	Levels	2	0.706	0.564	0.802	
	Budge	2	0.715	0.590	0.836	Confirmed
	Meaningful stories	4	0.758	0.794	0.846	Confirmed
	Achievements	7	0.736	0.864	0.815	Confirmed
Improvement performance	Efficiency	9	0.693	0.775	0.757	Confirmed
	Effectiveness	6	0.702	0.812	0.796	Confirmed
	Productivity	3	0.723	0.647	0.804	Confirmed
	Development	5	0.704	0.571	0.765	Confirmed
Knowledge management	Knowledge creation	7	0.820	0.889	0.767	Confirmed
	knowledge Shearing	6	0.850	0.940	0.890	Confirmed
	knowledge replication	5	0.833	0.930	0.883	Confirmed
	Knowledge storage and organization	7	0.898	0.950	0.992	Confirmed
Gamification --> KM		3.306	0.010	0.492	0.293	Confirmed
KM --> IP		6.433	0.0001	0.513	0.404	Confirmed
Gamification --> IP		2.860	0.019	0.452	0.297	Confirmed

Fig. 1: T-values and path coefficients of latent variables

Table 5: A Global Goodness-of-Fit Index for Structural Equation Modeling

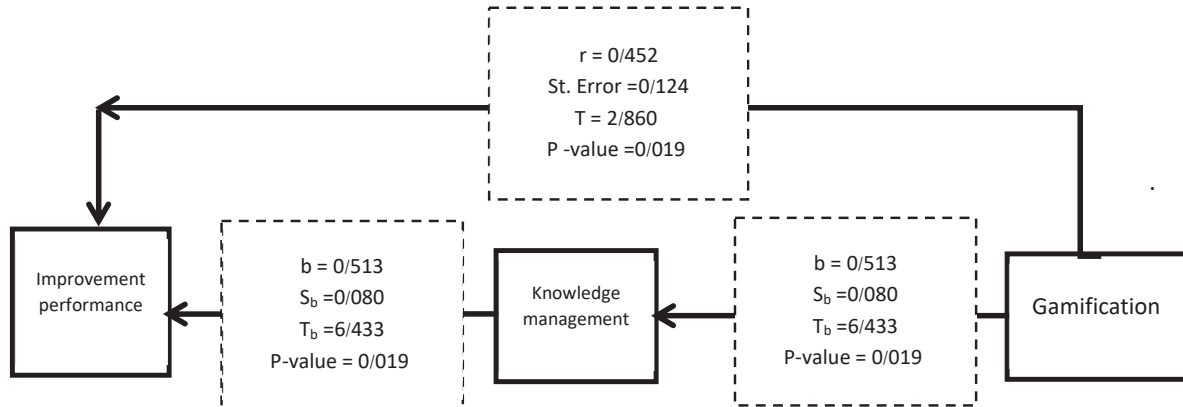| Dimensions	Average Commonality	R^2	GOF	Quality
Gamification	0.781	-	-	-
Improvement performance	0.649	0.403	0.511	Better fit
Knowledge management	0.919	0483	0.667	Better fit
Overall of models	0.783	0.443	0.589	Better fit

Fig. 2: Mediating Effects through Sobel Test.

Fig. 1 all the latent variables exhibit a significant level of predictive relevance ($0.291 < Q^2 < 0.647$).

The next statistical procedure which has been administered in the study relates to GOF. The calculated index of GOF for the current study in Table 5 is more than 0.36, representing a good criterion to confirm the model (Wetzels, *et al*. 2009). Thus, the estimated model has demonstrated adequate fit to the data, as indicated by GOF index.

To measure the significance of mediating variable knowledge management, the study conducted Sobel test. The Sobel test is used to measure the significance of a mediation effect. It is a specialized T-test providing a method to determine the significance of mediation effect after the reduction in the effect of the independent variable in the model (Sobel, 1982). Results were summarized in Fig. 2 showed that the value of the Sobel test statistic is greater than 1.96 in the positive direction. Therefore, the mediating effect of knowledge management can be confirmed at the 95% significance level. Considering the error level of the value ($Z \geq 0.05$), then the observed indirect effect of the mediating variable (KM) effect test is significant and confirms it.

Discussion

Due to the area of gamification being new as a phenomenon although with wide-spread recognition as a viable tool for various efficiency gains, there is not a lot of scientific data on the subject. Most of the research done is on a small scale and done in homogenous environments, which limits the scientific viability. What has been proven is the possibility of using gamification in various situations with a probable positive outcome. Though the research is not conclusive in any way, it shows a high degree of promise, but it needs further study in order to be an empirically proven tool for useful organizational improvement. The results in prioritizing the dimensions of the questionnaires with the confirmatory factor analysis test showed that: from the point of view of the respondents in the structure of gamification dimensions of municipality's: point and gift, challenges, levels, budge, meaningful stories, achievements, in the structure of improving employees' job performance dimensions efficiency, effectiveness, productivity, development and in the KM dimensions knowledge creation, knowledge shearing, knowledge replication

knowledge storage and organization respectively, are in priority and in a direct and meaningful relationship. also, the structure of gamification with the structure of improving the job performance of employees, the structure of gamification with the structure of KM and the structure of KM with the structure of improving the job performance of employees have a direct and positive relationship, moreover the variable of KM as a mediator in the relationship between the independent variable of gamification and the dependent variable Improving the job performance of employees plays a role. According to research findings, gamification as a new approach in organizational behavior issues can play a constructive and improving role in the direction of organizational KM processes among employees. This approach can improve individual and collective mechanisms to store, share, create and use knowledge by creating and strengthening motivation among employees through game mechanisms and dynamics (Krath, *et al.*, 2021). In explaining the results of the research on the structure of gamification in the organization of municipalities and its relationship with each of the dimensions, it can be said: progress is measured by scoring and giving tangible or intangible rewards by encouraging and persuading them to improve their job performance and duties. The challenges of gamification in the missions of the municipal organization are effective in increasing the productivity and efficiency of employees, as well as the mediating role of KM in providing innovation, creativity and attractiveness in the activities and programs provided by the municipal organization, for citizens. Leveling is effective in promoting the performance of the employees of the municipal sports organization and encouraging them to achieve the goals and strategies set by the organization (Huotari *et al.*, 2012, Levy, 2011). The analysis showed, that gamification indeed provides various possibilities to increase the motivation of employees for KM activities. But to unfold its potential a gamified KMS requires for a fitting environment. In other words, gamification will be successful in the long term only in combination with an appropriate corporate culture and an organizational climate that promote an open exchange of knowledge and rewards KM activities. A corporate culture, which is characterized by open exchange and fair feedback has a positive influence on the attitude of the employees towards the division

of knowledge exchange (Shpakova *et al.*, 2019).

CONCLUSION

This paper shows evidence that gamification, through points, badges, challenges, achievements and other game elements provides employees with the platform to compete in, enhances their confidence and assist to satisfy certain higher needs from Maslow's pyramid. In the end, it helps to fulfill the main goal, which is to increase employees' performance improvement with the KM when it comes to contributing valuable content, organizing and improving it, or using it in a meaningful way. All these could be achieved also with a financial reward system, but the advantage of gamification is the relatively low costs: although points and badges have to be earned by the employees, the company pays nothing to issue them. The role of gamification is not just about bringing more fun into work life and making unpleasant experiences feel good. It is not even only about raising the motivation of employees. Gamification can significantly increase the efficiency of many business processes, including performance appraisal. It is based on psychology and human instincts, like desire for competition, accomplishment, and status. It is important to remember that any form of performance appraisal, whether we speak about traditional appraisals or gamified ones, is only as good as the whole performance management system that it is operating within. Even the most up-to-date and efficient in sport organizations. This paper clarified what gamification is, what elements it uses and how it can support companies fulfill their KM oriented goals and performance improvement. Closer attention was paid to various psychological mechanisms and their role in gamification effectiveness. Additionally, demographic and cultural factors that can be of influence in gamification adoption and use were discussed.

Suggestions

According to the obtained results, the subsequent suggestions are suggested to the metropolitan municipality of organizational managers:

1. Use the research model that has a suitable fit to achieve their effective goals for performance improvement of employees;

2. By setting up an idea management system such as a suggestion system, a think tank, an advisory

council in the organization and using the experiences and knowledge of their employees, they should take advantage of the elements of gamification and aspects of knowledge management in order to improve the job performance of their employees;

3. Conducting this research in other organizations comparing the results obtained with the present study.

Limitations and future research

The present study is limited by the fact that it was carried out in a cultural organization. As a suggestion, more organizations can be involved to determine what other factors (for example, organizational culture) can affect the overall results. It is suggested to carry out more research that shows the impact of different motivational drivers on job satisfaction to finally investigate the relationship between job satisfaction and work commitment. Another interesting direction for future studies is to investigate the understanding of the role of different elements of game design and how and how much these elements affect long-term work commitment, motivation and job satisfaction, either negatively or positively.

AUTHOR CONTRIBUTIONS

M.R. Bahadoran performed the literature review, questionnaire design, analyzed and interpreted the data, prepared the manuscript text, and manuscript edition. H. Ghasemi, A. Farahani and M. Hosaini supervised and performed the corrections and reviewed the article and controlled the results of the research

ACKNOWLEDGEMENT

The authors would like to thank the administrators and experts working in the Municipality of Tehran, Mashhad, Tabriz and Shiraz who sincerely helped in conducting and gathering information related to research questionnaires

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

OPEN ACCESS

PUBLISHER'S NOTE

IJHCUM Publisher remains neutral with regard to jurisdictional claims in published maps and institutional afflictions.

ABBREVIATIONS (NOMENCLATURE)

CFA	Confirmatory Factor Analysis
CMS	Content Management System
EFA	Exploratory Factor Analysis
ESN	Enterprise Social Networks
GOF	Goodness of Fit Criterion
KM	Knowledge Management
KMO	Kaiser-Mayer-Olkin
KMS	Knowledge Management System
KS	Knowledge Sharing

REFERENCES

Abila, B.; Kantola, J., (2013). Municipal solid waste management problems in Nigeria: Evolving knowledge management solution. Int. J. Environ. Eng., 303-308 (**6 pages**).

Ahmed, A.; Sutton, M.J., (2017). Gamification, serious games, simulations, and immersive learning environments in knowledge management initiative. World Rev. Sci. Technol. Sustain. Dev., 35-49 (**15 pages**).

Alavi, M.; Leidner, D.E., (2001). Knowledge management and knowledge management systems: J. Foraminiferal Res., 25(1): 107-136 (**30 pages**).

Andrews, F.M.; Farris, G.F., (1972). Time pressure and performance of scientists and engineers: A five-year panel study. J. Organ. Behav., 8(2): 185-200 (**6 pages**).

Ardichvili, A.; Page, V.; Wentling, T., (2003). Motivation and barriers to participation in virtual knowledge-sharing communities of practice. J. Knowl. Manage., 7(1): 64–77 (**14 pages**).

Baumann, P.; West, S.C., (1998). Role of the human RAD51 protein in homologous recombination and double-stranded-break repair. Trends Biochem., Sci., 23(7): 247-251 (**5 pages**).

Braga, P.H.C., (2022). Game concepts in learning and teaching process. Res. Anth. Dev. Gamification Game-Based Learn., 21-54 (**34 pages**).

Becerra-Fernandez, I; Sabherwal, R., (2014). Knowledge management: Systems and processes. Routledge.

Bock, G.W; Zmud, R.W.; Kim, Y.G.; Lee, J.N., (2005). Behavioral intention formation in knowledge sharing: Examining the roles of extrinsic motivators, social-psychological forces, and organizational climate. MIS Q., 87-111 (**25 pages**).

Boer, N.I.; Berends, H.; Van Baalen, P., (2011). Relational models for knowledge sharing behavior. Eur. Manage. J., 29(2): 85-97 (**13 pages**).

Caponetto, I.; Earp, J.; Ott, M., (2014). Gamification and education: A literature review. In European Conference on Games Based Learning. Academic Conferences International Limited.

Cechanowicz, J.; Gutwin, C.; Brownell, B.; Goodfellow, L., (2013). Effects of gamification on participation and data quality in a real-world market research domain. In Proceedings of the first international conference on gameful design, research, and applications. 58-65 (**8 pages**).

Chennamaneni, A.; Teng, J.T.; Raja, M.K., (2012). A unified model of knowledge sharing behaviors: theoretical development and empirical test. Behav. Inf. Technol. BE., 31(11): 1097-1115 (**19 pages**).

Chin, C.P.Y.; Evans, N.; Choo, K.K.R., (2015). Exploring factors influencing the use of enterprise social networks in multinational professional service firms. J. Organ. Comput. Electron. 25(3): 289-15 (**27 pages**).Cohen, J., (1988). Set correlation and contingency tables. Appl. Psychol. Meas., 425-434 **(10 pages).**

Chuang, S.H., (2004). A resource-based perspective on knowledge management capability and competitive advantage: an empirical investigation. Expert Syst. Appl., 27(3): 459-465 (**7 pages**).

Da Silva Alcantara.; A., Bezerra Oliveira, S. R.; Monteiro Soares, E.; Ferreira Costa, I. E.; Viégas Junior, R.; Amoras Rodrigues, E.; and Monteiro Soares, E., (2022). An Application of a Gamified Approach to Learning of Knowledge Management: Evaluation of an Experience Report. Int. J. Emerg. Technol. Learn., 17(19).

Desouza, K.C.; Awazu, Y., (2005). Maintaining knowledge management systems: A strategic imperative. J. Assoc. Inf. Sci., 56(7): 765-768 (**4 pages**).

Deterding, S.; Dixon, D.; Khaled, R.; and Nacke, L., (2011). From game design elements to gamefulness: defining" gamification". In Proceedings of the 15th international academic MindTrek conference: Envisioning future media environments. 9-15 (**6 pages**).

Endramanto, V.; Telaumbanua, R.A.; Suparman, I.; Wang, G.; and Kaburuan, E.R., (2021). Applying the Gamification in Knowledge Management System. Int J., 10(5): 12-35(**34 pages).**

Fornell, C.; Larcker, D.F., (1981). Structural equation models with unobservable variables and measurement error: Algebra and statistics.

Friedrich, J.; Becker, M.; Kramer, F.; Wirth, M.; Schneider, M., (2020). Incentive design and gamification for knowledge management. J. Bus. Res., 106(4): 341-352 (**12 pages**).

Geisser, S., (1974). A predictive approach to the random effect model. Biometrika, 61(1): 101-107 (**7 pages**).

Hair Jr, J.F.; Sarstedt, M.; Hopkins, L.; Kuppelwieser, V.G., (2014). Partial least squares structural equation modeling (PLS-SEM): An emerging tool in business research. Eur. Bus. Rev., 107-122 (**16 pages**).

Helm, R.; Meckl, R.; Sodeik, N., (2007). Systematisierung der Erfolgsfaktoren von Wissensmanagement auf Basis der bisherigen empirischen Forschung. J. Bus. Econ., 77(2): 211-241 (**31 pages**).

Hong, D.; Suh, E.; and Koo, C., (2011). Developing strategies for overcoming barriers to knowledge sharing based on conversational knowledge management: A case study of a financial company. Expert Syst. Appl., 38(12): 14417-14427 **(11 pages).**

Huerta, E.; Salter, S.B.; Lewis, P.A.; Yeow, P., (2012). Motivating employees to share their failures in knowledge management systems: Anonymity and culture. J. Inf. Syst., 26(2): 93-117 **(25 pages).**

Huotari, K.; and Hamari, J., (2012). Defining gamification: a service marketing perspective. In Proceeding of the 16th international academic MindTrek conference 17-22 **(6 pages).**

Ikhide, J.E.; Timur, A.T.; and Ogunmokun, O.A., (2022). The potential and constraint of work gamification for employees' creative performance. Serv. Ind. J., 42(5-6): 360-382 (**23 pages**).

Javernick-Will, A., (2012). Motivating knowledge sharing in engineering and construction organizations: Power of social motivations. J. Manage. Eng., 28(2): 193-202 (**10 pages**).

Kline, R.B., (2015). Principles and practice of structural equation modeling. Guilford publications.

Krath, J.; Schürmann, L.; Von Korflesch, H.F., (2021). Revealing the theoretical basis of gamification: A systematic review and analysis of theory in research on gamification, serious games and game-based learning. Comput. Hum. Behav., 125(4): 106-120 (**15 pages**).

Levy, M., (2011). Knowledge retention: minimizing organizational business loss. J. Knowl. Manage.,

15: 582-600 (**19 pages**).

Mirzapour, M.; Toutian, S.S.; Mehrara, A.; Khorrampour, S., (2019). The strategic role of human resource management in crisis management considering the mediating role of organizational culture. Int. J. Hum. Capital Urban Manage., 4(1): 43-50 **(8 pages).**

Moore, D.A.; Tenney, E.R., (2012). Time pressure, performance, and productivity. In looking back, moving forward: Rev. Group Team-based Res.., 15: 305-326 (**22 pages**).

Orsini, L., (2010). History of Social Games.

Ozcinar, Z.; Orekhovskaya, N.; Svintsova, M.; Panov, E.; Zamaraeva, E.; Khuziakhmetov, A., (2021). University Students' Views on the Application of Gamification in Distance Education. Int. J. Emerg. Technol. Learn., 16(19): 4-15 **(12 pages).**

Powell, T.H.; Kouropalatis, Y.; Morgan, R.E.; and Karhu, P., (2016). Mapping knowledge and innovation research themes: Using bibliometric for classification, evolution, proliferation and determinism. Int. J. Entrep. Innov., 20(3-4): 174-199 (**26**

pages).

Ryan, R.M.; Rigby, C.S.; Przybylski, A., (2006). The motivational pull of video games: A self-determination theory approach. Motiv Emot., 30(4): 344-360 (**17 pages**).

Richter, A.; Derballa, V., (2009). Barriers to successful knowledge management. Enc. Inf. Sci.Technol. 2nd Edit., 315-321 (**7 pages**).

Riege, A., (2005). Three-dozen knowledge-sharing barriers managers must consider. J. Knowl. Manage., 144-165 (**22 pages**).

Ringle, C.M.; Sarstedt, M., (2016). Gain more insight from your PLS-SEM results: The importance-performance map analysis. Ind. Manag., Data Syst.

Shpakova, A.; Dörfler, V.; MacBryde, J., (2019). Gamifying innovation and innovating through gamification. Subsistence Entrep., 183-194 (**12 pages**).

Singh, M.D.; Kant, R., (2008). Knowledge management barriers: An interpretive structural modeling approachInt. J. Manag. Sci., 3(2): 141-150 **(10 pages).**

Serenko, A.; Bontis, N., (2016). Understanding counterproductive knowledge behavior: antecedents and consequences of intra-organizational knowledge hiding. J. Knowl. Manag.,

Šajeva, S., (2014). Encouraging knowledge sharing among employees: how reward matters. Procedia Soc. Behav. Sci., 156: 130-134 (**5 pages**).

Sawairnathan, M.; Halimoon, N., (2017). Assessment of the local communities' knowledge on mangrove ecology. Int. J. Hum. Capital Urban Manage, 2(2): 125-138 **(14 pages).**

Sobel, M.E., (1982). Asymptotic confidence intervals for indirect effects in structural equation models. Sociol. Methodol., 13: 290-312 **(23 pages**).

Stone, M., (1974). Cross-validation and multinomial prediction. Biometrika, 61(3): 509-515 (**7 pages**).

Suh, A.; Cheung, C.M.; and Lin, Y., (2022). Meaningful engagement with a gamified knowledge management system: theoretical conceptualization and empirical validation. Ind. Manag. Data Syst.

Swacha, J., (2021). State of research on gamification in education: A bibliometric survey. J. Educ. Sci., 11(2): 69- 89 (**21 pages**).

Trees, L., (2015). Encouraging millennials to collaborate and learn on the job. Strategic HR Review.

Tajpour, M.; Moradi, F.; Jalali, S. E., (2018). Studying the influence of emotional intelligence on the organizational innovation. Int.J. Hum. Cap. Urban Manage., 3(1): 45-52 (**8 pages**).

Werbach, K., (2014). Defining gamification: A process approach. International conference on persuasive technology. 266-272 (**7 pages**).

Wetzels, M.; Odekerken-Schröder, G.; Van Oppen, C., (2009). Using PLS path modeling for assessing hierarchical construct models: Guidelines and empirical illustration. MIS Q, 177-195 (**19 pages**).

Yamani, H. A., (2021). A Conceptual Framework for Integrating Gamification in eLearning Systems Based on Instructional Design Model. Int. J. Emerg. Technol. Learn., 16(4): 14-33 **(10 pages).**

International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: http://www.ijhcum.net/

ORIGINAL RESEARCH PAPER

An assessment of redeveloped public spaces in a city: Critical evaluation of parks and playgrounds

S. Sultana, A.M. Khan, A. Rahman*

Department of Urban and Regional Planning, Jahangirnagar University, Dhaka, Bangladesh

ABSTRACT

BACKGROUND AND OBJECTIVES: Though Public Spaces are the images of the social status of the community, but in case of Dhaka City (Bangladesh), there are intensely shortages of public open spaces. Recently a number of parks and playgrounds in Dhaka South City Corporation area have been redeveloped under a government project. So, this research has highlighted on the state of usefulness of these redeveloped public spaces of Dhaka South City Corporation.
METHODS: Amongst many types of public spaces, only parks and playgrounds had been counted for this research purpose. A mixed method approach had been opted as it includes both qualitative and quantitative data for the assessments. Qualitative assessment with pictures of structures in public spaces had been conducted and maps of the area had been produced using ArcGIS 10.5 software. Also, statistical analysis like descriptive analysis, chi-square test, multiple regression model etc. had been conducted using Statistical Package for Social Sciences and Microsoft Excel software which covered quantitative assessment.
FINDINGS: This study found that though the visitors had been increased after redevelopment, but the quality of infrastructures and accessibility were not up to the mark even after redevelopment. These public spaces were abandoned or vacant land formerly. But these places were refurnished with new structures. But there was cave-looked boundary in every public space and the area had been restricted and locked up by the authorities. Elderly people, less-educated people, high income group people, new inhabitants of that area visited most. And also, in every demographic group, visitors have been increased after redevelopments. The selected public spaces only serve 6.44% of the Dhaka South City Corporation area in terms of walking distance (400-meter). 'Unclean toilet' is the major problem and almost around 65% to 85% respondents had complaints on it in most of the public spaces. Besides, Women, new inhabitants of that area, visitors who faced problems in accessibility and who can't feel safe and secure in the public spaces have less satisfaction with these public spaces.
CONCLUSION: This research has addressed the efficiency of redeveloped public spaces in Dhaka South City Corporation area. A strong community involvement in public space is beneficial to improve wellbeing. So, it was an important affair to investigate the association between the public involvement in public space and the quality of public space. The research findings may help urban planners and policy makers in the development sectors of Bangladesh.

NUMBER OF REFERENCES

35

NUMBER OF FIGURES

6

NUMBER OF TABLES

6

*Corresponding Author:
Email: ashiqurrahman2140@gmail.com
Phone: +880-1677272020
ORCID: 0000-0002-6400-8891

Note: Discussion period for this manuscript open until April 1, 2023 on IJHCUM website at the "Show Article.

INTRODUCTION

In urban areas, public spaces are the main manmade places which designed to stimulate various physical activities and significant functions that effectively yield benefits and enhance the quality of life in cities (Chen *et al.*, 2016). There is a significant correlation between public space and urban life (Dhaliwal, 2012). Peoples are naturally social animals and public spaces are the stages to promote social and communal interaction and the representatives of culture and society (Carmona *et al.*, 2010). Urban public spaces offer people to gratify with an extensive latitude and fulfil their requirements of relaxation, comfort and socialization in a greater degree (Bierwiaczonek, 2018). Public spaces help to create social interaction, civic identity and culture phenomena by providing a place for social assignation (El-Husseiny and Kesseiba, 2012). By ensuring a common space and facilitating the procedure of social exchanges among neighbors, public space becomes a significant social arena (Abu-Ghazzeh, 1996). Sociability, uses and activities, comfort and image and access and linkages are the important components of public spaces which can ensure a sustainable and better public place (Sulaiman *et al.*, 2016). Usually, public spaces are considered as open spaces which include the streets, parks, playgrounds and amusement places, squares and other freely occupied and managed outside spaces in a city (Tonnelat, 2008). Actually, public space is the symbol of urban territorial recognition for the localities which can be considered or compared to a drawing room of the city (Maahsen-Milan and Oliva, 2014). Parks, playgrounds, squares, footways, shopping malls, community centers and schoolyards etc. are considered as public spaces (Carr *et al.*, 1992). Urban parks and playgrounds can contribute to social prosperity by giving urban inhabitants a place to recline, socialize and be in coalescence with nature (Maller *et al.*, 2009). According to Nilufar (1999), public spaces can be classified into after mentioned four classes- urban parks, urban recreational areas, urban development open spaces and functional open spaces. Still, different types of open spaces require to be designed and developed with suitable size and with optimum location as indicating in Table 1.

Historically in Dhaka city, public spaces were considered as the main focal points of the city. There happened a rustical paradigm changes in Dhaka's public spaces and urban life in cope up with the transformation of the various socio-political period (Rahman *et al.*, 2014). Recently Dhaka South City Corporation (DSCC) have worked on the improvement of parks and playgrounds of its jurisdiction area where includes the development of 19 parks and 12 playgrounds under the project titled 'JOL SOBUJE DHAKA (In English- Dhaka City with Waterbodies and Greeneries) (Siddiqui, 2019). Redevelopment is any renewed construction on an area that has pre-subsisting uses which conveys a process of land development to improve the physical, economic and social framework of urban space (Caves, 2004). Cities that have well-developed street areas, urban greenery, parks, playgrounds and recreation facilities give an improved and better quality of life for their citizens (Andersson, 2016). To make successful cities, redevelopment and modernization of public spaces are important keys (UN-Habitat, 2015). The importance of emphasizing the urban space as a meeting place improvises the function of supporting social cohesion and an open democratic society (Gehl, 2010). Urban redevelopment program can be helpful to ensure more functional urban public spaces and it positively affects not only the physical and environmental territories but also the socio-economic and cultural development of a city (Ramlee *et al.*, 2015). Almost half of the world population lives in urban areas now and it is expected that it

Table 1: Planning standard for urban recreational open spaces in Dhaka (RAJUK, 2016)

Hierarchy of Open Space	Facility	Size [Minimum]	Distance From Home [Optimum]
Metropolitan Park/Playground	General woodlands with facilities	150 + acres	2-3 miles
District Park/Playground	Children's play, court games, some special facilities	50-75 acres	3/4 mile
Local Park/Playground	Children's play areas, informal games, quite areas	5-10 acres	1/4 mile
Mini Park/Playground	Sitting area, flower garden, children's play areas	under 2 acres	less than 1/4 mile

will be risen to two-third of the population (United Nations, 2018). According to the Population and Housing Census 2022, Dhaka South City Corporation area has the second highest population with around 4.3 million people among all the 12 city corporations of Bangladesh and has the highest density of Bangladesh with 39,353 people which is 35 times higher than the national overall density (Bangladesh Bureau of Statistics (BBS), 2022). According to the 'Ecological Threat Report 2022', Dhaka became the fourth among twenty most unsustainable megacities in the world and it's predicted that notable ecological threats will be observed (Institute for Economics and Peace, 2022). Bangladesh has been undergoing rapid urbanization ever since its independence in 1971 and nearly one-third of the population are living in urban areas now which creates difficulties in providing urban recreation facilities to the city peoples (Urban Development Directorate, 2016). As a result of overpopulation and urban migrants in Dhaka city, the public spaces are rapidly decreasing and the rate was alarmingly high (Byomkesh *et al.*, 2012; Nilufar, 1999). Urban green spaces of Dhaka city drastically declining because of the high growth of population and the expansion of infrastructures (Nawar *et al.*, 2022). Total urban green space in DSCC is underneath the standard and the green spaces all over DSCC area is not properly distributed (Rahman and Islam, 2022). Regional Development Planning (RDP) project survey (RAJUK, 2016) have found that 48% of the total Dhaka region are urban features and 52% non-urban features. Only 1142.42 acres (0.30%) of Dhaka's land is presently having considered as urban outdoor recreational places. The alarming issue is, in 2035 population will be increased and accordingly, required area for open spaces will be 25.3% for Dhaka (Nilufar, 2015; RAJUK, 2016). Because of the scarcity of proper safety and appropriate facilities, the parks and playgrounds of Dhaka city are not accessible (Islam *et al.*, 2015). Due to having fewer public spaces, people have become home-centric, domesticated, less-active and inoperative in Dhaka city and it affected on their mental health (Labib *et al.*, 2020). The public spaces of Dhaka should be more secured and in a close-distance location for the inhabitants and more divergent so that maximum sociodemographic groups can utilize the places (Sultana *et al.*, 2022). It should be developed by providing and ensuring equipment, safety and security, natural settings,

utility services etc. (Rahman and Zhang, 2018). Safe and inclusive public spaces nourish not only public and cultural life but also have ecological benefits for the cities (UN-Habitat, 2022). This study is targeting to analyze the post-development circumstances of redeveloped public spaces of DSCC. Research question for this research is- What are the conditions of public spaces after redevelopment? The selected objectives of the research are- to analyze various physical change and changes of visitors in public spaces after redevelopment, to evaluate the quality of public spaces after redevelopment and to provide recommendation for improving public spaces as better recreational facilities. The research survey was carried out in Dhaka South City Corporation area, Dhaka, Bangladesh in 2022.

MATERIALS AND METHODS

It's needed to assess the impact of the development of these public spaces on the community. Actually, it's one kind of post assessment of this redevelopment project that how successfully the public spaces attract the people of the community. It's necessary to examine the impact of this redevelopment of the parks and playgrounds because redevelopment is an important tool in urban planning as to utilize urban areas. The research process includes conceptualization, literature review, designing the research including sample design, data collection and analysis. Though the term 'Public Space' has included a broad number of public places, but this study has only considered parks and playgrounds as these places are degrading in accounts of numbers in Dhaka.

Study Area Profile

Dhaka, the capital city of Bangladesh has been divided into two city corporation zones named Dhaka North City Corporation (DNCC) and Dhaka South City Corporation (DSCC). DSCC area has been selected as the study area which have the population of 4,299,345 and 38 parks and playgrounds in its jurisdiction area. The latitude and the longitude of DSCC area of Bangladesh are respectively 23.72° North and 90.39° East. The area of DSCC was 45 km^2 but expanded to 109.2 km^2 in 2017; where 18 new wards have been added to 57 wards and become a total of 75 wards. As the newly added areas haven't been developed yet or in the process of development, this study has
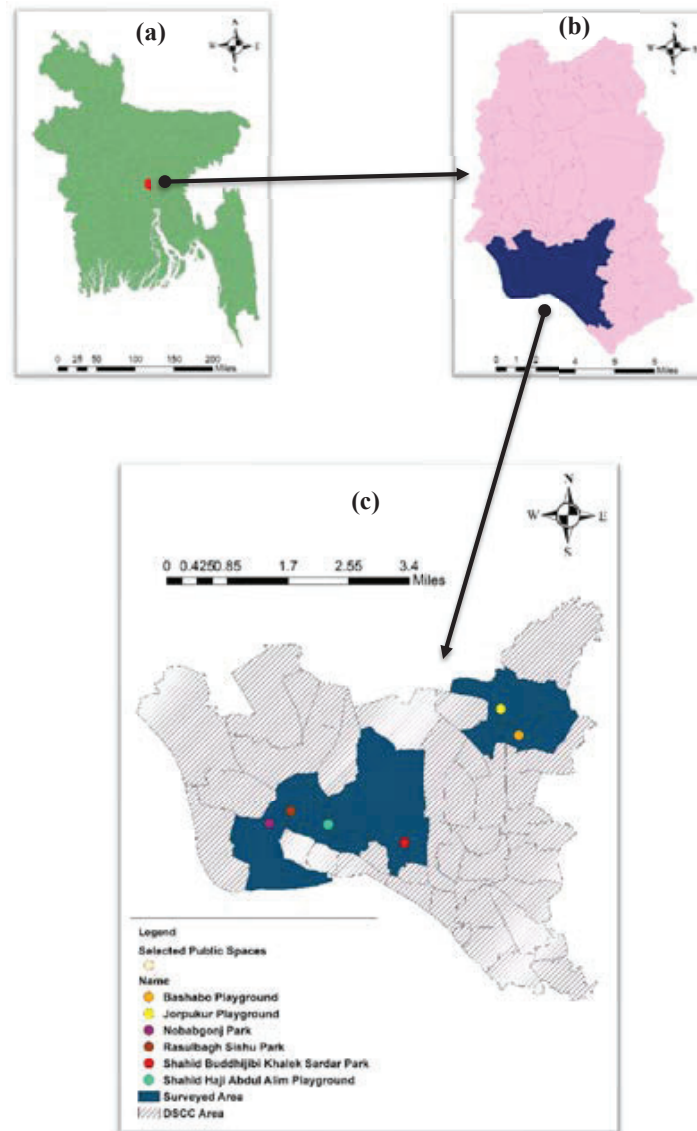
Fig. 1: Geographic location of the study area; (a) Bangladesh, (b) Dhaka City and (c) Dhaka South City

considered only old jurisdiction areas of DSCC.

The selection criteria of study area depend on the information of public spaces and the criteria are- government owned, recently redeveloped, well planned and equipped and located in specific neighborhood etc. 6 public spaces have been selected for this research and the selected public spaces are- Jorpukur Playground, Bashabo Playground, Shahid Haji Abdul Alim Playground, Nobabgonj Park, Rasulbagh Sishu Park and Shahid Buddhijibi Khalek Sardar Park which were shown in the study area map in Fig. 1 and the pictures of these public spaces were shown in Fig. 2. These public spaces are located in Ward 1, Ward 4, Ward 26, Ward 23, Ward 26 and Ward 33 respectively and their sizes are 3238 m^2, 10118 m^2, 3642 m^2, 2024 m^2, 1820 m^2 and 1376 m^2 respectively which are considered as mini parks (Bangladesh Bureau of Statistics (BBS), 2022; Bangladesh Bureau of Statistics (BBS), 2013; Dhaka South City Corporation (DSCC), 2020).

Jorpukur Playground

Bashabo Playground

Shahid Haji Abdul Alim Playground

Nobabgonj Park

Rasulbagh Sishu Park

Shahid Buddhijibi Khalek Sardar Park

Fig. 2: Selected parks and playgrounds

Data Collection and Analysis Technique

This research has followed a mixed method approach for preparing the research design of this study. To conduct observation and household survey, checklist and questionnaire have been used as data collection tool. To find out the structural changes and newly installed infrastructures in renovated parks and playgrounds in DSCC, pictures have been collected with direct field survey and observation. 6 public spaces have been surveyed (observation survey) and

residents of the surrounding wards (Total 15 wards) have been interviewed. 15 respondents have been interviewed per ward. Random sample technique has been followed in survey. In this sample design, total sample size was 225, where the population of the surveyed area was 131030; whereas, the population of DSCC was 1.2 crores. To fulfil the first objective, information of public spaces and its infrastructures, respondents' demography, characteristics and changes in visitors, increment assessment of visitors in pre and post renovation period etc. have been evaluated. To fulfil the second objective, problems, service area of public spaces, accessibility in the public spaces after redevelopment have been analyzed. Also, satisfaction level associating with some variables named demography, visiting frequency, visiting time, spending time, distance, time to reach, better footpath connectivity, costs to visit, getting chance, access in all the place, feel safe in the public spaces etc. have been evaluated and analyzed with statistical tools like chi-square analysis and multiple regression analysis in SPSS. Chi-square analysis has been done to assess the differences in subgroups of demography of the visitors in post development period and regression model analysis has been done to assess the dependency of users' satisfaction on above mentioned variables. To assess the increment of visitors from pre development to post development, percentages of increment has been calculated in excel with bar differences evaluation using the Eq. 1 which shows that what percentages of the increment portion covers of the visitors in post development period's bar graph.

The calculation assesses the percentages of growth portion in compared to visitors in post development period. So, Percentages of Growth (Increment) is equals to-

$$\frac{(\text{Visitors in post development period} - \text{Visitors in pre development period}) \times 100}{\text{Visitors in post development period}} \quad (1)$$

Map analysis to evaluate service area of these public spaces has been done with buffer zone analysis with the radius of 400 meter and 1000 meter using ARCGIS tool. For data analysis and graph preparation, software like SPSS, Microsoft Excel and ARCGIS 10.5 have been operated and used.

RESULTS AND DISCUSSION

Demography of the Respondents

From Fig. 3, it is shown that 87 respondents have visited only after redevelopment and 19 respondents have visited only before redevelopment. There are 61 respondents who have visited both after and before development. There are also 58 respondents who have not visited the public space before and after the redevelopment.

From the demographic frequency table (Table 2), it is found that 'Shahid Buddhijibi Khalek Sardar Park' has the most respondents in terms of nearest public space and 'Rasulbagh Sishu Park' have the lowest. There are 33.8% female and 66.2% male respondents. Among the respondents, age group '21-30' is the highest and age group 'Above 50' is the lowest. Among the respondents, most of them are students. Most of the respondents are in 'Graduate' group. Most of the
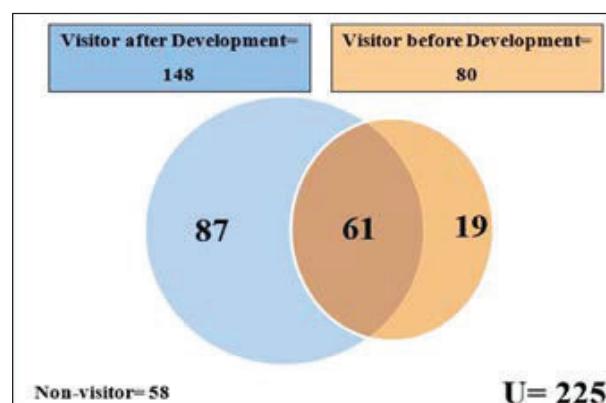

Fig. 3: Venn diagram of Frequency of Visitor and Non-user

Table 2: summary of respondents' background

Demography	Finding (Highest and Lowest)	Frequency	Percentages (%)
Nearest Public Space	Shahid Buddhijibi Khalek Sardar Park	62	27.6
	Rasulbagh Sishu Park	20	8.9
Gender	Male	149	66.2
	Female	76	33.8
Age	21-30	68	30.2
	Above 50	7	3.1
Occupation	Student	86	38.2
	Retired	3	1.3
Education	Graduate	68	30.2
	Below S.S.C	10	4.4
Income	40,001-60,000 TK	94	41.8
	10,001-20,000 TK	4	1.8
Duration of Residency	More than 12 years	80	35.6
	Less than 1 year	7	3.1

respondents includes in the income group of '40,001-60,000 TK'. Most of the respondents reside more than 12 years in their neighborhood.

Changes in Structures

The condition of physical structures in the pre and post renovation period of the public spaces has been assessed. Though these urban public spaces are in the jurisdiction of DSCC, these places were illegally occupied. These places were in the forms of vacant land, abandoned land, open field etc. Some of these places were informally used for playing areas for children; but also used for parking truck, mini bazar, garbage dump etc. Most commonly the public spaces have been provided playfield, boundary, seating place, footpath, drain and lighting after redevelopment as it had shown in Fig. 4. But the boundary looks like cave and it is been controlled by the authorities and most of the time the area has been locked up. The public spaces have been facilitated with various modern facilities like coffee shop, dustbin, washroom and CC TV camera etc. Most interesting equipment added to the public spaces are water filter for reusing rainwater. Most of public spaces have been used for playing, walking and gossiping place now. Most of the cases, the playfield is open only in the morning and afternoon.

Changes in Visitors and Chi-square Analysis

Change pattern of visitor in terms of demography (Gender, Age, Occupation, Education, Income, and Duration of Residency) has been assessed and chi-square analysis has been done. In every sector, visitors have been increased after redevelopments of these public spaces compared to before. From the Chi-square analysis (Table 3), it has found that comparatively elderly people, less-educated people, high income group people, new inhabitants of that area visited most. When the value of Asymptotic Significance is less than 0.05 it indicates a correlation between two variables.

Using the Eq. 1, from these following graphs (Fig. 5), it has clearly shown that in every demographic group, visitors have been increased after redevelopments in the studied public spaces. From Fig. 3, there were 80 respondents among 225 who have visited before redevelopment and in case of after redevelopment, the number of visitors is 148 which indicates overall increment scenario. That means, before redevelopment, 36% of the residents have been visited in these public spaces and after redevelopment it has been increased and that was 66%. There was a 45% increment in visitors. In terms of gender group, major increments happened in female (52%). In terms of age group, major increments happened in 31-40 age group (58%). In terms of occupation group, major increments happened in housewife (53%). In terms of education group, major increments happened in below SSC (Secondary School Certificate) group (63%). In terms of income group, major increments happened in 10000–20000-taka income group (67%). In terms of residency period, major increments happened in 1-4 years residency group (60%).

Boundary Wall · Footpath and Drain · Lights

CC TV Camera · Seating Place · Water Filter

Fig. 4: Newly Installed Infrastructure

Table 3: Chi-square analysis on association of demography with visitors after development

Characteristics	Visitors after Development		Result (Comparatively Visited Most)
	Pearson Chi-Square Value	Asymptotic Significance (2-sided)	
Gender	.090	.764	-
Age	11.032	**.026**	Elderly people
Occupation	7.320	.198	-
Education	11.076	**.050**	Less-educated people
Income	19.080	**.001**	High income group people
Duration of Residency	14.639	**.006**	Inhabitants who reside less time in that area

*p ≤ .05 (Significant)

Service Area of Public Spaces

The selected public spaces only serve 25.37% of the study area and 6.44% of the DSCC area in terms of walking distance (400-meter). When counts one kilometer radius, these public spaces serve 79.03% of study area and 29.71% DSCC area. Table 4 had shown the calculation of served area by the studied public spaces and the visual representation of this analysis had shown in Fig. 6.

Problems in Public Spaces

From the assessment showing in Table 5, clean toilet or toilet problem was the major problems in most of the surveyed public spaces. Percentages shows the percent of affected respondents who faced that particular problem.

