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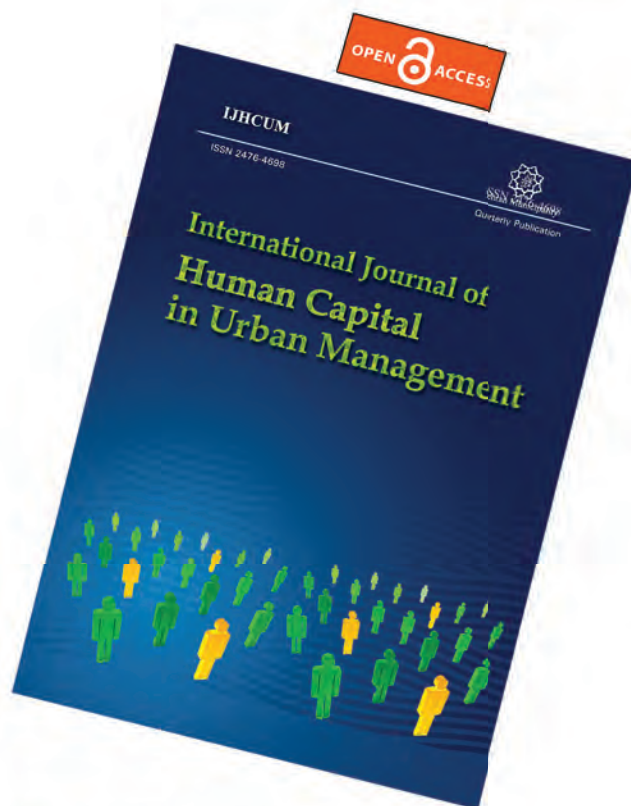
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ORIGINAL RESEARCH PAPER

Improvement of implementation processes of corporate environmental responsibility in conditions of urbanization

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ABSTRACT

BACKGROUND AND OBJECTIVES: During the disclosure of the conceptual foundations of the environmental responsibility implementation in the functioning of corporations, the need to implement such approaches to conducting business activities that will provide rational usage of nature and balanced development of the national economy in accordance with the concept of sustainable development, where economic interests will be combined with ecological and social one, was identified.

METHODS: On the basis of mathematical modeling methods and the developed algorithm, proposals regarding the implementation of economic forms of corporate environmental responsibility are substantiated. In particular, the author proposed a methodology for determining the integral indicator, which in turn makes it possible to calculate the level of corporative environmental responsibility.

FINDINGS: In general, only 30-40% of corporations in Ukraine are environmentally responsible. In 2022, the share of implemented quality management and environmental protection certification systems among environmentally responsible corporations was 67%. The following indicators have the most significant positive influence on the change in the implementation level of corporate environmental responsibility: the number of certified quality management and environmental protection systems by Ukrainian corporations and the amount of current corporations' expenditures on environmental protection.

CONCLUSION: It has been suggested to stimulate the formation of corporate environmental responsibility system at the national level by developing and using effective financial and economic tools. This will make it possible to level the capabilities of corporations, introduce proven international standards and principles of environmental responsibility, and bring the national economy to the path of sustainable development.

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INTRODUCTION

The problems of balanced and sustainable economy development, which have become especially urgent in recent years, point out the need to solve issues related to increasing the production efficiency of the economy corporate sector with the simultaneous improvement of the employees' social situation and the population of the region, where the main activities of corporations are carried out. The emphasis of many countries of the world on the innovative development of the economy, without which successful integration into the world economic system is impossible, reveals new issues connected with the corporations social and environmental responsibility to their employees and the state (Graafland and Noorderhaven 2018). Besides this, the development of each country's economy and its effective integration into the system of international relations require the announcement of strict requirements for the environmental safety of production and the development of effective economic implementation forms of the corporate environmental responsibility. According to the experience of the last decades (Chandna, 2017), the best results in ensuring sustainable economic growth were achieved by those countries that have managed to combine economic efficiency with social responsibility through the establishment of economic mechanisms with the simultaneous optimization of the social institutions activities, that act as a means of harmonizing the interests and purposes of subjects who interact in the process of economic activity. Therefore, not only the achievement of the main goals of human development is based on economic growth, but also economic growth, in turn, depends on social, demographic, cultural, political, environmental factors, etc. (Shubham et al., 2018). Nowadays, it is becoming obvious for corporate business that ensuring strong positions in the national and global economy is achieved through responsible entrepreneurship. Necessary aspects for ensuring responsible business include increasing openness and building balanced relationships with all those groups which are directly affected by the business, and, in turn, affect or depend on its success (Helfaya and Moussa 2017). This is actually one of the fundamental approaches to understanding the responsibility of business to society, that is, corporate social responsibility. This approach is

currently used by the majority of corporations (Chuang and Huang 2018) that are mainly industry leaders which have chosen a strategy of increasing openness and transparency, disclosing the results of their activities in non-financial reports, which are becoming an important element of the responsible business culture. This responsibility means the need to report to society for the economic, environmental, and social impact that occurs as a result of business activity (Tan et al., 2017). Thus, corporate social responsibility and environmental responsibility are important during the implementation of the sustainable development concept at the national level. Increasing level of environmental responsibility improves the corporations' efficiency both in the short- or in the long-term perspective (Zou et al., 2019). Therefore, Corporate Social Responsibility (CSR) and Corporate Environmental Responsibility (CER) are vital competitive factors. Since the level of corporate environmental responsibility, in the nearest future, will determine the company's position on the international market, as well as among consumers of its products (Han et al., 2019). In other words, environmental responsibility is the "entrance ticket" to the international business community. A decisive role in the implementation of CER is played by economic methods and tools, first of all, the creation of environmental funds and a system of material motivation for environmental protection activities (Li et al., 2017). The implementation of those tools will contribute to the improvement of the corporations' activities results, increase the efficiency of the management system, and will also form a positive corporations' image, expand the number of potential consumers at the expense of "environmentally conscious" buyers, as well as increase the corporations' competitiveness. In the process of forming the corporate environmental responsibility, a decisive role plays economic forms and tools, the implementation of which contributes to improving the corporations' activities results, increasing the efficiency of the management system, and forming a positive corporation image (Zou et al., 2019). There are two regulators groups of environmental behavior of economic entities. The first group is aimed at forcing environmental polluters to limit their ecologically destructive impact (Hartmann et al., 2017). In turn, the second group of regulators is aimed at encouraging nature users to improve the environment (Zare et

al., 2016). Society's awareness of responsibility for the state of the environment and natural resources for future generations necessitates the justification and implementation of ecological approaches to the operation of industrial corporations. These ecological approaches will ensure rational usage of nature and balanced ecological and economic development of the national economy. The global community is becoming more and more environmentally friendly, and consumer-oriented businesses take into account and support such changes by implementing the social responsibility concept. In the scientific literature, the general theoretical aspects of the corporate environmental responsibility are disclosed, however, not enough attention is paid to the analysis of the economic forms of the corporations' environmental responsibility and the justification of effective mechanisms for its implementation as integral prerequisites for the sustainable development of the national economy. This led to the search for ways to solve this problem and the choice of the research topic. The purpose of the study is to develop practical recommendations for the introduction of economic forms of implementation of corporate environmental responsibility. To achieve this purpose, the following tasks were set and solved: to develop a model of implementation of the principles of corporate social responsibility in the activities of Ukrainian corporations; using mathematical modeling methods, formulate proposals for the introduction of economic forms of implementation of environmental responsibility; justify ways to optimize the impact of corporations on the environmental situation in Ukraine. The study was conducted in Ukraine during the period of 2012-2022.

MATERIALS AND METHODS

The theoretical and methodological basis of the research became the fundamental provisions of economic theory, the economics of enterprise management, the economics of nature usage, the theory of social and corporate environmental responsibility and sustainable development, as well as scientific works and methodological developments of leading scientists in the field of economic forms implementation of corporate environmental responsibility. Before moving on to modeling the implementation of CER in accordance with the economic functioning forms, it is necessary to define

a number of key concepts of this process. The main principles of modeling are: identifying the purpose of the model; identification of a limited number of factors that have a decisive influence on the system; establishing the type of the relationship between the selected factors; establishing the principle of connections multiplicity between factors and highlighting the main connections that determine the nature of the development and changes of this system. The essence of mathematical modeling lays in replacing the original object with its mathematical model and in further studying of the model with the help of computational logic algorithms. The criterion of the CER level, as a dependent variable, can be the ecological and economic state of the economic entity, in turn, the independent variables will be represented by macroeconomic indicators that affect the formation of the ecological and economic state of corporations through internal and external influence. The authors propose to divide the algorithm for mathematical modeling of CER implementation into ten stages (Fig. 1).

Stage 1. Identification of economic forms of implementing corporate environmental responsibility (conducting a comparative analysis of economic forms of the implementation environmental aspect of corporation's social reports, as well as researching the level of implementation of the product (service) quality system; development analysis of the social and ecological corporation infrastructure; assessment of the corporations' impact on the environment, etc.). Stage 2. Analysis of problematic cases and threats to the CER formation (objectively existing threatening factors in certain spheres of corporate enterprises activity, in particular, challenges of the competitive environment, economic, political, social and environmental risks). External (exogenous) threats that depend on the state and characteristics of the environment in which the corporation exists. The effect of external threats is not controlled by the corporation; therefore, they must be considered when making management decisions, and targeted efforts must be made to reduce their impact. Internal (endogenous) threats are mostly formed within the business entity, i.e. corporations can directly influence them. In order to be environmentally responsible, corporations must constantly face internal and external threats affecting its activities in the field of ecology. Each corporation must have

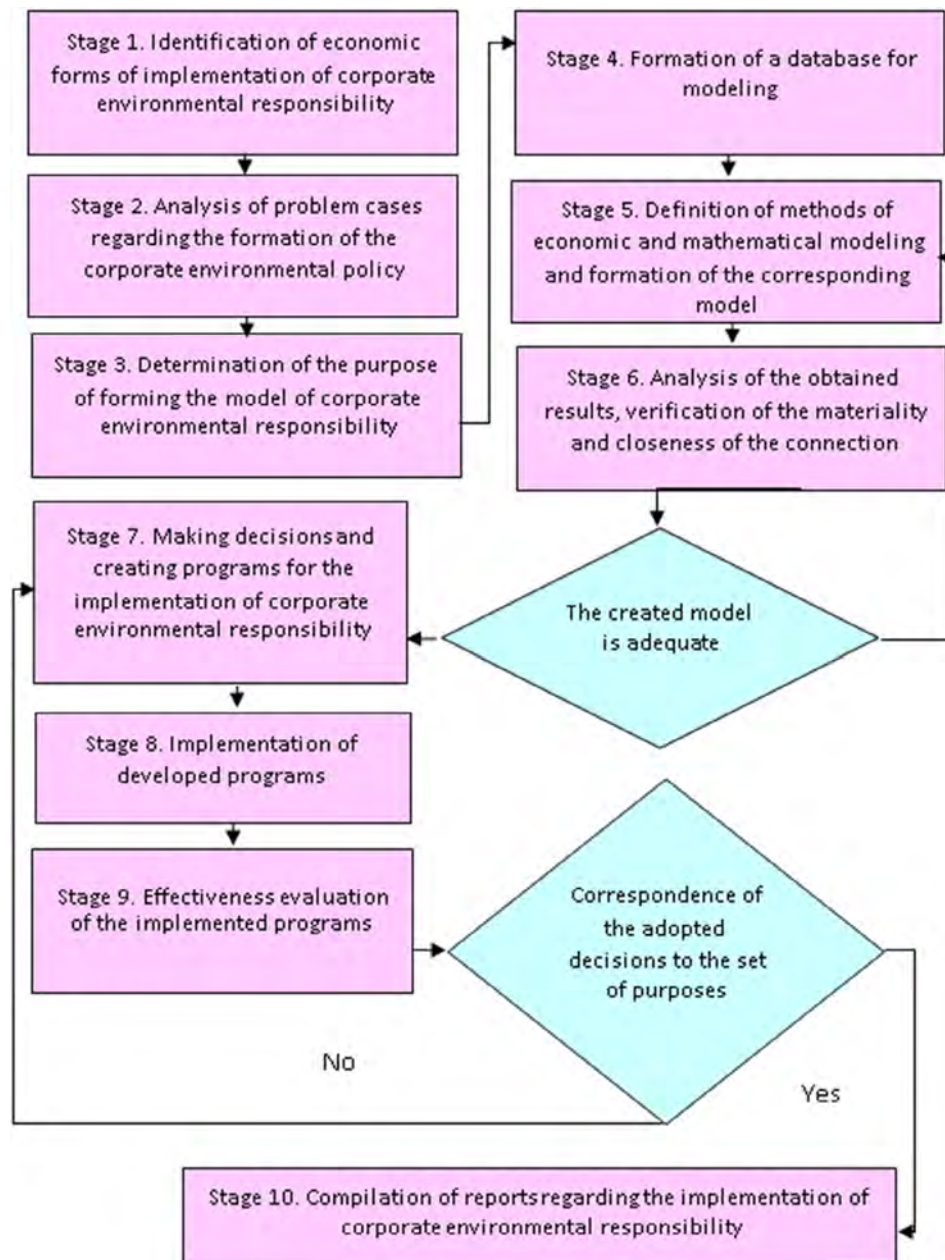


Fig. 1: Algorithm for step-by-step implementation of mathematical modeling regarding the implementation of corporate environmental responsibility

its own mechanism for environmental protection, which considers the size of the corporation, the field of its activity, and the level of corporate culture. However, most measures (elements of CER) to minimize the negative impact of their activities on the surrounding natural environment (SNE) are the

same for all organizations. Stage 3. Defining the purpose of the CER evaluation model (establishing mutually beneficial and long-term relations between all interested participants: consumers, management, state authorities, investors, shareholders, suppliers, partners, experts, public organizations, and other