Regression Analysis of Satisfaction Level with Public Space

If the value of P (Significant) is less than 0.05, it indicates a correlation between two variables; and also, positive or negative value of β indicates the positive or negative

relation between dependent and independent variables. From the following table (Table 6), multiple regression model showed that some of the variables have the correlation with satisfaction level with public space after development.
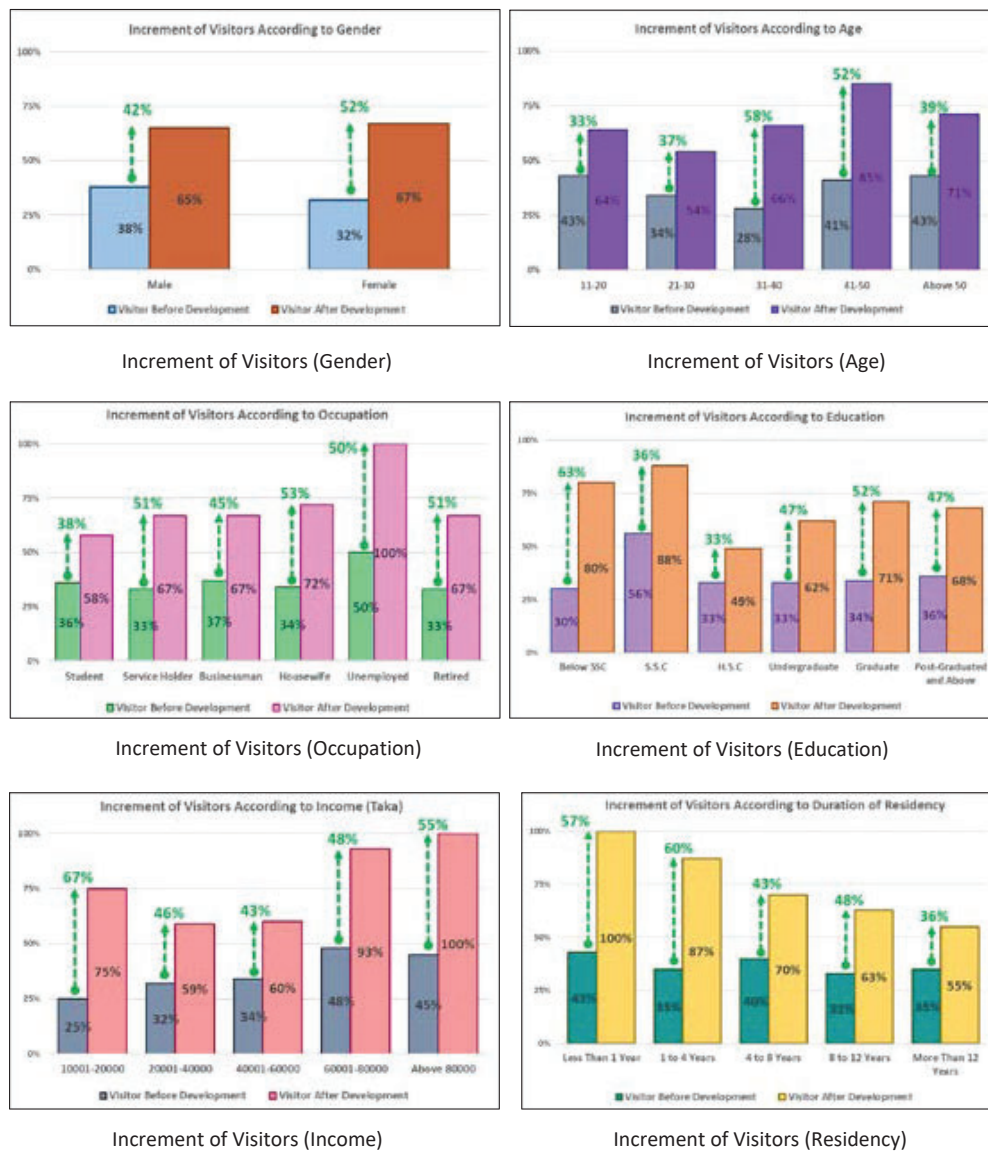

Increment of Visitors (Gender) — Increment of Visitors (Age) — Increment of Visitors (Occupation) — Increment of Visitors (Education) — Increment of Visitors (Income) — Increment of Visitors (Residency)

Fig. 5: Increment of Visitors According to Demography

Table 4: Calculation of service area

Jurisdiction Area	Area (km²)	400-meter Service Area		1000-meter Service Area	
		Area (km²)	Percentages	Area (km²)	Percentages
DSCC	45	2.90	6.44%	13.37	29.71%
Study Area	10.92	2.77	25.37%	8.63	79.03%
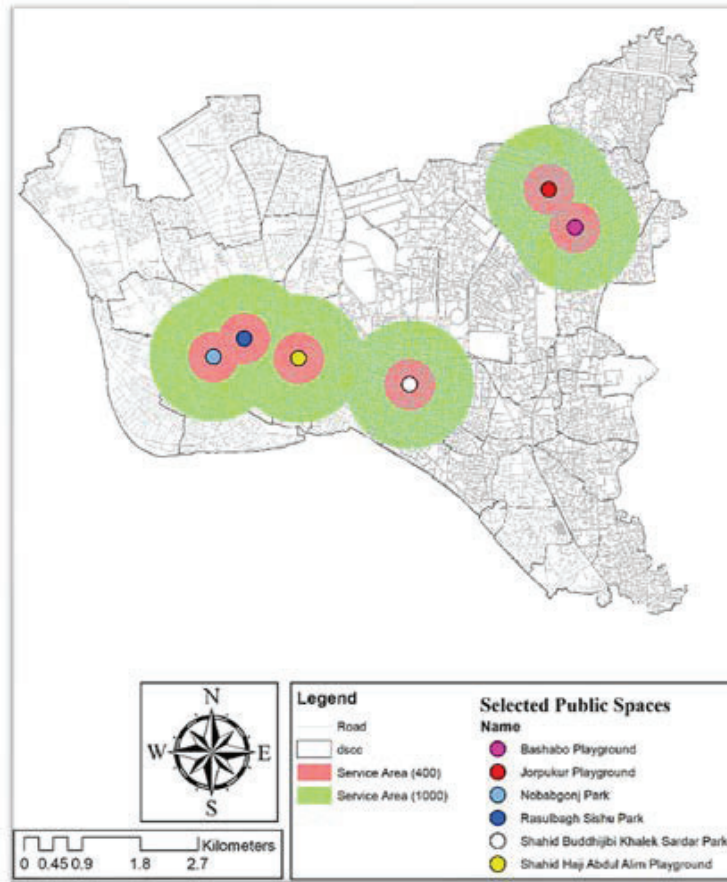
Fig. 6: Service area of the public spaces

Table 5: Public space wise major problems

Public Spaces	Major Problems				
	Priority-1	Priority-2	Priority-3	Priority-4	Priority-5
Jorpukur Playground	Lack of shed for shelter (73.70%)	Absence of enough bench (71.30%)	Playground/park is not open all the day (70.20%)	Air pollution (68.40%)	Small size (63.20%)
Bashabo Playground	No clean toilet (78.60%)	Crowded area (71.40%)	Lack of shed for shelter (57.10%)	Noisy area (54.20%)	Absence of enough bench (50.00%)
Nobabgonj Park	No clean toilet (84.60%)	Air pollution (82.40%)	Noisy area (76.90%)	No security (71.80%)	No restriction for anti-social people (61.50%)
Rasulbagh Sishu Park	Small size (100.00%)	Playground/park is not open all the day (92.30%)	Lack of playing equipment (84.60%)	Absence of enough bench (81.40%)	Existence of garbage and rubbish (76.90%)
Shahid Haji Abdul Alim Playground	Crowded area (68.20%)	No clean toilet (65.90%)	Noisy area (62.40%)	Air pollution (56.80%)	Playground/park is not open all the day (54.50%)
Shahid Buddhijibi Khalek Sardar Park	No clean toilet (75.60%)	Air pollution (62.20%)	Crowded area (57.80%)	Absence of enough bench (56.10%)	Noisy area (55.60%)

Table 6: Multiple regression model analysis of satisfaction level with public space

MODEL SUMMARY		
R (Correlation)	R Square	Adjusted R Square
.751	.565	.515
DESCRIPTIVE STATISTICS AND ANOVA				

Mean	Std. Deviation	N	F Statistic	Sig.
3.1297	.41853	148	11.416	.000

COEFFICIENTS				
Model			Dependent Variables	
			Satisfaction Level with Public Space	
			β (Beta)	P (Sig.)
Independent Variables	(Constant)		3.018	.000
	Gender		.168	**.037**
	Age		-.015	.644
	Education		-.029	.174
	Income		-.095	**.011**
	Duration of residency		.103	**.001**
	Visiting frequency		.032	.436
	Visiting time		.031	.376
	Spending time		.049	.224
	Distance		-.282	**.001**
	Time to reach		-.171	**.002**
	Better footpath connectivity		-.049	.516
	Costs to visit		.066	.297
	Getting chance		-.006	.951
	Access in all the place		.143	**.014**
	Feel safe		.166	**.014**

*p ≤ .05 (Significant)

From Table 6, it was shown that the correlation (R) is .751. That means satisfaction level with public space after development is strongly correlated with independent variables. Coefficient of determination or the R-Square value is .565. That means 56.5% changes in the satisfaction level can be explicated by the independent variables with this regression model. Value of adjusted R-Square is .515 that indicates only 51.5% variation in satisfaction level can be measured by the independent variables in this model. Here, F value is 11.416 which is high enough to confirm the correlation between variables. The Model is given below following the Eq. 2. Satisfaction Level with Public Space = 3.018 + .168 (Gender) - .095 (Income) + .103 (Duration of Residency) - .282 (Distance of Public Space from Home) - .171 (Time Required to Reach) + .143 (Access in All the Place) + .166 (Feel Safe in Public Space)

[Multiple Regression Model, $Y = a + b_1X_1 + b_2X_2 + b_3X_3 + \ldots\ldots\ldots + b_nX_n$] (2)

Some prime and foremost findings from this regression analysis are- women are less satisfied than men, residents who have newly resided to the community are less satisfied, visitors who faced problems to get access in entire places and who can't feel safe and secure in the public spaces have less satisfaction. Besides, low-income groups' people are more satisfied than high income groups, residents who resided close to the public spaces and need less time to reach in the public spaces are highly satisfied with the public spaces.

CONCLUSION

This paper outlined the infrastructural changes, visitor's scenario and quality of redeveloped public spaces which have tried to assess and find out the workability and fruition of the public spaces. Normally, public spaces become more public and usable after redevelopment projects. But also, the maintenance should be considered carefully. Otherwise, the functionality will be hampered. Increasing in visitors

and revitalization of infrastructures can't ensure accessibility and quality of the public places. There is a huge lacking of public spaces in Dhaka City. So, People will forgather in the few available places. So, it's not just the provision of public places but also the assurance of the quality of these areas. But interestingly study found that visitors of these public spaces have been increases which means people are eagerly interested to visit these places though Dhaka city offers a little. Accessibility should be provided properly in the public spaces to attract more visitors from all the demographic groups of people. So, the number of visitors from all groups have been increased but every group should get accessible environment in public spaces. Though it's necessary to have public spaces in walking distances, but because of shortages of parks and playgrounds the selected public spaces only serve 6.44% of the DSCC area in terms of walking distance. So, Government of Bangladesh should develop and construct new public spaces. Ward-wise community development can be a good solution for this shortage. It can also ensure the proper distribution. The playfields are open only in the specific time in a day. The opening time of the playfields should be 7 am and the closing time should be 8 pm. The playfields have cave-looking boundary. So, the boundary should be redesigned. The playfields have been locked down in most of the time. It prohibits the access of people to these public spaces. After renovation of the studied parks and playgrounds these includes many advanced infrastructures and equipment like playfield, boundary, seating place, footpath, drain and lighting dustbin, washroom and CC TV camera, water filter for reusing rainwater etc. Yet, there are lacking of playing equipment like merry-go-round, still rings, swings, slides, playground climbers, spring riders, spinners etc. Along with children's equipment and infrastructures, adult people's equipment should be installed in the parks. Major problems of these parks and playgrounds are no clean toilet, small sized public spaces, and crowded area. To ensuring a hygienic environment in public spaces it should be included regularly-cleaned toilets, functioning water taps, continually-emptied waste bins, and thorough ongoing maintenance. Proper maintenance is needed of these washrooms as to maintain better quality. Women, high income groups, residents who have newly resided to the community are less satisfied with these public spaces. Visitors who faced problems to get access in entire places and who can't feel safe and secured in the public spaces, residents who resided far from the public spaces and need more time to reach in the public spaces have less satisfaction. To maintain resilience of the public spaces, proper maintenance and security are needed. Better connectivity, safety and accessibility to do activities in all the area of public spaces should be provided as these issues directly connected to the satisfaction of the residents. Public spaces play an important role for developing community sense and strong community belongingness. As the elements of a city, not only the development of roads, houses and transportation is needed, but also the public spaces should be got attention and required to be acknowledged as important resources of a city. A good public space within a neighborhood helps to give the residents a sense of place where they can feel very homely and relate themselves close to the city and its' culture. Hence, for enhancing better functionality of Dhaka City it is a must to develop and improve the quality of existing public places. Policies and guidelines must be established defining better and optimum infrastructural design and management for these public spaces to create and develop a successful public space. So, renovation is a good practice for urban public spaces, but public spaces should be created as to enhance usability, public involvement, accessibility, restriction free, well equipped, well maintained and sustainability.

AUTHOR CONTRIBUTIONS

ACKNOWLEDGEMENT

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

PUBLISHER'S NOTE

Tehran Urban Planning and Research Center remains neutral with regard to jurisdictional claims in published maps and institutional afflictions.

ABBREVIATIONS

%	Percent
a	β (Beta) value of constant
Adjusted R Square	Adjusted coefficient of determination
b	β (Beta) value of independent variable(s)
BBS	Bangladesh bureau of statistics
CC TV	Closed-circuit television
DNCC	Dhaka north city corporation
DSCC	Dhaka south city corporation
Eq.	Equation
F	Fisher test (variation between sample means)
Fig.	Figure
GIS	Geographical information system
Km^2	Square kilometer
m^2	Square meter
N	Total case (sample)
p	Probability
R Square	Coefficient of determination
R	Pearson correlation coefficient
RAJUK	Rajdhani unnayan kartripakhya (capital improvement authority)
RDP	Regional development planning
Sig.	Significant
SPSS	Statistical package for social sciences
Std. Deviation	Standard deviation
UN	United nations
X	Value of independent variable(s)
Y	Value of dependent variable
β	Beta

REFERENCES

Abu-Ghazzeh, T.M., (1996). Housing layout, social interaction and place of contact in Abu-Nuseir, Jordan. J. Environ. Psychol., 19(1): 41-73 **(33 pages)**.

Andersson, C., (2016). Public space and the new urban agenda: UN Habitat. J. Public Space, 1(1): 5-10 **(6 pages)**.

Bangladesh Bureau of Statistics (BBS), (2013). District Statistics 2011: Dhaka. Ministry of Planning, Government of the People's Republic of Bangladesh.

Bangladesh Bureau of Statistics (BBS), (2022). Population and Housing Census 2022: Preliminary Report. Ministry of Planning, Government of the People's Republic of Bangladesh.

Bierwiaczonek, K., (2018). Miejskie przestrzenie publiczne i ich społeczne znaczenia: próba systematyzacji (Urban public space and its social roles: An attempt at systematization), Prz. Socjol., 67(1): 25-48 **(24 pages)**.

Byomkesh, T.; Nakagoshi, N.; Dewan, A.M., (2012). Urbanization and green space dynamics in Greater Dhaka, Bangladesh. Landscape Ecol. Eng., 8: 45-58 **(14 pages)**.

Carmona, M.; Heath, T.; Oc, T.; Tiesdell, S., (2010). Public places urban spaces: the dimensions of urban design (2nd Ed.). Routledge.

Carr, S.; Francis, M.; Rivlin, L. G.; Stone, A. M., (1992). Urban design reader: needs in public space. Cambridge University Press, Cambridge.

Caves, R. W., (2004). Encyclopedia of the City. Routledge.

Chen, Y.; Liu, T.; Liu, W., (2016). Increasing the use of large-scale public open spaces: A case study of the North Central Axis Square in Shenzhen, China. Habitat Int., 53: 66-77 **(12 pages)**.

Dhaka South City Corporation (DSCC), (2020). Dhaka South City

Corporation at a Glance. Ministry of Local Government, Rural Development and Co-operatives, Government of the People's Republic of Bangladesh.

Dhaliwal P., (2012). Public squares and resistance: the politics of space in the Indigenous movement. Interface: J. Soc. Movements, 4(1): 251-273 **(23 pages)**.

El-Husseiny, M.; Kesseiba, K., (2012). Challenges of social sustainability in Neo-liberal Cairo: Re- questioning the role of public space. Procedia- Social Behav. Sci., 68: 790-803 **(14 pages)**.

Gehl, J., (2010). Cities for people. Island Press, Washington DC.

Institute for Economics and Peace, (2022). Ecological threat report 2022: analysing ecological threats, resilience & peace. Sydney, Australia.

Islam, M.; Mahmud, A.; Islam, S. M. D., (2015). Open space management of Dhaka City, Bangladesh: a case study on parks and playgrounds. Int. Res. J. Environ. Sci., 4(12): 118-126 **(9 pages)**.

Labib, S. M.; Shuvo, F. K.; Browning, M. H. E. M.; Rigolon, A., (2020). Noncommunicable diseases, park prescriptions, and urban green space use patterns in a global south context: the case of Dhaka, Bangladesh. Int. J. Environ. Res. Public Health, 17(11): 1-23 **(23 pages)**.

Maller, C.; Townsend, M.; Leger, L. S.; Henderson-Wilson, C.; Pryor, A.; Prosser, L.; Moore, M., (2009). Healthy parks, healthy people: the health benefits of contact with nature in a park context. George Wright Forum, 26(2): 51-83 **(33 pages).**

Maahsen-Milan, A.; Oliva, L., (2014). The Place and the City: Trends in the Construction of the Public Space.

Nawar, N.; Sorker, R.; Chowdhury, F.; Rahman, M.M., (2022). Present status and historical changes of urban green space in Dhaka City, Bangladesh: a remote sensing driven approach. Environ. Challenges, 6: 1-11 **(11 pages)**.

Nilufar, F., (1999). Technical report on urban life and use of public space study of responsive public open spaces for supporting urban life in Dhaka City. Asiatic Society of Bangladesh.

Nilufar, F., (2015). Technical report on preserving open space for livability of Dhaka. Seminar on 'Public Space for All' in World Habitat Day 2015, Housing and Public Works Ministry, Government of Bangladesh.

Rahman, K.; Zhang, D., (2018). Analyzing the level of accessibility of public urban green spaces to different socially vulnerable groups of people. Sustainability, 10(11): 1-27 **(27 pages).**

Rahman, M.; Barua, U.; Stoican, I. A., (2014). The changing nature of urban public places in Dhaka City. Urban. Archit. Construct, 5: 5-16 **(12 pages).**

Rahman, S. H.; Islam, M., (2022). Urban green-space availability and recommended plantation area in Dhaka South City Corporation (DSCC) using RS-GIS. Bangladesh J. Environ. Res., 13: 1-12 **(12 pages).**

RAJUK, (2016). Dhaka Structure Plan (2016-2035). Regional Development Planning Project, Ministry of Housing and Public Works, Government of Bangladesh.

Ramlee, M.; Omar, D.; Yunus, R. M.; Samadi, Z., (2015). Revitalization of Urban Public Spaces: An Overview. Procedia- Social Behav. Sci., 201: 360-367 **(8 pages).**

Siddiqui, K., (2019). Children get back their playgrounds. The Business Standard, Bangladesh.

Sulaiman, N.; Zaman, N.; Hamdani, H., (2016). Rethinking potentials of public space and its management through placemaking in Kuala Lumpur. MATEC Web Conf., 66: 1-5 **(5 pages).**

Sultana, R.; Selim, S.A.; Alam, M.S., (2022). Diverse perceptions of supply and demand of cultural ecosystem services offered by urban green spaces in Dhaka, Bangladesh. J. Urban Ecol., 8(1): 1-12 **(12 pages).**

Tonnelat, S., (2008). The sociology of urban public spaces. The founding conference of the first Sino-French Research Center for Urban Planning, Nanjing, China.

UN-Habitat, (2015). Global public space toolkit: from global principles to local policies and practice. United Nations Human Settlements Programme, UN. Nairobi, Kenya.

UN-Habitat, (2022). World Cities Report 2022: envisaging the future of cities. United Nations Human Settlements Programme, UN. Nairobi, Kenya.

United Nations, (2019). World Urbanization Prospects: The 2018 Revision. Department of Economic and Social Affairs, Population Division. New York, United Nations.

Urban Development Directorate, (2016). Bangladesh Country Report: HABITAT III. Ministry of Housing and Public Works, Government of Bangladesh.

International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: http://www.ijhcum.net/

Evaluation of psychological factors affecting the decision of citizens to purchase renovated buildings with emphasis on maintaining urban environment

H. Rahimi Jafari[1], A. Faez[1,*], Y. Vakil Alroaia[1], M.D. Hosamane[2]

[1] Department of Management, Semnan Branch, Islamic Azad University, Semnan, Iran

[2] Department of Economics and Cooperation, University of Mysore, Maysor, India

ARTICLE INFO

ABSTRACT

BACKGROUND AND OBJECTIVES: During the past decades, architects have faced serious challenges in renovating buildings. Renovated buildings require activities that, besides energy savings and less damages to the environment, could have psychologically positive effects on customers. Renovation plays an important role in the development of the city of Tehran so that it can bring environmental, economic and social benefits and preserve the originality of the urban environment of this metropolis. Therefore, the purpose of this study was Evaluation of psychological factors affecting the decision of citizens to purchase renovated buildings with emphasis on maintaining urban environment.

METHODS: The present study used a mixed approach to achieve a general model to investigate the effects of such factors on customers' decision to buy renovated buildings. To validate the model, the qualitative approach was based on the Grounded Theory, and the quantitative approach used Structural Equation Modeling. In the qualitative analysis to identify the influential factors, the interview data were analyzed with ATLAS.Ti8 software version 8.0 by using the Grounded Theory coding method according to Strauss and Corbin's approach. Finally, the effects of psychological factors on the consumer decision to buy renovated buildings were identified.

FINDINGS: Perception index with two components of personality (factor loading 0.60) and experience (factor loading 0.69), learning index with two components of capacity change and behavior change with factor loading 0.56, attitude index with two components of self-esteem (0. 70) and excitement (0.76) and in the motivation index of the external motivation component (0.58) were confirmed in the final model. The indicators of needs and desires (0.31), change of status (0.42), identity (0. 32) and intrinsic motivation (0.49) were rejected and removed from the final model.

CONCLUSION: The findings showed that in order to maintain the authenticity of the urban environment as well as the satisfaction of citizens, the managers of architectural companies and senior officials of urban planning can use the investigated methods to make better decisions and encourage citizens to buy renovated buildings.

NUMBER OF REFERENCES

42

NUMBER OF FIGURES

4

NUMBER OF TABLES

6

*Corresponding Author:
Email: a.faez@semnaniau.ac.ir
Phone: +98989121318610
ORCID: 0000-0002-8105-2851

Note: Discussion period for this manuscript open until April 1, 2023 on IJHCUM website at the "Show Article.

INTRODUCTION

An observation of architectural spaces provides broad-spectrum aesthetic experiences, spanning from a sense of convenience and excitement to arbitrating the age and style of the building (Chatterjee and Vartanian, 2014; Coburn *et al.* 2017). Such feelings emerge when visiting buildings for buying, because individuals minds and bodies are overwhelms by architecture and cause changing emotions and behavior. Understanding such powerful influences, possible factors are identified by architecture firms in order to use in the renovation of buildings (Fathali and Kheyri, 2014). Residential buildings, expressly apartments, are continually renovated worldwide, and techniques to achieve, are becoming progressively imperative. Building renovation is broadly established and by possibility of reusing resources which is provided, causing enjoying and sustaining living space (Choi and Choi, 2022). Today, with the complex and exponential growth of science, technology, values, and criteria worldwide, most successful organizations across the world have shifted organizational goals, methods, and structure toward attracting customers. (Fathali and Kheyri, 2014). Such rules and guidelines are also applied to the architecture firms that attempt to renovate building units. Indeed, firms need to consider psychological factors to inspire customers to purchase renovated buildings and, hence, improve company's market share. Today, customers' desires, needs, and expectations are irrefutably changing; hence, it is pivotal to explore the effects of psychological factors on customers and, more broadly speaking, determine the needs of customers, and then find the means to realize such factors and requirements (Mansoori and Yavari, 2003). In general, people devote considerable time to the built environment(s). Moreover, the human visual brain shows a varying sensitivity to the psychological dimensions of the interior architecture space, including coherence, attractiveness, and similarity (Coburn *et al.* 2020). The evaluation and perception of environmental spaces and architecture are leading concerns in environmental psychology as such many environments, from landscapes to the interior of rooms, have been studied. However, old buildings have been substantially overlooked (Cheuk Fan, 2020), and renovated buildings are rarely investigated. Moreover, in recent years, the ascending trend in the price of houses in Iran has become a leading social

problem for customers. Hence, renovation, repair, and reconstruction of buildings have been broadly accepted during the past years. Building renovation allows the architects to create a new building with a minimum budget at the shortest duration possible with no destruction of the building structure. It is currently most appealing for architects, architecture firms, and especially for customers (citizens), owing to its economic efficiency. Architecture firms attempt to investigate the psychological effects on the design of these buildings as a means to proceed and realize marketing objectives. However, the extent to which psychological factors can affect the customer's decision to purchase a renovated building needs to be further illustrated. This research would help the architectural psychology to efficaciously conduct architectural projects of buildings across the process of renovating and selling these structures. The model proposed in this research is an interdisciplinary model consisting of marketing, psychology, architecture, and consumer behavior. This model was designed to be perceived efficient within all aforementioned disciplines. Accordingly, this study mainly aimed to develop a model to investigate the effects of psychological (architectural) factors on the decision to purchase renovated buildings. Over the past decades, architects have faced serious challenges in the renovation of buildings. Firms have pursued activities that, besides energy savings and less damages to the environment, could psychologically have positive effects on customers. These activities inspire the customers to purchase and provide them with a sense of peace steamed from a renovated building environment. unprecedentedly, and serving as a guide to architectural research, environmental psychology, marketing, and consumer behavior, this study proposes some solutions for managers of architectural firms to renovate buildings more insightfully. These solutions are supposed to be helpful as a mixed approach for all the disciplines mentioned above. Using a literature review, this research unprecedentedly investigated the effect of psychological factors on the customer's intention to purchase renovated buildings. Given the lack of similar studies in Iran, the present study is assumed to illustrate a new horizon for future research on this topic. This research showed the link between architecture, psychology and marketing as an interdisciplinary research and can provide architects

with deep insight in the field of buildings renovation. Therefore, the purpose of this study was Evaluation of psychological factors affecting the decision of citizens to purchase renovated buildings with emphasis on maintaining urban environment.

Theoretical foundations

Architectural psychology is an interdisciplinary subject merging psychology and architecture. It focuses on an architectural design by using Gestalt psychology, cognitive psychology, and other relevant psychology principles. During the past 33 years, researchers from China have gained fruitful achievements in architectural psychology. In China, the frontiers of the field are "architectural creation" and "environmental psychology", while the popular research topics include "residential environment", "spatial environment", "environmental psychology", "architectural theory" and "architectural psychology" (Zhu *et al.,* 2017). In this regard, psychological factors are as follows:

Perception

Perception is a complicated process through which one become aware of and perceive sensory information. Humans must receive and analyze data to interact with the surrounding physical environment. During perception, human beings pick the necessary information from the environment (Sharghi *et al*., 2017; Knox and Marston, 2003). The experience and perception of architecture are hardly quantifiable. Mental factors are constantly going beyond objective and measurable aspects. Similar to an object, architecture is calculable and quantifiable, and can be expressed with numbers and figures. However, human beings, who are the target for architecture and serve as "carriers of subjectivity", are different (Groter, 2013).

Motivation

Broadly defined, motivation refers to a psychological force driving the complicated processes of purposive thoughts and behaviors. These processes are based on individuals' internal psychological pressures and external environmental/contextual forces, collectively acting to specify the direction, intensity, and continuity of a specific behavior, while pursuing a given goal (Kanfer, 2009; Kanfer *et al.* 2017). They refer to processes such as

needs, cognition, emotions, and external events, which empower and direct behavior (Marshall Reeve, 2007).

Learning

Learning is a function enabling individuals to respectively understand, strengthen, and modify knowledge, behaviors, capabilities, and new or existing alternatives. Learning might result in a potential alteration of the data composition, depth of knowledge, and attitude or behavior toward the type and extent of experiences (Gross, 2012). The ability to learn is possessed by humans and animals (Karban, 2015).

Attitude

An attitude refers to beliefs and emotions that allow a person to evaluate others, objects, and groups positively or negatively. Attitudes give a summary evaluation of objects and predict or guide future measures or behaviors (Ganji, 2019). Allport, G. W. (1954) defines attitude as "a mental and neural state of readiness (Allport, 1954), organized through experience, exerting a directive or dynamic influence upon an individual's response to all objects and situations with which it is related" (Sear. 1991). Attitudes play a fundamental role in many aspects of social psychology. However, researchers have recognized that attitudes vary in susceptibility to change and influence on behavior and cognitive processes (Luttrell and Sawicki, 2020).

Purchase intention

Purchase intention is "the total of cognitive, affective, and behavioral attitudes toward adoption, purchase, and use of the product, services, ideas, or certain behaviors "and also refers to the consumer's intention to purchase a product (Roodani and Rahman Seresht, 2010). Purchase intention is "the total of cognitive, affective, and behavioral attitudes toward adoption, purchase, and use of the product, services, ideas, or certain behaviors "and also refers to the consumer's intention to purchase a product.

Renovation

Renovation is achieved when an urban space, a complex, or a building has suitable and present-day productivity, but a relative physical-spatial decay, has been diminished its efficiency and effectiveness. The

renovation consists of a set of adopted measures, which, besides protecting the building, the complex, or the old urban space, contemporize the relevant spatial organization and bestow the structure a possibility to achieve its optimal efficiency (Habibi and Maghsoudi, 2020). Renovation is a process in which the existing structures need to be upgraded to improve performance by either altering the scope of the structure, providing additional facilities, or improving existing ones (Anwar and Najam, 2017).

Literature review

Inspired by architectural marketing, Rahimi Jafari (2021) studied the effect of marketing on architecture, focusing on the role of consumers and architects to achieve a mutual agreement in the improvement of architecture and building renovation. Environmental psychology focuses on the interconnections between individuals and environment, the relevant theories and schools, and the qualitative effect of the built environment on human behavior and psyche. In the study, Kumar *et al.* 2020 indicated that psychological factors had a strong implication in the purchase decision. Understanding the mental triggers behind the purchase decision process is imperative which is why consumer psychology is related to marketing strategies. Malter *et al.* (2020) studied impulse buying from several perspectives: (1) rational processes, (2) emotional resources, (3) the cognitive currents arising from the theory of social judgment, (4) persuasive communication, and (5) the effects of advertising on consumer behavior. Yuen *et al.* (2020) studied the psychological factors of panic buying concerning the health crisis, where deal with individuals' perceptions of the threats of the health crisis and the social psychological factors (Neisiani *et al.,* 2016). Hellpach (1924) was the first scholar who introduced "environmental psychology" in the first half of the 20th century. As reported by Ricci (2018) thesis, numerous studies indicate that a good architectural design has noticeable psychological and physiological advantages, which go beyond a sense of aestheticism. According to Zhu *et al.* (2017), architectural psychology is an interdisciplinary subject, consisting of psychology and architecture which focuses on an architectural design by using Gestalt psychology, cognitive psychology, and other relevant psychological principles. Researchers from China have gained fruitful achievements in the field of architectural psychology during the past 33

years. In his research on "architectural psychology", Dimapur (2016) argues that "a majority of findings from psychologists into engineering and architectural space, design, and planning, further explain the inner psyche of people that is required for a healthy life". In his research entailed "a psychological-spatial approach to architectural design and research", Lawrence emphasized on redefining and diversifying the study of people and physical environment. Such a reorientation is beyond overemphasizing the physical environment and the physiological or subjective evaluation of existing buildings (Lawrence, 1982). Given that municipalities play an active role in social progress and they are important for sustainable development of societies, managers have a very serious and decisive responsibility in this regard (Hosseini *et al.* 2020). To achieve these goals, the present study was conducted in 2022 in Tehran with the aim of maintaining the originality of the urban environment and helping architects in their design by considering human psychological factors in the renovation of buildings.

MATERIALS AND METHODS

The present study is a practical, qualitative-quantitative investigation conducted based on an inductive and comparative paradigm which was carried out by employing a descriptive survey method. The statistical population consisted of managers and experts of architecture firms involved in design and architecture in Tehran. To design the model to examine the impacts of psychological (architectural) factors on the decision to purchase renovated buildings, the Grounded Theory (GT) method was used to choose the dimensions and components identified in the qualitative section. at the same time, the Structural Equation Modeling (SEM)and by the help of Lisrel software was used to find out the interaction and interconnections between the dimensions. To validate the mode, 22 managers and experts of architecture firms in Tehran were selected using the purposive and convenient sampling methods. In this study, to test and fit the design of the model investigating the effects of psychological (architectural) factors on the decision to purchase renovated buildings, the participants were the personnel of architecture companies and contractors involved in the renovation of buildings in Tehran. The sample size was determined to be 18

architecture design firms, proportional to the number of personnel working. Participants were sampled through the stratified-random sampling method. The research community was confined to a known number of participants. Cochran's formula was used for sampling, based on which 348 participants were selected.

Validity and reliability of data collection tools

In general, the accuracy of the obtained data cannot be ensured when there is no data available on the validity of the measurement tool. Such an evaluation aims to explore whether or not the content of the tool could measure the predefined goal(s) (Hajizadeh and Asghari, 2011). Accordingly, the opinions of experts in a specialized field are used to evaluate content validity. This study used the experts and professors' opinions to ensure the validity of the tool used for measuring the research variables. In this questionnaire, the suitability of each item, defined for the related variable, was determined in three scales, namely "necessary", "useful but not necessary" and "unnecessary. Then, the Lawshe Content Validity Ratio (CVR) of each question was calculated using Eq. 1. (Scally, 2013).

$$CVR = \frac{\left(ne - \dfrac{N}{2} \right)}{N/2} \qquad (1)$$

where, CVR is the Content Validity Ratio (CVR) of each item, N denotes the total number of experts or reviewers (n = 22), and "ne" represents the number of positive comments from all these 22 experts about the item of interest. The obtained coefficients were compared with the Lawshe CVR table, and the content validity of the tool was measured. The Lavshe coefficient for these 22 experts was acceptable (0.40). Table 1 presents the minimum acceptable values of CVR based on the number of scoring experts.

Data analysis method

Collected data was analyzed along with interviews and library studies for further processing. The analysis covered summarization, categorization, GT-based coding, and the definition of research concepts and categories in ATLAS Ti8 software. The GT-based theorizing was based on the well-established systematic approach developed by Strauss and Corbin. This section discusses theorizing, theoretical sampling, note-taking, data coding (e.g. open coding, axial coding, and selective coding), and theory building and presentation. then investigates the theory validation and the process of evaluating GT-based theorizing. When the model was designed based on the GT method, relationships between the categories and components were obtained using SEM. The questionnaire was developed according to the proposed model and submitted to the experts to obtain the primary data. The gathered data were then analyzed in SPSS, and the software outputs were used as inputs in Lisrel to specify the effect rate of each item.

Open coding

Open coding is an analytical process by which concepts are identified, and factors characteristics and dimensions in the data are discovered (Strauss and Corbin, 1990; Lee, 2001). The researcher organizes categories according to data collected by interviews, observations, events, and notes (Creswell, 2005). During the interviews and literature review on the psychological factors affecting the decision to purchase a renovated building, the components extracted from interviews are coded. Indeed, the open codes are classified in ATLAS.TI 8 into main categories according to Table 2.

Causal conditions

In the GT-based open coding, causal conditions are situations that influence the axial phenomenon

Table 1. The minimum acceptable CVR value based on the number of scoring specialists. (Hajizadeh and Asghari, 2011)

The minimum acceptable CVR value based on the number of scoring specialists					
Number of specialists	CVR value	Number of specialists	CVR value	Number of specialists	CVR value
5	99%	11	59%	22*	40%*
6	99%	12	56%	25	37%
7	99%	13	54%	30	33%
8	75%	14	51%	35	31%
9	78%	15	49%	40	29%
10	62%	20	42%		

Table 2. Open coding

Conditions	Categories	Open coding
Causal conditions	ideals	Traditional and modern thoughts, customer taste, employer taste, moods
	The state of the economy	Record, unemployment, people's income
Background conditions	feelings	Satisfaction, attachment, beliefs and values
	Personality traits	Social interactions, individual characteristics, behavior
Intervening conditions	Resource limitations	Financial and spiritual
	an epidemic	Public disease and its effect on mental health
	perception	Needs and desires, personality, experience
Strategies	motivation	External and Internal
	learning	Change in status, capacity and behavior
	attitude	Identity, self-esteem, excitement

and build or expand the desired phenomenon. Conventional and modern thoughts, customer preference, employer preference, and moods were extracted following the interviews were reviewed (Table 2), as specified as an abstract category of ideals. The human lives are intertwined with customs, principles, and rules. Humans use all mentioned under specific considerations and particular circumstances. However, the marked cultures and styles are sustained even when such thoughts and considerations are fixed or altered. This is why some people yet pursue and like the old lifestyles. In this regard, modern ideas are created along with conventional ones.

In other words, customers tend to experience a new lifestyle. Modern thinking is pondered in the individual area and is obtained over time as a result of variations in the lifestyle. All these thoughts or a combination of these thoughts build a customer's preference. Besides, the employer's preference also affects the implementation of construction projects. In this category, all elements were coded as ideals. Individuals' records, unemployment, and income were categorized as economic status, as these elements were reflected in interviewees to influence the customers' intention to purchase.

Background conditions

A relative satisfaction with the quality of life builds a space for social life for achieving more security. Accordingly, individuals will be provided with peace and can fix tensions during daily interactive relationships with others with the slightest confrontation (Mohammadi *et al.* 2016). Satisfaction with the renovated building and space, enriched with security and peace, bounding to the

building and the last place of residence, the beliefs, and values that serve as a basis for the feelings of individuals about place of living are classified as open codes in the category of emotions. Social interaction builds a relationship between two or more individuals, while causing to react to each other, and the occurred reaction is familiar to both sides. Accordingly, this definition does not cover meaningless relationships. Social interaction and communication of individuals entail defining proper events and activities, making individuals play a role in the space and have membership in social groups and networks (Daneshpour, 2007). Inherently, humans need social interactions. Here, social interactions mean a meaningful and conscious face-to-face relationship between two or more people. Such interactions influence the decision to buy buildings. Individual characteristics influence customers' purchase behavior and how they treat when facing buildings.

Intervening conditions

The restricted resources for the purchase of renovated buildings and the epidemic conditions governing the society were identified as intervening elements in the interviews.

Strategies

The actions or interactions resulting from the axial phenomenon (i.e. strategies) are based on actions and reactions to control, manage, and deal with interest. In general, plans are purposeful and developed for a particular reason. There are always some intervening conditions promoting or restricting plans (Strauss and Corbin, 1990).

Table 3: Core coding in categories and concepts related to the core category

Conditions	Categories	Open coding	
Axial category	Psychological (architectural) factors on the decision to purchase renovated buildings	Renovation stages of the building	Demolition, construction, interior design
		Purchase decision stages	Need recognition, information search, option evaluation, purchase decision, post-purchase decision

Table 4: Consequences

Conditions	Categories	Open coding
consequences	Customer satisfaction	Customer needs assessment, customer recognition, design according to customer taste, customer loyalty, value creation for customers, understanding customer behavior
	Increase sales and marketing	Improving the building renovation market, increasing purchasing power, competitive advantage, market prosperity
	Healthy environment	Reduce construction, save energy

Axial category

An axial category is the same conceptual tag pondered for the developed framework or design. In Table 3, the central category around the main axis of the topic is placed then the codes assigned are specified.

RESULTS AND DISCUSSION

This section discusses the results and outcomes expected from the extracted factors that influence the marketing process performed by architecture firms. For extracting these outcomes, the interviews were classified into three categories during open coding phase using rigorous analyses. Such effects were categorized while agreeing with the main components to allow architects to understand the results of this research properly. When a building is scheduled to be renovated for selling, knowing the customer's strategies to decide to buy such buildings can significantly promote the renovation and sale of these buildings. Given a rise in the buying cost of new buildings, the housing renovation market will become gradually prosperous and will see more players compete with each other. Thus, many criteria will be developed to choose and buy these buildings. The customers' approach in facing a renovated building allows architects to implement their design in line with these components and their needs. It further allows architects to pick materials and colors more precisely, aiming to

significantly affect the customers' minds and make them satisfied. Besides the market flourishing and financial advantages, the effects of industrialization and the transformation of a developing society into a developed one have also come with some problems. This is because individuals prefer to live in places where there are multiple positive and fortunate sources of inspiration. In simple words, customers explore a place in which are able to relax with no trouble, have no distressing issues during everyday life, have access to sufficient light, etc. all of which affect the person's intention to purchase. Taking these factors into consideration brings value to customers. In general, customer would get astonished to understand (and include) such items in the design of a building. Given the identified psychological approaches, such a need assessment in the service market can revolt the architecture firms. In this regard, psychological architecture in the building renovation serves as a competitive advantage for architecture firms

Consequences

With an increase in public awareness and following the progress of sciences, environmental issues have become integral to society. A downward trend in construction and saving energy and minerals are among the leading ecological outcomes of building renovation.the consequences are shown in Table 4.

Axial coding

Axial coding aims to link categories extracted in the open coding stage. This is typically achieved using a paradigmatic model and helps theorists enter the theorizing process straightforwardly (Fig.1):

Selective encoding

Selective coding refers to selecting a core category, systematically relating it to other categories, validating those relationships, and filling in categories requiring further refinement and development. To this end, the strategic and influential categories were divided into four groups after the interviews and analyses were carried out. This model aims to investigate the effects of psychological (architectural) factors on customers' intention to purchase renovated buildings. This model was designed based on the extracted information and the obtained results Fig. 2.

Quantitative findings

A questionnaire was developed according to the extracted variables and submitted to the customers of architecture firms. The data were collected for model validation using the confirmatory factor analysis in Lisrel. The results revealed significant relationships between written factors and apparent variables. In simple words, since the significance levels for all components are >1.96, the relationships between the variables are confirmed. Numerous methods are available to estimate the overall Goodness-Of-Fit (GOF) of the determined model. Generally, several criteria were used to measure the model; however, three to five criteria are sufficient for model validation. Hence, various measures were used in this study to evaluate the GOF of the model. The Table 5. presents the frequency of each of these criteria is.

Lisrel software measures a value of "t" (Fig. 4.) for each parameter estimated in the model. This test specifies the parameters that can be removed from the model. In simple words, at a CI of 95%, the relationships for which the "t" value is >1.96 are validated. The overall structural model is illustrated in Fig. 3. Likewise, the coefficients of the research's main variables are depicted. Similarly, Table 6 presents the SEM results and the confirmation or rejection of the research hypotheses concerning the relationships between the research variables.