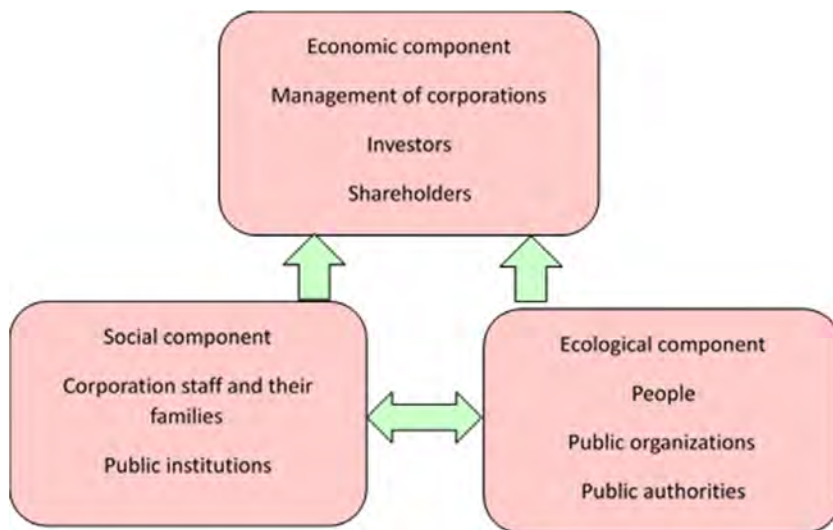


Fig. 2: Main categories of stakeholders involved into the process of CER implementation

participants) (Fig. 2).

Stage 4. Formation of indicators database for modeling (for developing and implementing the environmental responsibility of the corporation, it is necessary to form indicators system that will characterize various aspects of corporations' activities). Eventually, the system of these indicators determines the level of CER implementation (Wang *et al.*, 2018). Stage 5. Determination of economic-mathematical modeling methods based on the specifics of the task, as well as the content of the modeling object (a number of mathematical modeling methods are represented by the method of expert evaluations, the method of principal components, the method of correlation-regression analysis, the method of taxonomic indicators, the method of potential, the method hierarchy analysis, center of gravity method, etc.). Formation of the CER implementation model is the final point of this stage. Stage 6. Analysis of the obtained results, as well as verification of the materiality, closeness of the connection, model adequacy. The purpose of the analysis of the obtained results is to assess the impact of factor characteristics on the resulting characteristic. This, in turn, will make it possible to monitor significant changes in the corporations' activities, and take them into account in the process of development, implementation, adaptation and

adjustment of environmental responsibility and CSR in general. The study of factor characteristics should be carried out systematically and comprehensively, as well as determine which of the factors have the most significant influence, and the change of which can cause potential threats or, on the contrary, create additional opportunities for corporations. Stage 7. Making decisions and development of programs for the CER implementation (for example, the final form of environmental responsibility functioning is a system of programs, the coordination of which gives a set of tasks and an "ecological order", taking into account the characteristics of each region, therefore targeted programming can become the main tool for the implementation of environmentally oriented corporate policy). Stage 8. Implementation of developed programs (program implementation process consists of consecutive stages, which are developed by specialists from CSR and finally approved by the management). Stage 9. Evaluating the effectiveness of the programs implemented. It is carried out, as a rule, using a system of statistical and socio-ecological indicators, including integral indicators, that summarize objective and subjective components of the ecological situation. Stage 10. Compilation of reports on CER implementation. Formed reporting is a tool for informing employees, shareholders, partners and society in general

about how exactly and how quickly the corporation implements the goals of environmental stability and social well-being laid down in its mission or strategic plans (the report can be presented in the form of an appropriate thematic section of the annual corporate report or in the form of a separate document describing the corporation's activities in the environmental sphere, i.e. a report on sustainable development). The disclosed problems of environmental responsibility in the report allows to justify the management's actions in order to improve or maintain a certain level of activities effectiveness. The corporation's management, in compliance with a model, analyzes the management system with a certain periodicity in order to ensure its relevance, adequacy and effectiveness. The task of the analysis is to evaluate the implementation of environmental policy tasks, including the following indicators: ensuring the environmental safety of production, reducing the impact on the environment. Therefore, the basis of the model regarding the implementation of corporations' environmental responsibility are the subjects of the corporate sector, whose interests are mutually determined and interconnected: economic, environmental and social interests of consumers, business, the state and members of society.

RESULTS AND DISCUSSION

All developed countries of the world recognize the need for theoretical justification and financing of environmental policy, which, in turn, ensures the preservation of the natural environment, the rational usage of real and potential natural resources, the preservation of ecological balance and the provision of living conditions for society. Nowadays, many countries of the world have created national programs for environmental protection and rational usage of natural resources. They have a fundamentally new character compared to the previous nature protection policy, which had strict limits of action and was based on the concept of eliminating the consequences related with environmental damage. The basis of industrial policy in the sphere of environmental protection and its financing measures is the principle of a normative and qualitative state of the environment, which is ensured either by a system of norms and standards for the maximum allowable levels of anthropogenic load, the consist of pollution, emissions, or by a system of corporation's taxation

that allows non-compliance with the established requirements of nature usage. Both principles can be effectively combined. States use a variety of means in order to stimulate the private sector, encourage it to comply with new legislative norms. In total, there are more than 200 such mechanisms in the countries of the European Union, in particular: direct grants for the construction and operation of environmental protection equipment, as well as urban and rural water treatment facilities, which relieve industrial corporations from excessive costs; preferential provision of loans to the private sector; tax benefits system (Aguado and Holl 2018). The market mechanism of environmental protection activities, which includes the usage of environmental subsidies, loans, fees, fines, taxes, credits and quotas related to the emission of harmful substances, is becoming increasingly developed and widespread (Lee et al., 2018). They, in turn, make it possible to allocate financial resources and accumulate them in state accounts or in special funds. This is the practice in the USA, where private industrial capital receives a variety of assistance in the field of environmental (Yang and Liu 2018). State subsidies are of particular importance in this assistance. In addition to direct subsidies in the USA industry, indirect subsidies are also widely used: subsidies provided by municipalities are used for the construction of sewage treatment plants and processing of industrial waste, etc. Receiving subsidies is an encouraging mechanism for the further investment, which, in turn, leads to an increase of American corporations' current costs for environmental protection. Environmental subsidies take the form of innovation subsidies that cover part of the costs for the development of new technologies, and loans for environmental protection equipment, as well as for the restoration of environmental quality or subsidies to cover loans. Such a policy is typical for Austria, where, among other things, there is an investment premium for capital investments into nature protection (El Ghoul et al., 2018). In the Netherlands, at the expense of state funding, effective measures are being taken to reduce pollution and develop clean technologies. An additional discount (10-15%), compared to the usual tax discount on investment costs, is applied to specific investments in the field of reducing environmental pollution. Moreover, in many countries, such as: Denmark, Norway, Sweden, the Netherlands, Canada, the state