According to Table 6, needs and desires, variation in mood, identity, and internal motivation are rejected and excluded from the model. In other words, needs and desires (with a factor load
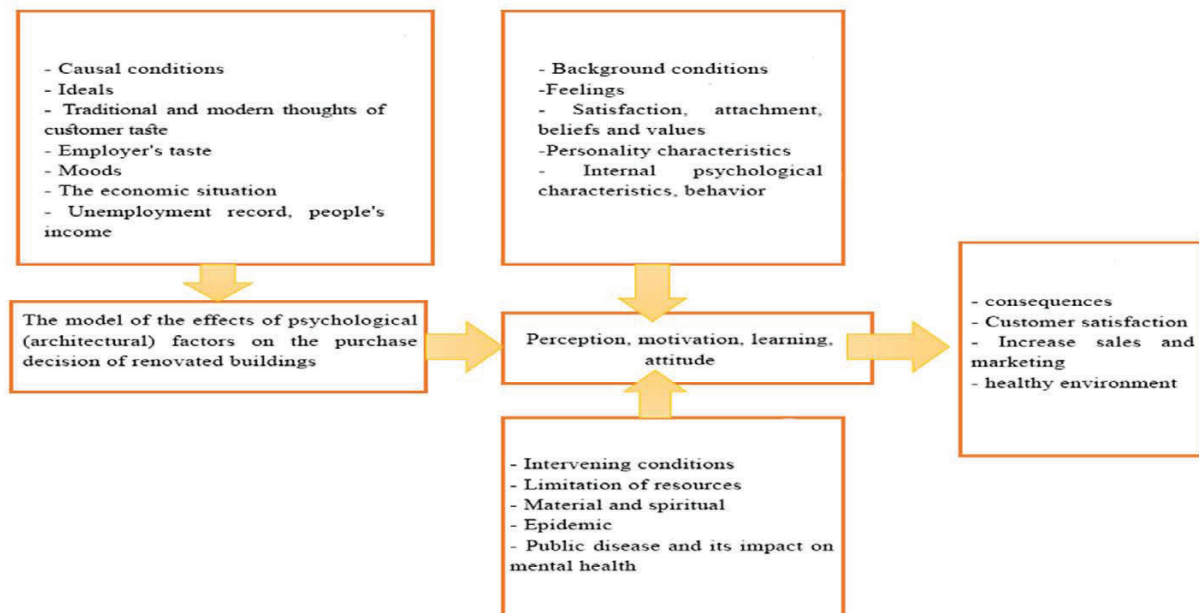

Fig. 1: The primary model of psychological (architectural) factors on the purchase decision of renovated buildings
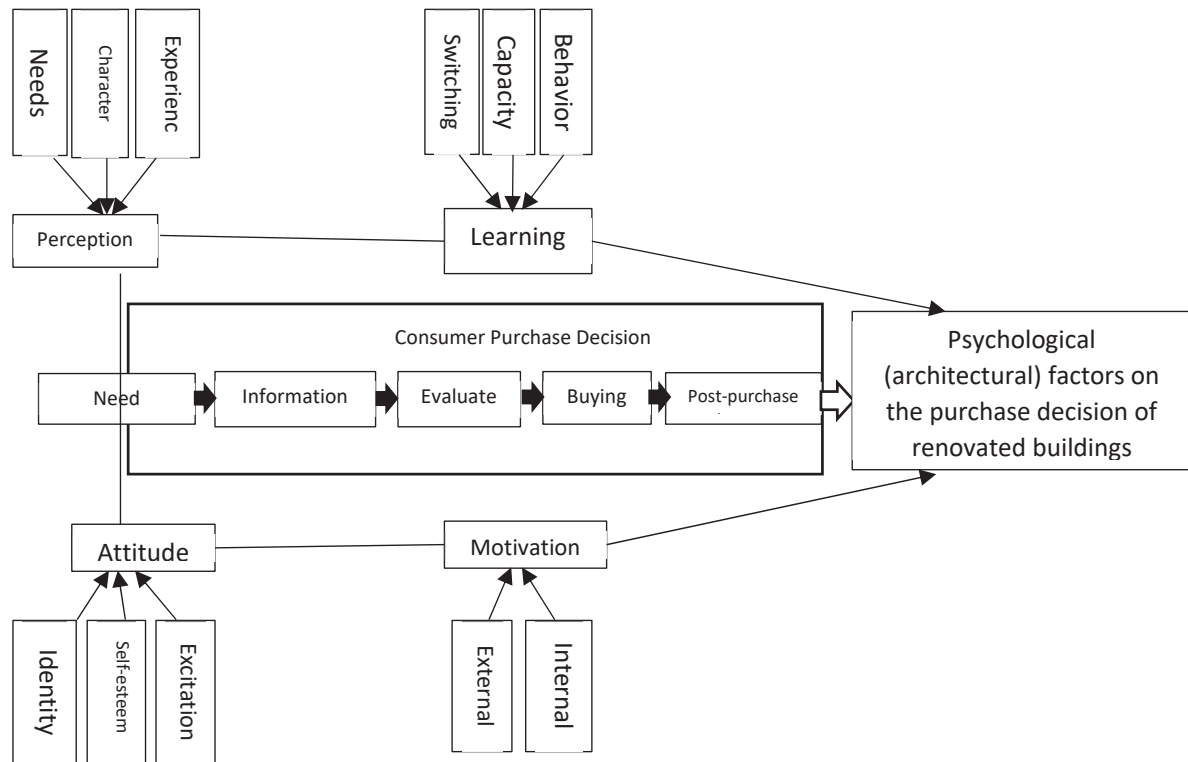
Fig. 2: The final model of psychological (architectural) factors on the purchase decision of renovated buildings

Table 5. Fitness index

Indicator	CFI	NNFI	NFI	GFI	AGFI	X^2 /df
Acceptance threshold	0.9<	0.9<	0.9<	0.9<	0.9<	3>
the amount of	0.92	0.91	0.85	0.93	0.89	1.801

of 0.31), variation in the person's mood, social and cultural status (with a factor load of 0.42), the identity of individuals (with a factor load of 0.32), and individuals' internal motivation (with a factor load of 0.49) have no effect on customers' intention to buy renovated buildings; hence, these factors were excluded from the model. The results of the output of the final model of this study are stated the architect, serving as a designer, needs to initially identify the human needs and collective behavior. Moreover, customer's perceptions can vary when encountering a renovated building for buying. In other words, such a perception is caused by each individual's needs and desires, personality, and life experience. Furthermore, personality is a key variable addressed by psychologists in their studies. The decision to buy renovated buildings is influenced by people's personality. Buying behavior is the result of each person's personality, which varies among people. This part of the research is consistent with Fathali and Kheyri (2014). individuals' overall experiences, either built in the previous living space or caused by a pleasing or disagreeable event, can be recall memories since visiting the renovated building.)According to the researches Sharghi, Motuf and Asadi (2017), Knox and Marston (2003), Kumar *et al.* (2020), Malter *et al.* (2020), Yuen et al. (2020), Abbas *et al.* (2018). Behavior change occurs within the environment due to a variation in the capacity or the state of the living space and refers to the effects that have involved the aspects of psychological architecture.
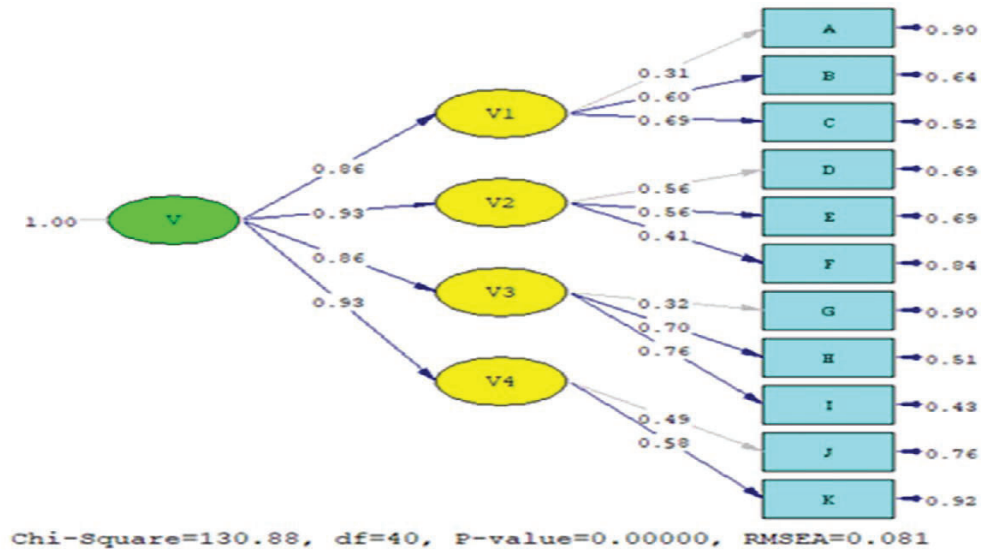
Chi-Square=130.88, df=40, P-value=0.00000, RMSEA=0.081

Fig. 3: Standardized model of confirmatory factor analysis of Lisrel software

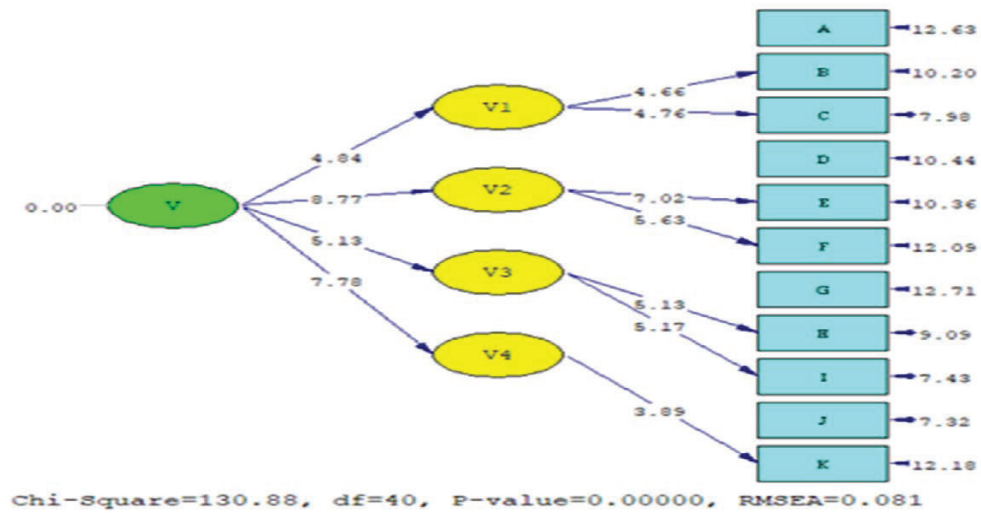Chi-Square=130.88, df=40, P-value=0.00000, RMSEA=0.081

Fig. 4: Path diagram t-values

Table 6: Relationships between research variables

Structures	The observers	t-value	Confirmatory factor loading	Reject/Confirm
Perception	Needs and Desires	-	0.31	Rejection
	Character	4.66	0.60	Confirm
	Experience	4.76	0.69	Confirm
learning	Switching	-	0.42	Reject
	Capacity change	7.02	0.56	Confirm
	Behavior change	5.63	0.56	Confirm n
Attitude	Identity	-	0.32	Reject
	Self-esteem	5.13	0.70	Confirm
	Excitement	5.17	0.76	Confirm ion
Motivation	Internal	-	0.49	Reject
	External	3.89	0.58	Confirm

The architects must ponder these factors in the customer's daily life, as well as in the design and renovation of buildings. (According to the researches Baron *et al.* (2014). Some examples of these factors include using calming colors, natural materials, appropriate lighting, and others. Typically, the individuals are exposed to unavoidable data, thus usually interpreting them in line with their attitudes. When a recently renovated building concluded, attitudes can be developed by persons in line with the renovated building. On the other hand, a pre-developed perspective has multiple beneficial applications for a class of stimuli, such as identity and self-esteem, which could affect a person's attitudes in purchasing decisions. Excitements are not unreasonable as they appear. This part of the research is consistent with Baron *et al.* (2014), Bonner *et al.* (2011). Indeed, excitement arising from the correlation between the brain and the environment. They unconsciously necessitate evaluating the environment and acting based on the assessment made. A couple of factors such as the interior design would inspire people's decision while purchasing a building. the present study agrees with the studies conducted by Kumar *et al.* (2020), Malter *et al.* (2020), Yuen *et al.* (2020), Abbas *et al.* (2018), and Lawrence (1982).

CONCLUSION

Since renovation has many environmental, economic and social achievements, and architects have faced serious challenges in the renovation of buildings during the past decades, the findings of this research showed that in order to maintain the originality of the urban environment as well as satisfaction Citizens, managers of architecture companies and senior officials of urban planning can make the right decisions by using the methods reviewed to encourage citizens to buy renovated buildings. Customer needs assessment in the building renovation allows for understanding customer needs, and leads to a design tailored to the customer's preference. Further, considering psychological factors in this area provides customer loyalty and value creation for the customer, resulting from understanding customers' behavior. In other words, the inclusion of psychological factors acts as a competitive advantage for architectural design firms, thereby improving the

building renovation market and enhancing the success of these firms. The final components of this research show the general stages of the consumer's purchase intention, which covers all aspects of the research topic in the purchase of renovated buildings. This is a general model and can be used and analyzed in the most areas of urban architecture. Such steps are introduced to purchase decisions, including need assessment, information search, and evaluation of items, purchase decision, and post-purchase decision. Such a process is also followed in the purchase of renovated buildings. Accordingly, the customer first feels need to buy a building. Then, necessary information is searched by using different offline or online channels. When the data required is obtained, the customer evaluates the available options and decides to buy based on the investigations. Generally, architects require comprehensive data from customers in order to design the needs that are matched with the personality characteristics and individual differences of each person. Thereby, the features of the environment can be designed based on the needs of customers. developing a standard model of the available architectural styles that includes the customers' preferences, while considering the operating budget and the materials used for renovation, is also influential. Using natural materials (e.g. wood and stone) and getting inspired by nature to achieve peace and link life to nature could allow architecture firms to enter a new phase of psychological architecture activities. Efficient marketing by these firms providing added value for the building (e.g. smart home systems, internal lighting and aesthetic aspects , eye-catching materials, and home green space) can trigger customers to buy renovated buildings, concerning the psychological architecture factors. Customers' decision to buy can be affected by providing explanations in simple, non-technical language and using software to model building data. In order to strengthen the components in this field, there is a need for synergy with coordination between legislators and municipalities regarding the support of renovation of buildings and their interaction with architecture companies and finally advertisements to encourage and motivate people to implement it. These measures will include customer satisfaction and greater profitability,

as well as social and civic responsibility, which includes preserving the environment, using renewable resources, reducing greenhouse gas emissions, and maintaining the authenticity of the urban environment. These achievements facilitate the scientific progress of researchers in this field so that they can reach newer knowledge in this field by relying on interdisciplinary knowledge. It should be noted that due to the pandemic conditions, this research had limited access to the companies due to the working distance of some managers and the geographical dispersion of architectural companies, the researcher faced access challenges. It is suggested that researchers in future studies should study more specific and similar geographical areas according to the region and income level. Also, it is recommended to focus on architectural marketing factors in future studies in such a way that people instead of selling own houses and buy renovated buildings, they themselves, with the help of an architectural company, will renovate the houses they are living in to reduce the risks of selling and buying a new house.

AUTHOR CONTRIBUTIONS

H.Rahimi Jafari performed research literature, interviewed the experts, the manuscript text and manuscript edition. A. Faez controlled the process of interviewing experts and reviewed research literature. Y.vakil alroaya analyzed and interpreted the data and selected interviewees. M. D. Hosamane controlled the project process and reviewed the research literature.

ACKNOWLEDGEMENT

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

OPEN ACCESS

PUBLISHER'S NOTE

IJHCUM Publisher remains neutral with regard to jurisdictional claims in published maps and institutional afflictions.

ABBREVIATIONS (NOMENCLATURE

SEM	Structural Equation Modeling
GT	Grounded Theory
CVR	Content Validity Ratio
GOF	Goodness-Of-Fit

REFERENCES

Abbas, A.; Afshan, G.; Haq, T.; Aslam, I., (2018). Effect of customer's psychological factors leading to purchase on online shopping: A study from the perspective of e-commerce in underdeveloped countries. Asian Res. J. Bus. Manage., 3(5): 34-44 (**11 Pages**).

Allport, G. W., (1954). The Nature of Prejudice. Addison Wesley.

Anwar, N.; Najam, A., (2017). Structural Cross Sections. Butterworth-Heinemann.

Baron, R.; Byrne, D.; Brenskamp, N., (2014). Social psychology, translated by Karimi, Y., Ravan. Iran-Tehran. (In Persian)

Bonner, J.; Wank, M., (2011). Attitude and attitude

change, translation: Tahourian, J. Rushd. Iran-Tehran. (In Persian)

Cheuk Fan Ng., (2020). Perception and Evaluation of Buildings: The Effects of Style and Frequency of Exposure. Collabra: Psychology, 6(1): 44 (**1 Page**s).

Chatterjee A.; Vartanian O., (2014). Neuroaesthetics. Trends Cognit. Sci. 18(7): 5-370 (**366 Pages**).

Choi, J.; Choi, J., (2022). Technical feasibility study model of aged apartment renovation applying analytic hierarchy process. J. Civ. Eng. Manage., 28(1): 39-50 (**12 Pages**).

Coburn, A.; Vartanian, O.; Kenett, Y.; Nadal, M.; Hartung, F.; Hayn-Leichsenring, G.; Navarrete, G.; González-Mora, J.L.; Chatterjee, A., (2020). Psychological and neural responses to architectural interiors. Cortex., 126: 217-241 (**25 Pages**).

Creswell, J.W., (2005). Educational research: planning, conducting, and evaluating quantitative and qualitative Research. (2nd edition).

Daneshpour, A.; Charkhchian, M., (2007). Public spaces and factors affecting community life, Bagh Nazar J., 4(7): 19-28 (**10 Pages**). (In Persian)

Dimapur, S., (2016). Architectural psychology. In book: Art and culture and gender, 1: 67-70 (**4 Pages**).

Fathali, M.; Kheyri, B., (2014). Investigating the effect of demographic and psychological characteristics on purchase intention, J. Modern Market. Res., 4th year, 3(14): 161-188 (**28 Pages**). (In Persian)

Ganji, M.; Ganji, H., (2010). The psychology of Atkinson and Hilgard, Savalan Publishing. (In Persian)

Groter, Y., (2014). Aesthetics in Architecture, translated by J. Pakzad and A. Homayoun. Shahid Beheshti University Printing and Publishing Center, Tehran. (In Persian)

Gross, R., (2012). Psychology: The science of mind and behaviour 7th edition: Hodder Education. Amazon Digital Services LLC.

Habibi, M.; Maghsoudi, M., (2020). Urban restoration, Tehran University Press, Tehran. (In Persian)

Hosseini, E.; Tajpour, M.; Lashkarbooluki, M., (2020). The impact of entrepreneurial skills on manager's job performance. Int. J. Hum. Capital Urban Manage., 5(4): 361-372 (**12 Pages**).

Hajizadeh, I.; Asghari, M., (2011). statistical methods and analyzes with a view to research methods in biological and health sciences. Academic Jihad Publications, Iran-Tehran. (In Persian)

Hellpach, W., (1924). Psychologie der Umwelt/ von Willy Hellpach. Handbuch der biologischen Arbeitsmethoden Abt. VI, Teil C1. Urban & Schwarzenberg o. J. ca. Germany.

Karban, R., (2015). Plant sensing and communication. University of Chicago Press. ISBN 9780226264844.

Kanfer, R., (2009). Work motivation: identifying use-inspired research directions. Indust. Organ. Psychol. 2: 77-93 (**19 Pages**).

Kanfer, R.; Frese, M.; Johnson, R., (2017). Motivation related to work: a century of progress. Appl. Psychol. J., 102: 338–355 (**18 Pages**).

Knox, P.; Marston, S., (2003). Human geography places and regions in global context New Jersey: Pearson Education Inc.

Kumar, A.; Chaudhuri, S.; Bhardwaj, A.; Mishra, P., (2020). Impulse buying and post-purchase regret: a study of shopping behavior for the purchase of grocery products. Int. J. Manage., 11: 614–624 (**11 Pages**).

Lawrence, R., (1982). A psychological-spatial approach for architectural design and research, J. Environ. Psychol., 37-51 (**15 pages**).

Lee, J., (2001). A Grounded Theory: Integration and Internalization in ERP Adoption and Use, ETD Collection for University of Nebraska - Lincoln.

Luttrell, A.; Sawicki, V., (2020). Attitude strength: Distinguishing predictors versus defining features. Social Personality Psychol. Compass, 14(8): 1-16 (**16 Pages**).

Mansoori, A.; Yavari, Z., (2003). A tool for transmitting customer voice to the QFD product design and development process, Sheikh Baha'i Res. J., 3: 72-91 (**20 Pages**). (In Persian)

Marshall Reeve, J., (2007). Motivation and excitement. Translated by Y. Seyed Mohammadi. Publishing House, Tehran, 7th Edition. (In Persian)

Malter, M.; Holbrook, M.; Kahn, B.; Parker, J.; Lehmann, D., (2020). The past, present, and future of consumer research. Market. Let. J., 31: 137–149 (**13 Pages**).

Mohammadi, J.; Alizadeh, J.; Rahimi, H.; Afsharipour, A., (2016). Investigating the effect of the level of satisfaction with the quality of life on the feeling of social security (case study: Aslandoz village-city), 5(3): 21-34 (**14 Pages**). (In Persian)

Neisiani, B.A.; Seyedan, S.M.; Radfar, E., (2016). Urban green spaces assessment approach to health, safety and environment. Int. J. Hum. Capital Urban Manage., 1(2): 123-132 (**10 pages**).

Rahimi Jafari, H., (2021). A review of architectural research in marketing, the third national conference on new studies in entrepreneurship and business management, Semnan. (In Persian)

Ricci, N., (2018). The psychological impact of architectural design. CMC Senior Theses. 1767.

Roodani, A.; Rahman Seresht, H., (2010). Incentives affecting the choice of brands in the insurance industry. Insur. Res. J., (Insurance Industry)., 25(2): 3-25 (**23 Pages**). (In Persian)

Scally, A.J., (2013). Critical Values for Lawshe's Content

Validity Ratio: Revisiting the Original Methods of Calculation. Meas. Eval. Couns. Dev. J. 47(1): 79-86 (**8 pages**).

Sear., (1991). (2011). Principles of psychometrics and psychoanalysis. Translated by H. Pasha Sharifi. Rushd, Tehran, 8th edition: 413 (**1 Page**). (In Persian)

Sharghi, A.; Motuf, S.; Asadi, S., (2017), analysis of the role of risk perception on environmental behavior during earthquakes in Ganj Ali Khan Complex and Kerman Bazaar. Iran. Islamic City Stud. J., 7(28): 77-85 (**9 Pages**). (In Persian)

Strauss, A.; Corbin, J., (1990). Basics of qualitative research: grounded theory procedures and techniques, Sage Publication.

Yuen, K.; Wang, X.; Ma, F.; Li, K., (2020). The psychological causes of panic buying following a health crisis. Int. J. Environ. Res. Public Health, 17(10): 3513 (**1 Page**).

Zhu, L.; Wang, Q.; Xu, J.; Wu, Q.; Jin, M.; JunLiao, R.; HaiBin.; Wang., (2017). The present of architectural psychology researches in china-based on the bibliometric analysis and knowledge mapping. In IOP Conference Series: Earth Environ. Sci., 128(1): p. 012043). IOP Publishing.

Performance optimization in bitumen properties from different sources modified with shredded tier waste

G. Aladekoyi[1,*], E.G. Olumayede[2], D. Malomo[2]

[1] Department of Science Laboratory Technology, Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria

[2] Department of Industrial Chemistry, Federal University, Oye - Ekiti, Ekiti State, Nigeria

ARTICLE INFO

ABSTRACT

BACKGROUND AND OBJECTIVES: Optimization of bitumen with Polymer modification such as a shredded tier, which serves as a waste in the environment has been used for road pavement to minimize common failure mechanisms associated with roads. The objectives aimed at using a shredded tier to modified bitumen (STMB) in ratio10:90, 20:80, 30:70, 40: 60, and 50:50, from Shredded tier were added to bitumen from Agbabu and Loda to study their performances when applied in the construction industry.
METHODS: Bitumen, which was obtained from Odigbo and Irele Local Government Area of Ondo State, Nigeria, was mixed at 3000C for two hours at different proportion with a shredded tier. Characteristics such as Penetration, Viscosity, melting point, marshal Stability, specific gravity and mechanical properties were determined.
FINDINGS: Marshall Stability (kg) at 600C increased with an increase in shredded tier modified bitumen from10% to 40% improved performance in both modifications and reduced in a 50% increase. This indicated that the increased in shredded tier reduced the measured value of penetration after the attainment values of 40:60 blends. This interaction between the bitumen-tier blends has a penetration value adequately agreed with the predicted value by the penetration index model. The rheological properties from different proportions at temperatures ranging from 45^0C to 65^0C at 40% modification were observed to have the least rutting parameter at 3.9 (G*/Sin δ (kPa) in Agbabu and 2.91(G*/Sin δ (kPa) in Loda for defects accountable to paving deformation and ageing as there was a decrease in the rutting parameter with the increase in temperature generally.
CONCLUSION: Generally, the values obtained for the physico-mechanical properties increased with an increase in modifiers from 10% to 40% modification in the two samples. Though, Agbabu is preferable and economical due to the percentage yield for road construction.

NUMBER OF REFERENCES

37

NUMBER OF FIGURES

9

NUMBER OF TABLES

3

*Corresponding Author:
Email: gbenga_aladekoyi@rugipo.edu.ng
Phone: +2348034651804
ORCID: 0000-0001-5714-0192

Note: Discussion period for this manuscript open until April 1, 2023 on IJHCUM website at the "Show Article.

INTRODUCTION

Modern society today is looking for a way of dealing with the disposal or recycling of solid waste produced by human activity (Bianchi et al., 2014, Martinez *et al.*, 2014). Also, scrap tires have been a great issue due to its major contribution to environmental pollution that they cause as explained by Rowhani and Rainey, (2016). The use of waste tire for modification may be one of the successes in getting them out of the environment instead of burning them. Modification of bitumen with polymer in recent time has become a mutual practice in road pavement (Masson *et al.*, 2005, Behera *et al.,* 2020). Therefore, the failure observed in the use of conventional bitumen as a result of its rheological properties has engendered a cumulative curiosity in finding and usage of polymer-modified binders to enhance conventional bitumen properties (Gonzalez *et al.,* 2010; Mohamed *et al.,* 2009). Most Studies from Anderson *et al.* (1993); Chen *et al.* (2002); have reported that bitumen modification produces products of good and improved performances; which invariably bitumen by itself cannot perform ultimately. Also, report from Yu *et al*, (2019) explained the modification effect of preparation of graphene oxide on base asphalt and Liu et al, (2018) emphasized on the use of graphene oxide and warm mix additive on mechanical performance and modification mechanism of asphalt. Bala *et al.,* 2020; Xin *et al.,* 2020; Wu *et al.,* 2021 have also adopted the composite modification to improve the performance of bare asphalt with the believe that modifying Asphalt by a single polymer may has some defects. These performances include improvement in fatigue resistance and performance in the high temperate regions with heavy traffic conditions, and this reduced the life cycle cost. Also, a softer mixture of modifiers with bitumen can improve the performances at low service temperatures with minimum cracking. According to Anderson *et al* (1993), polymer-modified bitumen augmented the elasticity of the combination and also the viscosity at high temperatures. A study indicated that the addition of Styrene-Butadiene-Styrene (SBS) to bitumen as explained by Chen *et al.* (2002) and Masson *et al.* (2005) observed a reduction in cracking and rutting of the mix. Similarly, the addition of Polyethylene Wax (PW) to bitumen has been explained Garcia-Morales *et al* (2004) and Polacco *et al* (2005), who observed a decrease in the rutting of the asphalt in the pavement. Transitorily, Crumb Rubber had been proven to decline cracking and rutting, but there is a reduced level to what can be reached when using SBS or PW (Gonzalez *et al.,* 2010; Frantzis, 2003; Yildrim, 2007). Although, modification of bitumen is frequently performed by the addition of thermoplastic or elastomers polymers as explained by Munera and Ossa, 2014, using numerous materials. Notwithstanding, the improvements in bitumen properties are not easy to study with the utilization of other Plastomeric polymer materials such as polyethylene and polypropylene as potential fillers in bitumen for use in road paving (Mohamed *et al.,* 2009). Tires contain are made up of large amount of rubber, which is a polymeric material, this can be used as feed stock material renewable polymeric products as explained by Rowhani and Rainey, (2016). To achieve this, the scrap tires (polymeric raw material) is required to be shredded or ground beforehand (Rowhani and Rainey, 2016).

Bitumen Failure in Pavement

The paramount problems that are related to the degradation of bitumen normally used in pavements are grouped into three categories, namely thermal cracking; surface deformations, which are due to the viscoelastic behavior of the material used, and surface defects. The two major failure mechanisms associated with asphalt mixtures are cracking and rutting, which leads to permanent deformation.

Cracking is usually recognized with brittle fracture of bitumen at low temperatures, but rutting is related to plastic or viscous behavior of bitumen at high temperatures. Bitumen has been typically modified by the addition of elastomeric polymers to reduce cracking. This usually requires mixing and shearing at high temperatures for uniform dispersal of the polymers into the bitumen blends (Chen *et al*., 2002; Navarro *et al.,* 2004; Masson *et al.,* 2005). Roberts *et al.,* (1991), describes bitumen behavior in terms of its failure mechanism and describe each failure mechanism as a function of bitumen's basic molecular chemistry.

Aging

Aging can be reversible and irreversible. Irreversible aging is generally connected with oxidation at the molecular level. Oxidation courses increase in bitumen viscosity with age, and it will get to a point when the bitumen will be able to reduce oxidation through the immobilization of the important chemically reactive elements present (Masson *et al.,* 2005). Reversible aging is emanated from the effect of molecular

organization. As a result of this, the molecules within bitumen will gradually reorientate themselves into a more shaped and bound system. The result of this is stiffer, and the formation of more rigid material. This form of aging can be reversed by applying heat with constant agitation. The removal of oily constituents like resins or asphaltenes, which is a major component f bitumen by selective absorption of some porous aggregates is termed separation. Also, there are no direct means of measuring bitumen aging, but aging effects are obtained by subjecting bitumen aggregates to simulated aging, and then conducting other known standard physical tests on it such as Viscosity, Dynamic Shear Rheometer (DSR), Bending Beam Rheometer (BBR), and The Direct Tension Test (DTT). Simulating the effect of aging is paramount because bitumen possesses a certain set of properties in its original state, which may show a different set of properties when aging, which is Short-term aging and Long-term aging as described by Vallerga *et al,* (1967). Types of Aging Simulation Tests are the Thin Film Oven (TFO) Test, Rolling Thin-Film Oven (RTFO) Test, and Pressure Aging Vessel (PAV) Test respectively.

Stripping

Polar molecules (positively charged on one side and negative on the other side) allows the bitumen adheres to aggregates because the properties within the bitumen are attracted to the polar molecules on the surface of aggregates (Masson *et al.,* 2005). It is known also that certain polar attractions are known to be interrupted by the water itself, which is polar. Moreover, the polar molecules in bitumen will change in their ability to bind to any particular type of aggregate, and this can result in the disintegration of the molecular structure (Chen *et al*., 2002).

Moisture Damage

Because it is a polar molecule, this reveals that water is readily recognized by the polar bitumen molecules. The presence of water can cause stripping and decrease bitumen Viscosity. It behaves typically like a solvent in bitumen and this results in a reduction in strength and increased rutting (Navarro *et al.,* 2004). A chemical view of it revealed that water should have a greater negative effect on older or aging bitumen. Oxidation causes aging, so, it makes bitumen have more polar molecules than necessary (Chen *et al*., 2002). The more polar molecules residing in bitumen, the more it will readily accept water. Therefore, this will set in an increase in the disintegration of the binding structure of the molecule.

Thermal Cracking

It is observed that normally fluid non-polar molecules begin to organize into a structured form at lower temperatures (Navarro *et al.,* 2004). The combination with the already structured polar molecules makes bitumen more rigid and probable to fracture relatively to deforming elastically under stress. Thermal cracking can emanate in all climates, be it hot or cold (Chen *et al*., 2002). Though, this is pronounced when there is temperature variation between day and night, also between summer and winter creating the risk of cracking increases with aging -induce brittleness.

Fatigue Cracking

Molecular networks can be too organized and rigid, if this exits bitumen will fracture instead of deforming elastically under stress. Therefore, bitumen with a more percentage of polar and network-forming molecules can be more prone to fatigue cracking (Chen *et al*., 2002). Also, cracking can lead to surface damage and road-based deformation. The constant destruction is equally caused or induced by traffic, thereby initiating cracks and ultimately resulting in pothole formation.

Rutting and Permanent Deformation

It is possible for the molecular network to be relatively not interconnected, in this situation, bitumen will tend to deform inelastically under heavy traffic and high temperature, and most of the deformations are irreversible (Navarro *et al.,* 2004). Moreover, bitumen with a higher percentage of non-polar dispersing molecules will flow better and deform plastically because the various polar molecules network pieces can be more relative to one another due to the higher percentage of fluid in non-polar molecules. An unexpected movement of vehicles and deliberate elusive action by driving on the shoulder of the road also results into Rutted roads. Accumulation of water in the ruts resulted in the aqua plane, causing skidding and reduced visibility reflections (Navarro *et al.,* 2004).

Used Tiers

Tiers is made for their use on vehicles; they are not made as a recycling industry feedstock. Their composition makes them difficult to recycle. The Table1 showed the composition of tiers, their toxicity (or lack of

Table 1: Composition of Tier (WRAP, 2006)

Compositions%	Car Tier%	Lorry Tier%	OTR Tier%
Rubber/Elastomers	47.00	45.00	47.00
Carbon Black	21.50	22.00	22.00
Metal	16.50	25.00	12.00
Textile	5.50	--	10.00
Zinc Oxide	1.00	2.00	2.00
Sulphur	1.00	1.00	1.00
Additives	7.50	5.00	6.00
Total Carbon-based materials used = 4			

toxicity), and the likely result of processing for recycling by shredding and grinding for modification.

Tire as Polymeric materials for bitumen modification

Plastomeric polymeric materials, namely Polyethylene (PE) and Polypropylene (PP) have induced great interest among engineers, builders, and manufacturers for use in road paving and roofing felt modification because of their viscoelastic properties and good adhesion to mineral aggregates in the bitumen (Al-Hadidy and Yi-Qiu, 2011; Pasetto and Baldo; 2010 and Yoon *et al*., 2006). The major reason for using polymers in asphalt concrete is to increase binder stiffness at maximum service temperatures and reduce the stiffness of asphalt at low service temperatures (Chen and Qian, 2003; Goodrich, 1991, Mull *et al.,* 2002). Polymer materials normally used for the modification of asphalt concrete can be divided into three major categories: these are thermoplastic elastomers, plastomers, and reactive polymers respectively (Metcalf *et al.,* 2000). Thermoplastic elastomers are ostensibly capable of having high elastic response characteristics and therefore resist permanent deformation by stretching and are able to recover their initial shape on the modified binder layer, whereas, plastomers are reactive polymers modifying asphalt by forming a tough, rigid, and three-dimensional network in order to increase stiffness and decrease deformations (Airey, 2004). The aim of this study is to modify bitumen with shredded tier crumbs for application in road pavement. Since it is difficult to recycle tire directly because of their component, the effective way of removing them from the environment is to use them as modifier of bitumen for road construction. The objectives of the study are to extract bitumen from samples collected from Agbabu and Loda, modify the obtained bitumen using different proportions of shredded tier waste crumbs at different percentages, determine the physico-mechanical properties and rheological parameter of extracted bitumen and polymer modified bitumen and to determine the optimum bitumen content suitable for filler in road construction. The current study has been carried out in chemistry laboratory in Federal University, Oye-Ekiti, chemistry laboratory and civil engineering workshop in Rufus Giwa Polytechnic, Owo, Ondo State in 2022.

MATERIALS AND METHODS

Collection and Preparation of Raw Samples

As indicated in Fig.1, raw bitumen and tar Sand samples used for this work were obtained from Agbabu and Loda in Odigbo and Irele Local Government Area, Ondo State, Nigeria. The two samples were collected randomly at the different point sources, so as to obtain good representative samples. Agbabu, as indicated in the map is located at latitude 6^035:19N and Longitude 4^050:3E in the tropical savanna of Nigeria. The raw bitumen from Agbabu and tar sands from Loda were extracted using Soxhlet extraction method and carbon disulphide as a solvent. These were stored in a clean container for further analysis.

Collection of Used Tire Waste

Used tier waste was obtained from a local vulcanizing dumpsite (Fig. 2)**,** in Owo town, Ondo state, Nigeria. A shredding machine was used to shred it to particle sizes. Fig. 3 revealed the pieces of tier and Fig. 4 revealed the shredded used tier after shredding.

Preparation of Polymer-Bitumen Blends

The extraction of bitumen samples from the bituminous oil was done using the Soxhlet extraction process and carbon disulphide as a solvent. A method explained by Fawcett *et al.,* (1999) was followed to have a homogenized polymer- bitumen blends. 200grams of shredded tier waste were mixed in ratios 10:90, 20:80,

30:70, 40:60, and 50:50 to extract bitumen sample from both Agbabu and Loda using a mechanical mixer Heidolph model RZR 2020. The mixtures of the different ratios were heated in a thermosetting oven at 300^0C for two hours. The temperature ensures that both polymers and bitumen were always above their softening point and temperature. The mixtures were brought out and blended together mechanically while still hot at a speed of 2000±10rpm. Mixing at high temperatures are required in order to have uniformly dispersed polymers in the blends. It was cooled at room temperature to solidify. Rheological properties of the resulting sample were determined: the penetration test, Viscosity, melting point, and marshal Stability were carried out by ASTM (2021), and specific gravity was determined according to AOAC (2000) (contact the textbooks for experimental details).

RESULTS AND DISCUSSION

Fig. 5 shows the variation of measured values of penetration for the different bitumen-tier blends. It can be observed that an increased amount of shredded tier waste (STW) increases the measured value of penetration attainment values (59.40) at 40:60 bitumen blends before diminishing. The interaction between the bitumen-tier blends can be calculated with routine test data Penetration Index (PI) as explained by Munera and Osa (2014) as of Eq. 1:

$$PI = \frac{1952 - 500 \log(Pen_{25}) - 20SP}{50 \log(Pen_{25}) - SP - 120.} \tag{1}$$

Where Pen_{25} is the penetration value at a specific softening point (SP).
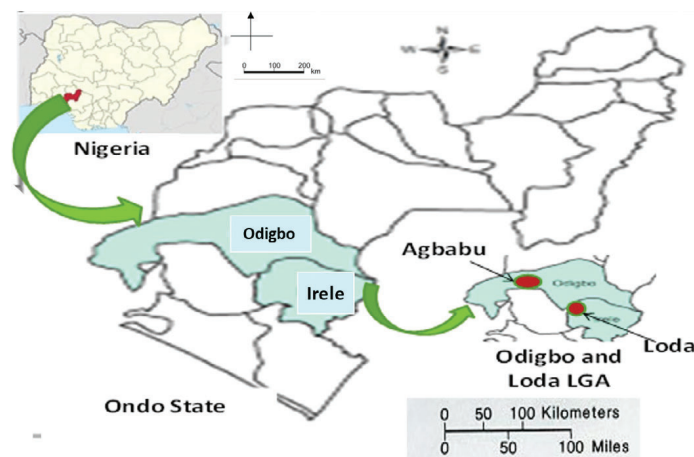

Fig. 1: Geographic location of the study area in Agbabu and Loda in Odigbo and Loda L.G.A., Ondo State, Nigeria

Fig. 2: Vulcanizing Used tyre dumpsite

Fig. 3: Pieces of used tier

Fig. 4: Shredded tier

Intermolecular interaction between the modifiers in Agbabu and Loda with Shredded tier showed that penetration value statistically correlated with polymer concentration. The correlation between the modifiers in Agbabu and Loda bitumen with shredded tier waste showed that penetration value is correlated with polymer concentration.

This indicated that adding a certain amount of modifier to bitumen above 40% can slightly decrease the shear stiffness. This is an indication of the ability to withstand the pressure that may act on it and this is higher in Agbabu bitumen. Fig. 6 shows the result from the specific gravity of bitumen modified with the shredded tier at different compositions. The specific gravity value (0.9754) obtained for raw bitumen in this study was comparably within the permissible limit of >0.99 as set by the Indian Standard Institute for paving bitumen Specification (IS: 73, 2001). However, there was a significant difference from the value (1.03) obtained by Sharma *et al*, (2012). An increase in modifier concentration seems not to show any impact on the specific gravity of modified bitumen. The result revealed that modified bitumen remains constant despite an Increase in modifier concentration, though there is a significant difference between the raw bitumen and the modified bitumen. The value obtained in raw bitumen indicated that there is no significant difference from the raw value (0.9517) obtained by Sharma *et al*, (2012). The value was comparably within the permissible limit of >0.99 as set by the Indian Standard Institute for paving bitumen Specification (IS: 73, 2001).

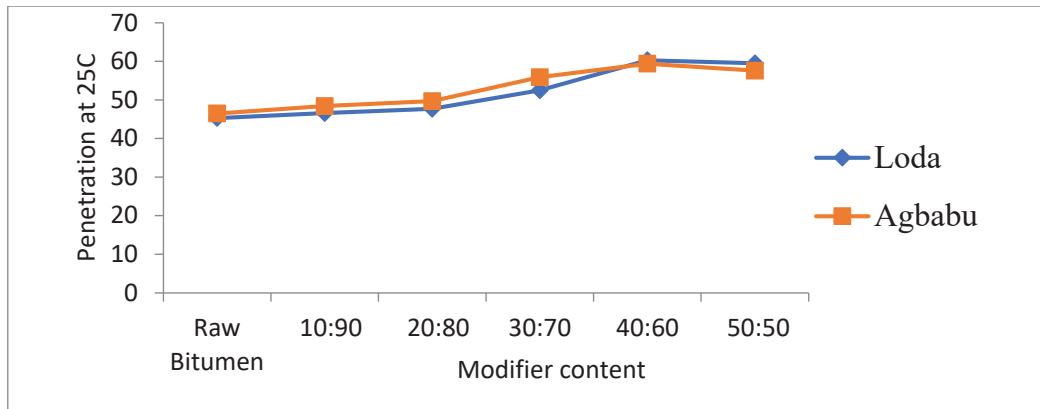From the Fig. 7, there is no significant increase in the

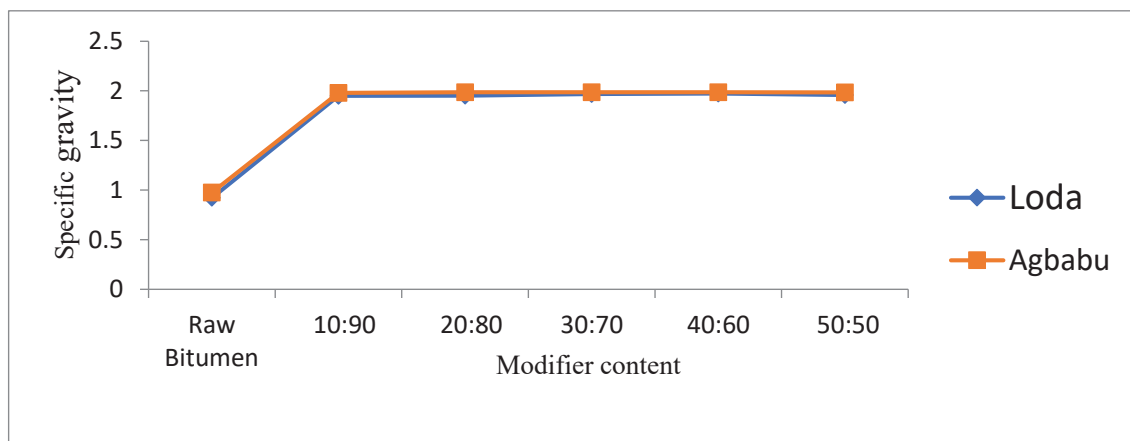Fig. 5: Penetration in raw bitumen and modifier content

Fig. 6: Specific gravity in raw bitumen and modifier content

bitumen modification from Loda from the raw sample, but there is a slight increase in viscosity in Agbabu modification at 30:70 (11.571) before reduction. The reduction in viscosity can be attributed to a significant reduction in the surface tension between the bitumen aggregate and binders which results in expelling air and increasing interfacial cohesion between the bitumen properties and modifier aggregate as explained by Huh, (2012) that when the surface tension is reduced, air is expelled, and viscosity is affected between the aggregates and binders.