subsidizes the development of technologies, equipment, alternative energy supply sources, energy-saving measures (Jiang *et al.*, 2018). Tax reductions for more environmentally friendly cars are applied in Austria, Germany, Norway, Sweden and the Netherlands, this is an example of tax benefits. In the USA, as one of the forms of state subsidies, it is practiced to withdraw interest received on obligations from the total amount of taxes, the funds from which were directed to reducing pollution of land and water resources, atmospheric air, etc. (Orsdemir *et al.*, 2019). In Spain, along with tax benefits, special subsidies (up to 30% of investment costs) are provided for research activities in the areas of monitoring, emission reduction, and prevention of environmental pollution (Kim *et al.*, 2017). All subsidies, aimed at programs to prevent environmental pollution, are provided to corporations from the state budget or from special funds of the nature protection ministries. Thus, for example, in Austria, there is an environmental fund, in Sweden — a fund for prevention of contamination as a result of fuel burning, in Turkey — a fund for prevention of environmental pollution, etc. (Chen *et al.*, 2018). Additional motivation for corporations' environmental responsibility are the reduction of tax rates, as well as the provision of preferential state subsidies to corporations that make changes in their production process to reduce harmful emissions; encouraging the processes for improvement of automobiles with the purpose of environmental protection. Thanks to subsidies, financial institutions can perform functions similar to licensing. In most countries that use such subsidies, there are laws according to which non-fulfillment of the established requirements leads to the termination of financial assistance. Direct state funding of scientific developments and research is quite important for the improvement of environmental awareness of society. In the USA, almost three quarters of the Environmental Agency's scientific budget directs on contracts and subsidies for individual developments, which are carried out mainly in industry. In contrast to subsidies for treatment facilities and equipment, the right to receive them is given to demonstration projects (Choudri *et al.*, 2017). Lending is an important economic lever for regulating nature protection activities. In particular, some economists point out that the Federal Reserve System of the United States,

which concentrates all banking capital, should set higher interest rates on loans directed to "polluting" projects and provide certain benefits to industry and factories that develop environmentally friendly technology or install purification equipment (Wong *et al.*, 2018). Accelerated depreciation of purification equipment is considered an important lever for stimulating environmental protection activities in the USA. The tax reform law established three times shorter amortization term for purification equipment compared to industrial one. In addition to the 10% tax discount for investments into purification equipment in the USA, there are also other tax benefits (Zhang 2017). Along with incentives, there are coercive levers that are applied to violators of environmental norms and standards. First of all, this is a prohibition on the production of any chemical substances with increased toxicity, and also requirements on stopping emissions of pollutants in cities and areas where a critical sanitary and hygienic situation has emerged (Testa *et al.*, 2017). In some countries, a progressive tax has been established for industrial corporations that emit pollutants beyond the limits of permissible norms. A number of legislative norms define possible sanctions in case of non-compliance with established environmental norms, and in some cases even criminal liability or prohibition of the corporation's production activities may occur (Ruepert *et al.*, 2017). Integral components of CSR are the following: environmental protection, rational usage of natural resources, creation of appropriate conditions for corporation's environmental responsibility and human life. A corporation's environmental responsibility is an indicator of its corporate social responsibility. Environmentally responsible corporations comply with the norms of current environmental legislation, which, in turn, contributes to reducing costs from environmental pollution. The main axiom of nature management is the principle "ecologically- means economically", which is implemented by minimizing environmental damage, minimizing waste (Samimi and Nouri, 2023) and preventing environmental pollution (Table 1).

Environmental responsibility is gaining more and more importance in the activities of global corporations, it is reflected in reporting and is an integral component of corporate strategy. A positive trend is observed in Ukraine, because over the past

Implementation of corporate environmental responsibility

Table 1: Corporations' benefits and losses depending on the level of environmental responsibility

Benefits of environmentally responsible corporations	Losses in business because of non-compliance with environmental requirements
Reduction of material losses due to reuse of recyclable materials and rational consumption of raw materials.	Excessive growth of material costs compared to competitors who use low- or no-waste technology
Reduction of production energy consumption, savings on lighting and heating.	Lagging behind in the field of promising scientific and research developments that contribute to the corporation's, compared to the similar development of competitors
Absence of unplanned expenses for payment of insurance	Worse opportunities to attract investors.
Recruitment of highly educated and qualified staff.	The growth of insurance costs.
Capital investment into promisingly profitable areas.	The increase in fines for violation of requirements, standards, etc.
Obtaining income from the sale of environmentally friendly products and/or the provision of environmental services.	Increased attention from the local authorities, as well as strict external control over the implementation of environmental standards.
Attracting "green consumers", increasing sales.	Worse conditions for employment of qualified personnel.
Strengthening the manufacturer's reputation, expanding the possibility of advertising goods and services on the market due to the usage of "green" marketing.	Loss of consumers who prefer to purchase ecologically safe goods and services.
Better cooperation with the local community.	Worsening of reputation.
	Unfavorable development perspective.

Table 2: Expert evaluation of the influence of socially responsible corporate activity on the implementation of the sustainable development principles in Ukraine

Potential consequences of socially responsible corporate activity	Probability, %
Caring for the environment, rational consumption and usage of natural resources	65.8
Social, economic and ecological balance and development	57.0
Improving population health, increasing life duration and labor activity	44.3
Activation of socially responsible activities of the state, society, business, and individuals in order to create conditions for sustainable development	43.7
The formation of a high values' system, as well as the cultural and spiritual development of human society	43.7
Use of resource-saving technologies in the production process	40.5
Modernization of social relations, consolidation of society and authorities' efforts in order to ensure sustainable development	39.2
Formation and implementation of a consumption model in compliance with the principles of sustainable development	26.6
High ranking of Ukraine in terms of sustainable development at the international level	12.0

two decades, the number of corporations participating in the policy of social responsibility has significantly increased. This is due to the following factors: a broad understanding of the connection between economic activity and issues of social development; recognition of the importance of risk management and an increasing awareness of the economic benefits that organizations can gain from integrating

social development policies into their strategies; the demands of stakeholders for corporations to provide the most transparent reporting system. Moreover, Ukraine belongs to those states that have taken a strategic course on introducing the sustainable development principles into the economic system (Table 2).

The method for determining the CER level of

Table 3: The initial data for calculating the level of environmental responsibility implementation of Ukrainian corporations

Initial data	Years									
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
The number of environmentally responsible corporations (which form a report on sustainable development), units, a_1	184	195	190	226	245	259	324	334	350	261
Total number of corporations, units, a_2	782	789	802	806	812	802	852	836	717	637
The number of corporations involved into environmental protection activities, units, a_3	508	513	521	524	528	521	554	543	466	414
Capital investments from the corporations' own funds for environmental protection, million USD, a_4	241.76	524.6	515.6	538.36	466.04	1327.04	1165.2	1045.4	1177.8	684.8
The total amount of current expenditures on the protection and rational usage of natural resources, considering all financing sources, million USD, a_5	441.24	585.03	768.46	727.27	960.65	1127.94	1316.47	1357.91	1320.57	1615.55
The number of corporations' certified systems the field of environmental quality management and nature protection, units, a_6	45	60	70	73	105	146	171	300	328	339
The number of new low-waste, resource-saving, ecologically oriented technological processes implemented by corporations, units, a_7	341	551	597	670	396	434	471	419	364	375
The total amount of capital investments aimed at the protection of the natural environment, considering all sources of funding, million USD, a_8	161.42	250.07	315.14	246.07	218.14	587.1	600.93	545.88	737.99	709.56
Amount of current corporations' expenses for environmental protection, million USD, a_9	442.44	576.66	752.45	707.92	936.3	1097.88	1283.24	1319.55	1288.92	1576.21

Ukraine was formed. The initial data for evaluating the level of corporations' environmentally responsible activities are given in [Table 3](#).

According to this methodology, the system of indicators for the analysis of environmentally responsible activities includes the following assessment criteria: the fullness of corporation's involvement into environmentally responsible activities; distribution range of economic forms

of environmental responsibility implementation; the degree of financial support for corporations' environmental responsibility ([Table 4](#)).

The conclusions of the conducted selective statistical study of Ukrainian corporations made it possible to interpret the trends of various indicators for all corporations of the country. In the author's opinion, the system of these indicators for assessing the corporations' level of environmental responsibility

Table 4: System of indicators for the analysis of corporations' environmental responsibility in Ukraine

Evaluation criteria	Indicator	Years									
		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
The fullness of corporation's involvement into environmentally responsible activities	The specific weight of ecologically responsible (ER) corporations in their total number ($a_1 / a_2 \times 100\%$)	23.53	24.71	23.69	28.04	30.17	32.29	38.03	39.95	48.81	40.97
	The specific weight of the corporations' current expenditures for environmental protection in the total amount of current expenditures, considering various sources ($a_9 / a_5 \times 100\%$)	97.27	98.57	97.92	97.34	97.47	97.33	97.48	97.18	97.60	97.56
	The average number of implemented quality management and environmental protection certification systems per unit of an ER corporation ($a_6 / a_1 \times 100\%$)	12.1	14.1	14.6	15.2	18.3	23.1	24.6	32.9	41.9	50.3
Distribution range of economic forms of environmental responsibility implementation	The average number of resource-saving technologies per one ER corporation (a_7 / a_1)	1.85	2.83	3.14	2.96	1.62	1.68	1.45	1.25	1.04	1.44
	The average amount of current expenditures on environmental protection per one corporation (a_9 / a_3)	0.870	1.124	1.443	1.351	1.774	2.106	2.317	2.428	2.766	3.807
	The level of financing of environmental activities by corporations (a_8 / a_4)	0.67	0.48	0.61	0.46	0.47	0.44	0.52	0.52	0.63	0.72

will contribute to the formation of a qualitative system of CSR in Ukraine. A comprehensive analysis of the calculated indicators revealed that Ukrainian corporations have an insignificant implementation level of the environmental component in their activities: only 30-40% of corporations from the total number are environmentally responsible; the share of implemented quality management and environmental protection certification systems among environmentally responsible corporations was 61% in 2019; the level of funding of environmental protection measures by Ukrainian corporations does not meet the real needs of investment in this area. It is hard to make an integral assessment of the implementation level of corporations' environmental responsibility using calculated indicators, because they have different dimensions, and their aggregation

is inefficient. For the purpose of defining the general implementation level of corporations' environmental responsibility, it was proposed to use the integral indicator, which in turn allows to determine the rank of corporations' environmental activities. The generalized utility function, or the Harrington scale, was used as an integral efficiency indicator (Mulia et al., 2017; Ayala-Ponce et al., 2018; Graafland 2019). The basis of the aforementioned indicator is the idea of transforming the natural values of each indicator of corporate environmental responsibility (Table 5) into a dimensionless form f_{h_i} (Table 6) with further determination of partial functions according to the Harrington scale k_{h_i} (Table 7) and the integral indicator of the realization level of corporate environmental responsibility K (Table 8).

Therefore, according to Harrington's scale of

Table 5: Natural values of CER implementation indicators

Year	h_1	h_2	h_3	h_4	h_5	h_6
2012	29	97.53	11.3	1.74	9.08	0.72
2013	30	96.62	13.0	2.49	10.90	0.74
2014	29	96.45	13.9	2.72	13.12	0.61
2015	33	95.85	14.2	2.63	12.01	0.76
2016	35	96.30	17.8	1.57	14.68	0.78
2017	37	96.34	22.7	1.62	17.94	0.67
2018	38	96.61	25.9	1.71	21.93	0.59
2019	40	96.35	41.9	1.50	23.28	0.60
2020	45	96.73	48.6	1.28	24.84	0.49
2021	41	96.85	61.1	1.75	38.38	0.35

Table 6: Definition of the dimensionless form of CER implementation indicators

Year	Dimensionless form of indicators					
	f_{h_1}	f_{h_2}	f_{h_3}	f_{h_4}	f_{h_5}	f_{h_6}
2012	0.644	1.000	0.185	0.638	0.236	0.930
2013	0.667	0.991	0.212	0.915	0.284	0.958
2014	0.644	0.989	0.228	1.000	0.342	0.783
2015	0.733	0.983	0.233	0.969	0.313	0.985
2016	0.778	0.987	0.291	0.577	0.382	1.000
2017	0.822	0.988	0.372	0.596	0.467	0.858
2018	0.844	0.991	0.425	0.629	0.571	0.761
2019	0.889	0.988	0.686	0.552	0.606	0.766
2020	1.000	0.992	0.797	0.470	0.647	0.635
2021	0.911	0.993	1.000	0.645	1.000	0.451

desirability, the implementation level of corporations' environmental responsibility in Ukraine is generally assessed as satisfactory. This is due to the influence of the following factors: low motivation for the implementation of resource-saving and low-waste technologies and processes by corporations; lack of qualified management in the field of corporations' environmentally responsible activities; insufficient efforts to form own standards for environmental protection, aimed at improving environmental friendliness and product quality, and as a result - obtaining competitive advantages; incompleteness of tools for legal regulation of corporations' greening

activities; insufficient financing in the sphere of reducing the impact of corporations activities on the environment. Based on the calculated integral indicator of the corporate environmental responsibility level, the authors will consider the approach of assessing the impact of various factors of corporation activities on the general CER level using mathematical modeling methods. With the help of a multifactor linear regression model, it is possible to reveal the type of dependency between the implementation level of corporations' environmental responsibility and the proposed factors. In order to determine the influence of various factors on the