Fig. 8 presents the softening point measured for each of the blends as a function of modifier concentrations. A suggestion by Highway engineers have indicated 2℃ temperature difference as the maximum temperature for monitoring polymer modifies bitumen stability (Huh,

2012). It was observed from the results that the blend with 40:60 had the highest softening point temperature, reaching up to 65^0C. At a 40:60 ratio, blends increase the softening point to 73.2 and 67.16 in Agbabu and Loda bitumen modifications. Similarly, at 50:50 blends the decreases in softening point are 72.78 and 64.01 in the bitumen-shredded tier from both samples respectively. This implies that at 40:60 loading, the shredded tier showed appreciable softening for Loda and Agbabu. This is an indication that shredded tier modifiers are compatible with raw bitumen.

Fig. 9, presents the mean values of Marshall Stability for various blends of shredded tier. The highest mean value was observed at a ratio of 40:60 modification. This ratio has the most significant impact on the Marshall characteristics of the blends. This trend can be attributed
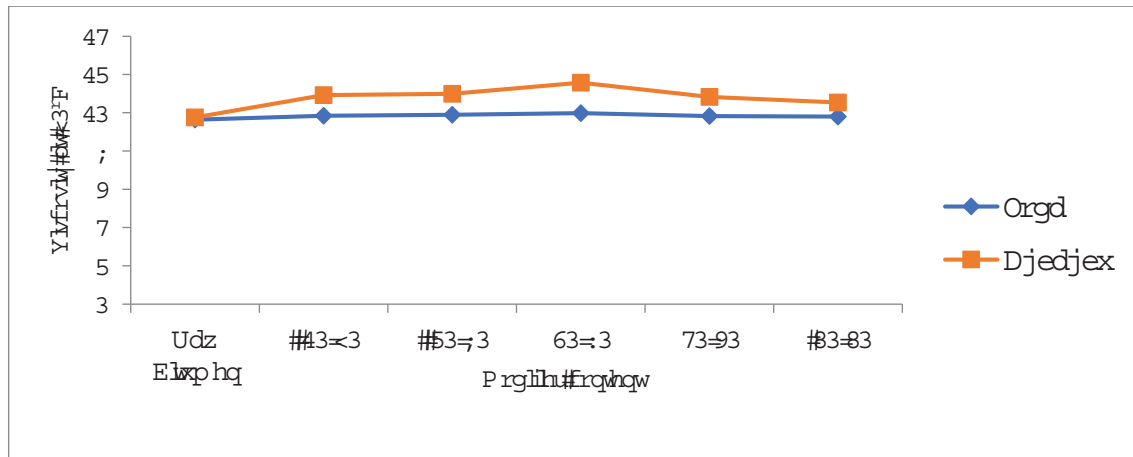
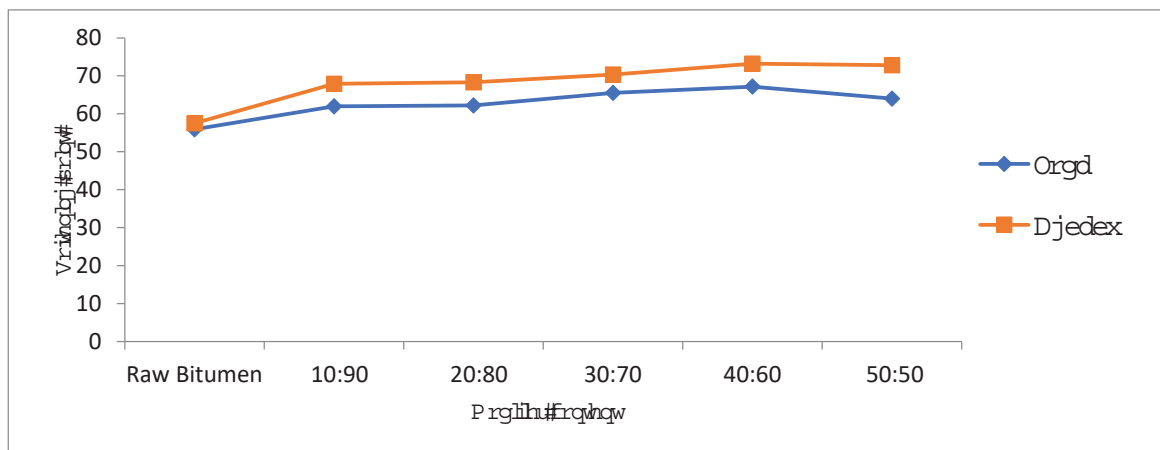Fig. 7: Viscosity in raw bitumen and modifier content

Fig. 8: Softening point in raw bitumen and modifier content

to the size effect of the modifiers used. The implication of this is that there might have been an increased in the stiffness of the modified bitumen to soil aggregates.

Rheological properties

Rheological properties (complex modulus, phase angle, and rutting) of bitumen polymer blends as a function of modifier concentrations are shown in Tables 2 and 3 for Shredded Tier-Modified Bitumen (STMB) from Agbabu and Loda respectively.

a) Complex modulus: The complex shear modulus (G*) is defined as a measure of a material's total resistance to deformation when it is constantly sheared. In this study, the complex modulus (G*) was measured

as a function of the frequency at a temperature of 40^0C for base bitumen and at various blends. The maximum complex modulus was 3.90 at a 40:60 ratio at 65 ^{O}C in both Agbabu and Loda, subsequent to this, there was a considerable decrease in complex modulus as modifier concentration increased. This is a suggestion that maximum shear stress and shear strain due to improvement in intermolecular forces binding modifier to bitumen is at a 40:60 ratio and at 65 ^{O}**C**.

b) Phase angle: Phase angle (**δ**) measurements are generally considered to be more profound to the chemical structures as can be observed in the Tables 2 and 3 for STMB respectively. The trend observed
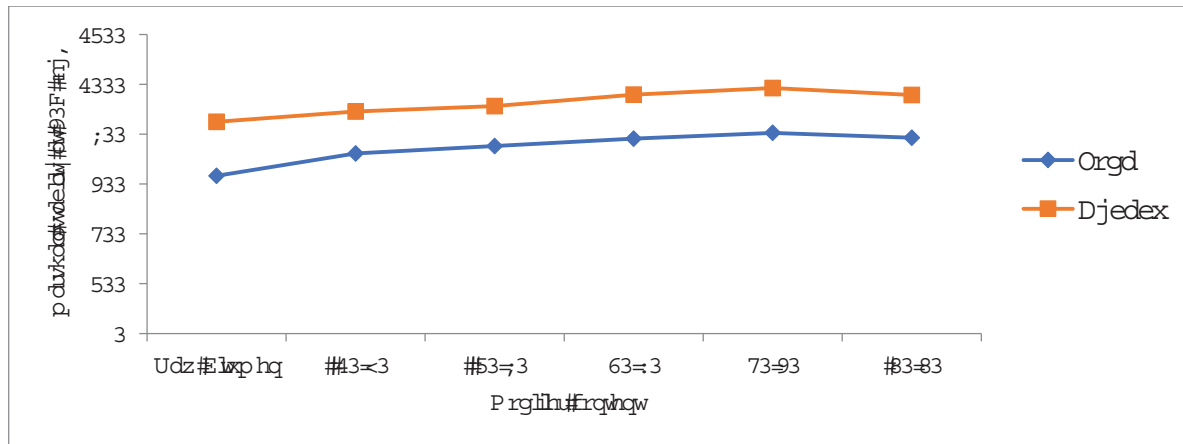
Fig. 9: Marshall Stability in raw bitumen and modifier content

Table 2: Result of Rheological Properties of Shredded Tier Modified Bitumen (STMB) from Agbabu.

Waste/ Bitumen %	Temp $^{\circ}$C	Complex modulus G* (kPa)	Phase angle(δ)	Storage modulus G' (kPa)	Loss modulus G" (kPa)	Rutting parameters G*/Sin δ (kPa)
	45	28.10	71.50	2.60	28.00	29.63
10:90	55	11.50	73.20	0.30	11.40	12.01
	65	3.50	75.50	0.06	3.40	3.62
	45	28.80	77.20	2.50	28.70	29.53
20:80	55	11.80	77.70	0.35	11.60	12.15
	65	3.85	80.30	0.05	3.80	3.91
	45	30.30	79.20	2.57	30.10	30.85
30:70	55	10.50	78.90	0.42	10.40	10.70
	65	3.83	82.10	0.05	3.80	3.87
	45	31.50	81.80	3.00	31.50	31.83
30:70	55	12.20	82.90	0.50	12.10	3.18
	65	3.70	84.50	0.04	3.50	3.72
	45	32.50	88.30	3.50	32.40	32.51
40:60	55	12.70	91.40	0.35	12.70	12.70
	65	3.90	92.80	0.02	3.80	3.90
	45	32.40	86.40	3.40	86.30	32.47
50:50	55	12.50	90.10	0.30	12.45	12.51
	65	3.70	91.60	3.40	3.50	3.70

showed that phase angle increases with increasing temperature and the maximum attainment was 92.80δ in Agbabu and 80.50δ in Loda before depreciation. This observation agrees with the reported trend for Unaged Polyethylene Modified Bitumen (PMB-70) (Ashok *et al.,* 2012). However, the result showed that phase angle increases with increased modifier concentration up to 40:60 and thereafter declines by almost 1.8% for shredded tier-modified bitumen respectively.

Rutting Parameters: Rutting is evaluated by determining the ratio of the complex shear modulus (G*) to the sin of phase angle (δ). Rutting measures, the aging period in bitumen as a result of a deformity of the surface tension due to temperature changes. The lowest value was observed in Loda modification (2.91) at 65 $^{\circ}$C temperature range and 40:60 ratio. This was a little lower than that of Agbabu (3.90) in the same range. However, the values obtained at these levels indicated the good performance of both bitumen modifications at that temperature.

The relative increase in the penetration test in Agbabu bitumen-modified samples may be ascribed

Table 3: Result of Rheological Properties of Shredded Tier Modified Bitumen (STMB) from Loda.

Waste/ Bitumen %	Temp °C	Complex modulus* (kPa)	Phase angle(δ)	Storage modulus G' (kPa)	Loss modulus G" (kPa)	Rutting parameters G*/Sin δ (kPa)
	45	27.90	68.70	2.70	27.80	29.95
10:90	55	8.70	72.90	0.41	8.70	9.10
	65	2.90	75.30	0.05	2.70	3.00
	45	29.10	70.20	2.75	29.00	30.93
20:80	55	9.50	75.10	0.40	9.50	9.83
	65	3.20	76.20	0.06	3.10	3.30
	45	30.10	75.90	2.86	30.00	31.03
30:70	55	9.70	77.20	0.40	9.50	9.95
	65	4.20	77.90	0.08	4.10	4.29
	45	32.70	78.80	3.50	32.60	33.33
40:60	55	11.50	79.80	0.57	11.30	13.66
	65	3.90	80.50	0.07	3.60	2.91
	45	31.50	78.10	3.45	31.40	32.19
50:50	55	10.20	79.20	0.55	10.00	10.71
	65	3.50	79.85	0.07	3.40	3.56

to the augmentation in sheared Stress in shredded tier waste content as a result of its intermolecular forces. The rutting parameters obtained from the rheological properties revealed that Shredded tire modified bitumen samples can withstand many of the defects accountable to paving deformation and aging as there was a decrease in the rutting parameter with an increase in temperature from 45°C to 65°C due to considerable reduction in rutting parameters with an increase in temperatures. Complex modulus decreased while there is an increase in the phase angle of the modified bitumen from both modifiers in ratio 10:90 to 40: 60 due to a decline in shear stress and shear strain at ratio 50:50 at the same range of temperature. The decrease in Complex modulus begins and the phase angle is an indication of the maximum shear stress and shear strain as explained by Mohamed *et al.,* (2009).

CONCLUSION

Bitumen modification has been practicing for ages, but there is not logical conclusion on a specific modifier at a given temperatures that can withstand change in temperatures in the temperate and cold region of the globe. Studies on modified bitumen from Agbabu and Loda at different temperatures and deferent percentages of shredded tier modifier for their rheological properties proved a success. Physico-mechanical characteristics such as Marshall Stability at 60°C, viscosity at 90°C, and penetration at 60°C were also studied for appropriate application in the construction industries. Modifier from Agbabu in ratio10:90 and 40:60 indicated an increase in the intermolecular activities between the bitumen and

shredded tier than Loda respectively. These showed the differences in their chemical properties, but better than the base bitumen at the given temperatures and modifications. Generally, the tensile strength of the Shredded tier modified bitumen at 40:60 modification is higher at 45 °C, which contributed to the maximum rutting parameters obtained and will provide good performance in road paving. This demonstrated that bitumen modified with shredded tier can withstand environmental stress more than base bitumen when the temperature at 45 °C is equally put into consideration, most especially the temperate regions. For maximum rutting parameters, modification at 40% shredded tier with %60 base bitumen at45 °C should be encouraged, most especially in the construction industries for better performance. Application of used of waste tire as the aggregate for modification at the stipulate temperature and the modification ratio will help to reduce its impact in environmental pollution.

AUTHOR CONTRIBUTIONS

G. Aladekoyi sought study authorization from the relevant government institutions. G. Aladekoyi, E.G. Olumayede, and D. Malomo developed the study methodology that also comprised preparing a checklist that was used in data collection. G. Aladekoyi and E.G. Olumayede analysed the samples and interpreted the data. E.G. Olumayede and D. Malomo undertook the literature review that included the introductory background information and the theoretical context. All authors edited the paper to ensure completeness and consistency with the journal's formatting guidelines.

ACKNOWLEDGEMENT

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript. In addition, the ethical issues; including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy have been completely observed by the authors

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

OPEN ACCESS

ABBREVIATIONS (NOMENCLATURE)

%	Percentage
BBR	Bending beam rheometer
°C	Degree celsius
DTT	Direct tension test
DSR	Dynamic shear rheometer
G*	Complex modulus
G*/Sin δ	Rutting parameters
G′	Storage modulus
G′′	Loss modulus
Kg	Kilogram
Kpa	Kilo pascal
PI	Penetration index
PMB	Polyethylene modified bitumen
PW	Polyethylene wax
rpm	Revolution per minute
RS	Rapid setting
RTFO	Rolling thin film oven
RC	Rapid curing
SBS	Styrene—butydiene styrene
SC	Slow curing
SP	Soft point
SS	Slow setting
STMB	Shredded tyre modified bitumen
STW	Shredded tyre waste
Temp.	Temperature
TFO	Thin film oven
δ	Phase angle

REFERENCES

Airey, G.D., (2004). Styrene butadiene styrene polymer modification of road bitumen. J. Mat. Sci., 39(3): 951-959 (9 pages).

Al-Hadidy, A.I.; Yi-Qiu, T., (2011). The effect of plastomers polymer S and concentration on asphalt and moisture damage of SMA mixtures. Al-Rafidain Eng., 19: 1-11 (11 pages).

Rowhani, A.; Rainey, T.J., (2016). Scrap tyre management pathways and their use as a fuel—a review Energies, 9(11): 126 (26 pages).

Anderson, D.A.; Kennedy, T.W.; Thomas, W., (1993). Development of SHRP binder specification.

J. Assoc. Asphalt Paving Tech., 62: 481-507 (27 pages).

AOAC, (2000). Official Methods of Analysis. Association of Official Analytical Chemists 15th edition, Washington DC, USA.

Ashok, P.; Sharma, R.K.; Trilok, G., (2012). Performance of polymer modified bitumen for flexible pavements. Int. J. Strict. Civil Engr., 1(1): 77-87 **(11 pages).**

ASTM, (2021). Standard test method for industrial determination of carbon, hydrogen, and nitrogen in petroleum products and lubricants. ASTM International d-5291, West Conshohocken, USA.

Bala, N.; Napiah, M.; Kamaruddin, I., (2020). Nanosilica Composite Asphalt Mixtures Performance-Based Design and Optimisation Using Response Surface Methodology. Int. J. Pavement Eng. 21 (1), 29-40 **(12 pages).**

Baldo, N.; Pasetto, M., (2010). Recycling of steel slags in road foundations. Environ. Eng. Manage. J., 9(6): 773-777 **(5 pages).**

Behera, H.K.; Giri, D.; Das, S.S., (2020), November. Modification of Bitumen Using Sustainable Materials for Pavement Design. In IOP

Conference Series: Materials Science and Engineering 970(1): p. 012022). IOP Publishing. 1-10 **(10 pages)**.

Bianchi, M.; Bortolani, G.; Cavazzoni, M.; De Pascale, A.; Montanari, I.; Nobili, M.; Peretto, A.; Tosi, C.; Vecci, R., (2014). Preliminary design and numerical analysis of a scrap tires pyrolysis system. Energy Procedia, 45: 111-120 **(10 pages)**.

Chen, F.; Qian, J., (2003). Studies of the thermal degradation of waste rubber. Waste Manage., 23(6): 463–467 **(5 pages).**

Chen, J.S.; Liao, M.C.; Shiah, M.S., (2002). Asphalt modified by styrene–butadiene–styrene triblock copolymer: morphology and model. J. Mater. Civil Eng., 14(3): 224-229 **(6 pages)**.

Fawcett, A.H.; McNally, T.; McNally, G.M.; Andrews, F.; Clarke, J., (1999). Blends of bitumen with polyethylenes. Polymer, 40: 6337-6349 **(13 pages).** Frantzis, P., (2003). Development of crumb rubber reinforced bituminous binder under laboratory conditions. J. Mat. Sci., 38: 1397-1401 **(5 pages).**

Garcia-Morales, M.; Partal, P.; Navarro, F.J.; Martinez-Boza, F.; Mackley, M.R.; Gallegos, C., (2004). The rheology of recycled EVA/LDPE modified bitumen. Rheol Acta., .43: 482-490 **(9 pages).**

Gonzalez, V.; Martinez-Boza, F.; Navarro, F.; Gallegos, C.; Perez-Lepe, A.; Paez, A., (2010). Thermomechanical properties of bitumen modified with crumb tire rubber and polymeric additives. Fuel Proc. Tech., 91 (9):1033–1039 **(7 pages).**

Goodrich, J.L., (1991). Asphalt binder rheology, asphalt concrete rheology and asphalt concrete mix properties. Asphalt Pav. Tech. J., 60: 80–120 **(41 pages).**

Huh, J. D., (2012). Temperature-Adjusted and Modified Recycled ASCON Composition for Reusing 100% of Waste ASCON for Road Pavement, and Method for Manufacturing Same.

Indian Standard, (2001). Paving bitumen specification Indian Standard Institute. New Delhi, India.Sp:73

Liu, K.; Zhang, K.; Wu. J.; Muhunthan, B.; Shi, X., (2018). Evaluation of mechanical performance and modification mechanism of asphalt modified with graphene oxide and warm mix additives J. Cleaner Prod. 193**:** 87-96 **(10 pages)**.

Masson, J.; Polomark, G.; Collins, P., (2005). Glass transitions and amorphous phases in SBS bitumen blends. Themo. Chim. Acta., 436: 96-100 **(5 pages).**

Martinez, J.D.; Veses, A.; Mastral, A.M.; Murillo, R.; Navarro, M.V.; Puy, N.; Artigues, A.; Bartroli, J.; Garcia, T., (2014). Co-pyrolysis of biomass with waste tyres: Upgrading of liquid bio-fuel. Fuel Process. Technol., 119, 263-271 (10 pages).

Metcalf, J. B.; Gopalakrishnan, K.; Waters, M.D., (2000). An initial investigation of the use of a rubber waste (EPDM) in asphalt concrete mixtures. Waste Manage. Series, 1: 940- 952 **(12 pages).**

Mohamed, A.A.; Husaini, O.; Hamzah, M.O.; Ismail, H., (2009). Rheological Properties of Crumb Rubber modified Bitumen Containing Antioxidant. Arab. J. Sci. Eng., 1-11 **(11pages).**

Mull, M.; Stuart, A.K.; Yehia, A., (2002). Fracture resistance characterization of chemically modified crumb rubber asphalt pavement. J. Mat. Sci. 37(3): 557-566 **(10 pages).**

Munera, J.C.; Ossa, E.A., (2014). Polymer modified bitumen: Optimization and selection. J. Mat. Des., 91-97 **(7 pages).**

Navarro, F.J.; Partal, P.; Martinez-Boza, F.; Gallegos, C., (2004). Thermo-rheological behaviour and storage stability of ground tire rubber-modified bitumen. Fuel 2004; 83: 2041–2048 **(8 pages).**

Polacco, G.; Berlincioni, S.; Biondi, D.; Stastna, J., (2005). Asphalt modification with different polyethylene-based polymers. Euro. Polymer. 2005; 41: 2831-2844 **(14 pages).**

Roberts, F.L.; Kandhal, P.S.; Brown, E.R.; Lee, D.Y.; Kennedy, T.W., (1991). Hot mix asphalt materials, mixture design, and construction. Nat. Asphalt Pavement Assoc. Edu. Found. Lanham, MD. 1-603 **(603pages)**

Sharma, R.; Ashok, P.; Trilok, G., (2012). Performance of polymer modified bitumen for flexible pavements. Int. J. Strut. Civil. Engr., ISSN 2319 – 6009 1(1):77-86 (**9 pages).**

Vallerga, B.A.; Finn, F. G.; Hicks, R. G., (1967). Effects of asphalt aging. Proceedings, Second Int. Conf. Struct. Des. Asphalt Pavement, 2: 4-6 **(3 pages)**.

WRAP, (2006). Composition of Tyre. The Waste & Resources Action Programme, the Old Academy, 21 Horse Fair, Banbury. 1-5 **(5 pages)**.

Wu, C.;Li, L.; Wang, W.; Gu, Z., (2021). Experimental Characterization of Viscoelastic Behaviors of Nano-TiO2/CaCO3 Modified Asphalt and Asphalt Mixture. Nanomaterials 11 (1), 1- 106 **(106 pages)**.

Xin, X.; Yao, Z.; Shi, J.; Liang, M.; Jiang, H.; Zhang, J., (2020). Rheological Properties, Microstructure and Aging Resistance of Asphalt Modified with CNTs/PE Composites. Constr. Build. Mater. 262, 120100. 1-11 **(11 pag**es).

Yoon, S.; Prezzi, M.; Siddiki, N.Z.; Kim, B., (2006). Construction of a test embankment using a sand-tire shred mixture as fill material. Waste Manage., 26(9):1033–1044 **(12 pages).**

Yu, R.; Zhu.; Hu, J.; Zhao, W.; Fang, C., (2019). Preparation of graphene oxide and its modification effect on base asphalt. Fullerenes, Nanotubes Carbon Nanostructur., **27** 256-264 **(9 pages).**

International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: http://www.ijhcum.net/

ORIGINAL RESEARCH PAPER

Defining the social-sustainable framework for smart cities

L. Tavanaei Marvi, M. Behzadfar*, S.M. Mofidi Shemirani

Department of Urban Design, School of Architecture and Environmental Design, Iran University of Science and Technology ,Tehran, Iran

ARTICLE INFO

ABSTRACT

BACKGROUND AND OBJECTIVES: Smart cities have been criticized for being too technologically driven and reinforcing entrepreneurial thinking rather than focusing on citizens and social sustainability. This paper aims to "define the implementing principles for Smart Cities in Tehran as a social construct". In this regard, this study tries to develop smart city indicators and suggest a set of implementing principles for smart cities, citizens, and civic organizations in Tehran. Furthermore, this paper illustrates how in-progress smart city projects are meeting the citizens' needs in 22 districts of Tehran Municipality.

METHODS: The present study has used a qualitative and quantitative methodology based on theoretical frameworks. In this paper, Maslow's hierarchy of needs acts as a meta-method for defining the principles of social sustainability to implement smart city projects. First, smart sustainable cities and associated indicators were evaluated based on Maslow's hierarchy of needs. Second, a case study approach was utilized to assess Tehran's smart city projects. Finally, the Strengths, Weaknesses, Opportunities, Threats and Quantitative Strategic Planning Matrix techniques were used to define strategies based on internal and external environmental factors and relation to social sustainability.

FINDINGS: The results indicated that promoting innovation centers and living labs to create a vibrant, active, and healthy public realm was the most effective strategy for smart city development in Tehran (Weaknesses-Opportunities8=.1.323). Two important additional strategies were "involve stakeholders and focus on people and consider urban residents not only as recipients or users of smart cities but also as designers of smart cities" (Strengths-Opportunities3=1.075) and "promote community involvement in council decision-making by developing interactive platforms" (Strengths-Opportunities8=0.884).

CONCLUSION: This paper contributes knowledge on how cities such as Tehran can achieve and implement social sustainability using a smart city approach. Plans and projects for a smart city in Tehran were deemed neither realistic nor sufficiently strategic, and they are assumed to satisfy neither policymakers nor citizens. Social sustainability-based principles and strategies are necessary to incorporate citizen perspectives into Tehran's smart city plan and policies. The present study adds several significant insights to the existing frameworks for implementing smart city frameworks in Tehran.

NUMBER OF REFERENCES

38

NUMBER OF FIGURES

4

NUMBER OF TABLES

8

*Corresponding Author:
Email: behzadfar@iust.ac.ir
Phone: +989123726354
ORCID: 0000-0003-2882-694X

Note: Discussion period for this manuscript open until April 1, 2023 on IJHCUM website at the "Show Article.

INTRODUCTION

Sustainability is considered as a value, goal, or set of norms that need indicators for describing a balance situation between people's needs and "environmental," "social," "economic," and "institutional" dimensions (Badi *et al.*, 2022; Sharifi, 2021). Sustainable development was originally defined by the World Commission on Environment and Development (WCED) (Shmelev and Shmeleva, 2019). These dimensions are inextricably intertwined, making it futile to pursue one while ignoring the others (Fig. 1) (Song *et al.*, 2017).

Diverse urban indicators were developed to provide an assessment tool for planning and decision-making to create a sustainable city (Agency, 2012; Marzukhi *et al.*, 2011), where these indicators can be used as a guide for sustainability policies. In this regard, indicators focus on evaluating the performance of the presented policies. Phillis *et al.* (2017) define the Sustainability Assessment by a Fuzzy Evaluation (SAFE) model, which uses environmental and socioeconomic indicators to rank 106 cities. Gonzalez-Garcia *et al.* (2018) define indicators from a sustainability perspective. The Reference Framework for Sustainable Cities (RFSC) is one of the toolkits designed to facilitate the implementation of sustainability objectives in European cities. The indicator set consists of 16 key and more than 300 supplementary indicators covering the economy, society, environment, and governance (European Commission DG, 2012). Reviewing the sustainable city indicators reveals that sustainability assessments are a prevalent tool that attempts to address sustainability by controlling the sustainability indicators in all steps of the urban development process or measuring the performance of cities aligned with sustainability. However, a comprehensive framework for policy-making from the visionary level to the operational level is neglected in the literature related to sustainability. Reviewing sustainability indicators show that the normative aspect, which focuses on qualities and implication indicators, specifically in the field of social sustainability, is ignored (Branny *et al.*, 2022). Thus, this study aims to define principles as a guide for the implication of sustainability whit emphasis on a social aspect related to smart cities (Freestone and Favaro., 2022). A social and sustainability critique of how Information and Communications Technology (ICT) infrastructure and new technologies are used in cities has led to the development of sustainable smart cities (Harrison *et al.*, 2010; Marsal-Llacuna, 2016). Consequently, some experts criticized smart cities as being too technically oriented and suggested adding a strong citizen-oriented approach that emphasizes the role of social capital and governance in this concept (Albino *et al.*, 2015; Komeily and Srinivasan, 2017; Jiang *et al.*, 2022). The term "smart sustainable city" is defined as "a city that meets the needs of its present inhabitants, supported by ICT infrastructure" (Höjer and Wangel, 2014; Martin *et al.*, 2018). The significance of sustainability in smart cities motivates the development of sustainability assessment indicators for smart cities. In recent years, studies on smart city indicators have increased continuously. Multiple research has addressed the assessment and evaluation of smart cities, but cities' strategizing and operationalizing indicators have received less attention. Huovila *et al.* (2019) introduced published indicator standards for smart sustainable cities to assist city managers and policymakers, select the indicators and standards that correspond most closely to their assessment needs and objectives. A taxonomy was developed to evaluate each of their 413 indicators against five conceptual urban focuses (types of urban sustainability and smartness), ten sectorial application domains (energy, transport, ICT, economy, and others), and five indicator types (input, process, output, outcome, impact). The indicators used in the current study were collected from resources to emphasize standardization, including International Telecommunication Union, International Organization for Standardization, The European Telecommunications Standards Institute, and United Nations, to create an assessment framework for smart cities. Moreover, they were aligned with their respective stage in smart sustainable city implementation. Most of the sustainability assessment indicators suggested in this study consist of people (social sustainability), planet (environmental sustainability), and prosperity (economic sustainability). In addition, Bouzguenda *et al.* (2019) focus on the importance of citizen participation in developing a smart sustainable city and introduce a hierarchical model between sustainability and digital citizen participation based on an exhaustive review.

Bouzguenda *et al*. (2019) show that ICT is vital in planning smart and sustainable cities. Yigitcanlar *et al*. (2019) proposed that cities could not be smart without being sustainable, even when evidence in the practical application of "smartness" point to the contrary. However, sustainability is not limited to environmental concerns. It also incorporates social and economic aspects, although the social aspect is addressed the least. Ben Yahia *et al*. (2019) discuss the concept of collaborative governance in the context of smart cities, focusing on supporting and recommending performing organizational structures for Sustainable Collaborative Networks. The work conducted by the British Standards Institution is one of the most-discussed attempts to operationalize the smart city approach to urban sustainability (Caird, 2018; Caird and Hallett, 2019; Joss *et al.*, 2017). This research aims to create an "interface between research, policy, and practice" (Joss *et al.*, 2017). A study by Mora and Deakin (2019) demonstrates that implementing smart cities is a complex issue that requires distinguishing between utopian ideas and reality and that strategizing smart city development practice is necessary to deal with the complexity of a socio-technical transformation triggered by the alignment of technological development with human, social, cultural, economic, and environmental factors. Humans are the primary focus of the sustainability concept, but social sustainability has received less

attention in built environment disciplines. In the past decade, academics from various disciplines have discussed social sustainability's academic and policy implications within urban studies (Hosseini *et al.*, 2020). Less emphasis has been placed on social sustainability's conceptual framework and practical reporting (Monfaredzadeh and Krueger, 2015). Sustainability is the most significant element in the definitions and concepts of the smart city, which is paying attention to and meeting human needs in all areas. Social sustainability is considered one of the basic elements of sustainability, as seen in Fig. 1. As such, this study examines smart cities from the perspective of social sustainability. Maslow (1954; 1967) theory of motivation, commonly called the "Hierarchy of Needs," organizes a set of human needs into five general categories: physiological, safety, belongingness, esteem, and self-actualization needs. Regarding Maslow's hierarchy of needs, Lang (1994) conceded, "No design can meet all of everybody's needs simultaneously." However, he successfully documents the complexity and occasionally contradictory user experience concerns that urban designers should incorporate into their work (Lang, 1994). In this respect, a study evaluating smart cities in China using an evaluation index system based on resident needs was conducted by Zhang *et al.* (2019). According to Maslow's theory and the literature review on social smart city indicators, there are common needs among communities to
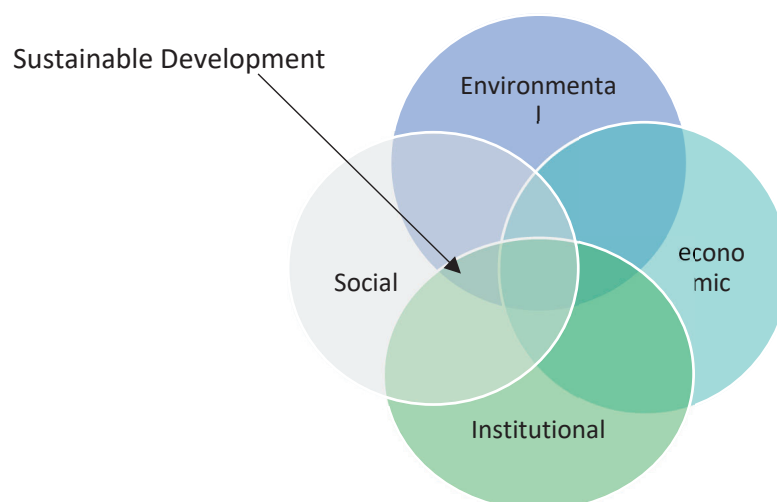

Fig. 1: The proposed diagram of sustainable development dimensions

which cities must respond. To this end, the current study tries to define and develop the hierarchy of needs in the context of smart cities as a meta-method for defining the implementation framework for smart cities with a focus on social sustainability. The hierarchy of human needs in smart cities based on what Maslow (1954) and Lang (1994) stated includes Physiology (Smart city infrastructure), Safety (Reliable and resilient city), belonging (Smart collaboration cities), Esteem (Recognized smart communities), and Self-actualization (Smart vision) Fig. 2.

By using a descriptive-analytical approach, this paper attempted to "define the implementing principles for Smart Cities in Tehran as a social construct." This study's academic merit is that it emphasizes social sustainability and citizen needs perspectives, which are frequently neglected in smart city research, in order to develop a policy framework for smart cities in Tehran. The implementing principles for Smart Cities in Tehran refer to finding the right tools and approaches to reduce urbanization's impacts and leverage the potential that bringing people together can offer. Based on theoretical frameworks, a qualitative and quantitative study method was employed to define implementing principles for sustainable cities from a social perspective in Tehran. Two major

steps to achieve the study's goal are:1-Adjustment of sustainable smart cities indicators to the hierarchy of needs: in this step, a review of the literature about smart cities, social sustainability, and smart sustainable cities indicators are carried out to understand the relationship between the theoretical foundations and indicators of smart cities and the relationship between them and operational issues. In order to provide a general overview of the smart city development process in Tehran, 22 districts have been selected to illustrate how in-progress smart city projects are meeting the needs of the citizens in those districts. 2-Analysis of Tehran's smart city context and requirements: In this step, a case study approach was used to evaluate Tehran's smart city projects. SWOT and QSPM were used to determine strategies based on internal and external factors and their relation to social sustainability. Through QSPM, the implementing principles of smart city development in Tehran are defined. These principles are primarily concerned with social sustainability. According to the synergistic value of this research, smart cities must be developed in consideration of citizens' needs and wishes. Therefore, people-centered policies and strategies are critical in the realization of a smart city. The current study has been carried out in Tehran in 2022.
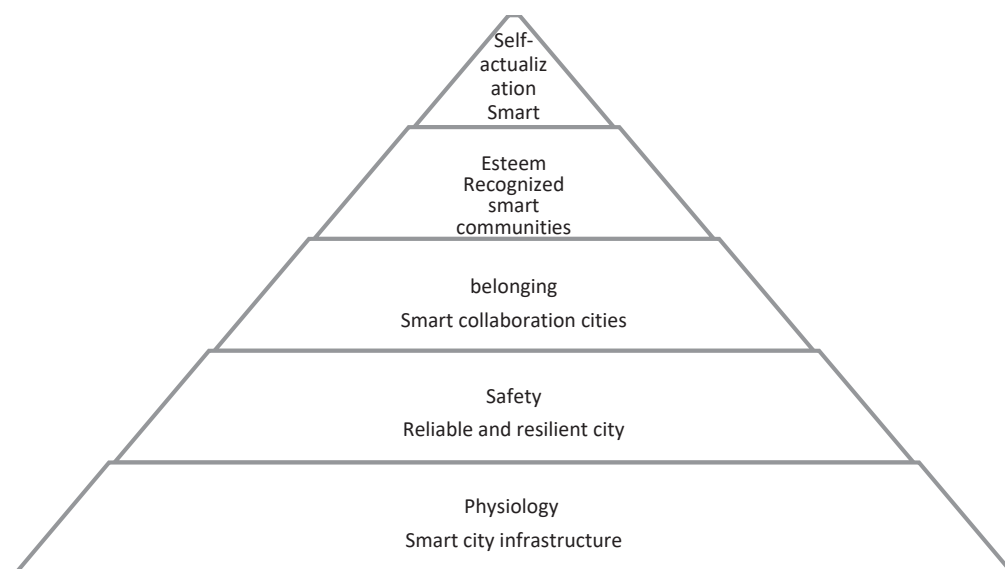
Fig. 2: Hierarchy of needs: application in smart communities (Maslow 1954; Lang1994)

MATERIALS AND METHODS

From the perspective of Maslow's hierarchy of needs theory, a research by Zhang *et al.* (2019) established an evaluation model of smart cities based on residents' needs. Also in the subject of sustainable smart cities, diverse urban indicators were developed intensively to provide an assessing tool for planning and decision-making to create a sustainable city (Agency, 2012; Marzukhi *et al.*, 2011). This paper's main difference and innovation are related to developing principles for smart cities and strategies for improving citizen engagement in Tehran. The study also focuses on social sustainability and citizen needs, which have been neglected in many smart city studies. In the present study, Maslow's hierarchy of needs theory was used as a basis meta-method for defining the sustainable smart city principles with an emphasis on social sustainability. The mixed approach utilizes both qualitative and quantitative methods. First, using a qualitative approach, content analysis was employed on the subject of smart sustainable cities and related indicators to evaluate approximately 359 indicators using the focus group method based on Maslow's hierarchy of needs. Second, in order to develop a thorough understanding of Tehran Municipality's smart city projects based on Maslow's hierarchy of needs, a case study approach was used to evaluate Tehran Municipality's smart city projects based on five levels: physiological demand, safety demand, social demand level, esteem demand, and self-actualization demand, in order to clarify the social sustainability level of these projects. Finally, the Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis and The Quantitative Strategic Planning Matrix (QSPM) techniques were used to analyze the smart city plan in Tehran based on the hierarchy of needs. The strategies were defined based on internal and external environmental factors and weighed regarding social sustainability. In conclusion, smart sustainable principles emphasizing social sustainability were defined. The research method structure of this study is mentioned in Table 1.

Adjustment of sustainable smart cities indicators with the hierarchy of needs

Focus groups comprised of a mix government officials, experts, academics, and information technology specialists. So, the purposive sampling technique was used. According to Babbie (2013), purposive sampling is used when a study focuses on a particular setting with specific experts and study domains. The criteria for choosing experts include the following. (i) Working in smart cities theme and sustainable indicators. (ii) Working or having sufficient knowledge of Tehran innovation ecosystem. 30 experts were purposefully selected with the help of experts' selection criteria, and 25 of these experts participated in the focus group (about 80 percent). The response rate was considered appropriate according to Moser and Kalton (2017) affirmation that the survey results could be considered insufficient and biased if the return rate is lower than 30–40% of the totals sampled or distributed. In each focus group meeting, several smart city indicators were compared with the hierarchy of needs to reach a consensus. Approximately 359 smart, sustainable city indicators collected from various sources (Table 2) were classified based on Maslow's hierarchy of needs through the focus group method. Finally, the 359 indicators were matched to the five levels, including physiological, safety, social, esteem, and self-actualization demands. The frequency of smart sustainable city indicators in each level of the hierarchy of needs is presented in Table 3. Most indicators are related to physical, social, and safety demands. The frequency of esteem demand and

Table 1: The Summary of The research method structure

Steps	Methods	Details
Adjustment of sustainable smart cities indicators with the hierarchy of human needs	Focus groups of a mix of government officials, experts, academics, and information technology specialists to classify smart, sustainable city indicators	Purposive sampling is considered. After purposively targeting 30 experts, 25 (80%) experts participated.
Exploratory Case Study in Smart City of Tehran	Case study approach was used to evaluate Tehran's smart city projects and SWOT and QSPM were used to determine strategies.	Analysis of the internal and external factors of smart cities in Tehran and their relation to social sustainability through documentary and library information.

Table 2: The Summary of indicator on Smart sustainable cities from various sources

Name	Year	Subject
ISO 37120:2018	2018	Sustainable development of communities, indicators for city services and quality of life
ISO/DIS 37122:2018	2018	Sustainable development in communities, indicators for Smart cities
ETSI TS 103 463 (2017)	2017	Key performance indicators for sustainable digital multiservice cities
ITU-T Y.4901 (2016)	2016	Key performance indicators related to the use of information and communication technology in Smart sustainable cities
UN IAEG SDG 11+ (2016)	2016	Sustainable Development Goal 11+ monitoring framework
U4SSC KPIs for smart sustainable cities	2019	Key performance indicators for Smart Sustainable Cities

(Huovila *et al.,* 2019; Wang *et al.*, 2022)

Table 3: The frequency and percentage of smart sustainable city indicators in each level of the hierarchy of needs

	Level of needs	Frequency	Percent	Valid Percent	Cumulative Percent
	Esteem demand	42	11.7	11.7	11.7
	Physical demand	109	30.4	30.4	42.1
	Safety demand	87	24.2	24.2	66.3
Valid	Self-actualization demand	11	3.1	3.1	69.4
	Social demand	110	30.6	30.6	100.0
	Total	359	100.0	100.0	

self-actualization demand indicators is low. The low number of sustainability indicators of smart cities in the high levels of human needs makes it impossible to evaluate smart cities at high levels of human needs.

Exploratory Case Study: Smart City of Tehran

Tehran is the capital of Iran and the Tehran Province. With the population of approximately 9 million in the city and 16 million in the surrounding metropolitan area, it holds a unique position among Iran's other major cities (Statistical Center of Iran, 2016). The high concentration of population and facilities results in complex issues and problems, such as pollution, traffic, poverty, and unequal access to facilities. The method of urban management contributes significantly to this issue. Using traditional urban management methods like in the past or utilizing new technologies and smart strategies to solve urban problems. To this end, the concept of a smart city and virtual space can reduce problems and aid the real space in Tehran in terms of global connectivity between cities, thereby enhancing the quality of life.

Smart City Approach in Tehran

Three phases (phase zero, phase one, and phase two) are planned for the Smart Tehran program, which is the Municipality of Tehran's primary smart city initiative. Due to internal and external resistance, a lack of proper executive guarantee, a lack of efficient monitoring mechanisms, a lack of citizen participation, and weak inter-organizational partnerships, the projects outlined in the first phase (approximately 54 projects) have not been effective in improving the quality of life. Based on the Smart Tehran vision, Tehran is a city with an ever-increasing quality of life, based on citizens, public and private partnerships, and a place to live a healthy and happy life, with an integrated infrastructure managed by an efficient and economically dynamic urban administration. Strategic objectives of the Smart Tehran program include achieving sustainable urban development, guiding urban innovation and citizen satisfaction, and fostering participation and openness. (Smart Tehran Center, 2019) Consequently, "citizen participation" is one of the central pillars of the smart Tehran program. For this reason, defining a coherent program for citizen engagement and active participation is essential for enhancing social capacities. Each year, the Municipality of Tehran hosts smart programs, plans, and initiatives from various organizations; some of these actions encounter several difficulties, particularly in communicating with people, resulting in the dissatisfaction of citizens and the failure of these actions. From the perspective of Maslow's theory of the hierarchy of needs, this paper evaluates

Table 4: The frequency of Tehran smart city projects in the level of the hierarchy of needs

Hierarchy of needs in smart initiatives	Frequency of each need in Districts 1-22
Physical demand	54
Safety demand	8
Social demand1	19
Esteem demand	11
Self-actualization demand	6
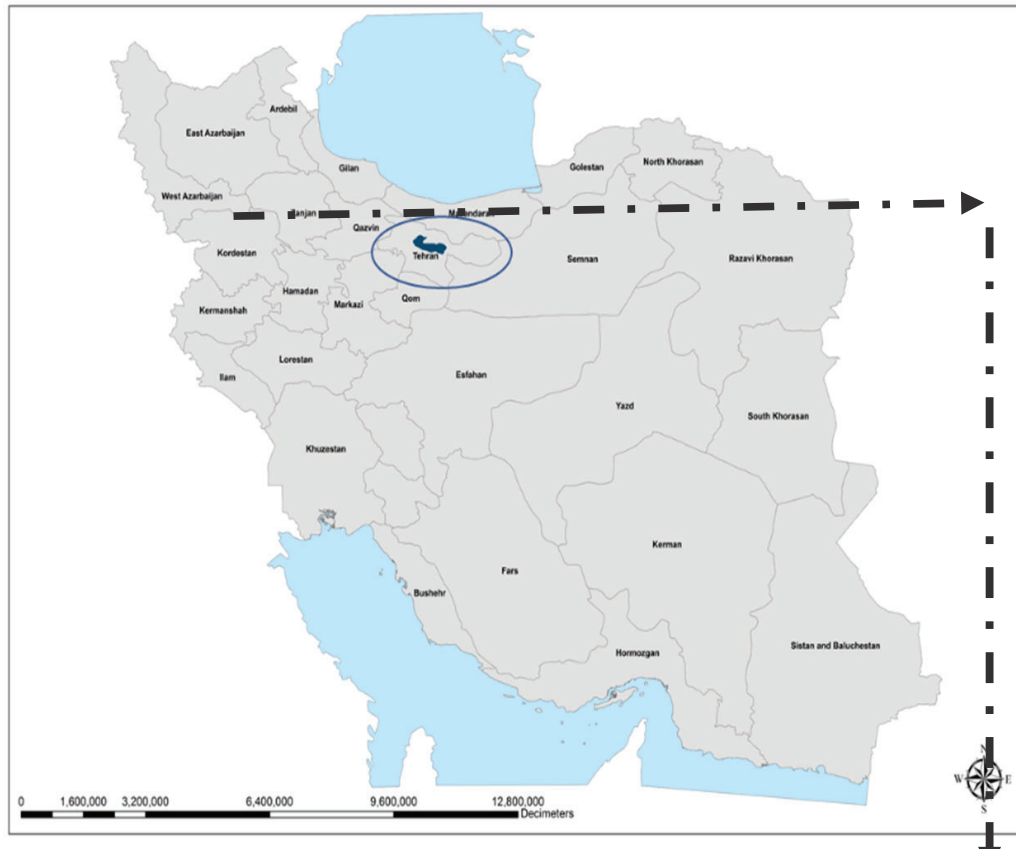
Fig. 3: Geographic location of the study area in Iran map

the smart city projects of Tehran Municipality based on five levels: physiological, safety, social, esteem, and self-actualization demands, in order to meet the various levels of citizen needs. As shown in Table 4, most projects are associated with the physical demand of human needs and smart city infrastructure.

The geographic location of the study area in Iran map is shown in Fig. 3. The distribution of the smart projects in the 22 districts of the Tehran Municipality is an additional important aspect of these projects. As depicted in Fig. 4, each region has projects addressing varying degrees of human needs. The lack of effective evaluation and performance assessment models to demonstrate the smart cities projects implemented in 22 Tehran districts is the primary obstacle in how projects respond to human needs.

RESULTS AND DISCUSSION

Analysis of the contexts and requirements for Tehran smart city implementation

Information regarding smart projects implemented in 22 districts of Tehran in 2020 and smart

Fig. 4: Smart cities implemented projects in 22 districts of Tehran from the perspective of Maslow's hierarchy of needs

city indicators are analyzed in this study from the perspective of human needs. Based on the hierarchy of needs, Tehran smart city project's strengths, weaknesses, opportunities, 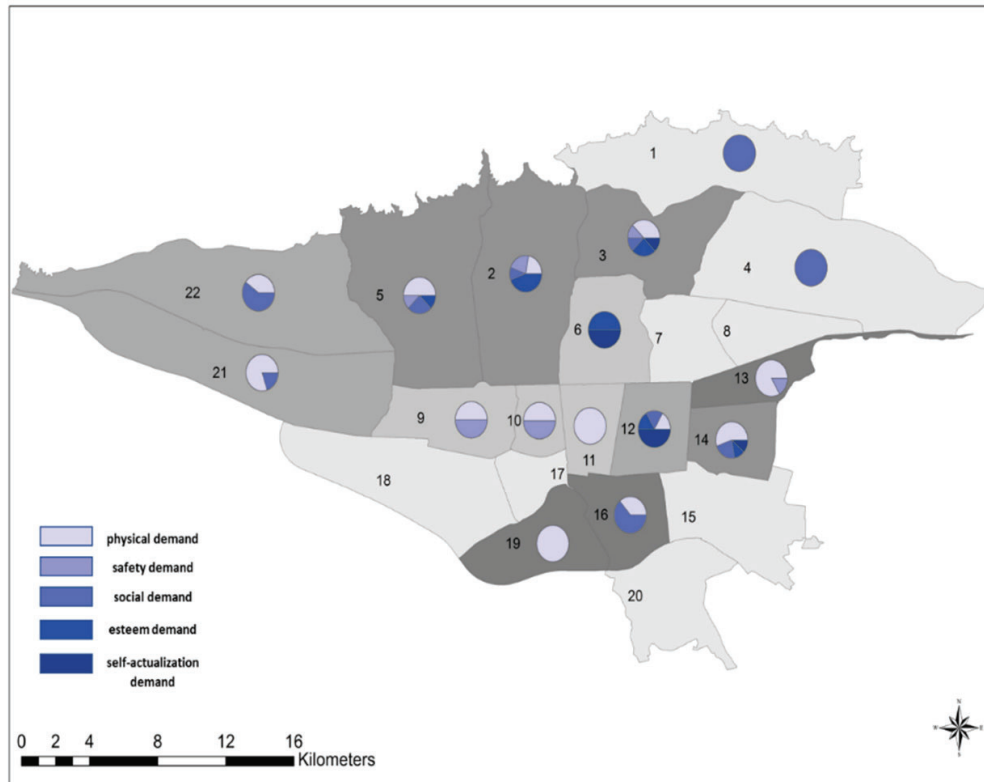and threats were evaluated using SWOT analysis. The SWOT analysis matrix is shown in Table 5. Thus, SO strategies (aggressive strategies) utilize strengths and are opportunities to capitalize on opportunities. ST Strategies (diversification) utilize the strengths to avoid potential threats. WO Strategies (review strategies) take advantage of opportunities to reduce weaknesses, whereas WT Strategies (defensive strategies) reduce vulnerabilities and avoid the threats indicated in Table 5 (Pourahmad *et al.*, 2013). A weight or coefficient is assigned to the external and internal factors crucial to achieving the objectives. In the subsequent step, the matrices from the second phase were compared, and the strategies the system will adopt and implement were determined. The top row of the strategic planning matrix lists these strategies. Then, strategies are ranked in order of importance based

on their scores (Mohebbi *et al.*, 2020).

As shown in Table 6, the weighted score of the opportunities equals 2.26, indicating the dominance of potential opportunities that necessitate strategies to realize these capacities. Overall, 2.2 weighted strength and weakness scores indicate that the internal environment dominates the external environment. SWOT analysis was used to develop four types of strategies that can be used effectively to define strategic principles after selecting and evaluating the most important internal and external factors and identifying relationships between internal and external features. For example, strong interactions between strengths and opportunities (SO) can represent favorable conditions for the development of smart cities in Tehran and allow for the use of aggressive strategies. On the other hand, strong interactions between weaknesses and opportunities (WO) could be analyzed as a potential for using review or overview strategies. Furthermore, strong interactions between weaknesses and threats

Table 5: SWOT analysis in the smart city of Tehran based on the hierarchy of needs

		STRENGTHS	Weighted score
1	S1	Capital of Iran and the largest city in the country	0.1
2	S2	The high number of innovation-based acts and rules	0.2
3	S3	Access to advanced modern technologies: sensors, devices, and measuring instruments	0.1
4	S4	The high number of video surveillance cameras for monitoring road traffic	0.1
5	S5	Willingness and culture to use information technology	0.2
6	S6	Information platforms and electronic services for citizen participation	0.1
7	S7	The specialized knowledge of the private sector in the production of electronic systems and the enhancement of the technological level	0.1
8	S8	The existence of unique qualities and potential for each neighborhood in Tehran	0.1
		WEAKNESSES	Weighted score
1	W1	Lack of sustainable infrastructure and environment	0
2	W2	Lack of free Wi-Fi coverage in streets and public places	0
3	W3	High project costs and lack of inter-organizational communication with foreign companies due to sanctions	0.1
4	W4	Lack of public awareness of the project's advantages	0.1
5	W5	Vulnerability to cyber security threats and insecure data storage	0.1
6	W6	Lack of resources, especially highly qualified human resources	0
7	W7	Lack of active innovation centers	0.1
8	W8	Lack of integration in Tehran Municipality's existing systems	0
9	W9	Lack of suitable and reliable statistical system	0
10	W10	High unemployment and poverty rate in Tehran	0.1
11	W11	Neglecting Tehran's most pressing problems and challenges in smart city projects	0.1
12	W12	Lack of physical and mental healthcare services, including telemedicine, sustainable infrastructure, and environment	0
13	W13	Neglecting inclusive ICT education	0.1
14	W14	Weakness in crisis management and innovative methods of city flexibility	0
15	W15	Lack of equal access to affordable ICT services and facilities	0.1
		OPPORTUNITIES	Weighted score
1	O1	Expertise and human resources in the field of ICT	0.4
2	O2	The potential for transforming older structures into innovation and technology centers	0.3
3	O3	The possibility of using the social capacities of the neighborhoods (councils, N.G.O.s, Sarai Mahalat, and others) to increase people's participation	0.4
4	O4	The concentration of top Iranian universities in Tehran	0.3
5	O5	The potential for cooperation and partnership with innovative and creative information technology companies	0.2
6	O6	Appropriate medical equipment and a large number of specialists and doctors	0.3
7	O7	High investment opportunity in the development of the urban district of Tehran	0.4
		THREATS	Weighted score
1	T1	Lack of investors	0.1
2	T2	Cyber security threats and vulnerabilities of the city's integral information system	0.2
3	T3	Outdated planning system	0.1
4	T4	Aggravation of transportation problems	0.2
5	T5	Increased environmental pressures	0.1
6	T6	Instability of management in the field of smart city	0.1

Internal factor evaluation matrix (spans STRENGTHS and WEAKNESSES sections)

External factor evaluation matrix (spans OPPORTUNITIES and THREATS sections)

Table 6: Factors analysis of Tehran

Factors	Weight	Score	Weighted score
Strengths	65	26	1.18
Weaknesses	116	23	1.02
Opportunities	57	27	2.26
Threats	41	8	0.58

Table 7: The Strategies prioritization by QSPM matrix for smart city developments in Tehran

| No	Strategies	Factors	Total score
WO8	Promoting innovation centers and living labs to create a vibrant public realm, active and healthy lifestyle	O5O4O2O1W7	1.323
SO3	Involve stakeholders and focus on people and consider urban residents not only as recipients or users of smart cities but also as designers of smart cities	S5S6S2O3	1.075
SO8	Promote community involvement in council decision-making by developing interactive platforms	S6S2O3O5	0.884
SO4	Promote social participation in all the smart cities project processes	S5S6O3	0.711
WO10	Considering the main challenges of cities and stakeholders' preferences for designing and planning smart city initiatives	W11O5O3	0.684
ST2	Show that the analysis will be reported to stakeholders and discussed with them, and show the basis on which it may be considered accurate and honest.	S2S5S7S6T3	0.673
WT2	Do not exaggerate - when defining smart city initiatives, consider financial and specialized resources	W1W3W6W9 W10T6T1T4T5	0.66
SO2	Make the city more responsive to the public and open it up to the public by utilizing data and analytics	S4O1	0.568
WO6	Manage cyber attacks, information infrastructure, and data needed to prevent and manage cyber attacks	W5O1	0.568
SO1	Promoting efficient energy infrastructure by transforming utilities, manufacturing, transportation, energy, and waste treatment sectors to reduce the carbon footprint and greenhouse gas emissions for a cleaner, healthier environment	S3S7O5	0.535
SO7	Enable benchmarking of regions and neighborhoods across cities to expand the competitive atmosphere in cities	S8O7	0.522
SO6	Create opportunities for people to personalize places with artificial intelligence, augmented reality, and virtual reality	O1S1	0.494
WO1	Improve healthy life through increasing access to physical and mental healthcare services, including telemedicine, integrated health information systems, and ambient assisted living	O1O6W12	0.482
WO2	Develop an inclusive education to provide education for all resident's ages, gender, culture, and status	O1W13	0.467
WO5	Responding to damages related to information infrastructure and data needs to prepare for damage reduction and rapid response to emergencies occurring in the city	W14O1	0.439
SO5	Enhance community identity by providing new technology to heritage and historical sites	O2S7	0.435
WO3	Prevent traffic offenses, road violence, and accidents by supporting smart mobility and ITS infrastructure	O5W11W1	0.435
WO7	Promote social justice and equity by providing equal access to affordable digital services and facilities	O7W15	0.422
ST1	Define a clear, transparent, and accountable framework for the engagement process in line with authority, proposed timeline, targeted objectives, expected outcomes, and others	T3S5	0.33
WO9	Strengthen entrepreneurship and support start-up businesses to improve an inclusive, equitable economy	W10O5	0.306
WO4	E-Government implementation providing all eligible public services through digital channels and targeting full digital adoption	W8O5	0.299
WT1	Improve cross-departmental coordination and data-sharing to deliver optimized experiences	T6W8	0.096
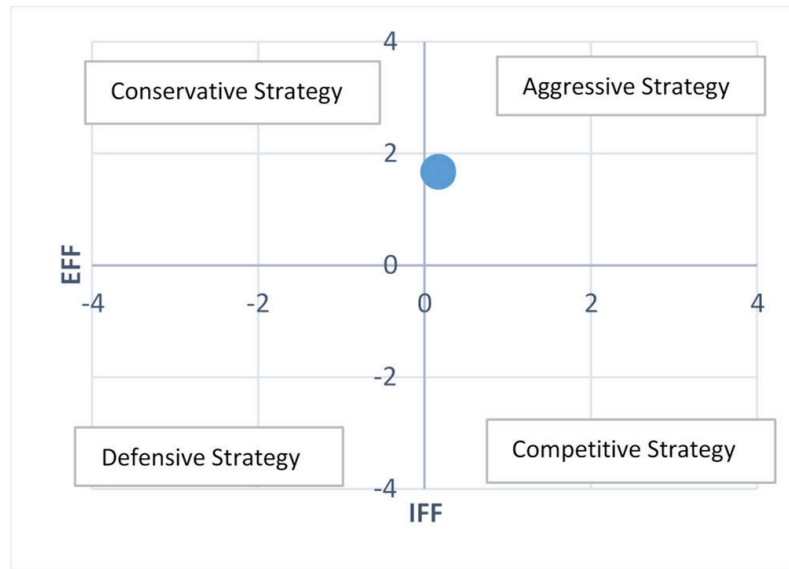
Fig. 5. Position of smart city strategies in Tehran

(WT) could be interpreted as a potential warning and recommendation to employ defensive strategies. In addition, strong relationships between strengths and threats (ST) allow for the use of a variety of strategies. Table 7 displays the results of this stage. As shown in the SWOT matrix in Table 5, key strategies for smart city development in Tehran were identified through pairwise matching of SO, WO, ST, and WT. The SO strategies proposed opportunities that were complementary to Tehran's strengths. The best SO strategy was the "involvement of stakeholders and considering people not only as users of smart cities but also as designers of smart cities." The ST strategies identify methods for reducing vulnerability to external threats. "Being transparent - demonstrate the basis on which the analysis may be considered accurate and honest" was the best ST strategy realized. The WO strategies identify ways to overcome weaknesses in order to identify opportunities. This study identified the best WO strategy as "Promoting innovation centers and living labs to create a vibrant public realm, active and healthy lifestyle." The WT strategies establish a defensive strategy to prevent the wetland's flaws from making it vulnerable to external threats. According to Table 4, the best WT strategy was "improving cross-departmental coordination and data-sharing to deliver optimized experiences." Table 7 shows the details of the results. The QSPM analysis was performed to provide additional principles for smart city developments in Tehran and classify strategies based on priorities. Based on the final results of the QSPM analysis (Table 7), the following ranking can be obtained. The best strategy for smart city development in Tehran, according to the QSPM results, was WO8 (promoting innovation centers and living labs to create a vibrant public realm active and healthy lifestyle) (Table 7). Following that, two other important strategies are SO3 (Involve stakeholders and focus on people, and consider urban residents not only as recipients or users of smart cities but also as designers of smart cities;) and SO8 (Involve stakeholders and focus on people and consider urban residents not only as recipients or users of smart cities but also as designers of (promote the community involvement in council decision-making by developing interactive platforms). The results are shown in detail in the. Fig. 5 depicts the position of smart city strategies in Tehran, which are classified as Conservative or Aggressive. It demonstrates the significance of the internal environment. The alignment of strategies with the goal is shown in Fig. 5. Moreover, the implementing principle for smart city development in Tehran is defined by the featured strategies via QSPM. These principles are primarily concerned with social sustainability. Table 8 depicts the application of smart city principles for the smart city of Tehran based on Maslow's hierarchy of needs.

The implications of this study directly address a

Table 8: Smart city implementation principles for Tehran smart city based on Maslow's hierarchy of needs

Human needs	Smart cities Needs	Principles
Physiology	Smart city infrastructure	• Connecting communities by equipping households with internet and wireless broadband coverage • Transforming utilities to promote efficient energy infrastructure • Improving city services and broadening public access • Promoting the Tehran City Council's crowdsourcing network through well-known institutions
Safety	Reliable and resilient city	• Defining the security and safety attachment for each Tehran smart city initiative, with safety as the foundation of smart city plans • Enhancing the information and data infrastructure needs to prepare for damage reduction for responding to damages and crises • Enhance public supervision through the usage of artificial intelligence and digital technologies
Belonging	Smart collaboration cities	• Increasing transparency and accountability framework for citizen engagement • Providing equal access to public services through digital services and facilities • Promote social participation in all steps of smart city processes • Equipping heritage and historic places with new technology and creating an innovative identity
Esteem	Recognized smart communities	• Benchmarking of the 22 districts of Tehran and neighborhoods to expand the competitive atmosphere • Develop an inclusive education to increase knowledge and capacity of smart citizen's rights for all residents' age, gender, culture, and status • Capacity building at the local level to develop smart city strategies and attract people's participation in all areas of Tehran
Self-actualization	Smart vision	• Using artificial intelligence, augmented reality, and virtual reality to beautify places • Promoting innovation centers and living labs to Create a vibrant public realm, active and healthy lifestyle • Defining a realistic vision by considering financial and specialized resources in defining smart cities projects

gap in the literature regarding implementing a smart sustainable city from a social perspective. Despite the advances in smart city indicators, these lack the ability to strategize and operationalize social sustainability principles in an integrated way, which requires interaction between all dimensions of smart cities. For example, Zhang *et al*. (2019) evaluate the level of smart city construction in five hierarchies of needs, but less attention has been given to the definition of strategic principles to improve the level of needs that, smart cities are capable of responding to. Citizen participation is essential to implementing smart sustainable cities, so Bouzguenda *et al*. (2019) propose a hierarchical model that connects sustainable cities with citizen participation in digital media. But indicators or principles relating to socially sustainable smart cities are ignored. The present study covers the shortcoming of Strategizing and operationalizing principles, particularly in the field of sustainability, in smart cities. These

results add a few significant insights to Tehran's existing smart city implementation frameworks. Smart cities and sustainability are characterized by practical elements, standards, indicators, and sub-indicators, but fewer include socially oriented and implementing principles. In this paper, a new set of implementing principles for smart cities, citizens, and civic organizations is presented in order to aid in the focus on social sustainability in smart cities by researchers, policymakers, and planners.

CONCLUSION

This paper aimed to "define the implementing principles for Smart Cities in Tehran as a social construct through a descriptive-analytical approach." The current study's academic merit is that it developed a policy framework for smart cities in Tehran by emphasizing social sustainability and citizen needs perspectives, which have often been overlooked in smart city research. An in-

depth study of the existing literature and an examination of Tehran's internal and external environments were conducted to identify the city's strengths, weaknesses, opportunities, and threats to becoming a smart city. This study proposes principles for implementing smart city transition in Tehran. Furthermore, these principles suggest social sustainability requirements in smart cities for developing a social-centric strategic plan. It also addresses the following questions: Does Tehran meet the basic needs of its citizens? Is Tehran bridging the gap between basic needs and deeper engagement? According to the literature review, reviewing the sustainable city indicators focuses on sustainability assessments, while implication indicators, particularly in the field of social sustainability, are ignored. As a result, this study attempted to define implementing principles for the development of smart cities in Tehran. The 359 indicators were then matched to the five levels of the need's hierarchy. Most indicators are concerned with physical, social, and safety demands. The low frequency of indicators in high levels of Maslow's hierarchy of needs makes evaluating smart cities at high levels of human needs impossible. The case study method was used in this paper to investigate and analyze smart city projects in Tehran. This analysis revealed that most needs are at the basic level, and adequate attention has not been paid to higher levels of human needs. Furthermore, a spatial analysis of Tehran's 22 districts reveals that different areas of Tehran respond to varying levels of human needs, and the level of these projects varies according to the socioeconomic and local conditions in each region of Tehran. Consequently, future policies must consider each district's unique capacities and conditions. As a result, smart city principles based on social sustainability were compiled in Tehran using SWOT and QSPM analysis methods. Tehran has planned to become smart, but it appears its plans are neither realistic nor strategic. It does not appear to satisfy either policymakers or citizens. To include citizen perspectives in Tehran's smart city plan and policies, principles, and strategies based on social sustainability are required. Compared to good practices of sustainable smart cities indicators, the smart cities principles proposed for Tehran provide a clear horizon and systematic guide through social sustainability analysis in Tehran. The current study

adds a few significant insights to Tehran's existing smart city implementation frameworks. This paper adds to our understanding of how cities like Tehran can achieve and implement social sustainability using a smart city approach. One significant limitation of our work is that the application of Maslow's theory of the hierarchy of human needs to respond to societal demands appears individualistic and subjective. Regardless of the ambiguity surrounding the Classification of Human Needs, the hierarchy of human needs should be viewed as a starting point for discussing social sustainability in a smart city. Future research may examine Maslow's theoretical framework in greater depth in conjunction with other aspects of smart cities, such as urban governance and developing human needs in response to the specific needs of smart city actors. As a result of the Social Smart City framework, digital strategies for citizen engagement in smart cities can be refined. In this framework, various digital strategies for citizen engagement in smart cities are described. Although the framework provides a refined approach to social strategies for smart cities, it should also be used as a tool to implement smart city initiatives. It is possible to add other strategies that are not already included in this overview. This framework could be adapted into a benchmarking tool for smart social cities in the future. Based on the findings of the current study, it can be concluded that Tehran can define a framework for citizen engagement that is transparent and accountable. In addition, it is suggested that promoting innovation centers and living labs is necessary to create a vibrant public realm and an active and healthy lifestyle. Consequently, developing a realistic vision for smart cities in Tehran by considering financial and specialized resources for smart city projects is the key to achieving reliability and resiliency. There have been few studies conducted in recent decades that have focused on the feasibility and operationalization of smart cities, and of those few that have, they were conducted based on the positivist paradigm, which ultimately led to either confirming or rejecting the research hypotheses. One of the most important knowledge gaps in smart cities involves the absence of a critical perspective that can explain a comprehensive framework built upon pragmatism and quantitative and qualitative approaches. This research seeks to determine

the principles for the realization of smart cities in Tehran with a social approach. For future research, it is suggested that the representation of social qualities of urban design in smart cities should be investigated. Also, the processes and procedures for developing smart cities at the neighborhood scale are highly recommended.

AUTHOR CONTRIBUTIONS

M. Behzadfar developed the idea of this study; designed, analyzed, and interpreted the data. While L. Tavanaei Marvi worked out the literature review and compiled the data and formatted the manuscript. M. Mofidi Shemirani helped in the literature review, analyzed, and interpreted the data. M. Behzadfar and L. Tavanaei Marvi contributed to the manuscript preparation and performed some of the remaining work like the formatting of the manuscript and placement of maps.

ACKNOWLEDGEMENT

CONFLICT OF INTEREST

The authors declare that there is no potential conflict of interest in the publication of this work. Furthermore, the authors observed ethical issues such as plagiarism, informed consent, misconduct, data fabrication or falsification, double publication and submission, and redundancy.

OPEN ACCESS

PUBLISHER'S NOTE

Tehran Urban Planning and Research Center remains neutral with regard to jurisdictional claims in published maps and institutional afflictions.

ABBREVIATIONS (NOMENCLATURE)

EFE	External Factor Evaluation
EI	Environmental Indicators
ICT	Information and Communications Technology
QSPM	Quantitative Strategic Planning Matrix
RFSC	Reference Framework for Sustainable Cities
SAFE	Sustainability Assessment by a Fuzzy Evaluation
SO	Strengths and Opportunities strategies
ST	Strengths and Threats strategies

REFERENCES

Agency, (2012). Indicators for Sustainability: How Cities are Monitoring and Evaluating Their Success. Canada: p. 84 **(1 page)**.

Albino, V.; Berardi, U.; Dangelico, R. M., (2015). Smart cities: Definitions, dimensions, performance, and initiatives. J. Urb. Tech., 22(1): 3–21 **(18 pages)**.

Babbie, E., (2004). The logic of sampling, The basics of social research, Cengage Learning.

Badi, I. ; Muhammad, L.J. ; Abubakr, M. ; Bakir, M., (2022). Measuring Sustainability Performance Indicators Using FUCOM-MARCOS Methods. Oper. Res. Eng. Sci., 5(2): 99-116 **(18 pages)**.

Ben Yahia, N.; Eljaoued, W.; Bellamine Ben Saoud, N.; Colomo-Palacios, R., (2019). Towards sustainable collaborative networks for smart cities co-governance. Int. J. of Inf. Manage., 56: 1-16 **(16 pages)**.

Bouzguenda, I.; Alalouch, C.; Fava, N., (2019). Towards smart sustainable cities: A review of the role digital

citizen participation could play in advancing social sustainability. S. C. S., 50(101627): 1-15 (**15 pages**).

Branny, A.; Møller, M. S.; Korpilo, S.; McPhearson, T.; Gulsrud, N.; Olafsson, A. S.; Andersson, E., (2022). Smarter greener cities through a social-ecological-technological systems approach. Curr. Opin. Environ. Sustain., 55: 1-11 (**11 pages**).

Caird, S., (2018). City approaches to smart city evaluation and reporting: case studies in the United Kingdom. Urban Res. Pract., 11(2): 159-179 (**20pages**).

Caird, S. P.; Hallett, S. H., (2019). Towards evaluation design for smart city development. J. Urban Des., 24(2): 188-209(**21 pages**).

European Commission DG. (2012). Science for environment policy: European Commission DG environment news alert service.

Freestone, R.; Favaro, P., (2022). The social sustainability of smart cities: a conceptual framework. City Cult. Soc., 29(1): 1-14 (**14 pages**).

Gonzalez-Garcia, S.; Manteiga, R.; Moreira, M. T.; Feijoo, G., (2018). Assessing the sustainability of Spanish cities considering environmental and socioeconomic indicators. J. of Clea. Prod., 178: 599–610 (**11 pages**).

Harrison, C.; Eckman, B.; Hamilton, R.; Hartswick, P.; Kalagnanam, J.; Paraszczak, J.; Williams, P., (2010). Foundations for smarter cities. IBM J. of Res. and Dev., 54(4): 1-16 (**15 pages**).

Hosseini, E.; Tajpour, M.; Lashkarbooluki, M., (2020). The impact of entrepreneurial skills on manager's job performance, Int. J. Hum. Capital Urban Manage., 5(4): 361-372 (**11 pages**).

Höjer, M.; Wangel, J., (2014). Smart sustainable cities: definition and challenges. Adv. in Intel. Sys. and Comp., 310: 333–349 (**16 pages**).

Huovila, A.; Bosch, P.; Airaksinen, M., (2019). Comparative analysis of standardized indicators for smart sustainable cities: what indicators and standards to use and when?. Cities, 89: 141–153 (**12 pages**).

Jiang, H.; Geertman, S.; Witte, P., (2022). Smart urban governance: an alternative to technocratic "smartness". GeoJournal, 87(3): 1639–1655 (**16 pages**).

Joss, S.; Cook, M.; Dayot, Y., (2017). Smart cities: Towards a new citizenship regime? A discourse analysis of the British smart city standard. J. Urban Technol., 24(4): 29-49(20 pages).

Komeily, A.; Srinivasan, R. S., (2017). Sustainability in smart cities: balancing social, economic, environmental, and institutional aspects of urban life. smart cities: foundations, principles, and applications. 503–534 (**31 pages**).

Lang, J. T., (1994). Urban design: the American experience. John Wiley & Sons.

Marsal-Llacuna, M. L., (2016). City indicators on social sustainability as standardization technologies for smarter (citizen-centered) governance of cities. Soc. Ind. Res., 128(3): 1193–1216 (**23 pages**).

Martin, C. J.; Evans, J.; Karvonen, A., (2018). Smart and sustainable? five tensions in the visions and practices of the smart-sustainable city in Europe and North America. Tec. Fore. and Soc. Chan., 133: 269–278 (**9 pages**).

Maslow, A. H., (1967). A Theory of meta motivation: the biological rooting of the value-life. J. of Hum. Psych., 7(2): 93–127 (**34 pages**).

Maslow, A. H, (1954). The instinctoid nature of basic needs. J. of Pers., 22(3): 326–347 (**21 pages**).

Marzukhi, M. A.; Omar, D.; Leh, O. L. H.; Hamir, M. S.; Barghchi, M. , (2011). Malaysian urban indicators network: a sustainable development initiative in Malaysia. Eur. J. of Soc. Sci., 25(1): 77-83 (**6 pages**).

Mohebbi, N.; Nouri, J.; Khorasani, N.; Riazi, B. , (2022). Environmental management for human communities around wetlands adjacent urban region by ecological risk approach. Int. J. Hum. Capital Urban Manage., 7(1): 1-16 (**16 pages**).

Monfaredzadeh, T.; Krueger, R., (2015). Investigating social factors of sustainability in a smart city. Proc. Eng., 118: 1112–1118 (**6 pages**).

Mora, L.; Deakin, M., (2019). The social shaping of smart cities, untangling smart cities. Elsevier, 215–234 (**19 pages**).

Moser, C. A.; Kalton, G., (2017). Survey methods in social investigation. Routledge.

Phillis, Y. A.; Kouikoglou, V. S.; Verdugo, C., (2017). Urban sustainability assessment and ranking of cities. Comp., Env. and Urb. Sys., 64: 254–265 (**11 pages**).

Sharifi, A., (2021). Urban sustainability assessment: an overview and bibliometric analysis. Ecol. Indic, 121: 1-18 (**18 pages**).

Shmelev, S. E.; Shmeleva, I. A., (2019). Multidimensional sustainability benchmarking for smart megacities. Cities, 92: 134–163 (**29 pages**).

Smart Tehran Center., (2018). The Local model of Tehran smart city.

Song, H.; Srinivasan, R. S.; Sookoor, T.; Jeschke, S., (2017). Smart Cities: foundations, principles, and applications. John Wiley & Sons.

Statistical Centre of Iran, (2016). National population and housing census Tehran: Statistical Center of Iran.

Wang, J. ; Liu, C. ; Zhou, L. ; Xu, J. ; Wang, J. ; Sang, Z., (2022). Progress of standardization of urban infrastructure in smart city. standards, 2(3): 417-429 (**12 pages**).

Yigitcanlar, T.; Kamruzzaman, M.; Foth, M.; Sabatini-Marques, J.; da Costa, E.; Ioppolo, G. , (2019). Can cities become smart without being sustainable? A systematic review of the literature. Sus. Cit. and Soc., 45: 348–365 (**17 pages**).

Zhang, Y.; Liu, F.; Gu, Z.; Chen, Z.; Shi, Y.; Li, A., (2019). Research on smart city evaluation based on hierarchy of needs. Proc. Comp. Sci., 162: 467–474 (**7 pages**).

International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: http://www.ijhcum.net/

Monitoring urban growth and changes in land use and land cover: a strategy for sustainable urban development

P. Shehu[1,*], L.S. Rikko[1], M.B. Azi[2]

[1] Department of Urban and Regional Planning, Faculty of Environmental Sciences, University of Jos, Nigeria

[2] Department of Geography, School of Arts and Social Sciences, Aminu Sale Collage of Education Azare, Nigeria

ARTICLE INFO

ABSTRACT

BACKGROUND AND OBJECTIVES: Recently, Jos Metropolis, Nigeria is witnessing a strong trend toward urban growth and expansion. This phenomenon has impacted Land Use/Land Cover and efficient management of land. This paper evaluated urban growth and changes in Land Use /Land Cover and examined the land use efficiency of the metropolis. Land Use and Land Cover changes were established from 1999 to 2022; Land consumption rate and population growth rate were determined, and computation of the SDG 11.3.1 framework was done to examine the efficiency of land use.

METHODS: Data were collected through official documents, the use of remote sensing, and, geographic information systems. Satellite imageries used to determine the classes and changes in Land Use/Land Cover changes were Landsat 5 TM (1999), Landsat 7 ETM+ (2004, 2009, and 2014), and Landsat 8 ETM+ (2018 and 2022). Global positioning system was used for ground-truthing, IDRISI Taiga software was used for image classification, and ArcGIS was used for map visualization. Four classes of Land Use and Land Cover were identified: Built-up, Meadows, Mountain/Vegetation, and Water bodies.

FINDINGS: Results revealed that built-up area increased consistently from 3494.007 hectares in 1999 to 16995.360 ha in 2022 leading to a substantial reduction in other land use and land cover. The study confirmed a burgeoning population growth from 780,000 in 1999 to 1,563,193 in 2022. This growth had a significant impact on urban land use management, consuming a large proportion of land from 3494.007 hectares to 16995.36 hectares in 1999 and 2022 respectively. Results revealed a high land consumption rate of 0.0962 and 0.0884 during 2018-2022 and 1999-2004. A high population growth rate (0.0414) was recorded during 2018-2022. These dynamics intensified the rate of land acquisition for urban development. The average value of the SDG 11.3.1 framework was 2.3 which is higher than 1, indicating that urban expansion is moving away from land use efficiency.

CONCLUSION: The paper recommended the establishment of a Growth Management Monitoring system by the state government for effective and efficient management of land resources through a spatial plan for the metropolis. This study has provided insight into the dynamics of Jos metropolitan LULC and land use efficiency management which could be useful to policymakers, urban planners, and researchers in initiating sustainable urban development strategies and inclusive structure for its planning and management.

NUMBER OF REFERENCES
57

NUMBER OF FIGURES
3

NUMBER OF TABLES
7

*Corresponding Author:
Email: shehupatrick@gmail.com
Phone: +2348032919037
ORCID: 0000-0003-2802-9000

Note: Discussion period for this manuscript open until April 1, 2023 on IJHCUM website at the "Show Article.

INTRODUCTION

The dynamic nature of urban areas the world over suggests that the future of planet earth is an urban one. Urban areas all over the world are in a state of flux, especially in less developed countries, and a strong trend toward urban growth and expansion has been observed (Rikko, 2016). The United Nations predicted that by the year 2030, more human population will live in urban than in rural regions, majorly in Asia and Africa, which presently are the slightest urbanized parts of the globe (Abdulkadir *et al.* 2019, Sustainable Development Solutions Network, 2012). In Sub-Saharan Africa, Nigeria has the highest proportion (52.764%) of the urban population (The World Bank Data, 2022; Rowland, 2016). This unprecedented increase in population has a significant impact on the land due to human-associated sustenance activities, such as shelter, infrastructure development, food production, and extraction of natural resources. However, land resources are becoming increasingly scarce on a global scale, as a result of continued exploitation and mismanagement (Fikadu, 2022; Gessese, 2018). The rapid increase in urban population derived several cities globally into having high land consumption due to increased demand, which is evidenced in city boundaries often extending to further peripheries (Nicolau *et al.,* 2019; UN-Habitat, 2018; Seto *et al.,* 2011). This development according to Mustard *et al.* (2012) changes the entire spatial distribution of Land Use and Land Cover (LULC) of cities. The rapid changes in LULC, are one of the major forces of environmental change globally and are focal to the sustainable development debate. These changes in LULC, include the rampant conversion of agricultural land to urban development due to urban growth, and environmental degradation (Hegazy and Kaloop, 2015; Tsegaye, 2014). It is, therefore, crucial to evolve approaches that monitor and measure urban growth and LULC change for sustainable and efficient land management. The present study area is witnessing rapid population growth coupled with haphazard and unguided expansion occurring in the metropolis which has accelerated due to international crises, environmental changes, and urbanization. The expansive nature of growth and the change occurring in the LULC of the metropolis is unsustainable. This growth has serious environmental challenges ranging from loss of agricultural land (d'Amour *et al.,* 2017; Pandey and Seto, 2015), poor/lack of infrastructure, and growing sprawl/squatter settlements (Wang *et al.,* 2021), urban greenhouse gas emission (IPCC, 2014), habitat fragmentation and biodiversity loss (Cameron *et al.,* 2021; McDonald *et al.,* 2020; Guneralp *et al.,* 2013). Interestingly, UN-Habitat, (2018) posits that more than half of the area expected to be urban in 2030 has yet to be built. Thus, there is a great chance to make the future city more productive and sustainable, and cities that have the potential to improve the lives of half the world's population today, and 80% by 2030 (UN-Habitat and UNEP, 2013). However, most cities are forfeiting these advantages, growing spatially faster than their population and haphazardly absorbing land needed for agriculture and ecosystem services (UN-Habitat, 2018; UN DESA, 2022). Given the increasing environmental challenges posed by urban growth, growth monitoring techniques have been reviewed. The United Nations Human Settlements Programme proposed the adoption of a framework for urban growth monitoring, titled "ratio of Land Consumption Rate to Population Growth Rate" (UN-Habitat, 2018). This framework is also known as SDG 11.3.1, because it is associated with Sustainable Development Goal 11 which is aimed at "making cities inclusive, safe, resilient and sustainable", and, more specifically with the target 11.3 that envisages "enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries" by 2030 (UN-Habitat, 2018, Nicolau *et al.,* 2019). The framework SDG 11.3.1 is intended to understand the relationship between population shifts and urban land (Sharma *et al.,* 2012). It informs and enables policymakers and urban planners to monitor and manage urban land efficiently and ensure cities that are productive and environmentally sustainable (Sustainable Development Solutions Network, 2012). The framework SDG 11.3.1 has been grouped as grade II due to its universally proven technique for its calculation, even though, the data for its establishments are not often produced by nations (Nicolau *et al.,* 2019). In the foregoing, experts view the formula suggested for working out of framework 11.3.1 as inadequate because it ends with uncertain values. The discussion on the method and accessibility of datasets for the calculation of the framework has been limited to a set of scholars

working together with the UN for this reason. In line with (Nicolau *et al.,* 2019; Abdulkadir *et al.,* 2019) that this framework aims to examine the extent of areas occupied by urban settlements relative to population increase. There is a lack of clarity regarding the standard definition and measurement of what constitutes the category of land referred to by the framework. However, scholars assume the category of land referred to by the framework is the urban spatial extent which includes the entire built-up areas of the target regions or cities (UN-Habitat, 2018, Abdulkadir *et al.,* 2019). Global Human Settlement Layer (GHSL), has been used in a variety of urban studies to source data on built-up areas and the population of regions within a given period which is crucial in determining the relationship between the spatial extent and population increase of an area. For instance, Abdulkadir *et al.,* (2019); Freire and Pesaresi (2015), acquired data on built-up area and population densities from the GHSL in the development of the framework SDG 11.3.1. The results calculated in the framework have been useful in monitoring Land Use Efficiency (LUE) in the respective regions. However, data obtained from the GHSL may not be always correct, sometimes the built-up areas may be falsely detected, being that some settlements are not detected because of their size or material used for construction or they were below a dense tree canopy (Cai *et al.,* 2020). Other open data sources like satellite images, such as Thematic Mapper (TM), Enhanced Thematic Mapper (ETM+), and Operational Land Imager (OLI) from Landsat satellites, with a spatial resolution of 30 meters, have been reliable in providing substantial data for geographical studies (Chen and He, 2018), especially on LULC including built-ups and changes that have occurred in the environment. Remote Sensing and Geographic Information Systems (GIS) have been widely used and can provide scientifically reliable data on urban spatial extent and detection of changes in the LULC (Hossain and Moniruzzaman, 2021; Chen *et al.,* 2020; Rimal *et al.* 2018; Wang *et al.* 2020; Mohamed, 2017). Remote sensing data particularly Landsat images provide a suitable possibility for LULC change monitoring, particularly for developing countries where geospatial technologies are not well developed (Adepoju *et al.* (2006) cited in Leta *et al.* 2021). Geographic Information Systems provide maps, geographically referenced spatial analysis, and

tabular information on the extent and changes in LULC (Kotaridis and Lazaridou, 2018). Pieces of literature on LULC have been reviewed (Agarwal *et al.,* 2002; Ochuka *et al.,* 2019; Bashir, 2012; Minale, 2013; Hegazy and Kaloop, 2015; Rikko, 2016; Farrell, 2017; Yohanna*, et al.* 2015; Mahmoud *et al.,* 2016; Fikadu *et al.,* 2022; Arifeen *et al.,* 2021; Hassan and Nazem, 2016; Liping *et al.,* 2018). These studies have generated credible information on the extent and changes in LULC, which can provide better decision-making for sustainable development in various areas. Studies conducted in Jos south Local Government Area of Plateau State Okafor *et al.,* (2014), mapped out land use and land cover between 1993 and 2013 using remote sensing and GIS, and Adzandeh *et al.,* (2015) analyzed urban growth agents in Jos metropolis. The studies revealed significant transformations in LULC. However, the previous studies concentrated on LULC changes and the identification of growth agents, in certain areas. The extent of land consumption to the population growth rate of the region has not been considered. This study fills the knowledge gaps. The present study employed remote sensing and GIS techniques to determine the LULC areal extent and changes of the entire metropolis and applied the framework SDG 11.3.1 to measure the rate of land consumption to the population growth rate of the region. The present study focused on the evaluation of the spatial changes in LULC along with the relationship between the extent of built-up areas and population growth rate from 1999 to 2022 in Jos metropolis. Statistics of LULC and changes and location of change were established, land consumption and population trend of the metropolis were determined, and computation of SDG 11.3.1 which determines the LUE was carried out. In the end, the computed value of the SDG 11.3.1 framework determines whether the extent of land consumption is higher or lower than the rate of population growth. The current study have been carried out in Jos Metropolis, Plateau State, Nigeria in 2022.