Table 7: Calculation of partial functions for different years

Year	Partial function $k_{h_i} = \exp(-\exp(-f_{h_i}))$					
	k_{h_1}	k_{h_2}	k_{h_3}	k_{h_4}	k_{h_5}	k_{h_6}
2012	0.59	0.69	0.44	0.59	0.45	0.67
2013	0.60	0.69	0.45	0.67	0.47	0.68
2014	0.59	0.69	0.45	0.69	0.49	0.63
2015	0.62	0.69	0.45	0.68	0.48	0.69
2016	0.63	0.69	0.47	0.57	0.51	0.69
2017	0.64	0.69	0.50	0.58	0.53	0.65
2018	0.65	0.69	0.52	0.59	0.57	0.63
2019	0.66	0.69	0.60	0.56	0.58	0.63
2020	0.69	0.69	0.64	0.54	0.59	0.59
2021	0.67	0.69	0.69	0.59	0.69	0.53

Table 8: Calculation of the integral indicator of the CER implementation level

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
K	0.574	0.584	0.584	0.593	0.588	0.596	0.608	0.617	0.620	0.643
Evaluation according to the result on Harrington's scale of desirability	S	S	S	S	S	S	S	S	S	D

Remark: S – satisfactorily; D – good

CER level, multiple correlation coefficients were calculated using the “data analysis — correlation” package of the Excel spreadsheet. The authors select the parameters of the multi-factor linear model of the dependence of the integral indicator of CER level (K) on the number of environmentally responsible corporations (a_1), the size of capital investments for environmental protection at the expense of own funds (a_4), the number of certified corporate quality management and environmental protection systems (a_6), the number of new low-waste, resource-saving, ecologically-oriented technological processes implemented by corporations (a_7), the volume of current expenses of corporations for environmental protection (a_9) (Eq. 1):

$$k = c_0 + c_1 a_1 + c_4 a_4 + c_6 a_6 + c_7 a_7 + c_9 a_9 \quad (1)$$

where $c_0, c_1, c_4, c_6, c_7, c_9$ – coefficients of the factor linear model dependence of the integral indicator level in relation to the CER implementation.

Equation parameters (Eq. 1): correlation coefficients are determined using the “regression” tool of the “Data Analysis” package of the Excel spreadsheet (Microsoft Office). The authors build a multifactorial regression of the dependence of the integral level of corporate environmental responsibility on the most significant factors of the ecological and economic state of corporations in Ukraine. After calculations of the equation parameters, the multivariable linear model of the dependence of the CER implementation level will have the following form (Eq. 2):

$$k = 0.531 + 0.057 a_1 + 0.002 a_4 + 0.137 a_6 + 0.053 a_7 + 0.003 a_9 \quad (2)$$

The research has shown that the value of the determination coefficient ($R^2=0.9839$) – close to unity. Therefore, the model can be considered as adequate. The determination coefficient estimates the variation share of the result due to the factors presented in the equation in the overall variation of the characteristics values. This share is 98.39%, it indicates a high degree of dependence of the result variation on the variation of factors, that is, a close connection between the factors and the result. A high value of R^2 confirms that the application of this model is adapted for any corporations. It has been proven that the following factors have the greatest positive influence on the change in the CER level: factor a_6 , which reflects the amount of certified quality management and environmental protection systems in the field of enterprises activities (correlation coefficient $r=0.9395$) and factor a_9 , which reflects the amount of corporations' current expenses aimed at environmental protection ($r=0.9358$). Analysis of the multi-factor regression equation makes it possible to estimate the influence degree of key factors on the resulting indicator:

- an increase in the amount of environmentally responsible corporations (a_1) by 1 point, in case when all other factors remain unchanged, will lead to an increase in the integral indicator of the implementation level of corporations' environmental responsibility by 0.0574 units;
- an increase in the size of capital investments for environmental protection at the expense of corporations' own funds (a_4) by 1 point, in case when all other factors remain unchanged, will lead to an increase in the integral indicator of the implementation level of corporations' environmental responsibility by 0.002 units;
- an increase in the number of implemented certified systems of quality management and environmental protection by corporations (a_6) by 1 point, in case when all other factors remain unchanged, will lead to an increase in the integral indicator of the implementation level of corporations' environmental responsibility by 0.1371 units;
- an increase in the number of new low-waste, resource-saving, ecologically oriented technological processes implemented by corporations (a_7) by 1 point, in case when all other factors remain unchanged, will lead to an increase in the integral

indicator of the CER implementation level by 0.0533 units;

- an increase in the size of corporations' current expenses for environmental protection (a_9) by 1 point, in case when all other factors remain unchanged, will lead to an increase in the integral indicator of the CER implementation level by 0.0031 units.

If the values of all factors are equal to zero, then the level of corporate environmental responsibility is equal to 0.5311 units. The following indicators have the greatest positive influence on the change in the implementation level of CER: the number of implemented certified systems of quality management and environmental protection by Ukrainian corporations, as well as the number of corporations' current expenses for environmental protection. As a detailed analysis of Ukrainian corporations shows, the practical implementation of the proposed theoretical and mathematical models is complicated by: the low motivation to implement resource-saving and low-waste technologies and technological processes; lack of qualified management of corporations' environmentally responsible activities; insufficient attention to the formation of own standards in the field of environmental protection; incompleteness of tools for legal regulation of corporations' greening activities; insufficient financing in the sphere of reducing the impact of corporations activities on the environment. Therefore, it is proposed to stimulate the formation of the CER system at the national level, first of all, by developing and applying effective financial and economic tools of motivation. A perspective for further studies can be the correction of the obtained results based on the ESG Transparency Index methodology ([ESG transparency index 2020 Ukraine, 2021](#)). The ESG Transparency Index of Ukrainian companies calculated by the Corporate Governance Professional Association (CGPA) and the Center for the Development of Corporate Social Responsibility supported by the Center for International Private Enterprise (CIPE). The index evaluates the transparency of Ukrainian companies using the ESG criteria (social, environmental and governance ones). Based on these criteria there was evaluated information posted on the websites of Ukrainian companies, top 50 taxpayers, for 2020, and the companies that voluntarily joined the study.