MATERIALS AND METHODS
The Study Area
Jos Metropolis is the administrative and commercial hub of Plateau State. Located in north-central Nigeria, it is about 288 kilometers from Abuja the federal capital territory. The metropolis lies between latitude 9º55'0" N to 9º47'40" N and
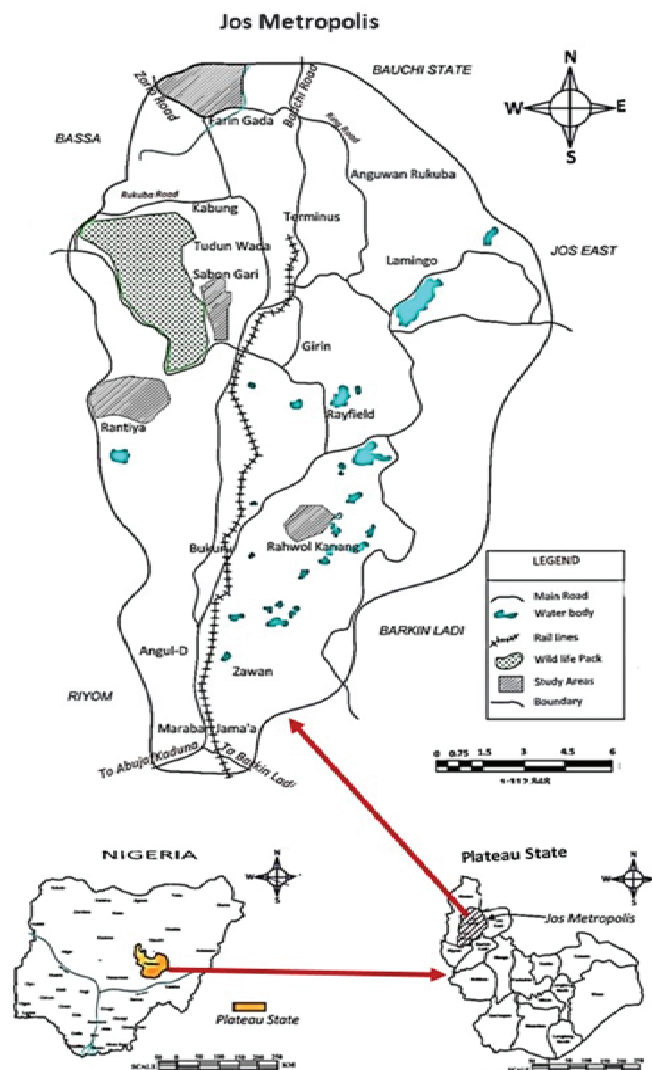
Jos Metropolis

Fig. 1: Jos Metropolis.

Longitude 8º57'20" E to 8º50'0" E (Hassan *et al.* 2015). It is bordered to the North-West by Bassa Local Government, North-East by Bauchi state, the South-West by Bassa and Riyom Local government, and the South-East by Barkin Ladi Local Government areas respectively (Fig. 1). The metropolis existed as a small mining city in 1904, demand for tin ore paved way for its fast urban population, consequently physical expansion (Dung-Gwom and Rikko, 2009; Wapwera *et al.,* 2015).

Methodology

The flow chart (Fig. 2) outlines the procedures involved in this study.

Data Sources

In this research, data were collected through the application of Remote Sensing and GIS tools. The image data used were Landsat images. These images were acquired from the United States Geological Survey's (USGS) spatial portal. The images were from six different epochs; the first epoch (1999) was collected from Thematic Mapper (TM) Sensors with Seven Bands in Geotiff format. The other collections were that of LANDSAT 7, with Enhance Thematic Mapper Sensor (ETM). As shown in table 1, 2004, 2009, and 2014 images are from LANSAT 7 ETM sensors; while 2018 and 2022 were from LANSAT 8 ETM sensors (Table 1). Key land-cover modification

114

Fig. 2: Flow method Chart Modified from Yohanna *et al.* (2015).

information and road networks were gathered using Global Positioning System (GPS) during the field visit and field confirmation operations.

Image processing procedures and composite image creation

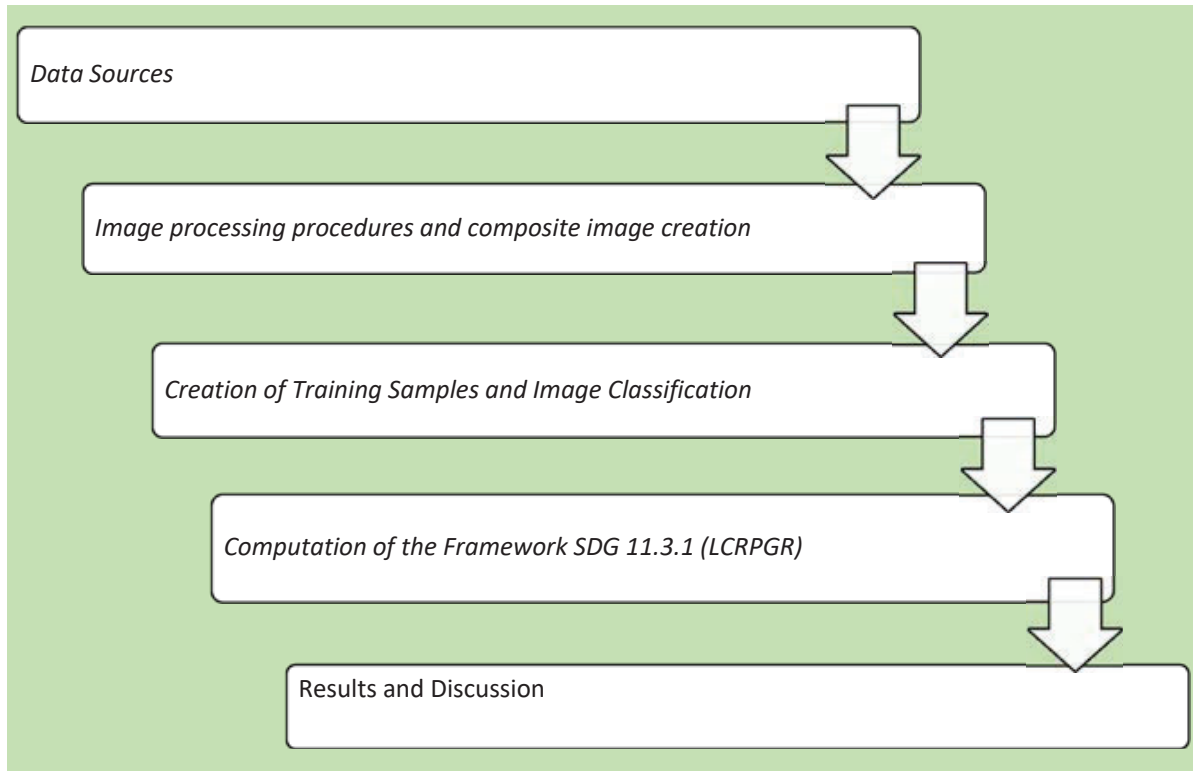All the image collections downloaded for the three epochs fall under WRS_PATH = 188, and WRS_ROW = 53. This means that the images spanned beyond the Jos metropolis, thereby requiring a means of being clipped to fit the study area. The image analysis, processing, classification, and analysis of the images were concentrated on the metropolis. Therefore, some secondary administrative data with the help of Google Earth were used to delineate the Jos Metropolis. These shapes in Google.klm formats were converted in ArcGIS' ArcMap to ESRI shapefiles as polygonal features. These features represented the areal extent of Jos Metropolis which was subsequently used in Clipping or extracting Jos Metropolis from the images. The researcher used a combination of

three clean bands for each epoch for the creation of composite images. A strand of the band in an image collection comes stretched in black and white; therefore composite mapping is geared towards combining a minimum of three bands to achieve an RGB color combination using sensors reflectance. In ArcMap, in the Toolbox, Create Composite tool was used in the Raster Data Management section. Three clean bands for each epoch were selected after which composite maps were created respectively.

Creation of Training Samples and Image Classification

The clarity of the images used by the researcher warranted the adoption of the Supervised Classification Method. With the researcher's firsthand knowledge of the study area, and the help of Google Earth Imagery software, a ground truth exercise was conducted to ascertain the different land uses in the study area and equally compare them with the spectral signatures of the composite images. The training samples were proportionally registered

Table 1: Data type and sources

Data type	Acquisition date	Number of bands	ELLIPSOID AXES	WRS PATH/ROW	EPHEMERIS EPOCH DAY	Source
Thematic Mapper (L5_TM)	18/11/1999	7	6378137.000000, 6356752.314200	188/53	322	USGS
LANDSAT 7 (ETM)	22/01/2004	9	6378137.000000, 6356752.314200	188/53	008	USGS
LANDSAT 7 ETM+	08/11/2009	9	6378137.000000, 6356752.314200	188/53	322	USGS
LANDSAT 7 ETM+	26/12/2014	7	6378137.000000, 6356752.314200	188/53	008	USGS
LANDSAT 8 ETM+	09/01/2018	11	6378137.000000, 6356752.314200	188/53	009	USGS
LANDSAT 8 ETM+	05/02/2022	11	6378137.000000, 6356752.314200	188/53	036	USGS

Table 2: Land use and land cover classification

LULC Categories	Description
Built-up	Urban, peri-urban and rural settlements, commercial areas, government offices, industrial zones, royal palaces, road networks, airports, and all public services including hospitals, schools, colleges, worship centers, etc)
Meadows	Bare/farmlands, undeveloped plots, organize open spaces, and orchards.
Mountain Vegetation	Bare rocks, hills, tree coverage, and or scattered and spare forest.
Water Bodies	Rivers, ponds, dams, and reservoirs.

using the respectful composite images for four land uses and land covers in the metropolis, namely: Built-up area, Mountain Vegetation, Meadows, and Water bodies (Table 2). Having the training sample registered, and the signature files for each epoch created, a supervised classification scheme was utilized. The classification of land use and land cover of Jos Metropolis was performed in the Image classification toolbar of ArcGIS thus yielding four major LULC categories. The overall classification accuracy was assessed using a dendrogram.

Computation of the Framework SDG 11.3.1 (LCRPGR)

The main data applied in the calculation of SDG 11.3.1 comprised the metropolitan population data for the period of study acquired from the National Population Commission and Greater Jos Master plan, and the metropolitan area extent extracted from the LULC statistical data. The population data were the census of the registered household population in the spatial unit of the metropolis. Due to rapid urbanization, movement or increasing population is a common occurrence, so it is hard to get the permanent population of a unit area that meets the requirements of the time series data (Cai, *et al.,*

2020). Thus, this study used the estimated population obtained from the National population commission and the Greater Jos Master Plan for the computation of the SDG framework (Table 3). According to the SDG 11.3.1 monitoring framework, the metropolitan area, or the urban agglomeration can be measured as the built-up land (UN-Habitat, 2018). Thus, the built-up area (herein referred to as the "metropolitan area") has been used in the computation of the framework. The mathematical equation recommended for defining the relationship between the metrics of the framework is presented in Eqs. 1, 2, and 3.

$$LCRPGR = \left(\frac{\text{Land Consumption Rate}}{\text{Population Growth Rate}} \right) \quad (1)$$

$$LCR = \frac{In(mt|m\varepsilon)}{n} \quad (2)$$

$$PGR = \frac{In(pt|p\varepsilon)}{n} \quad (3)$$

Where:

LCRPGR = Ratio of land consumption rate and Population growth rate; LCR = Land consumption rate; PGR = Population growth rate; In = Natural logarithm;

Table 3: Population data of Jos Metropolis

Year	Population Figure
1999	780,000
2004	877,500
2009	987,185
2014	1,130,325
2018	1,324,741
2022	1,563,193

mt = Metropolitan area at the final year;

$m\varepsilon$ = Metropolitan area at the initial year; pt = Population of metropolitan area at the final year;

$p\varepsilon$ = Population of the metropolitan area at the initial year; n = Number of years between the two-time intervals.

RESULTS AND DISCUSSION

Land Use and Land Cover Change and Location of Change

The LULC classification from 1999 to 2022 is shown in Fig. 3 and the trend of changes based on the interval of five years has been examined (Tables 4 and 5). From 1999 to 2004, a remarkable increase was observed in built-up areas and meadows, and a drastic decline in mountain vegetation and water bodies. The built-up area increased by 1942.6 hectares (ha) from 3494.007 ha to 5436.57 ha. The meadowland use including farmlands, undeveloped plots, organize open spaces, and orchards increased rapidly by 7066.6 ha from the initial 4968.9 ha to 12035.5 ha. These sharp alterations affected other LULCs, in which mountain vegetation and water bodies recorded a loss of 9006.5 ha and 2.7 ha respectively to meadows and built-up areas. Between 2004 and 2009, an increase in the built-up area and water bodies and a drop in meadows and mountain vegetation occurred during this period. The built-up area progressively increased by 1454.0 ha from 5436.57 ha to 6890.538 ha and water bodies expanded by 2.3 ha. The sudden decline in meadows and vegetation was due to the conversion of 894.5 ha and 561.8 ha respectively to built-up land. The expansion of water bodies could be attributed to increased mining activities in the region resulting in the proliferation of more mining ponds and ditches. The period from 2009 to 2014 witnessed a continuous increase in built-up land and a rise in vegetation cover and a decline in meadows and water bodies. Built-up areas expanded by 2538.3 ha from the initial 6890.538 ha to 9428.859 ha and a sharp rise of vegetation cover by 1350.8 ha from 21247.0 ha to 22596.3 ha. The increase in vegetation cover was a positive development owing to the ailing surge in environmental challenges and a call for the protection of the biodiversity and promotion of sustainable development (UN-Habitat and UNEP, 2013; UN DESA, 2022). Intense pressure upon undeveloped and farmlands resulted in a devastating drop of the meadow land cover by 3890.9 ha from 11140.96 ha to 7250.047 ha. The huge loss of meadows was evident in the increased expansion of settlements. In the period 2014 to 2018, the trend of the built-up area increased and a sharp decline across meadows, mountain vegetation and waterbodies occurred in this period. The built-up area increased by 2136.5 ha from 9428.859 ha to 11565.35 ha. This change affected the mountain vegetation cover, meadows land cover, and waterbodies by 1069.7 ha, 939.5 ha, and 127.3 ha respectively. The increased expansion of built-up areas was evident in the massive conversion of farmlands, vegetation, and hills into residential settlements. Due to the rapid expansion of built-ups, hill-tops and rocky areas have been converted into residential settlements in the Zinariya, Kabong, Sabon-gari, and Tudun Wada neighborhoods of the Jos metropolis. From 2018 to 2022, the continuous expansion of built-ups and meadows and a decline in vegetation and waterbodies were the main changes that occurred during this period. Built-up areas and meadows expanded highly by 5430.0 ha and 597.9 ha respectively. These transformations culminated in the conversion of 5876.2 ha and 151.7 ha of mountain vegetation cover and water bodies into urban settlements and farms, parks, and organized open spaces. The continued decrease of water bodies could be attributed to the season of the
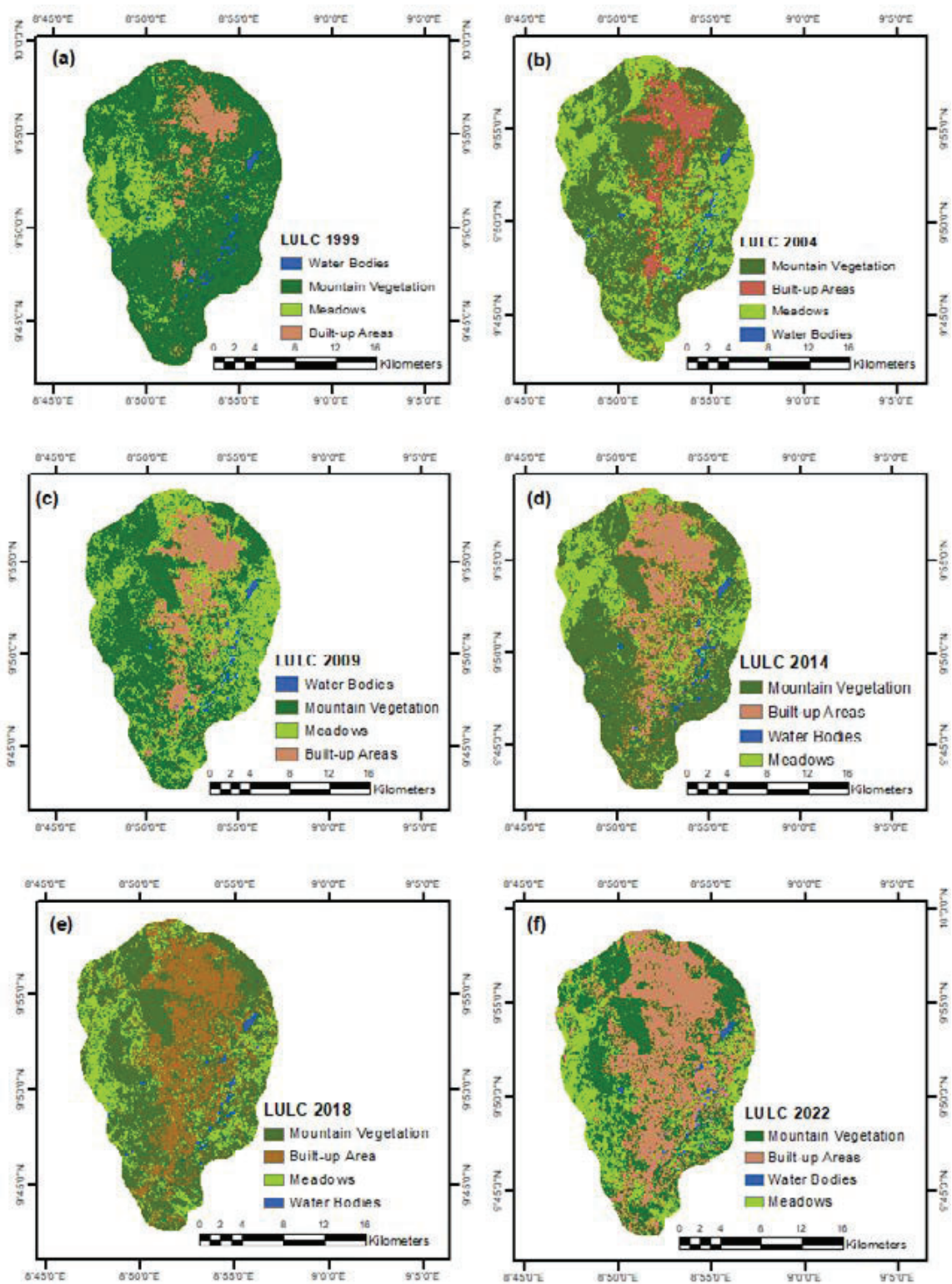
Fig. 3: LULC of Metropolitan Jos from 1999 to 2022.

Table 4: Land Use-Land Cover Statistics

LULC Category	1999 Area (Ha)	2004 Area (Ha)	2009 Area (Ha)	2014 Area (Ha)	2018 Area (Ha)	2022 Area (Ha)
Built-Up	3494.007	5436.57	6890.538	9428.859	11565.35	16995.36
Meadows	4968.9	12035.5	11140.96	7250.047	6310.579	6908.504
Mountain/Vegetation	30825.21	21798.81	21247.0	22596.3	21526.64	15650.46
Water bodies	668.8048	665.9288	668.2215	666.3864	539.0864	387.3464

Table 5: LULC change detection from 1999 to 2022

LULC Category	1999 – 2004 Change (Ha)	2004 – 2009 Change (Ha)	2009 -2014 Change (Ha)	2014-2018 Change (Ha)	2018 -2022 Change (Ha)
Built-Up	+1942.6	+1454.0	+2538.3	+2136.5	+5430.0
Meadows	+7066.6	-894.5	-3890.9	-939.5	+597.9
Mountain/Vegetation	-9006.5	-561.8	+1350.8	-1069.7	-5876.2
Water bodies	-2.7	+2.3	-1.8	-127.3	-151.7

NB: Ha indicates Hectares, the (+) sign indicates an increase and the (–) sign indicates a decrease in a different time frame

year when the images were taken in the dry season when the volume of water is low in all waterbodies and seasonal streams dry up due to the absence of rain and excessive usage for irrigation/dry season farming. Also, observed, drying up and disappearing of some mining ponds around Rahowl Kanang and Gura-top around Bukuru/Rayfield and Du, Zawan toward Hiepang due to reclamation activities. Further, unsustainable disposal of solid waste were observed in Farin-Gada and Dilimi River leading to obstruction and shrinking of the water ways. Unless drastic measures are taken such rivers may cease to exist. It is quite evident, from the result that the Jos metropolitan area (built-ups) has been growing progressively at an alarming rate over the last two decades owing to the rapid rate of urbanization and global crises leading to an increase in population and economic activities. The favorable climate, and the incessant crises and insecurity that have ravaged the entire nation and particularly the rural areas and the entire northern part of Nigeria aggravated the immigration of people into the metropolis of Jos. These results corroborate the findings of Rimal *et al.,* (2018); Hegazy and Kaloop (2015); Rikko (2016); Appiah *et al.,* (2015); Mahmoud *et al.,* (2016), and Dung-Gwom (2008). Uncontrolled urban expansion presents particular challenges to the sustainability of cities such as the high cost of planning and service provision and environmental challenges as established (Zhao *et al.,* 2018; Rikko, 2016).

Critical observation of the image maps from 2009 to 2022, there seems to exist a growth away from the city center following the concentric zone model of city growth postulated by Ernest Burgess, discussed in Planning Tank, (2020). From 1999 to 2009, there was all-round growth occurring majorly in the fringes of the metropolis evident around Farin-Gada sprawling into Unguwan Jarawa, Naraguta, ECWA Staff, Army engineer, and Mista Ali along Zaria road to the north while state low-cost and Rantya engulfing surrounding villages toward Wildlife Park to the southwest and around the Bukuru axis, Gura-top, Rahowl Kanang, Du, Zawan, Hiepang and Shen dam toward southern part and Rayfield, Kwang, Gwarandok, Rikkos, Eto-Baba, and Bauchi bye-pass toward the southeast of the metropolis. This development may not be far from the reasons discussed earlier and the fact that people build houses close to their places of work. From 2013 to 2018, the growth tended majorly toward the south, east, and southwestern parts of the metropolis. This could be attributed to the improvement and development of infrastructure and services such as roads as witnessed in Rantya, Gura-top, and Rahowl Kanang (Fig 3).

Land Consumption and Population Trend

Table 6 presents the land consumption of Jos metropolis and the trend of the population within the span of the study. It is quite evident, from the result that the metropolitan area has been expanding increasingly at an alarming rate over the last two decades. The table revealed that during the year 1999,

Table 6: The Metropolitan Land Consumption and Population statistics.

Years	Metropolitan Spatial Extent (Ha)	Estimated Population
1999	3494.007	780,000
2004	5436.570	877,500
2009	6890.538	987,185
2014	9428.859	1,130,325
2018	11565.350	1,324,741
2022	16995.360	1,563,193

Table 7: The Ratio of Land Consumption Rate and Population Growth Rate.

Interval (Years)	Land Consumption Rate (LCR)	Population Growth Rate (PGR)	LCRPGR
1999-2004	0.0884	0.0236	3.75
2004-2009	0.0474	0.0236	2.01
2009-2014	0.0627	0.0271	2.31
2014-2018	0.0511	0.0397	1.29
2018-2022	0.0962	0.0414	2.32

the metropolitan area consumed 3494.007 ha of land and unremittingly expanded to occupy 16995.360 ha in 2022. The increase in land consumption is associated with an increase in urban population and economic activities. The table indicated a rapidly burgeoning population, from 780,000 in 1999 to 1,563,193 in 2022. This frequent upsurge in the metropolitan population has contributed to the increasing rate of land consumption in efforts to meet its need. The growth trend of the Jos metropolis population is a thing of serious concern to sustainable development. This is because the alteration of the environment due to human-associated activities such as urban development can have far-reaching consequences on land. It was observed that population growth depletes resources and could trigger a social or economic catastrophe if it is not contained. Moreover, the rising population put swelling demand on land and, generate contaminations, such as air and water pollution and greenhouse gas emission along with increasing quantities of waste as already manifested in Dilimi, Gangare, Rikos, Unguwan Rogo, Nasarawa-Gwom, Sabon-layi, Unguwan Rukuba, Kongo-Rosha, Jenta and Tudun-Wada areas of the metropolis. This result settles with Sharma *et al,* (2012), where population growth in Bhagalpur played a crucial role in the environmental destruction of the city: from cultivation to land depletion or modification, increasing solid waste leading to nuisance, foul smell, and water pollution, and increased social and economic turmoil, hunger, migration, and conflict. The case of Tanzania, (UNFPA, 1991; Green, 1992 cited in Gwani and Galadima, 2015), where many areas especially around Dar es Salam and Mwanza witnessed environmental degradation due to increased demand for housing and other infrastructure development and arable land, to the extent that it could not support ecological balance and the provision of necessary resources to the present and future population. The incidence of rapid urban growth is likened to the situation in Indian cities, the cities are subject to an influx of over 38,000 new residents every day as India continues to urbanize at a rapid rate (Metropolis, 2011). Although the case of Indian cities is overwhelming compared with the situation in Jos, the resultant effect of rapid urban growth could be devastating if no measures are put in place to cater to the rising population and the associated challenges such as inadequate infrastructure and social services, increase in crime and insecurity, poverty and hunger, environmental pollution, susceptibilities to natural and man-induced hazard, and the proliferation of slums and informal settlements as already the case in the metropolis.

Computation of the SDG 11.3.1

The study reveals that the land consumption rate for the period 1999-2004, 2004-2009, 2009-2014, 2014-2018, and 2018-2022 is 0.0884, 0.0474, 0.0627, 0.0511, and 0.0962 respectively (Table 7). It was high from 2018-2022 and 1999-2004 but dropped in the period 2004-2009 and slightly increased from 2009 to

2018. The decrease observed during the years 2004 to 2009, could be attributed to the 2001, 2008, and 2010/2011 Jos crises that devastated parts of the metropolis leading to the displacement of people to other regions (Krause, 2011), and the fact that most of the population concentrated within the urban core. The increase in land consumption lately, suggests that during the period (2009 to 2022), people dispersed towards the peripheries of the metropolis for better living in an open space away from the densely populated area due to the relative peace restored. Thus, the rate at which lands were acquired for built-up development heightened. This situation poses a negative impact on the urban region because of the associated complications of land depletion, increased environmental pollution, and climate change. The Jos metropolitan population growth rate during the period 2018-2022 and 2014-2018 was high with a growth rate of 0.0414 and 0.0397 respectively. This proportion has been connected with the rapid increase of migration from within the Plateau State, the country, and other parts of the world owing to the moderate weather, economic improvement in the metropolis, and the disturbing insecurity that has devastated the entire northern region of Nigeria and Africa. This growth uses land resources for several land use to provide for its needs. This then suggests that the more the population in a given urban area, the more meadows and vegetation cover are lost to development (McDonald *et al.* 2010).

In computing the framework SDG 11.3.1, two main metrics are basic; Land Consumption Rate (LCR) and Population Growth Rate. The framework intends to monitor and achieve urban expansion effectively to encourage LUE. Thus, the framework (LCRPGR) is calculated at a five-year interval in this study. Based on the LCRPGR results, the average speed for the metropolitan area development is about 2.3 times faster than the population growth. According to the United Nations Human Settlements Programme, if the framework value is above or greater than one (1), it means that Land consumption is higher than the population growth rate or urban expansion is moving away from LUE (UN-Habitat, 2018), as such peri urbanization is the order of the day and result into uncontrolled physical expansion, physical infrastructure deterioration, greenhouse gas emission, environmental contamination among others. Abdulkadir, *et al.,* (2019) posits that efficient

consumption of land is key to sustainable land use and management. In the present research, the framework exposed that the rate of consumption of land during the period of studies is higher than the population growth rate because the resultant ratio stands at greater than one (1). It then implies that the expansion of Jos metropolis is moving away from land use efficiency (LUE). This result can be compared with the case in Scotland, England and France metropolitan areas where a high LCRPGR was recorded (UK Office for National Statistics, 2018; Ministère de la Transition Écologique et Solidaire, 2018). The result differs from the situation in Wales where the population growth rate surpassed land consumption rate (UK Office for National Statistics, 2018).

CONCLUSION

This study evaluated the changes that occurred in the land use and land cover, the land consumption and population growth rate and determined the urban land use efficiency of Jos metropolis in the past two decades using population data, remote sensing and GIS techniques, and computation of the SDG 11.3.1. Overall, this study established that there has been a phenomenal transformation in land use and land cover throughout the study. The built-up area experienced a maximum and consistent increase in the spatial extent from 3494.007 ha in 1999 to 16995.360 ha in 2022 leading to a substantial reduction in other land use and land cover. There was a drastic loss in vegetation cover from 30825.21 ha in 1999 to 15650.46 ha in 2022. Meadows increased from 4968.9 ha in 1999 to 6908.504 ha in 2022 and a decrease in water bodies from 668.8048 ha in 1999 to 387.3464 ha in 2022. The modification in LULC is linked to the increase in population and economic activities, manifested in the rapid spread of housing development, commercial development, and the construction of infrastructures. Concerning the location of change, this study observed an all-around growth majorly occurring in the fringes of the metropolis witnessed in the proliferation of slums and informal settlements. The study confirmed a burgeoning population growth in the metropolis from 780,000 in 1999 to 1,563,193 in 2022. This growth had a significant impact on urban land use management, consuming a large proportion of land from the initial 3494.007 ha in 1999 to 16995.36 ha in 2022. To ensure sustainable urban development and

efficient management of urban land use, the study evaluated the ratio of land consumption rate and population growth rate (LCRPGR). The study revealed a high urban land consumption rate of 0.0962 and 0.0884 during the period 2018-2022 and 1999-2004. The metropolitan population growth rate was high during 2018-2022 and 2014-2018 with a growth rate of 0.0414 and 0.0397 respectively. These dynamics intensified the rate of land acquisition for urban development. The average value of the SDG 11.3.1 framework was 2.3 which is higher than 1, indicating that urban expansion is moving away from land use efficiency. Thus, it is inferred that Jos metropolis is an urban settlement where the land consumption is greater than the population growth. A scenario like this leads to peri-urban development and results in spontaneous and uncontrolled urban expansion, slum development, depletion of infrastructure, increased crime and insecurity, hunger and poverty, and environmental pollution.

Thus, the study recommends that:

1   There should be a Growth Management Monitoring System (GMMS) using Geographic Information System technology to monitor and assess land use and land cover changes as well as periodic mapping and production of spatial and temporal models. The system should include the integration of GIS techniques, planning, population data, or socio-economic data to manage urban growth. This could be spearheaded by PlaGIS (Plateau Geographic Information Services) and the Ministry of Lands, Survey, and Town Planning.

2   There is a need to promote urban greeneries. This may include checking the conversion of agricultural land into urban land use by introducing land-saving construction designs and enhancing the effective utilization of inner-city land and protecting and developing greeneries.

3   There is a need for the state government to know the absolute population change each year. This includes the number of newcomers (by birth or in migration) needing housing and public services. This is crucial in determining and managing land consumption.

4   Policymakers and planning authorities should promote efficient use of urban land and sustainable growth through renewing existing urban land and urban infill. This is better than extending the occupied land encroaching into farmland.

This study has provided insight into the dynamics of Jos metropolitan LULC and land use efficiency management which could be useful to policymakers, urban planners, and researchers in initiating sustainable urban development strategies and inclusive structure for its planning and management. Universally, this study also adds the literature to lay the grounds for effective management of urban land and development policy relating to Jos Metropolis and maybe cities of developing countries. Furthermore, the findings could pave the way for further investigations on the spatial pattern, nature, and drivers of growth in peri-urban areas of the metropolis as well as the provision or adequacy of services in the peri-urban areas.

AUTHOR CONTRIBUTIONS

P. Shehu performed the review of related literature, designed the procedures for carrying out the research, collected and computed data, produced maps, analyzed and interpreted the data, designed the graphical abstract, and prepared the manuscript text and editing. L.S. Rikko supervised the research work and assisted in the review of the literature and the manuscript. M.B. Azi assisted in the data collection and collation and editing of the manuscript.

ACKNOWLEDGEMENT

CONFLICT OF INTEREST

The authors have no conflict of interest to be declared concerning this review paper. Also, the authors have checked all the ethical affairs comprising duplicates, misconduct, data making, informed consent, and plagiarism.

OPEN ACCESS

PUBLISHER'S NOTE

Tehran Urban Planning and Research Center remains neutral with regard to jurisdictional claims in published maps and institutional afflictions.

ABBREVIATIONS (NOMENCLATURE)

Eq.	Equation
ETM	Enhance Thematic Mapper
GIS	Geographic Information System
GMMS	Growth Management Monitoring System
GPS	Global Positioning System
Ha	Hectare
In	Natural logarithm
LCR	Land consumption rate
LCRPGR	The ratio of land consumption rate and Population growth rate
LUE	Land use efficiency
LULC	Land Use and Land Cover
$\mathring{m}$	Metropolitan area at the initial year
mt	Metropolitan area at the final year
	Number of years between the two-time intervals
OLI	Operational Land Imager
$\mathring{p}$	The population of the metropolitan area in the initial year
PGR	Population growth rate
PlaGIS	Plateau Geographic Information Services
pt	The population of the metropolitan area in the final year
SDG	Sustainable development goal
TM	Thematic Mapper
USGS	United States Geological Survey

REFERENCES

Abdulkadir, I.; Kumar, J.S.; Noon, M., (2019). The ratio of land consumption rate to the population growth rate- A case of metropolitan Gombe. Preprints. Org., 47(1): 1-17 (**17 pages**).

Adzandeh, E.A.; Akintunde, J.A.; Akintunde, E.A., (2015). Analysis of urban growth agents in Jos Metropolis, Nigeria. Int. J. Remote Sens., 4(2): 41-50 **(10 pages).**

Agarwal, C.; Green, G.M.; Grove, J.M.; Evans, T.; Schweik, C.M., (2002). Review and assessment of land-use change models: dynamics of space, time, and human choice. General Technical Report NE-297. Newton Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Center Station **(61 pages).**

Appiah, D.O.; Schröder, D.; Forkuo, E.K.; Bugri, J.T., (2015). Application of geo-information techniques in land use and land cover change analysis in a peri-urban district of Ghana. Int. J. Geog. Inf. Sci., 4: 1265-1289 **(25 pages).**

Arifeen, H.M.; Phoungthong, K.; Mostafaeipour, A.; Yuangyai, N.; Yuangyai, C.; Techato, K.; Jutidamrongphan, W., (2021). Determine the land-use Land-cover changes, urban expansion, and their driving factors for sustainable development in Gazipur Bangladesh. Atmosfere, 12: 1353 (**19 pages**).

Bashir, M., (2012). The impact of land-use change on the livelihoods of rural communities: a case study in Edd Al-Furssan locality, South Darfur State, Sudan. Ph.D. Thesis, Technische University Dresden.

Cai, G.; Zhang, J.; Du, M.; Li, C.; Peng, S., (2020). Identification of urban land use efficiency byIndicator-SDG 11.3.1. PLoS ONE 15(12): e0244318 (**14 pages**).

Cameron, C.; Maharaj, A.; Kennedy, B.; Tuiwawa, S.; Goldwater, N.; Soapi, K.; Lovelock, E.C., (2021). Landcover change in mangroves of Fiji: Implications for climate change mitigation and adaptation in the Pacific. Environ. Challenges, 2(2021): 1-11, (**11 pages**).

Chen, J.; He, C.W., (2018). Global land cover mapping and its application for SDGs, National Geomatics Center of China, May 30, 2018, Copenhagen.

Chen, J.; Peng, S.; Chen, H.; Zhao, X. S.; Ge, Y.J.; Li, Z.L., (2020). A comprehensive measurement of progress toward local SDGs with geospatial information: methodology and lessons learned. ISPRS Int. J. Geo-Info., 9(9): 552 (**19 pages**).

d'Amour, C.B.; Reitsma, F.; Baiocchi, G.; Barthel, S.; Güneralp, B.; Erb, K.H.; Haberl, H.; Creutzig, F.; Seto, K.C., (2017). Future urban land expansion and implications for global croplands. Proceedings of the National Academy of Sciences of the United States of America. 114(34): 8939-8944 (**6 pages**).

Dung-Gwom, J.Y. (2008). Nature of peri-urban development in Jos, Nigeria. World Congress on Housing, National Housing Programme—New Vision XXXVIIAHS. Kolkata, India.

Dung-Gwom, J.Y.; Rikko, D.S.L., (2009, September). Urban violence and emerging housing markets in Jos, Nigeria. International Sociological (ISA) Housing Conference. Glasgow, GB.

Farrell, K., (2017). The rapid urban growth traid: a new conceptual framework for examining the urban transition in developing countries. J. Sustain., 9(8): 1-19 **(19 pages).**

Fikadu, G., (2022). Impact of land use land cover change using remote sensing with the integration of socio-economic data on rural livelihoods in case of Nashe Watershed, Ethiopia. Res. Square, 1-12 **(12 pages).**

Freire, S.; Pesaresi, M., (2015). GHS population grid, derived from GPW4, multi-temporal (1975, 1990, 2000, 2015). European Commission, Joint Research Centre, 2015.

Gessese, B., (2018). Impact of land use/land cover change on rural community's livelihood of Ethiopia. Res. Rev. J. Ecol. Environ. Sci., 6(1): 8-15 **(8 pages).**

Güneralp, B.; Seto, K.C., (2013). Futures of global urban expansion: uncertainties and implications for biodiversity conservation. Environ. Res. Lett. 8(1): 014025 (**10 pages**).

Gwani, J.; Galadima, A., (2015). Population. In Egunjobi, L., (Eds.), Contemporary concepts of physical planning. Department of Urban and Regional Planning, University of Ibadan, Ibadan, Nigeria. 894-914 (**21 pages**).

Hassan, A.; Raji, B.; Malgwi, W.; Agbenin, J., (2015). The basaltic soils of Plateau State, Nigeria: properties, classification, and management practices. J. Soil Sci. Environ. Manage., 6(1): 1-8 **(8 pages).**

Hassan, M.M.; Nazem, M.N.I., (2016). Examination of land use/land cover changes, urban growth dynamics, and environmental sustainability in Chittagong city, Bangladesh. Environ. Dev. Sustain., 18(3): 697-716 (**20 pages**).

Hegazy, R.I.; Kaloop, R.M., (2015). Monitoring urban growth and land-use change detection with GIS and remote sensing techniques in Daqahlia Governorate Egypt. Int. J. Sustainable Built. Environ., 4(1): 117-124 **(8 pages).**

Hossain, F.; Moniruzzaman, M., (2021). Environmental change detection through remote sensing technique: A study of Rohingya refugee camp area (Ukhia and Teknaf sub-district), Cox's Bazar, Bangladesh. Environ. Challenges, 2: 1-11 (**11 pages**).

Leta, M.K.; Demissie, T.A.; Tränckner, J., (2021). Modeling and prediction of land use land cover change dynamics based on land change modeler (LCM) in Nashe Watershed, upper Blue Nile Basin, Ethiopia. Sustainability, 13(7): 3740 (**24 pages**).

Liping, C.; Yujun, S.; Saeed, S., (2018). Monitoring and predicting land use and land cover changes using remote sensing and GIS techniques—A case study of a hilly area, Jiangle, China. PLoS ONE, 13(7): e0200493 (**24 pages**).

Kotaridis, I.; Lazaridou, M., (2018). Environmental change detection study in the wider area of lignite mines. Civil. Eng. Archit., 6(2):108-114 (7 pages).

Krause, J., (2011). A deadly cycle: ethno-religious conflict in Jos, Plateau State, Nigeria. Geneva Declaration. **(68 pages).**

McDonald, R.I.; Mansur, A.V.; Ascensao, F.; Colbert, M.; Crossman, K.; Elmqvist, T.; Gonzalez, A.; Güneralp, B.; Haase, D.; Hamann, M.; Hillel, O.; Huang, K.; Kahnt, B.; Maddox, D.; Pacheco, A.; Pereira, H.M.; Seto, K.C.; Simkin, R.; Walsh, B.; Werner, A.S.; Ziter, C., (2020). Research gaps in knowledge of the impact of urban growth on biodiversity. Nat. Sustain., 3(1): 16-24 (**9 pages**).

McDonald, R.I.; Forman, R.T.T.; Kareiva, P., (2010). Open space loss and land Inequality in United States Cities, 1990–2000. PLoS ONE 5(3): e9509 (**7 pages**).

Mahmoud, I.I.; Duker, A.; Conrad, C.; Thiel, M.; Ahmad, H.S., (2016). Analysis of settlement expansion and urban growth modeling using geo-information for assessing potential impacts of urbanization on climate in Abuja city, Nigeria. Remote Sens., 8(3): 1-24 **(24 pages).**

Metropolis, (2011). Managing urban growth. Barcelona. Commission 2 Report **(86 pages).**

Minale, A.S., (2013). Retrospective analysis of land cover and use dynamics in Gilgel Abbay Watershed by using GIS and remote sensing techniques, Northwestern Ethiopia. Int. J. Geosciences, 4(7): 1003-1008 **(6 pages).**

Ministère de la Transition Écologique et Solidaire (2018). Observation et Statistiques. Indicateurs Nationaux de Suivi de la Transition Écologique vers un Développement Durable (2015 2020): Artificialisation des Sols.

Mohamed, M.A., (2017). Monitoring of temporal and spatial changes in land use and land cover in metropolitan regions through Remote Sensing and GIS. Nat. Resources, 8: 353-369 (**17 pages**).

Mustard, J.F.; Defries, R.S.; Fisher, T.; Moran, E., (2012). Land-use and land-cover change pathways and impacts. In Gutman et al. (eds). Land change science. Remote Sensing and Digital Image Processing, Springer,

Dordrecht, 6: 411-429 (**19 pages**).

Nicolau, P.; David, J.; Caetano, M.; Pereira, J.M.C., (2019). Ratio of land consumption rate to population growth rate—Analysis of different formulations applied to mainland Portugal. Int. J. Geo-Inf. 8(10): 1-21 **(21 pages).**

Ochuka, M.; Ikporukpo, C.; Mijinyawa, Y.; Ogendi, G., (2019) Land use/land cover dynamics and anthropogenic driving factors in Lake Baringo catchment, Rift Valley, Kenya. Nat. Resour. J., 10(10): 367-389 **(23 pages).**

Okafor, C.; Lekwot, E.; Baji, J.; Yakubu, A., (2014). An appraisal of urban land use and land cover changes in Jos South Local Government area of Plateau State, Nigeria using remote sensing and GIS. Academia.

Pandey, B.; Seto, K.C., (2015). Urbanization and agricultural land loss in India: comparing satellite estimates with census data. J. Environ. Manage., 148: 53–66 (**14 pages**).

PlanningTank, (2020). Concentric zone model by Ernest Burgess: Burges Model. Settlement Geography.

Rikko, L.S., (2016). Urban Growth and the planning challenges of the Greater Karu urban area (Gkua), Nasarawa State. Lambert Academic publishing.

Rimal, B.; Zhang, L.; Keshtkar, H., Haak, B.N; Rijal, S.; Zhang, P., (2018). Land use/land cover change dynamics and modeling of urban land expansion and land use and land cover change by the Integration of cellular Automata and Markov chain. Int. J. Geo-Info., 7(4): 154 (**21 pages**).

Rowland, E.A., (2016). City growth: issues and challenges of urban sustainability in Nigeria. The 46th Annual Conference of the Nigerian Institution of Estate Surveyors and Valuers. Transcorp Hilton Hotel, Abuja, Nigeria.

Sharma, L.; Pandey, P.C.; Nathawat, M.S., (2012). Assessment of land consumption rate with urban dynamics changes using geospatial techniques. J. Land Use Science, 7(2): 135-148 (**14 pages**).

https://planningtank.com/settlement-geography/concentric-zone-model-burgess-model

Seto, K.C.; Fragkias, M.; Güneralp, B.; Reilly, M.K., (2011). A Meta-Analysis of global urban land expansion. PLoS ONE, 6(8): e23777 (**9 pages**).

IPCC, (2014). Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. (**16 pages**).

Sustainable Development Solutions Network, (2012). Ratio of land consumption rate to population growth rate, at comparable scale: Indicators and monitoring frameworks.

Tsegaye, L., (2014). Analysis of land use and land cover change and its drivers using GIS and remote sensing: The case of West Guna Mountain, Ethiopia. Int. Res. J. Earth Sci., 3: 53-63 (**11 pages**).

The World Bank Data, (2022). Nigeria - urban population (% of total) - actual values, historical data, forecasts, and projections. Data World Bank.

UK office for national statistics (2018). Using innovative methods to report against the sustainable development goals.

UN DESA (2022). World Population Prospects 2022: Summary of Results. UN DESA/POP/2022/TR/NO. 3.

UN-Habitat, (2018). SDG Indicator 11.3.1 Training Module: Land Use Efficiency. United Nations Human Settlement Programme (UN-Habitat), Nairobi.

UN-Habitat and UNEP, (2013). TST Issues Brief: sustainable cities and human settlements.

Wang, S.W.; Gebru, B.M.; Lamchin, M.; Kayastha, R.B.; Lee, W.K., (2020). Land use and land cover change detection and prediction in the Kathamandu district of Nepal using remote sensing and GIS. Sustainability, 12(9): 122 (**18 pages**).

Wang, S.W.; Munkhnasan, L.; Lee, W., (2021). Land and land cover change detection in Bhutan's high altitude city of Thimphu, using cellular automata and Markov chain. J. Environ. Challenges, 2(2021): 1-11 (**11 pages**).

Wapwera, S.D.; Ayanbimpe, G.M.; Odita, C.E., (2015). Abandoned Mine, Potential Home for the People: A Case Study of Jos Plateau Tin-Mining Region. J. Civ. Eng. Archit., 9(2015): 429-445 **(17 pages).**

Yohanna, P.; Bulus, L.G.; Alfred, D.M., (2015). Landuse/landcover change detection of Mubi metropolis, Adamawa State, Nigeria. Sky J. Soil Sci. Environ. Manage., 4(6): 070-078 **(9 pages).**

Zhao, M.; Cheng, W.; Zhou, C.; Li, M.; Huang, K.; Wang, N., (2018). Assessing spatiotemporal characteristics of urbanization dynamics in Southeast Asia using time series of dmsp/ols nighttime light data. Remote Sens., 10(1): 47 (**20 pages**).

International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: http://www.ijhcum.net/

The socio-demographic determinants of urban household demand for road travel in urban areas

S. Watundu[1*], B. Kalinda Mkenda[2], N. Mwelu[3]

[1] Department of Management Science, Makerere University Business School, Kampala, Uganda, Africa

[2] Department of Applied Economics, University of Dar es Salaam, Dar es Salaam, Tanzania, Africa

[3] Department of Procurement and Supply Chain Management, Makerere University Business School, Kampala, Uganda, Africa

ARTICLE INFO

ABSTRACT

BACKGROUND AND OBJECTIVES: The demand for travel is increasing along with the development of the urban city. Since its establishment in 1890, the same situation has been replicated in Uganda, particularly in Kampala, the capital city. The city has grown tremendously, and this has spilled over to neighboring towns. Road transport carries 99 percent of the traffic in Kampala Capital City, causing massive congestion on city roads. Increased traffic could result from residents of the city or visitors from other parts of the country. Thus, understanding societal travel behaviours of city dwellers is necessary for better planning and policy guidance. This study examines the socio-demographic determinants of urban household demand for road travel in Kampala City.

METHODS: Data from the Kampala Capital City Authority's transport and household travel habits survey were used in this study. A sampling plan developed by the Greater Kampala Metropolitan Area Transport Master Plan Project was followed. Households were drawn from parishes stratified by residential typology using a simple random sampling method. Based on the social economic groupings, a proportional sample of 1906 households was drawn. Data on household characteristics, personal attributes of the household head and travel habits data were obtained. Given the observed over dispersion, a Negative Binomial Regression was estimated.

FINDINGS: The results show that household daily demand for travel increase with the size, age, and education level of the head. Compared to households with 1-3 members, results indicate a significant increase in the difference between the logs of the daily trips taken by 0.329 and 0.587 for households with 4-6 and above 6 members, respectively; the older the household head, the higher the difference between the logs of expected number of trips, compared to households with heads aged 15-24 years, those whose heads are aged 25-34, 35-44, 45-54 and above 54 years, the difference of the logs of the expected number of trips taken increases significantly by 0.0769, 0.149, 0.163 and 0.212 trips, respectively; household heads working in the private sector reduces the difference in the logs of daily travel by 0.0659 trips when compared to the public sector; the more educated the household head, the more trips taken daily. Households with a private car make fewer trips than those without.

CONCLUSION: Sensitization programmes for reducing unnecessary and avoidable travel and family size are required. Uptake of distribution and or redistribution polices for development activities and investments to other urban centers and regions.

NUMBER OF REFERENCES

82

NUMBER OF FIGURES

1

NUMBER OF TABLES

5

*Corresponding Author:
Email: swatundu@mubs.ac.ug
Phone: +256782658703
ORCID: 0000-0002-4097-4657

Note: Discussion period for this manuscript open until April 1, 2023 on IJHCUM website at the "Show Article.

INTRODUCTION

Travel demand rise concurrently with economic development (Coutinho *et al.*, 2020; Ignacio, 2019). This has been the case in Uganda, particularly in the Kampala Capital City Authority (KCCA), since its founding in 1890. One of the major causes of traffic congestion has been identified as high demand for travel. Ccongestion is a problem for all large and growing urban areas, not just in developed countries, but also in medium and small cities in developing countries, particularly those with less developed road infrastructure. Cities and road traffic congestion have coexisted since the dawn of large human settlements (Organization for Economic Co-operation and Development (OECD/ECMT, 2007; Mirzapour *et al.,* 2017). This is because of increased movements caused by increased rural-urban migration and the need for travel (Kampouri *et al.*, 2021; *Ortega et al.,* green). Although traffic congestion is caused by an imbalance between supply and demand for road infrastructure, understanding societal travel behaviour is important. In Uganda, Kampala, as the capital city and thus the major business center where most important government ministries' offices are located, has drawn the desire and the need for people to frequently move to the city. Overtime, Kampala has experienced massive congestion on the city roads, which has worsened by extending into late hours in the night and almost every day of the week. Congestion is a negative externality that comes with a number of high economic costs or time losses. Traffic congestion also raises air pollution levels, which is dangerous and goes against the principles of the Green Deal (Sharifi *et al.*, 2021; Stilwell, 2021; Beaudoin *et al.*, 2015). Congestion has a knock-on effect in that events that cause congestion may also cause other events. According to Alinange (2010) and Kiggundu (2007), the traffic jam in Kampala is caused by the city's structure, which is single-centred and poorly planned, disorganised and outdated, with an expensive transportation system. Despite the congestion, road transport remains the most popular mode of transportation, carrying over 90%of all transit and traffic in the country and 99% of all traffic in Kampala (Azad and Chakraborty, 2021; KCCA), 2011). It transports approximately 95% of the country's goods and 99% of its passengers (Sanya, 2011; O'Donnell *et al.*, 2011). Given the importance

of Kampala city to the country's economic growth, traffic to the city is expected to increase at a much faster rate. The labor force participation rate in Kampala is increasing at a faster rate than in other cities such as Mbarara in the western region, Mbale in the eastern region and Gulu in the northern region of the country. Nonetheless, all of these urban centres have a high day-time population, which includes people who work in the city but do not live there (UBOS, 2014). According to the Greater Kampala Metropolitan Area study, there are approximately 3 million people who travel to and from the city centre every day. By 2024, the day population is expected to double (KCCA, 2012). As the population grows, so will the number of people who travel to cities. Despite the increased congestion, only 38% of Kampala's total road network is paved, and 89% of gravel roads are in poor condition (KCCA, 2010). KCCA and the Ugandan government have devised traffic management strategies. These include road rehabilitation, the creation of new parks to relieve congestion the city centre's taxi and bus parks, the recruitment of traffic wardens and police at congested intersections, the construction of outer ring roads, the prohibition of street businesses the introduction of buses on major arterials, and the reorganisation of traffic flow on some city roads. The heavy traffic congestion on Kampala roads has drawn the attention of city authorities and the Ugandan government, who have tried and are still trying to find solutions to manage this problem. Despite these efforts, traffic congestion remains severe. Recent studies emphasise the importance of sustainable travel demand management policies in situations of limited road infrastructure supply and for long-term solutions (Lozzi and Monachino, 2021; Sarkar, 2019; Stanford, 2017; Malayath and Verma, 2013). Since good road infrastructure may instead cause congestion, supply side solutions may have short-term advantages. Since congestion is an excess demand for road space, other approaches to managing and/reducing excess demand for road travel are required. Understanding the relationship between societal dynamics and mobility has been identified as critical in achieving sustainable mobility and travel demand management policies (Himanen *et al.* 2005). Studies on congestion have focused on identifying causes and potential solutions without taking into account household

travel demand behaviour and characteristics as an important factor in planning (Troy, 2017; Kaine and Brigden, 2015). This is demonstrated by the supply side solutions offered. Further, increased traffic may result from residents of the city or visitors from geographical locations. Thus, understanding societal travel behaviors of the city dwellers in necessary for better planning and policy guidance. The purpose of this study is to evaluate the socio-demographic determinants of urban household demand for road travel in order to provide a link between societal dynamics and mobility in Kampala City. The specific objectives of this study are: to investigate the social drivers of the level of household urban road travel demand; and to investigate the demographic drivers of the level of household urban road travel demand. The paper is organised as follows: after the introduction in section one, the second section of the paper reviews relevant theoretical and empirical literature. The study's data is discussed in the third section on methods and materials, which includes data sources, descriptive statistics, and multicollinearity and heteroscedasticity tests. Section four presents the estimation method, and section five presents and discusses the results. Section six concludes the paper by discussing some policy implications, areas for further research and limitations of the study

Theoretical and empirical literature

According to the words of Golob, *et al.* (1981); Niedercorn and Bechdolt (1969), the utility theory-travel demand has been the most elaborative and appealing for urban travel demand studies thus far (Winkler, 2015). The former asserts that travel is derived demand while the later considers it to be direct demand. According to Golob *et al.* (1981), an individual chooses a travel option that maximises his/her utility based on the activities to be engaged in, implying that travel is an induced demand rather than a need in and of itself. The consumer is constrained by both money and time, and thus spends money on a variety of consumption goods, including travel and leisure. As a result, the consumer maximises utility (u) subject to the two budget constraints as stated in (Eq. 1). Thus,

$$\max u(x, c, t)$$
$$s.t \tag{1}$$

$$p_x x + p_c c \le Y$$

$$t_x x + t + t_c c \le \hat{T}$$

Where,

x is the amount of travel, c is the consumption of non-travel goods and services and t is leisure time. Among the assumptions, u is expected to be monotonically increasing and quasi-concave in the domains of goods and services. Y and T are the money and time budget constraints respectively. p_x and p_c are price indices for travel and general consumption respectively. t_x and t_c are given time per unit distance travelled and time for general consumption respectively. According to this approach, travel is expected to increase as income, available time and speed increases and decrease as costs increase, emphasising that the demand curve for travel is always downward sloping. Of course, this is only true if travel is assumed to be a normal good, but it may not be obvious if travel demand exhibits characteristics of other types of goods. For example, if we consider travel to work, where individuals have no choice but have to travel for work, we can conclude that travel is a necessity. The elasticity of demand for travel to cost of travel may then be positive rather than negative. All of the preceding is consistent with neoclassical theory of consumer behaviour, which ignores the fact that consumption (activities) cannot be fulfilled without incurring travel costs. Travel, on the other hand, can explicitly be treated as a resource-constrained activity subject to both financial and time constraints (Sultan and Khan, 2012). This is consistent with the gravity approach of utility maximisation proposed by Niedercorn and Bechdolt (1969), who contend that demand for travel is direct demand based on the individual trips taken regardless of the desire to fulfil certain activities. Trip planning is viewed as some kind of resource allocation behaviour in which both monetary and travel time budgets act as constraints in deciding how much travel should be consumed (Niedercorn and Bechdolt, 1969). This implies that travel is a need in and of itself and thus is a direct demand. The gravity model of trip distribution is used to estimate travel demand in this. This method is based on origin–destination (O-D) characteristics, with an individual in the

originating zone travelling to a specific destination. This person is assumed to derive a positive amount of utility from repeated trips. The utility derived is constrained by monetary constraints. The cost of a trip, income and distance are all factors to consider when making a decision. Impedance factors include distance and cost. As a results, the total number of trips taken is inversely proportional to the total distance travelled and cost of travel, but positively related to income the traveller's willingness to spend money on travel. Bierlaire (1995) cites gravity model theory derived from Casey Jr's (1955) analogy with Newton's gravitational law. Travel demand is determined by impedance factors such as travel time and/or cost of travel between zones, as well as the number of trips made in both the origin and destination zone, and the socio-economic factors. Impedance factor represents the generalized cost of travel between two zones. The basic component is travel time that represents impedance. Travel can be quantified using aggregate mathematical models such as the gravity model. Adjustments are made in this model using a friction factor. A friction factor fails individuals to make their desired trips which could be the cost of travel (time/money) from one zone to another. This implies that as travel costs rise, the likelihood of traveler's taking trips of the expected length decreases. The number of trips T_{ij} between origin i and destination j is proportional to the number of people leaving i (O_i), to the number of people arriving at j (D_j), and inversely proportional to the square of the (generalized) cost C_{ij} of travelling between zones i and j as indicated in (Eqs. 2, 3 and 4);

$$T_{ij} = \alpha \frac{O_i D_j}{C_{ij}^2}$$

(2)

C_{ij} being the deterrence/impedance factor

Based on the deterrence function $f(C_{ij})$, equation (2) can be used;

$$T_{ij} = \alpha O_i D_j f(C_{ij})$$

(3)

The typical form of a gravity model for travel demand is given as;

$$T_{ij}^p = P_i^p \left[\frac{A_j^p * F(t_{ij}) * K_{ij}}{\sum_{j \in zones} A_j^p * F(t_{ij}) * K_{ij}} \right]$$

(4)

Where;

T_{ij}^p = Total trips taken from zone i to zone j

P_i = Total trips taken from zone i for purpose p

A_j = Total trip destined to zone j for purpose p

$F(t_{ij})$ = $\frac{C}{t_{ij}^n}$ = Friction factor, a function of travel cost and travel distance between zone i and zone j

t_{ij} = Distance between the zone i and j

K_{ij} = Effects of other variables on travel demand other than travel distance

C = Cost of travel between the zones

n = Number of zones

Regardless of the controversy, both theories measure travel in terms of total distance travelled or the total number of trips taken by the traveller. These are observed over time rather than based on responses to hypothetical questions. For empirical studies, this argument could thus presuppose Samuelson's (1947) concept of revealed preference. According to the two theories, a consumer only chooses a bundle of goods, including travel that maximises the utility based on income, travel cost, and time. The two theories focus on economic factors while ignoring the importance of societal dynamics. Nonetheless, utility maximisation theory is advocated (Becker et al., 2017). In the study of the driving factors of passenger transport, Belzer and Sedo, (2018); De Jong and Van de Riet (2008); Kansky (1967); Doubleday (1977); Goeverden and Hilbers (2001) identify passenger demand parameters in terms of number of trips and trip length or distance among others. Trip volumes and distance travelled are regarded as good indicators of urban dwellers' travel habits (De Bok *et al.*, 2021). Findings from a pooled sample Ordinary Least Squares (OLS) and generalised least squares in Limited Dependent (LIMDEP) of unbalanced panel of 22 countries, including developed and developing countries, show that car ownership with a positive elasticity, is one of the significant factors influencing mobility. This implies that car-owning households are more likely to travel than non-car-owning households. Household size, age, and education are all likely to increase travel demand for. However, due to the

socialising effect, age has an ambiguous effect on travel demand in some studies. It is expected to rise with more social activities but to fall with other activities. Furthermore, demand for transportation requires a time investment on the part of the traveller or the provider of transportation services to invest time (Guo *et al.,* 2020; Lindsey *et al.,* 2011). Empirical evidence from Giuliano and Dargay's (2006) study of car ownership, travel and land use compared the United States and Great Britain by modelling daily travel conditional upon car ownership. Using a pooled sample for both countries, a model excluding car ownership was estimated, and results revealed that demographic factors and car ownership were the most significant factors influencing travel demand. Travel is regarded as a positive function of employment, with females travelling more than males. It does, however, decrease with age, implying that older people travel less than younger people. Travel also decreases as the number of adults in a household increases. This study, however, ignores the employment sectors. However, while emphasising the important determinants of travel, Litman (2021) contends that the majority of these factors do not work in unison. Demographic factors, for example, may influence the mode of transportation chosen and thus the frequency of travel, whereas automobile travel may also be a supplement to vehicle parking and a substitute for transit travel. The majority of studies discussed above were conducted in the developed world, with a few exceptions from Latin America, South and East Asia. A few African studies have also emphasised the importance of socio-demographic factors in analysing travel behaviour. There may be some socio-demographic factors influencing household urban travel in developed countries that do not affect travel in developing countries' urban centres. Similarly, the magnitude and direction of these influences may differ, rendering the existing studies inconclusive. A study on urban travel in Ogun State, Nigeria, using a multiple regression model discovered that social factors, particularly trip generation by households have a significant influence on intra-urban travel (Olayiwola, 2014). It should be noted, however, that the influence varies between urban centres based on their level of development. Some factors are more pronounced in some urban areas than others. However, in the same

model, this study examines travel as a function of mode choice and car ownership. Such estimates are vulnerable to endogeneity, which has a significant impact on model robustness, particularly when multiple regression is used. The current study have been carried out in Kampala, Uganda's capital city in 2021.

MATERIALS AND METHODS
Study area and data source

This study makes use of secondary data from the KCCA transport and household travel habits survey. A sampling plan of 3000 households based on zonal system created by the Greater Kampala Metropolitan Area (GKMA) Transport Master Plan Project was used from a population of 418,787 households in Kampala city. Three super-zones were defined from the 22 identified super zones, and seven major corridors were and several representative transportation zones were chosen for the super-zones. The zones and corridors selected were all in Kampala. Households were drawn at random from parishes stratified by residential typology, and these were further sub-divided into three socioeconomic groups based primarily on education levels as proxies. However, because half of the population is low-income and tends to exhibit similar travel behavior, the sampling rate for this category was considerably reduced, and only 1906 households were sampled. Data on socio-demographic characteristics as well as travel habits data were obtained. The information gathered included household and personal characteristics as well as daily trips made by each household member. To reduce data errors and ensure data quality, the Global Positioning System (GPS) was used where each household head was receiving a GPS logger for 24 hours. Every three seconds, the coordinates of each individual were collected. The GPS trip data was compared to reported trips to allow for any necessary correction. Fig. 1 shows the map of Uganda including the location of the study area of Kampala city and other major urban centres. Kampala city is located 0 19 N, 32 33 E.

Description of study variables
Dependent variable
Trip Volume

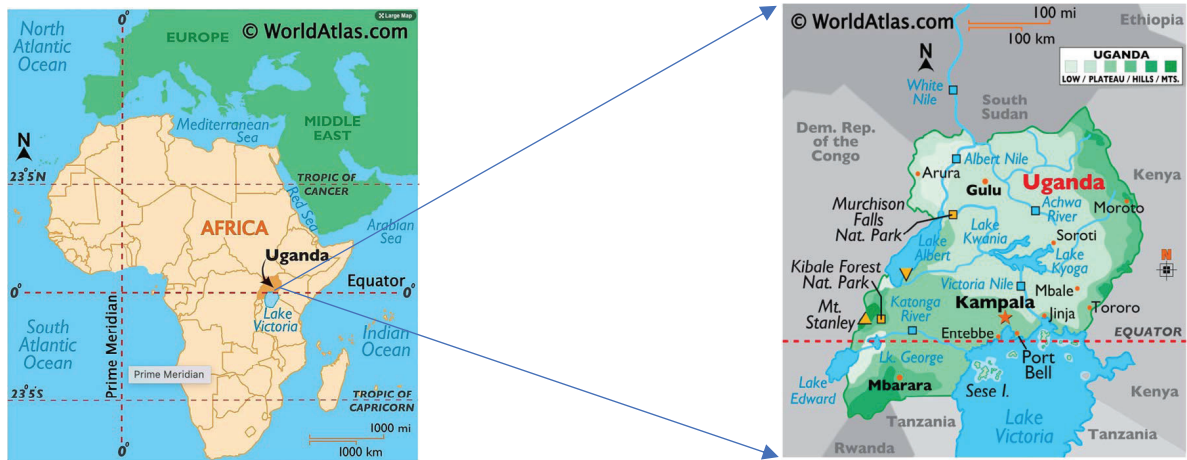The daily household trip volume is used as a

Fig. 1: Geographical location of study area (a) Uganda (b) Kampala City

proxy for urban road travel demand. According to both theoretical and empirical literature, travel demand can be estimated in terms of trip volumes taken by an individual or household over a given time period. It is a discrete count variable. The average daily number of trips taken by a household is taken into account in this study. Since the average daily trips taken by individuals in a household are obtained in the questionnaire, the average daily trip volume for a household is calculated by summing the average number of trips taken by all members on a daily basis.

Independent Variables
Household Size (hhsize)

Household size is an important factor to consider when estimating urban travel demand. The size of the household is related to the amount of travel that a household makes each day. According to UBOS (2012); UBOS and ICF (2018), household size in Uganda refers to the number of usual members in a household, with usual members defined as those who have lived in the household for at least 6 months in the previous 12 months, including persons who may have spent less than 6 months in the previous 12 months but have joined the household with the intention of living there permanently or for an extended period of time. Since it is a discrete variable, it is first used in its original form before being classified into three groups. The categories are; 1-3, 4-6 and above 6, with 1-3 members serving as the base category. The three categories

reflect households with few members, which is less than the average urban household size, within the average range and above the average size, implying larger households respectively.

Vehicle/Car Ownership

Vehicle ownership must be considered when estimating urban travel demand. Vehicle ownership in this study refers to private car ownership for personal use. Private car ownership is associated with household's daily amount of travel. It is defined as 0 for households that do not own a private vehicle and 1 for those that own a personal vehicle.

Age

Another important factor in determining urban travel demand is age. Since the unit of analysis is a household, such individual characteristics are taken into account for the household head. As a result, in this study, the age of the household head is used. This variable is used in its original form before being categorized into five groups. The age groups are as follows: 15-24, 25-34, 35-44, and 45-54 and above 54. The age group 15-24 years old is the base category. These categories distinguish teenagers, youths, adult youths and those nearing retirement as pensioners and retirees.

Gender

Gender is another important factor to consider when estimating urban travel demand. The gender of the household head is related to the amount of

132

travel taken by that household the daily basis. This variable is used in its original form, with values 0 for female and 1 for male. Female = 0 is used as a base category. Therefore, the terms female-headed and male-headed households are used in the discussion of results.

Education Level

Another factor to consider when estimating urban travel demand is education level. The education level of the household head is used in the same way that age and gender are. The education level of the household head is related to the amount of travel taken by that household on a daily basis. There are four levels to this variable; no education, primary, secondary and tertiary education levels. Post-secondary education is referred to as tertiary education

Employment Sector

This is another important factor when estimating urban travel demand. The employment sector of the household head is used the same way that age, gender and education level are used. The employment sector of the household head is related to the amount of travel that a household takes on a daily basis. This variable is categorized into three sectors; public, private, and other sectors. The private sector includes the formal and informal sector while others include manufacturing, building and construction, transportation, agriculture, unemployed/job seeking, domestic service, pensioners and those not in labor force.

Model Specification

The estimation of travel demand is adopted from Golob *et al.* (1981), but with a focus on household socio-demographic variables as proposed by Giuliano and Dargay (2006), Souche (2010); Litman (2021). The model takes into account household size (*hhsize*), car ownership (*vown*), age, gender, education level (*edlevel*) and employment sector (*esect*). Borrowing from Niedercorn and Bechdolt (1969), and focusing on household socio-demographic factors, travel demand (*dt$_i$*) is therefore given as (Eq. 5).

$$d_t = \beta_0 + \beta_1 hhsize_i + \beta_2 vown_i + \beta_3 age_i +$$
$$\beta_4 gender_i + \beta_5 edlevel_i + \beta_6 esect_i + e_i \quad (5)$$

Where, $\beta_1, \beta_2 > 0; \beta_3, \beta_4, \beta_5, \beta_6 >< 0$ as derived from literature.

e_i = error term
Where,
hhsize is household size, *vown* is private vehicle/car ownership, *edlevel* is the level of education, and *esect* is employment sector.

Method of estimation

Urban demand for travel can be measured in terms of the number of trips taken (Giuliano and Dargay (2006); Bacon (1995); Gordon and Richardson (2000); and Anas, (2007).This study takes into account the average number of trips made by a household level. The main methodological issue with using cross-sectional data in this study is that of unobserved heterogeneity which is best solved with longitudinal studies. However, the only available data set is cross sectional. As a result, just as in developed countries, it may be difficult to capture the complex inter-relationships among factors in our urban systems in order to allow detailed and sophisticated analyses of the urban phenomenon. This is one of the limitations of estimating demand models in developing countries. A Negative Binomial Regression (NBR) is estimated using the average number of trips as a measure of a household's daily travel demand.

Negative Binomial Regression (NBR)

Although the Poisson model is commonly used in estimations involving count data, the NBR is preferred in this study due to the observed over dispersion. The number of trips taken is the dependent variable which is a count variable with a variance of 15.21 and the mean of 9.7. The variance is 57% greater than the mean, indicating over dispersion and justifies the use of the NBR. In order to estimate the NBR model, the maximum likelihood approach. The superiority of the NBR over other estimation methods for count data stems from its disturbance term composition and ability to account for over dispersion. To avoid biased standard error, the assumptions of conditional normality, homoscedasticity of the errors and independence must be met. One problem with count data is conditional normality and homoscedasticity of the error term can be difficult to achieve. This is due to the fact that such data frequently exhibits increasing

conditional variance with increasing predictor value and has positively skewed distributions (Gardner *et al*., 1995; and Long, 1997). This could affect the convergence of the model being estimated. However, after 9 iterations the estimated NBR model converged. Furthermore, the NBR was chosen over a Poisson regression because the Poisson regression model does not account for individual heterogeneity (Coxe *et al*., 2009). The Poisson distribution is based on assumption that the conditional mean and conditional variance are the same. The Negative binomial, on the other accounts for over dispersion by assuming the existence of unexplained variability among individuals with the same predicted value. This may result in larger variation but has no effect on the mean (Hilbe, 2011 and 2007; Neisiani *et al.,* 2016; Coxe *et al.,* 2009; Greene, 2006; Long, 1997; Land *et al.,* 1996; Gardner *et al.,* 1995). Greene (2006); Hilbe (2011); Zwilling (2013) advocate for use of the log-likelihood NBR function.

RESULTS AND DISCUSSION
Descriptive and summary statistics

The primary purpose of travel in Kampala has been categorized into three categories. The purpose for the household head's first trip taken on a daily basis is captured in this case as per Table 1.

Approximately 81% of the first journey made by the household head is for the primary purpose of going to work, while 14% are for social services such as education, shopping, health and sports, only 5% are for the primary purpose of returning home. This

finding may imply that some people work at night since their first trip of the day is to get going home. However, it also suggests that the majority of travels to Kampala city are primarily for work purposes. Since the cost of living is expected to be higher in terms of housing and food, as one moves closer to the city center, larger households that require more space and food are expected to stay farther from the city center. However, the situation in Kampala is quite different as shown in Table 2.

Larger households prefer to live closer to the city center. Fewer and larger households stay far from the city center. Among these households, 28% own private vehicles for personal use. Approximately 49% household heads have a tertiary education, 37% have a secondary education, 12% have a primary education and 2% have no education. This is not surprising given that household heads in Kampala have a literacy rate of more than 90%. Approximately 59% of the respondents work in the private sector employment, with 40% in formal employment and 19% informal employment. Approximately 21% of those in the private sector have a tertiary education while 16% have a secondary education. In the private informal sector, approximately 10% have a secondary education and 6% have a primary education. Only 19% work in public sector, with approximately 16% having a tertiary education. The average household size is approximately 4 people, which is the same as the national average for urban areas (UBOS and ICF, 2018). The largest household can accommodate up to 15 people. A household's

Table 1: Distribution of the primary purpose of travel

Purpose of travel	Frequency	Percent	Cumulative Frequency
Work	1,545	81	81
Social	260	14	95
Home	101	5	100
Total	1,906	100	

Table 2: Distribution of Household Size by Proximity to the City Centre

Proximity to Kampala city center	Grouped household size (number of people)				
(Kilometers)	1 - 3'	4 -6'	7 - 9'	Above 9	Total
0.00-3.0km	134	219	25	7	385
3.01-6.0km	311	492	72	8	883
6.01-9.0km	148	261	32	3	444
Above 9.0km	73	113	7	1	194
Total	666	1,085	136	19	1,906

Table 3: Summary Statistics of the Selected Variables (in levels)

Variable	Mean	Standard deviation	Minimum	Maximum	Skewness	Kurtosis
Average daily trips taken	9.7	3.9	2	32	0.87	4.28
Age	38	11.2	19	90	0.97	3.97
Household size	4.2	1.6	1	15	1.09	5.76

average number of daily trips is approximately 10. The average age of respondents is 38 years, with the youngest and oldest being 19 and 90 years old as shown by Table 3:

Multicollinearity and Heteroscedasticity Tests

Survey data is notorious for having collinearity and non-constant variance of the error term, so testing for the two is essential. If collinearity is high and the error term exhibits heteroscedasticity, this must be corrected prior to model estimation to improve the model's robustness. In order to identify such variables, the Collin test that provided a Variance Inflation Factor (VIF) as well as the tolerance level and other tests is used (Ender, 2010). The rule of thumb is that any individual variable with a VIF greater than 10 should be checked (Wang *et al*., 2019; Tridico and Paternesi, 2018; Marquardt, 1970). Similarly, when all variables are combined, an average VIF greater than 5 indicates that the variables may exhibit collinearity in the error term. Therefore, the use of groupings and or other models other than the Ordinary Least Squares (OLS) may be recommended. Continuous variables exhibited multicollinearity in their original form and where thus log transformed. The average VIF was 1.62 with no individual covariate having a VIF of greater than 10. This implies that if continuous variables are log-transformed before being used in model estimation, there is no significant multicollinearity in the error term. Tolerance was greater than 0.1 for all the covariates, indicating non-collinearity. As a result of these findings, each covariate is regarded as a non-linear combination of other independent variables in the model. Therefore, the estimated empirical model does not exhibit significant multicollinearity. Following preliminary estimation of the variables in their original form, additional tests show that heteroscedasticity of the error term exists, as indicated by the Breusch-Pagan test, which yields the Prob > chi2=0.000. As a result of these findings, the null hypothesis that the error term is homoscedastic

is rejected. Logarithmic transformation of the continuous covariates is expected to reduce this risk in order to solve the heteroscedasticity problem (Greene, 2006; Maddala, 2008). Thus, the natural logarithm of all continuous variables is used to transform them. In addition, a robust model was estimated using the NBR regression to ensure that the standard errors from the estimated models are consistent with the heteroscedasticity assumption.

Model estimation and discussion of findings

An assessment of the individual influence of socio-demographic factors on travel demand was performed during the estimation process. Individual characteristics of the household head are used where individual characteristics are important because the household head is considered to be the decision maker for the entire household. The McFadden Pseudo R-square (0.063 and 0.054, in Tables 4 and 5 respectively) with a significant probability of the Chi2 (Prob>Chi2=0.000) indicate a good fit for the Negative binomial regression. According to the NBR estimations shown in Table 4, household size, vehicle ownership, education level, and age and employment sector of the household head all play a significant role in the variations in daily travel demand for households in Kampala. These factors affect the frequency with which people travel to the city center on the daily basis.

Socio-demographic factors

According to the estimates in Table 4, almost all the social factors, with the exception of gender, have a significant effect on household travel demand. While household size, age, and level of education have a positive effect on travel demand, car ownership and employment sector have a negative effect on travel demand. Notably, households travel more as their heads grow older, and those who own cars take fewer trips than those who do not own cars, people with education attainment travel more than those who have no education, those employed

Table 4: Results for the Negative Binomial Regression.

Variable	Coefficients -
Household size	0.112***
	(0.006)
Age	0.003***
	(0.001)
Gender	0.010
	(0.022)
Vehicle ownership	-0.056***
	(0.018)
Education level	Base = No education
Primary	0.112**
	(0.052)
Secondary	0.116**
	(0.050)
Tertiary	0.116**
	(0.049)
Employment sector	Base = Public sector
Private	-0.047**
	(0.023)
Others	-0.054**
	(0.025)
Constant	1.575***
	(0.063)
lnalpha	-4.675***
	(0.374)
N	1906
pseudo R^2	0.063
Walds Chi2(3;9;12)	613.45
Prob > Chi2	0.000

*Standard errors are in parentheses; * p < 0.10, ** p < 0.05, *** p < 0.01; Dependent Variable is the household average daily number of trips taken.*

in the private and other sectors take fewer trips than those employed in the public sector. Table 4 shows that, household size has a significant positive effect on travel demand. This means that adding a member to a household increases the difference in the logs of the expected household daily demand for travel by 0.112 trips at 1% level of significance holding other covariates constant. While holding other covariates constant, the age of the household head significantly increase the difference of the logs of the expected household daily demand for travel by 0.001 trips at 1% level of significance. Furthermore, vehicle ownership by a household reduces the difference of the logs of the expected household daily demand for travel by 0.056 trips at 1% level of significance, holding other covariates constant. Holding other covariates constant, households whose heads have completed primary, secondary and tertiary education have a significant increase in the difference of the logs of the expected household

daily demand for travel by 0.112, 0.116 and 0.116 trips, respectively, at 5% level of significance. Holding other covariates constant, households with heads employed in the private and other sectors of the economy, experience a significant decrease in the difference of the logs of the expected household daily demand for travel by 0.047 and 0.054 trips respectively at 5% level of significance. The results in Table 4 are supported by those in Table 5 which group household size and age.

Table 5 shows that, when compared to households with 1-3 members, there is a significant increase in the difference of the logs of the expected household daily demand for travel by 0.329 and 0.587 for the household size of 4-6 and above 6 members respectively at 1% level of significance, holding other covariates constant. Thus, the greater the number of people in a household, the greater the number of daily trips taken, as well as the rate of change. Given the urban nature of a typical African

Table 5: Negative binomial regression results of travel demand using trip volume as a measure with categorized household size and age of the household head

Variables	Coefficients
Household size	Base = 1 - 3
4 - 6	0.329***
	(0.018)
Above 6	0.587***
	(0.065)
Age (in years)	Base = 15 - 24years
25 - 34	0.0769**
	(0.033)
35 - 44	0.149***
	(0.035)
45 - 54	0.163***
	(0.037)
Above 54	0.212***
	(0.042)
Gender	0.021
	(0.022)
Car ownership	-0.0580***
	(0.018)
Education level	Base = No education
Primary	0.111**
	(0.050)
Secondary	0.111**
	(0.048)
Tertiary	0.102**
	(0.048)
Employment sector	Base = Public
Private	-0.0659***
	(0.0229)
Others	-0.060**
	(0.026)
Constant	1.960***
	(0.058)
lnalpha	-4.313***
	(0.281)
N	1906
pseudo R^2	0.054

*Standard errors are in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Dependent Variable is the household average daily number of trips taken.*

society, where an average household is expected to have a spouse, a child and a household helper, travel demand is likely to increase particularly if the household has school-aged children and both spouses are employed. Regardless of car ownership, even if all members of a household use the same mode of transportation, the number of travels will still be higher with the exception of cases where they all travel to the same destination. The age of the household head is another significant factor identified as having a significant positive effect on household daily demand for travel in Kampala, which is consistent with the findings by Belzer and Sedo, (2018), Metz (2011, 2012) but differs from the findings of Giuliano and Dargay, (2006), who found that household demand for travel decreases with aging populations. Holding other covariates constant, the result implies that the older the household head, the greater the difference in the logs of the expected household daily demand for travel, with an increase of 0.003 trips. Thus, the number of daily trips taken by a household increases with the age of the household head. This result is supported by the estimates in Table 5 which categorizes age. Table 5

shows that households with older heads take more trips than those with younger heads. Compared to households whose heads are 15-24 years old, those with older heads who are in the age groups of 25-34, 35-44, 45-54 and above 54 years, see a significant increase in the expected household daily demand for travel of 0.077, 0.149, 0.163 and 0.212, respectively. These findings are significant at 1 percent level of significance for all age groups except for age group 25-34 that is significant at 5%. To affirm the results, descriptive statistics, show that the majority of the household heads are between the ages of 25 and 54. In a typical African setting, these are expected to work and have families resulting into increased household demand for urban travel. The household head's employment sector has a significant impact on the volume of trips taken by the household. Households with heads who work in the private and other sectors travel less than those in the public sector. The results in Table 5 show that working in the private sector reduces the difference in the logs of travel by 0.066 trips per household as compared to working in the public sector, holding other covariates constant. When compared to working in the public sector, working in other employment sectors reduces the difference in the logs of travel by 0.060 per day. Manufacturing, building and construction, transportation, agriculture, domestic, voluntary employees, as well as job seekers and students, all fall under the purview of the private sector. Households with heads who work in the public sector may have more commuter travels because government workers are required to report to work and are mostly salaried, whereas those in the private sector and other sectors may not be required to report to work. According to findings in Tables 4 and 5, the gender of the household head has an insignificant influence on household travel demand. The results contrast with those of Giuliano and Dargay, (2006), who found that females travel more than males. Even when comparing male headed to female headed households in Kampala, gender is an insignificant factor. The findings also show that household size has a significant effect on urban travel demand. This is intuitively true because having more people in a household means more trips. This implies that the number of people in a given household increases the demand for travel. Car ownership reduces the number of trips

taken, implying car owners take fewer trips. These findings contradict those of Sharifi *et al*., (2021); Olayiwola (2014); Souche (2010); Metz (2011, 2012) who found a positive relationship between car ownership and household travel demand. Other factors such as high fuel costs may make it difficult for car owners to drive frequently. The majority of them drive, park and use other modes of transportation to get around the city. They are also more likely to own houses. Most car owners in Uganda have average income and may live further away from the city center because land ownership closer to the city center may be difficult for such earners. These people usually buy land on the outskirts of the town. The level of Education has a significant positive effect on trip volume. This means that highly educated people take more trips than the less educated. Such a situation may arise when highly educated people are employed or looking for work and must commute as a result. Some choose to live closer to the city center so that they can commute more often as needed. Therefore, using the Negative Binomial regression a log-likelihood model, fits well data with over-dispersion.

CONCLUSION

Estimated NBR results confirm the influence of household socio-demographic factors on urban households travel demand. Trip volumes rise in direct proportion to household size, age, and education level of the household head. However, the daily number of trips taken by households in Kampala City decreases with car ownership, as does the number of trips taken by household whose heads work in the private sector and other sectors of the economy, as opposed to those employed in the public sector. The findings are consistent with theory and empirical literature, implying that they should be heavily emphasized in policy making. Finally, the majority of the obtained coefficients have economically and intuitively correct signs.

Policy implications

The study findings are informative of households' travel behaviors in Kampala City and should thus guide policy in regulating the frequency of urban travel. Sensitization programmes aimed at reducing unnecessary and avoidable travels are required. This should be combined with planning for future

urban travel demand. Given that 60% of Uganda's population is young, the significant positive effect of household size and age of household head implies that future demand for travel is bound to grow at a much faster rate, particularly in Kampala. Household size can be reduced through population reduction policies. The findings also show that households with heads employed in the private and other sectors travel less than those employed in the public sector, implying that policymakers must distribute and/or redistribute government development activities and private investments to other urban centres and regions in order to reduce rural-urban migration towards Kampala city and thus divert traffic to other urban centres. The significance of the socio-demographic determinants on households' demand for road travel suggest that travel demand theories should not neglect this influence and thus incorporate them in theory development.