CONCLUSION

Based on the study of world experience, it was found, that the main economic means to stimulate the environmental responsibility of corporations are the following: application of a diverse system of tax payments and tax benefits, provision of subsidies and loans, as well as direct government funding of scientific developments and research, which in turn will significantly promote the implementation of environmental technologies by private business. The following taxes are the most common in European countries: tax on products containing environmentally harmful substances; tax on waste and its disposal; tax/charge for water pollution. Particular attention should be paid to the experience of the Scandinavian countries, whose tax systems define clear directions of environmental taxation and specify tax payments by objects, which in turn allows implementing the principle of targeting the received income. At the stage of analyzing the obtained results, checking the materiality, closeness of the connection and adequacy of the model, it was proved that the built regression model is completely valid, the application of this model is adapted for any corporation. It is mathematically proven that the following two factors have the greatest positive influence on the change in the CER level: the amount of certified quality management and environmental protection systems in the field of enterprises activities (correlation coefficient $R = 0.9395$) and the amount of corporations' current expenses aimed at environmental protection ($R = 0.9358$). According to Harrington's scale of desirability, the implementation level of corporate environmental responsibility in Ukraine is generally assessed as satisfactory. The prospect of further research is the development of strategies regarding the improvement of corporations' environmental responsibility for the purpose of country's sustainable development and increased rational nature usage. To solve the problems mentioned in the paper systematically and qualitatively, a theoretical model has been developed that combines the basic principles of corporate social responsibility (sustainable development, accountability, transparency), the mechanisms of their implementation and the corresponding methodology for assessing the level of their implementation in the economic activity of corporations. An integrated approach to the implementation of the above basic

principles by Ukrainian corporations will make it possible to significantly increase their environmental responsibility, in particular ecological, economic and social efficiency, to ensure the sustainable development of the national economy as a whole.

AUTHOR CONTRIBUTIONS

O. Katerna performed an experimental design and analyzed the data. O. Prykhodko defined the concept and methodology of the research. M. Yudin ranked the data into tables and figures. K. Molchanova performed the literature survey.

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CONFLICT OF INTEREST

The author declares that there is no 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 have been completely observed by the authors.

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ABBREVIATIONS

a_j	Value of the j -th indicator, characterizing the i -th year
a_1	The number of environmentally responsible corporations (which form a report on sustainable development), units
a_2	Total number of corporations, units
a_3	The number of corporations involved into environmental protection activities, units
a_4	Capital investments from the corporations' own funds for environmental protection, million USD
a_5	The total amount of current expenditures on the protection and rational usage of natural resources, taking into account all financing sources, million USD
a_6	The number of corporations' certified systems the field of environmental quality management and nature protection, units
a_7	The number of new low-waste, resource-saving, ecologically oriented technological processes implemented by corporations, units
a_8	The total amount of capital investments aimed at the protection of the natural environment, taking into account all sources of funding, million USD
a_9	Amount of current corporations' expenses for environmental protection, million USD
$c_0, c_1, c_4, c_6, c_7, c_8$	Coefficients of the factor linear model dependence of the integral indicator level in relation to the CER implementation.
CER	Corporate Environmental Responsibility
D	Good
ER	Ecologically responsible
Eq.	Equation
et al.	et alii

etc.	et cetëra
Fig.	Figure
f_{h_i}	The indicator of corporations' environmental responsibility in dimensionless form.
f_{h_j}	The standardized value of the j -th indicator, characterizing the i -th year
h	The number of indicators used to assess the level of corporations' environmental responsibility
i.e.	id est
k_{h_i}	The partial function that was defined using the Harrington scale
R^2	The determination coefficient
r	The correlation coefficient
S	Satisfactorily
SNE	surrounding natural environment
USA	The United States of America

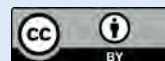
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ORIGINAL RESEARCH PAPER

Servant leadership and work engagement: Exploring the mediation role of affective commitment and job satisfaction

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ABSTRACT

BACKGROUND AND OBJECTIVES: As organizations seek effective ways to lead in a dynamic world, servant leadership will likely remain relevant. Servant leaders focus on serving others and nurturing the growth of employees to create positive work environments. However, there still exists a gap in the literature on the link between servant leadership and work engagement. Thus, this study aims to investigate the relation between servant leadership and work engagement by exploring the mediating role of affective commitment and job satisfaction.

METHODS: Using a purposive sampling process, self-administered questionnaires are distributed to 154 employees working in Central Java – Indonesia public health institution from March to June 2023. Partial least squares-structural equation modeling (PLS-SEM) with SmartPLS 3.0 software is utilized to analyze the data.

FINDINGS: The results indicate that servant leadership has a significant direct effect on affective commitment ($\beta=0.321$, t -statistic = 3.226, $p<0.05$) and job satisfaction ($\beta=0.429$, t -statistic = 5.556, $p<0.05$). Furthermore, it is found that affective commitment ($\beta=0.527$, t -statistic = 8.518, $p<0.05$) and job satisfaction ($\beta=0.306$, t -statistic = 4.275, $p<0.05$) significantly affect work engagement. This study, upon further investigation, reveals that affective commitment ($\beta=0.170$, t -statistic = 3.079, $p<0.05$) and job satisfaction ($\beta=0.131$, t -statistic = 3.179, $p<0.05$) significantly mediate the relationship between servant leadership and work engagement.

CONCLUSION: The results from PLS-SEM analysis reveal no direct relationship between servant leadership and work engagement. Additionally, the roles of affective commitment and job satisfaction are found to mediate the relationship between servant leadership and work engagement of employees in public health institution. When employees are satisfied and feel emotionally connected to their leader and organization, they are more likely to find their work meaningful and enjoyable, leading to higher levels of work engagement.

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INTRODUCTION

The emergence of leadership in modern organizations is a dynamic and multifaceted process in response to changing business environments, technological advancements, and shifts in organizational structures. Successful leaders can navigate the complexities of the modern business landscape (Hayes, 2020) while prioritizing and empowering their employees to achieve individual and collective success (Udin, 2023b). Effective leadership is crucial for public health organizations to successfully navigate challenges (Apornak, 2021; Velthuis et al., 2018) and protect the well-being of the communities they serve (Mousavi et al., 2021). When leaders provide a clear vision for the organizations, it can lead to clarity among employees and hinder progress. Also, leaders who are slow to adapt (Kozlowski et al., 2008; Udin, 2023a) can hinder the institution's ability to respond effectively to emerging health threats. Therefore, to address these issues, public health institutions should focus on developing leaders with strong leadership skills and fostering a culture of open communication for maintaining standards and driving continuous improvement. Indonesia's public health institutions play a vital role in addressing the complex health challenges facing the nation. While progress has been made, there is still much work to be done to ensure equitable access to healthcare and promote overall well-being. By seizing opportunities and addressing these challenges, Indonesia can continue to improve the quality of life and health of its people in the years to come. Thus, applying servant leadership principles (i.e., serving and empowering others) can be highly beneficial for addressing complex health challenges and improving the overall effectiveness of these institutions. Servant leaders, in essence, emphasize a strong sense of empowering and supporting their employees to reach their full potential (Karatepe et al., 2020), which in turn contributes to the overall success of the organization. However, since there has been significant research on the topic of servant leadership and its positive impact on various organizational outcomes, there still exists a gap in the literature when it comes to fully understanding the link between Servant Leadership (SL) and Work Engagement (WE). Numerous empirical studies have emerged regarding the contradictory findings of SL on employee WE. SL, in one side, has a direct

positive impact on WE (Rabiul et al., 2023; Rahal and Farmanesh, 2022; Sims et al., 2021). SL places a strong emphasis on the growth and development of employees. When employees are offered opportunities for skill enhancement and career progression, they are more likely to be engaged in their work. However, on another side, Christianto (2021), Shim et al. (2021), Srimulyani (2021) found that SL has no direct effect on WE. To navigate these contradictory findings, based on the Job Demands-Resources (JD-R) model, this study proposes the mediator variables (i.e., Affective Commitment (AC) and Job Satisfaction (JS) to link SL and employee WE. Higher AC (Kobayashi et al., 2020) and JS (Aboramadan et al., 2021) provide insights into how SL practices contribute to the greater WE.