Limitations of the study and areas for further research

The main limitation in this study is the cross sectional set, which makes it impossible to trace the consistency in the travel behaviour of urban households. Nonetheless, a household's daily number of trips was provided and used in the study. Further, detailed information about the purpose of all these trips was lacking. Travel demand is derived demand, and thus trip purpose would provide a better understanding behavior of Kampala city residents' travel behaviour for better policy guidance. Given how travel demand is derived, a study that focuses on purpose of travel would improve the understanding of the travel behaviour of households in Kampala city. Further, a panel data research approach would also reveal the consistency in urban households' travel behaviour

AUTHOR CONTRIBUTIONS

S. Watundu conducted the literature review, collected data, analyzed and interpreted data, prepared and edited the manuscript and is the corresponding author. B. Kalinda Mkenda was the supervisor, reviewed literature, interpreted the data, prepared the manuscript and edited the manuscript. N. Mwelu was involved in data collection, preparing the manuscript and edited the manuscript.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

PUBLISHER'S NOTE

Tehran Urban Planning and Research Center remains neutral with regard to jurisdictional claims in published maps and institutional afflictions.

ABBREVIATIONS (NOMENCLATURE)

AERC	African Economic Research Consortium
ECMT	European Conference of Ministers of Transport

GKMA   Greater Kampala Metropolitan Area

ICF   Inner City Fund

KCCA   Kampala Capital City Authority

NBR   Negative Binomial Regression

OLS   Ordinary Least Squares

OECD   Organization for Economic Co-operation
            and Development

UBOS   Uganda Bureau of Statistics

REFERENCES

Alinange, D., (2010). Kampala City to get more tarmac and be Jam Free. Uganda National Roads

Authority, Kampala. "The New Vision", Retrieved from All Africa.com June 22nd, 2010, 06:56PM.

Anas, A., (2007). A unified theory of consumption, travel and trip chaining. J. Urban Econ., 62(2): 162-186 **(25 pages)**.

Azad, R.; Chakraborty, S., (2021). Toward inverting environmental injustice in Delhi. Econ. Labour

Relat. Rev., 32(2): 209-229 **(21 pages)**.

Bacon, R., (1995). Combined trips and the frequency of shopping. J. Retail. Consum. Serv., 2(3): 175-

183 **(9 pages).**

Beaudoin, J.; Farzin, Y H.; Lawell, C.Y.C.L., (2015). Public transit investment and sustainable

Transportation: A review of studies of transit's impact on traffic congestion and air quality. Res. Transp. Econ., 52: 15-22 **(8 pages)**.

Becker, G.S.; Michael, G.; Michael, R.T., (2017). Economic theory. Routledge.

Belzer, M.H.; Sedo, S.A., (2018). Why do long distance truck drivers work extremely long hours? Econ. Labour Relat. Rev., 29**:** 59-79 **(21 pages)**.

Bierlaire, M., (1997). Mathematical models for transportation demand analysis. Transp. Res. A: Policy Pract, 31 (1), 86-219 (**134 pages**).

Casey Jr, H. J. (1955). The law of retail gravitation applied to traffic engineering. Traffic Q., 9 (3).

Coutinho, F.M.; Van Oort, N.; Christoforou, Z.; Alonso-González, M.J.; Cats, O.; Hoogendoorn, S., (2020). Impacts of replacing a fixed public transport line by a demand responsive transport system: Case study of a rural area in Amsterdam. Res. Transp. Econ. 83**:** 100910.

De Bok, M.; De Jong, G.; Wesseling, B.; Meurs, H.; Van Bekkum, P.; Mijjer, P.; Bakker, D.; Veger, T., (2021). An ex-ante analysis of transport impacts of a distance-based heavy goods vehicle charge in the Netherlands. Res. Transp. Econ. 101091.

De Jong, G.C.; Van de Riet, O., (2008). The driving factors of passenger transport. Eur. J. Transp. Infrastruct. Res., 3(8): 227-250 **(24 pages).**

Doubleday, C., (1977). Some studies of the temporal stability of person trip generation models. Transp. Res., 11: 225-263 **(9 pages)**.

Ender, B.P., (2010). Multicollinearity Test. From UCLA Office of Academic Computing, distributed on 23/11/2010.

Gardner, W.; Mulvey, E.P.; Shaw, E.C., (1995). Regression analyses for counts and rates: Poisson, over dispersed Poisson and negative binomial models. Psychol. Bull. 118: 392-404 **(13 pages)**.

Giuliano, G., (2003). Travel, location and race/ethnicity. Transp. Res. A: Policy Pract., 37(4): 351-372 **(22 pages)**.

Giuliano, G.; Dargay, J., (2006). Car ownership, travel and land use: a comparison of the

US and Great Britain. Transp. Res. A: Policy Pract., 40(2): 106-124 **(9 pages)**.

Greene, W.H., (2008). Econometric Analysis. Granite Hill Publishers.

Greene, W.H., (2006). Econometric Analysis, 6th edition, New Jersey, Prentice Hall.

Goeverden, V.D.; Hillbers, H.D., (2001). A pattern-card of travel demand. Proceeding of the 9th

World Conference on Transport Research. COEX, Seoul, Korea, July 22-27.

Gordon, P.; Richardson, H., (2000). Critiquing sprawl's critics. Cato Institute. *Policy Analysis*, No. 365.

Guo, M.; Tang, K.; Wang, Z., (2020). Commuting time and sickness absence in China: Rural/urban

variations and Hukou impacts. Econ. Labour Relat. Rev., 31**:** 76-95 **(20 pages)**.

Hilbe, J.M., (2011). Negative Binomial Regression. 2nd ed., New York: Cambridge University Press.

Hilbe, J.M., (2007). Negative binomial regression. New York. Cambridge.

Himanen, V.; Lee-Gosselin, M.; Perrels, A., (2005). Sustainability and the interactions between

External effects of transport. J. Transp. Geogr., 13: 23–28 **(6 pages)**.

Ignacio, E.R., (2019). The elasticities of passenger transport demand in the Northeast Corridor. Res. Transp. Econ., 78**:** 100759.

Kaine, S.; Brigden, C., (2015). Union Responses to regulatory change: Strategies of protective layering.

Econ. Labour Relat. Rev., 26**:** 614-630 **(17 pages)**.

KCCA (2012). 2040 Modeling and Forecasting. Long term Report

KCCA (2010). Upgrading Kampala Structure Plan and Upgrading the Kampala GIS Unit: transportation Surveys. Working paper.

KCCA (2011). Programme for Improvement of Roads in Kampala. Final Report. Final Report. Kampala, Uganda.

Kampouri, A.; Politis, I.; Georgiadis, G., (2021). A system-optimum approach for bus lanes

dynamically activated by road traffic. Res. Transp. Econ., 92: 101075.

Kansky, K.J., (1967). Travel patterns of urban residents. Transp. Sci., 1**:** 261-285 **(25 pages)**.

Kiggundu, A.T., (2007). Traffic jam in Kampala City. Centre for Urban Studies and Research, Kampala, Uganda.

Land, K.C.; McCall, P.L.; Nagin D.S., (1996). A comparison of Poisson negative binomial and semi-

parametric mixed Poisson regression models: With empirical applications to criminal careers data. Sociol. Methods Res., 24: 387-442 **(56 pages).**

Lindsey, R.; Quinet, E.; Vickerman, R., (Eds.). (2011). A Handbook of Transport Economics. Edward Elgar Publishing.

Litman, T.A., (2021). Understanding Transport Demands and Elasticities-How Prices and Other Factors Affect Travel Behaviour.

Long, J.S., (1997). Parametric and Semi-Parametric Modeling of vacation expenditures. J. Econom., 11: 59-76 **(18 pages)**.

Lozzi, G.; Monachino, M.S., (2021). Health considerations in active travel policies: A policy analysis at the EU level and of four member countries. Res. Transp. Econ.*,* 86**:** 101006.

Maddala, G.S., (2008). Introduction to Econometrics. Third Edition, Wiley and Sons.

Malayath, M.; Verma, A., (2013). Activity based travel demand models as a tool for evaluating Sustainable transportation policies. Res. Transp. Econ., 38: 45-66 **(22 pages)**.

Marquardt, W.D., (1970). Generalized Inverses, Ridge Regression and Biased Linear Estimation. Technometrics, 12: 591-612 **(22 pages)***.*

Metz, D., (2012). Demographic determinants of daily travel demand. Transp. Policy, 21: 20-25 **(6 pages)**.

Metz, D., (2011). A delicate balance: Mobility and access needs, expectations and costs. International Transport Forum Discussion Paper.

Metz, D., (2010). Saturation of demand for daily travel. Transp. Rev., 30(5): 659-674 **(16 pages)**.

Mirzapour, M.; Toutian, S.S.; Mehrara, A.; Khorrampour, S., (2019). The strategic role of human resource management in crisis management considering the mediating role of organizational culture. Int. J. Hum. Capital Urban Manage., 4(1): 43-50 **(8 pages).**

Niedercorn, J.H.; Bechdolt, B.V., (1969). An economic derivation of the "gravity law" of spatial interaction. J. Reg. Sci., 9(2): 273-282 **(10 pages)**.

Neisiani, B.A.; Seyedan, S.M.; Radfar, E., (2016). Urban green spaces assessment approach to health, safety and environment. Int. J. Hum. Capital Urban Manage., 1(2): 123-132 **(10 pages).**

O'donnell, M.; Glennie, M.; O'keefe, P.; Kwon, S.H., (2011). Privatization and 'light-handed 'regulation: Sydney Airport. Econ. Labour Relat. Rev., 22**:** 65-80 **(16 pages)***.*

OECD/ECMT, (2007). Managing Urban Traffic Congestion. ECMT Publications –Distributed by OECD. Publishing No. 2.

Olayiwola, S.M., (2014). Urban Socio-Economic Variables and Intra-Urban Trips in Ogun State, Nigeria. Indones. J. Geogr., 46(1): 15-20 **(6 pages)**.

Ortega, A.; Vassallo, J.M.; Pérez, J I., (2021). Modelling some equality and social welfare impacts of road tolling under conditions of traffic uncertainty. Res. Transp. Econ.**,** 88: 101110.

Republic of Uganda, Ministry of Works and Transport, (2010). The Study on Greater Kampala Road Network and Transport Improvement in the Republic of Uganda*.* Kampala: Japan International Cooperation Agency.

Republic of Uganda, (2009). Report of the Committee on National Economy on a Request by

Government to the parliament of Uganda on the Road Sector Support Project 3. Kampala, Uganda.

Republic of Uganda, (2006). The Uganda National Roads Authority Act 2006. Kampala, Uganda.

Sarkar, S., (2019). How independent is India's labour law framework from the state's changing

Economic policies? Econ. Labour Relat. Rev.*,* 30**:** 422-440 **(19 pages)**.

Samuelson, P.A., (1947). Foundations of Economic Analysis. Cambridge, Mass: Harvard University Press.

Sanya, P., (2011). Road Safety in Uganda. Ministry of Works and Transport, Kampala, Uganda.

Sharifi, F.; Meitiv, A.; Shelton, J.; Xu, X.; Burris, M.; Vallamsundar, S.; Xu, Y.A., (2022). Regional traffic

Operation and vehicle emission impact assessment of lane management policies. Res. Transp. Econ., 91: 101067.

Stanford, J., (2017). Automotive surrender: The demise of industrial policy in the Australian vehicle Industry. Econ. Labour Relat. Rev., 28**:** 197-217 **(21 pages)**.

Stilwell, F., (2021). From green jobs to green new deal: what are the questions? Econ. Labour Relat. Rev., 32**:** 155-169 **(15 pages)**.

Souche, S., (2010). Measuring the structural determinants of urban travel demand. Transp. Policy, 17 (3): 127-134 **(8 pages)**.

Sultan, R.; Khan, N.M. (2012). An analysis of travel frequency using the com-Poisson regression

Model–implications for environmentally sustainable transport in Mauritius. J. sustain. dev. Afr, 14 (6) ISBN 1520-5509 (**15 pages**).

Train, K., (1980). A structured logit model of auto ownership and mode choice. Rev. Econ. Stud., 47(2):357-370 (**14 pages**).

Tridico, P.; Paternesi Meloni, W., (2018). Economic growth, welfare models and inequality in the context of globalisation. Econ. Labour Relat. Rev.*,* 29**:** 118-139 **(22 pages)**.

Troy, P., (2017). A national strategy for a low-carbon economy: The contribution of regional development planning. Econ. Labour Relat. Rev.*,* 28: 57-76 **(20 pages)**.

UBOS and ICF (2018). Uganda Demographic and Health Survey 2016.

Kampala, Uganda and Rockville, Maryland, USA: UBOS and ICF.

UBOS, (2014). National Population and Housing Census. Provisional Results. Kampala, Uganda.

UBOS, (2012). Statistical Abstract.

UBOS, (2010). Uganda National Household Survey. Report 2009/2010: Socio-Economic Module. Kampala, Uganda.

Wang, F.; Gan, B.; Cheng, Y.; Peng, L.; Feng, J.; Yang, L.; Xi, Y., (2019). China's Employment Contract Law: Does it deliver employment security? Econ. Labour Relat. Rev., 30**: 99-119 (21 pages)**.

Winkler, C., (2015). Transport user benefits calculation with the "Rule of a Half" for travel demand models with constraints. Res. Transp. Econ.**,** 49**: 36-42 (7 pages)**.

Zwilling M.L., (2013). Negative Binomial Regression. Math. J., 15: 1-18 **(18 pages).**

PUBLICATION ETHICS

The ethical policy of IJHCUM is based on the Committee on Publication Ethics (COPE) guidelines and complies with International Committee of IJHCUM Editorial Board codes of conduct. Readers, authors, reviewers and editors should follow these ethical policies once working with IJHCUM. The ethical policy of IJHCUM is liable to determine which of the typical research papers or articles submitted to the journal should be published in the concerned issue. For information on this matter in publishing and ethical guidelines please visit http://publicationethics.org

Duties and Responsibilities of Publishers

1. IJHCUM is committing to ensure that editorial decisions on manuscript submissions are the final.
2. IJHCUM is promising to ensure that the decision on manuscript submissions is only made based on professional judgment and will not be affected by any commercial interests.
3. IJHCUM is committing to maintain the integrity of academic and research records.
4. IJHCUM is monitoring the ethics by Editor-in-Chief, Associate Editors, Editorial Board Members, Reviewers, Authors, and Readers.
5. IJHCUM is always checking the plagiarism and fraudulent data issues involving in the submitted manuscript.
6. IJHCUM is always willing to publish corrections, clarifications and retractions involving its publications as and when needed.

Duties and Responsibilities of Editors

1. The Editors of the journal should have the full authority to reject/accept a manuscript.
2. The Editors of the journal should maintain the confidentiality of submitted manuscripts under review or until they are published.
3. The Editor-in-Chief should take a decision on submitted manuscripts, whether to be published or not with other editors and reviewers
4. The Editors of the journal should preserve the anonymity of reviewers.
5. The Editors of the journal should disclose and try to avoid any conflict of interest.
6. The Editors of the journal should maintain academic integrity and strive to meet the needs of readers and authors.
7. The Editors of the journal should be willing to investigate plagiarism and fraudulent data issues and willing to publish corrections, clarifications, retractions, and apologies when needed.
8. The Editors of the journal should have the limit themselves only to the intellectual content.
9. The Editors of the journal must not disclose any information about submitted manuscripts to anyone other than the corresponding author, reviewers, potential reviewers, other editorial advisers, and the publisher, as appropriate.
10. Unpublished materials disclosed in a submitted paper will not be used by the editor or the members of the editorial board for their own research purposes without the author's explicit written consent.

Duties and Responsibilities of Reviewers

1. The Reviewers of the journal should assist the Editors in taking the decision for publishing the submitted manuscripts.
2. The Reviewers should maintain the confidentiality of manuscripts, which they are invited to review.
3. The Reviewers should provide comments in time that will help editors to make decision on the submitted manuscript to be published or not.
4. The Reviewers are bound to treat the manuscript received for peer reviewing as confidential, and must not use the information obtained through peer review for personal advantage.
5. The Reviewers comments against each invited manuscript should be technical, professional and objective.
6. The Reviewers should not review the manuscripts in which they have found conflicts of interest with any of the authors, companies, or institutions.
7. The Reviewers should disclose and try to avoid any conflict of interest.

Duties and Responsibilities of Authors

1. Manuscripts must be submitted only in English and should be written according to sound grammar and proper terminology.
2. Manuscripts must be submitted with the understanding that they have not been published elsewhere (except in the form of an abstract or as part of a published lecture, review, or thesis) and are not currently under consideration by another journal published by or any other publisher.
3. The submitting (corresponding) author is responsible for ensuring that the manuscript article's publication has been approved by all the other coauthors.
4. In order to sustain the peer review system, authors have an obligation to participate in peer review process to evaluate manuscripts from others.
5. It is also the authors' responsibility to ensure that the manuscripts emanating from a particular institution are submitted with the approval of the necessary institution.
6. It is a condition for submission of a manuscript that the authors permit editing of the paper for readability.
7. Authors are requested to clearly identify who provided financial support for the conduct of research and/or preparation of the manuscript and briefly describe the role of the funder/sponsor in any part of the work.
8. A copy right release and conflict of interest disclosure form must be signed by the corresponding author in case of multiple authorships, prior to the acceptation of the

manuscript, by all authors, for publication to be legally responsible towards the Journal ethics and privacy policy.

9. Under open access license, authors retain ownership of the copyright for their content, but allow anyone to download, reuse, reprint, modify, distribute, and/ or copy the content as long as the original authors and source are cited properly.

10. All authors have agreed to allow the corresponding author to serve as the primary correspondent with the editorial office, to review the edited manuscript and proof.

11. When author(s) discovers a significant error or inaccuracy in his/her own published work, it is the author's obligation to promptly notify the journal editor or publisher to retract or correct the manuscript.

12. All authors must know that that the submitted manuscripts under review or published with IJHCUM are subject to screening using Plagiarism Prevention Software. Plagiarism is a serious violation of publication ethics.

Violation of Publication Ethics

1. **Plagiarism:** Plagiarism is intentionally using someone else's ideas or other original material as if they are one's own. Copying even one sentence from someone else's manuscript, or even one of your own that has previously been published, without proper citation is considered by IJHCUMJournal as plagiarism. All manuscripts under review or published with IJHCUM are subject to screening using plagiarism prevention software. Thus, plagiarism is a serious violation of publication ethics. The development of CrossCheck is a service that helps editors to verify the originality of papers. CrossCheck is powered by the Ithenticate software from iParadigms, known in the academic community as providers of Turnitin. For a searchable list of all journals in the CrossCheck database, please visit: www.ithenticate.com/search

2. **Data Fabrication and Falsification:** Data fabrication and falsification means the researcher did not really carry out the study, but made up data or results and had recorded or reported the fabricated information. Data falsification means the researcher did the experiment, but manipulated, changed, or omitted data or results from the research findings.

3. **Simultaneous Submission:** Simultaneous submission occurs when a manuscript (or substantial sections from a manuscript) is submitted to a journal when it is already under consideration by another journal.

4. **Duplicate Publication:** Duplicate publication occurs when two or more papers, without full cross referencing, share essentially the same hypotheses, data, discussion points, and conclusions.

5. **Redundant Publications:** Redundant publications involve the inappropriate division of study outcomes into several articles, most often consequent to the desire to plump academic vitae.

6. **Improper Author Contribution or Attribution:** All listed authors must have made a significant scientific contribution to the research in the manuscript and approved all its claims. Don't forget to list everyone who made a significant scientific contribution, including students and laboratory technicians.

7. **Citation Manipulation:** Citation Manipulation is including excessive citations, in the submitted manuscript, that do not contribute to the scholarly content of the article and have been included solely for the purpose of increasing citations to a given author's work, or to articles published in a particular journal. This leads to misrepresenting the importance of the specific work and journal in which it appears and is thus a form of scientific misconduct.

Handling Cases of Misconduct

Once IJHCUM confirms a violation against IJHCUM's publication ethics, IJHCUM addresses ethical concerns diligently following an issue-specific standard practice as summarized below.

1. The first action of the journal Editor is to inform the Editorial Office of IJHCUM by supplying copies of the relevant material and a draft letter to the corresponding author asking for an explanation in a nonjudgmental manner.

2. If the author's explanation is unacceptable and it seems that serious unethical conduct has taken place, the matter is referred to the Publication Committee via Editorial Office. After deliberation, the Committee will decide whether the case is sufficiently serious to warrant a ban on future submissions.

3. If the infraction is less severe, the Editor, upon the advice of the Publication Committee, sends the author a letter of reprimand and reminds the author of IJHCUM publication policies; if the manuscript has been published, the Editor may request the author to publish an apology in the journal to correct the record.

4. Notification will be sent to corresponding author and any work by the author responsible for the violation or any work these persons coauthored that is under review by IJHCUM journal will be rejected immediately.

5. The authors are prohibited from serving on IJHCUM editorial board and serving as a reviewer for IJHCUMJournal. IJHCUM reserves the right to take more actions.

6. In extreme cases, notifications will be sent to the affiliations of the authors and the authors are prohibited from submitting their work to IJHCUM for 5 years.

7. In serious cases of fraud that result in retraction of the article, a retraction notice will be published in the journal and will be linked to the article in the online version. The online version will also be marked "retracted" with the retraction date.

GUIDE FOR AUTHORS

International Journal of Human Capital in Urban Management (IJHCUM) is a double blind peer reviewed electronic and print quarterly publication concerned with allaspects of environmental science and management. IJHCUM publishes original research papers, review papers, case reports and short communications, letters to editor and authors' response about letters to editor across the broad field of human capital in urban management and the related fields of urban management. The publication appears at regular intervals time quarterly. The Journal database is fully openaccess and full text of published articles are available for everyone who can get access to the Journal website free of cost. The authors never pay any charges for submission, article processing and publication.

Guide for Authors: More details on guide for authors refer: http://ijhcum.net/journal/authors.note

GENERAL

1. Authors should submit their contributions electronically through the IJHCUM website submission system to the Editorial Office.

2. Manuscripts must be submitted only in English and should be written according to sound grammar and proper terminology. Manuscripts should be typed in Times New Roman of 11 pt. font and in MS-Word format in one column with 2.5 cm margin at each side. Manuscript submission must be applied once in order to obtain only one submission ID number. More than one submission for a single manuscript can lose the chance of the manuscript consideration. Manuscript must be accompanied by a covering letter including title and author(s) name.

3. There are no strict formatting requirements but all manuscripts must contain the essential elements needed to convey your manuscript, for example Abstract, Keywords, Introduction, Materials and Methods, Results, Conclusions, Artwork and Tables with Captions. Please ensure the figures and the tables included in the single file are placed next to the relevant text in the manuscript, rather than at the bottom or the top of the file. There are no strict requirements on reference formatting at submission. References can be in any style or format as long as the style is consistent.

BEFORE YOU BEGIN

1. Peer-Review Process: In order to sustain the peer review system, authors have an obligation to participate in peer review process to evaluate manuscripts from others. When appropriate, authors are obliged to provide retractions and/or corrections of errors to the editors and the Publisher. All papers submitted to IJHCUM journal will be peer reviewed for at least one round. IJHCUM journal adopts a double-blinded review policy: authors are blind to reviewers, but reviewers are not blind to authors. After receiving reviewers' comments, the editorial team member makes a decision. Because reviewers sometimes do not agree with each other, the final decision sent to the author may not exactly reflect recommendations by any of the reviewers. The decision after each round of peer review may include (a) Accept without any further changes, (b) Accept with minor revision, (c) Major changes are necessary for resubmission and (d) Decline without encouraging resubmission.

2. Post-Publication Evaluation: In addition to rapid Peer Review Process, the IJHCUM Journal has Post-Publication Evaluation by the scientific community. Post-Publication Evaluation is concentrated to ensure that the quality of published research, review and case report meets certain standards and the conclusions that are presented are justified. The post-publication evaluation includes online comments and citations on published papers. Authors may respond to the comments of the scientific community and may revise their manuscript. The Post-Publication Evaluation is described in such a way; it is allowing authors to publish quickly about Environmental science, management, engineering and technology concepts.

3. Publication Ethics: The ethical policy of IJHCUM is based on the Committee on Publication Ethics (COPE) guidelines and complies with International Committee of IJHCUM Editorial Board codes of conduct. Readers, authors, reviewers and editors should follow these ethical policies once working with IJHCUM. The ethical policy of IJHCUM is liable to determine which of the typical research papers or articles submitted to the journal should be published in the concerned issue. The ethical policy insisted the Editor-in-Chief, may confer with other editors or reviewers in making the decision. Visit at: http://publicationethics.org

4. Conflict of Interest: Authors are requested to evident whether impending conflicts do or do not exist. A copyright transfer agreement is signed by the corresponding author, upon the acceptance of the manuscript, on behalf of all authors, for publication to be legally responsible towards the journal ethics and privacy policy. Authors will be notified as soon as possible of decisions concerning the suitability of their manuscripts for publication in the journal. The submitted materials may be considered for inclusion but cannot be returned and Editors of the journal reserve the right to accept or reject any article in any stage, if necessary. Conflict of Interest Disclosure form can be found at: http://ijhcum.net/data/ijhcum/news/Conflict of Interest.doc

5. Submission Declaration and Verification: While submitting a manuscript to IJHCUM, all contributing author(s) must verify that the manuscript represents authentic and valid work and that neither this manuscript nor one with significantly similar content under their authorship has been published or is being considered for publication elsewhere including electronically in the same form, in English or in other language, without the written consent the copy right holder.

6. Authorship: All contributing authors should qualify for authorship and corresponding author should sign the authorship form while submitting the manuscript. It can be found at: http://ijhcum.net/data/ijhcum/news/Authroship form.docx

7. Changes to Authorship: After the manuscript is submitted or accepted for publication, the corresponding author is required to send a request to add or remove an author or to rearrange the author names of the submitted/accepted manuscript by sending the change of authorship form to editorial office. No authorship change is allowed after publication of manuscript. More details may be found at: http://ijhcum.net/data/ijhcum/news/change of authorship form.docx

8. Retained Author Rights: As an author, author or authors' employer or institution retains certain rights. For more information on author rights, found at: http://ijhcum.net/data/ijhcum/news/retained_authors_right.docx

9. Copy Right: Journals should make clear the type of copyright under which authors' work will be published. For open access articles the publisher uses an exclusive licensing agreement in which authors retain copyright in their manuscript. More details may be found at: http://ijhcum.net/data/ijhcum/news/copyright form.doc

10. User license Agreement: IJHCUM provides access to archived material through IJHCUM archives. Manuscripts are the parts of an open archive are made freely available from IJHCUM website after certain period, which begins from the final publication date of the manuscript. All articles published open access will be immediately and permanently free for everyone to read and download. Permitted reuse is defined by Creative Commons user license called ***Creative Commons Attribution***. Visit at: (Creative Commons Attribution 4.0 International (CC BY 4.0))

11. Plagiarism Prevention and Violation of Publication Ethics: All manuscripts under review or published with IJHCUM are subject to screening using Plagiarism Prevention Software. Plagiarism is a serious violation of publication ethics. Other violations include duplicate publication, data fabrication and falsification, and improper credit of author contribution. Thus, the Plagiarism or Fraudulent or knowingly inaccurate statements constitute unethical behavior are unacceptable and submitting the same manuscript to more than one journal concurrently constitutes unethical publishing behavior and is unacceptable. The development of CrossCheck is a service that helps editors to verify the originality of papers. CrossCheck is powered by the Ithenticate software from iParadigms, known in the academic community as providers of Turnitin. For more details visit at: www.ithenticate.com/search

12. Handling Cases of Misconduct: Once IJHCUM confirms a violation against IJHCUM's publication ethics, the following actions will be taken.

a. The work is rejected / retracted immediately. Notification will be sent to corresponding authors. In extreme cases, notifications will be sent to the affiliations of the authors.
b. The authors are prohibited from submitting their work to IJHCUM for 5 years.
c. Any work by the authors responsible for the violation or any work these persons coauthored that is under review by any IJHCUM journal will be rejected immediately.
d. The authors are prohibited from serving on IJHCUM editorial board. IJHCUM reserves the right to take more actions.

MANUSCRIPT PREPARATION

1. Title Page: The title page should include: the name(s) of the author(s), a concise and informative title, the affiliation(s) and address (es) of the author(s), and e-mail address, telephone and fax numbers of the corresponding author.

2. Manuscript Title: Title of up to 17 words should not contain the name of locations, countries or cities of the research as well as abbreviations. The title should be oriented to Environmental issues while not being obscure or meaningless.

3. Abstract: An abstract of 150 to 250 words that sketches the purpose of the study; basic procedures; main findings its novelty; discussions and the principal conclusions, should not contain any undefined abbreviations or references.

4. Keywords: Provide 5 to 7 keywords which can be used for indexing purposes. Keywords should not repeat the words of the manuscript title or contain abbreviations and shall be written in alphabetical order as separated by semicolon.

5. Introduction: The Introduction should state the purpose of the investigation and identify clearly the gap of knowledge that will be filled in the Literature review study. Date and location of the research carried out throughout the study must be mentioned at the end of this section.

6. Materials and methods: The Materials and Methods section should provide enough information to permit repetition of the experimental work. It should include clear descriptions and explanations of sampling procedures, experimental design, and essential sample characteristics and descriptive statistics, hypothesis tested, exact references to literature describing the tests used in the manuscript, number of data involved in statistical tests, etc.

7. Results and Discussion: The Results section should describe the outcome of the study. Data should be presented as concisely as possible - if appropriate in the form of tables or figures, although very large tables should be avoided. The Discussion should be an interpretation of the results and their significance with reference to work by other authors. Please note that the policy of the Journal with respect to units and symbols is that of SI symbols.

8. Tables: Do not submit tables and graphs as photograph. Place explanatory matters in footnotes, not in the heading. Do not use internal horizontal and vertical rules. Tables should be called out in the text and should have a clear and rational structure and consecutive numerical order. All tables should be numbered 1, 2, 3, etc. Give enough information in subtitles so that each table is understandable without reference to the text. Footnotes to tables should be indicated by superscript lower-case letters (or asterisks for significance values and other statistical data) and included beneath the table body.

9. Figures: Figures/ illustrations should be in high quality art work, within 200-300 dpi and separately provided in Excel format. Ensure that figures are clear, labeled, and of a size that can be reproduced legibly in the journal. Each figure should have a concise caption describing accurately what the figure depicts. Figure captions begin with the term Fig. Figures should be with the captions placed below in limited numbers. No punctuation is to be placed at the end of the caption.

10. Conclusion: This section should highlight the major, firm discoveries, and state what the added value of the main finding is, without literature references.

11. Acknowledgements: Acknowledgments of people, grants, funds, etc. should be placed in a separate section before the reference list. The names of funding organizations should be written in full. Financial support affiliation of the study, if exists, must be mentioned in this section. Thereby, the Grant number of financial support must be included.

12. References: All the references should be cited throughout the manuscript text as well as in the Reference section organized in accordance with Harvard system. Groups of references should be listed first alphabetically, then chronologically. The number of references extracted from each journal should not exceed 3 to 5 citations, which is the average acceptable amount. The number of references should not be less than 30 for original paper, less than 100 for review paper. It is substantially recommended to the authors to refer to more recent references rather than old and out of date ones. Volume, issue and pages of the whole references must be specified according to the IJHCUM format.

Citing and listing of Web references: As a minimum, the full URL should be given. Any further information, if known (Author names, dates, reference to a source publication, etc.), should also be given.

Text: All citations in the text should refer to: 1. Single author: the author's name (without initials, unless there is ambiguity) and the year of publication; 2. Two authors: both authors' names and the year of publication; and 3. Three or more authors: first author's name followed by "et al." and the year of publication. Citations may be made directly (or parenthetically). Groups of references should be listed first alphabetically, then chronologically. Examples: "as demonstrated (Allan, 1996a, 1996b, 1999; Allan and Jones, 1995). Kramer *et al.,* (2000) have recently shown …".

List: References should be arranged first alphabetically and then further sorted chronologically if necessary. More than one reference from the same Author(s) in the same year must be identified by the letters "a", "b", "c", etc., placed after the year of publication.

Journal article: Nouri J.; Lorestani B.; Yousefi N.; Khorasani N.; Hassani A. H.; Seif, F.; Cheraghi M., (2011). Phytoremediation potential of native plants grown in the vicinity of Ahangaran lead-zinc mine. Environ. Earth Sci., 62(3): 639-644.

Book: Davis, M. L., (2005). Introduction to Environmental Engineering, 3rd. Ed. McGraw Hill Inc.

Book chapter: Mettam, G. R.; Adams, L. B., (1999). How to prepare an electronic version of your article, in: Jones, B. S., Smith, R. Z. (Eds.), Introduction to the electronic age. E-Publishing Inc., New York.

Conference paper: Brown, J., (2005). Evaluating surveys of transparent governance. In UNDESA, 6th. Global forum on reinventing government: towards participatory and transparent governance. Seoul, Republic of Korea 24-27 May. United Nations: New York.

Dissertation: Trent, J. W., (1975). Experimental acute renal failure. Ph.D. Dissertation, University of California. USA.

Online document: Cartwright, J., (2007). Big stars have weather too. IOP Publishing Physics Web. http://physicsworld.com/cws/article/news/2007/jun/26/big-stars-have-weather-too

AFTER ACCEPTANCE

1. Online Proof Correction: Corresponding authors will receive an e-mail with a link to our online proofing system, allowing annotation and correction of proofs online. Use this proof only for checking the typesetting, editing, completeness and correctness of the text, tables and figures. Significant changes to the article as accepted for publication will only be considered at this stage with permission from the Editor-in-Chief. It is important to ensure that all corrections are sent back to us in one communication. Please check carefully before replying, as inclusion of any subsequent corrections cannot be guaranteed. Proofreading is solely the corresponding author responsibility.

2. Offprints: The offprints can be downloading from the IJHCUM website once the final corrected manuscripts are disseminated.

AUTHORS INQUIRIES

Authors can track their submitted article through IJHCUM website on author's login section at: http://ijhcum.net/contacts?_action=login

International Journal of Human Capital in Urban Management (IJHCUM)

Copyright Transfer Agreement

1. Parties of the agreement

Author (s):

Manuscript Title:

Manuscript ID:

(Herewith referred to as the "materials"),

Journal Title: International Journal of Human Capital in Urban Management (IJHCUM)

2. Subject of the agreement

A) Copyright
1- The Author and each co-authors shall transfer and sell to the Publisher for the length of the copyright starting from the moment the present agreement comes into force the exclusive rights to the materials, including the rights to translate, reproduce, transfer, distribute or otherwise use the materials or parts (fragments) contained therein, for publication in scientific, academic, technical or professional journals or other periodicals and in derivative works thereof, worldwide, in English, in print or in electronic editions of such journals, periodicals and derivative works in all media or formats now existing or that may exist in future, as well as the right to license (or give permission to) third parties to use the materials for publication in such journals, periodicals and derivative works worldwide. The transfer under this agreement includes the right to adapt the presentation of the materials for use in conjunction with computer systems and programs, reproduction or publication in machine-readable format and incorporation into retrieval systems.
2- Reproduction, placement, transfer or any other distribution or use of the materials, or any parts of the materials contained therein, in any way permitted under this Agreement, shall be accompanied by reference to the Journal and mentioning of the Publisher, namely: the title of the article, the name of the Author (Co-authors), the name of the Journal, volume/number, copyright of the publisher.

B) Reserved Rights
The Author (Co-authors) or the employer of the Author (Co-authors) of the materials shall retain all proprietary rights (with the exception of the rights transferred to the Publisher under the present Agreement).

C) Author Guarantee
The Author (Co-authors) guarantees that the materials are an original work, submitted only to IJHCUM, and have not been published previously.
In case the materials were written jointly with co-authors, the Author guarantees that he/she has informed them of the terms of this Agreement and obtained their signatures or written permission to singe on their behalf.
The Author guarantees as well that:
The materials do not contain libelous statements.
The materials do not infringe on other persons' rights (including without limitation copyrights, patent rights and the trademark right).
The materials do not contain facts or instructions that can cause damage or injury to third parties and their publication does not cause the disclosure of any secret or confidential information

Author (Corresponding Author):

Correspondence Address:

Phone:

Fax:

Email:

Corresponding Author Name: Signature   Date

On Behalf of the Publisher:

Human Resource Development,
Navab High Way, Tehran 1346914117
Iran

Phone: (+9821) 6403 8606

Fax: (+9821) 6403 8226

Email: *editor@ijhcum.net*

      ijhcum@gmail.com

Website: www.ijhcum.net

Accepted for publication ☑   Signature   Date

PLEASE NOTE: The accepted manuscript cannot be processed for publication until the publisher has received this signed form. The form MUST be signed by the Corresponding Author and then scanned and sent through the system or email. If the manuscript is not published in the Journal, this release will not take effect.

The sole responsibility for the whole content (s) of the article remains only with the corresponding author. However, Editor would reserve the right to adjust the style to certain standards of uniformity before publication.

CONFLICT OF INTEREST DISCLOSURE FORM

Conflict of Interest is defined as a set of conditions in which professional judgment concerning a primary interest, such as the validity of research, may be influenced by a secondary interest, such as financial gain. A Conflict of Interest Disclosure is an agreement or notification from the authors that they have not been paid for the work, or if they have, stating the source of their payment. The purpose of Conflict of Interest Disclosure form is to provide readers of authors' manuscript with information about authors' interests that could influence how the authors receive the work. The corresponding author (on behalf of all co-authors) should submit a conflict of interest disclosure form and is responsible for the accuracy and completeness of the submitted manuscript. Conflict of Interest Disclosure form can be signed by the corresponding author on behalf of all co-authors and stating that the submitted manuscript is the authors' original work, has not received prior publication and is not under consideration for publication elsewhere, permission has been received to use any material in the manuscript much as tables, figures etc. or no permissions have necessary to publish the authors' work.

1. Name of the corresponding author

2. Affiliation including e-mail and phone number

3. Manuscript Title

4. Do the authors or authors' institution at any time receive payment or services from a third party (government, commercial, private foundation, etc.) for any aspect of the submitted manuscript (including but not limited to grants, data monitoring board, study design, manuscript preparation, statistical analysis, etc.)?

   Are there any relevant conflicts of interest?   Yes   /   No

5. Do the authors have any patents, whether planned, pending or issued, broadly relevant to the work?

   Are there any relevant conflicts of interest?   Yes   /   No

6. Are there other relationships or activities that readers could perceive to have influenced, or that give the appearance of potentially influencing, what the authors' information in the submitted manuscript?

   Are there any relevant conflicts of interest?   Yes   /   No

7. Are there any aspect of the work covered in this manuscript that has involved either experimental animals or human patients has been conducted with the ethical approval of all relevant bodies or not.

   Are there any relevant conflicts of interest?   Yes   /   No

---

Corresponding Author   Print Name   Date
Signature

AUTHORSHIP FORM

By completing and signing the following statements, the corresponding author acknowledges and accepts the responsibility on behalf of all contributing authors, if any, concerning Authorship Responsibility.

Manuscript title:

Corresponding author:

Affiliation:

Email:

Phone No:

By signing and filling this form, the corresponding author certifies that each author has met all criteria below (A, B, C, and D) and indicates each author general and specific contributions by listing his or her name next to the relevant section.

A.   I certify that

- The manuscript is authentic and valid and that neither this manuscript nor one with considerably similar content under my authorship has been published or is being considered for publication elsewhere, except as described in an attachment, nor copies of closely related manuscripts are provided.
- I will provide the data or will contribute fully in providing and obtaining the data on which the manuscript is based for examination by the editors or their assignees, if requested.
- Every author has agreed to allow the corresponding author to serve as the primary correspondent with the editorial office, to review the edited manuscript and proof.

B.   Each author has given final approval of the submitted manuscript.

C.   Each author has participated sufficiently in the work to take public responsibility for the whole content.

D. Each author qualifies for authorship by listing his or her name on the appropriate line of the categories of contributions listed below. List appropriate author next to each section – each author must be listed in at least 1 field. More than 1 author can be listed in each field.

- conception and design
- acquisition of data
- analysis and interpretation of data
- drafting of the manuscript
- critical revision of the manuscript for important intellectual content
- statistical analysis
- obtaining funding
- administrative, technical, or material support
- supervision
- no additional contributions
- other (specify)

Corresponding Author Signature   **Print Name**   **Date**

VII

FINAL CHECKLIST

International Journal of Human Capital in Urban Management (IJHCUM)

Prior to acceptance of the manuscript, the corresponding author is responsible to adjust the whole manuscript according to the following items and then the marked final checklist should be attached along with the covering letter:

☐ A covering letter herewith, **not previously published and submitted elsewhere, fully or partially,** must be signed and accompanied by the corresponding author in the time of manuscript submission.

☐ All authors have read the **Ethics in publishing, Plagiarism prevention and violation of Publication Ethics and Handling cases of misconduct**.

☐ The Manuscript has been **read and approved by all listed authors**.

☐ The title page contains the **Title, Author (s) Name, Degree (s), Addresses, Tel., Fax and Email** of author (s) separated from the manuscript body.

☐ Not only the corresponding author, but also the whole contributors of the manuscript are advised to be registered at the journal website in order to keep their names in the manuscript biosketches.

☐ The abstract words content is not less than **150** and more than **250 words**, which brings upper scores for both; the publication as well as author (s).

☐ Key words count should be 5 to 7 words.

☐ It is suggested to the authors to define some proper main subjects related to their manuscript topic.

☐ Figures / illustrations are **in high quality art work**, with at least 200 dpi to 300 dpi. All graphs preferred to be provided in excel format.

☐ All Figures and Tables are cited throughout the text.

☐ The references are cited based on the authors surname and year of publication (Harvard System) throughout the text body. Moreover, the list of the references is carefully arranged alphabetically at the end of manuscript.

☐ The number of references in the review paper preferred to be not contain less than 100; for original research paper or case report not less than 30 and for short communication 20 references are required.

☐ The majority of manuscript references must not be extracted from a single journal. The acceptable average can be indicated at most 4 to 6 references from each journal.

☐ A **copy right release and conflict of interest disclosure form** must be signed by the corresponding author in case of multiple authorships, prior to the acceptation of the manuscript, by all authors, for publication to be legally responsible towards the Journal ethics and privacy policy.

☐ The manuscript is in structured format with; **Abstract; Key words; Introduction; Materials and Methods; Results and Discussion; Acknowledgements and References.**

☐ The author(s) are appealed to provide the source(s) of financial support along with the grand number for the study in the acknowledgements section.

☐ Hereby, I accept liability for the scientific integrity of the manuscript contents.

Name:

Corresponding Author Signature:

Date:

International Journal of
Human Capital in Urban Management

Int. J. Hum. Capital Urban Manage.

Please enter my annual subscription to the International Journal of Human Capital in Urban

Management, including 4 quarterly issues for the year .... Vol. .... Nos.............

	Domestic	**Foreign**
Institutional	IRR. 1,000,000	USD 100
Individual	IRR. 800 , 000	USD 80
Student	IRR. 600,000	USD 60
Single copy	IRR. 3 00,000	USD 30

Name: Tel.:   Email:

Mailing Address:

* Please allow 3 to 5 weeks for delivery

Please send this filled in order form along with the Bank receipt payment to:

International Journal of Human Capital in Urban Management (IJHCUM),

No. 32, Akbari St. Pol-e-Roomi, Tehran 1964635611 Iran

International

Journal of Human Capital in Urban Management

CONTENTS

Volume 8, Number 1, Winter 2023

(Serial # 29)