Literature review and hypotheses development *Job demands-resources theory*

The Job Demands-Resources (JD-R) theory serves as a conceptual framework employed in the field of organizational behavior for elucidating the interplay between job characteristics, employee well-being, and work-related outcomes (Bakker et al., 2014). The JD-R model was first introduced by Demerouti et al. (2001) and has gained widespread recognition in research and practice to create healthier work environments. Within the JD-R model, there are two broad categories of factors in the workplace: job demands and job resources. These factors exert substantial influence on shaping employee JS, engagement, and overall performance (De Carlo et al., 2016). Job demands refer to the physical, psychological, and social aspects of a job that require sustained physical and psychological effort. Job demands include time pressure, role ambiguity, and interpersonal conflicts. High job demands can lead to stress, burnout, and decreased well-being. On the contrary, job resources encompass the spanning physical, psychological, and social elements of a job, that can assist employees in attaining their work objectives and fostering their overall well-being. Job resources include supervisor support, coworker relationships, job autonomy, skill variety, and opportunities for growth and development. When employees have access to sufficient job resources, they are more likely to experience positive emotions, higher WE, and a sense of accomplishment to improve JS and higher performance (Bakker and

Demerouti, 2008).

Work engagement

Work Engagement (WE) refers to a positive and energetic state of mind (Bakker and Albrecht, 2018) that employees experience when they are fully immersed in their work activities. Engaged employees are not only committed to their job roles (Singh, 2022) but are also focused and motivated to beyond in their efforts. WE is characterized by high levels of dedication, energy, and absorption in one's work, leading to increased productivity, JS (Yandi and Havidz, 2022), and overall well-being. Key components of WE, according to Schaufeli and Bakker (2010), include (a) vigor (i.e., a high level of energy and enthusiasm an employee brings to their work to effectively accomplish their tasks); (b) dedication (i.e., being strongly committed to one's work and finding meaning in it); (c) absorption (i.e., being fully engrossed in one's tasks and losing track of time while working). Engaged employees often have a high level of autonomy and encounter a sense of flow, wherein the challenges of their tasks are balanced by their skills, leading to a rewarding experience.

Servant leadership

Servant Leadership (SL) is a leadership style that underscores and emphasizes the leader's primary role as a servant to their employees and organization. SL is popularized by Greenleaf (1970) in his essay "*The Servant as Leader*". Rather than focusing solely on their authority and control, servant leaders prioritize the well-being and growth of their team members, helping them achieve their full potential and contributing to the overall success of the organization. The key dimensions of SL according to Greenleaf (1970) include (a) stewardship (i.e., leaders view themselves as stewards of their organizations and the well-being of their employees); (b) listening (i.e., leaders become a good listener to the needs and concerns of their employees); (c) empathy (i.e., leaders are able to understand the feelings and perspectives of their employees, and demonstrate genuine care for their well-being); (d) healing (i.e., leaders promote emotional and spiritual healing among their employees to creating a nurturing environment for recovering challenges); (e) awareness (i.e., leaders

possess a high level of self-awareness to understand their own strengths and weaknesses); (f) persuasion (i.e., leaders use persuasion to guide and convince their employees of the right course of action based on shared values); (g) conceptualization (i.e., leaders are capable of thinking beyond day-to-day tasks to conceptualize the bigger picture and considering long-term consequences); (h) foresight (i.e., leaders have the ability to anticipate potential outcomes for navigating challenges); (i) commitment to the growth of others (i.e., leaders are committed to the personal and professional growth of their employees); (j) building community (i.e., leaders strive to create a sense of community to promote a culture of mutual respect). SL aims to create an environment where employees feel valued, motivated, and empowered to reach their fullest potential (Canavesi and Minelli, 2022). Servant leaders foster trust within their employees through approachable communication to encourage open discussions, idea-sharing, and collaboration. Servant leaders emphasize and focus on serving others and promoting their personal and professional growth. Thus, numerous studies on SL have shown a range of positive impacts on individuals, teams, and organizations. SL is related to WE (Khan et al., 2021; Ozturk et al., 2021; Zeeshan et al., 2021; Zhou et al., 2022), JS (Al-Asadi et al., 2019; Ozturk et al., 2021; Zargar et al., 2019), and AC (Bai et al., 2023; Clarence et al., 2021; Ghasemy and Frömbing, 2022; Ng, 2022) of employees. Employees under servant leaders often demonstrate greater emotional attachment to the organization. When leaders exhibit care and support, employees are more likely to identify with the organization's values and goals. Within the JD-R model, SL serves as a critical job resource that enhances employees' engagement (Bao et al., 2018), ultimately leading to higher levels of AC. By providing the necessary support and opportunities for growth, servant leaders create an environment that nurtures employees' emotional attachment to the organization. Therefore,

H1: SL has a significant positive effect on WE

H2: SL has a significant positive effect on JS

H3: SL has a significant positive effect on AC

Affective commitment

Affective Commitment (AC) refers to an employee's identification and emotional attachment

(Evanschitzky *et al.*, 2006) with their organization. Employees with high AC have a genuine emotional attachment towards their organization, where they experience a sense of pride, satisfaction, and happiness in being associated with the organization. AC is one of the three organizational commitment components (Meyer and Allen, 1991), and the other two being continuance commitment (based on perceived costs of leaving) and normative commitment (based on a sense of obligation). AC is considered particularly important because it reflects a genuine desire to stay with the organization due to positive feelings with its values and goals. By fostering AC (Mercurio, 2015), organizations can create a productive workplace that benefits everyone involved. AC in JD-R model acts as a job resource that positively influences WE. By fostering positive emotions and a sense of resilience, AC contributes to an engaged workforce, ultimately benefiting both employees and the organization. Employees with AC tend to be more dedicated to their jobs. Ly (2023), Jia-Jun and Hua-Ming (2022) found that AC positively and significantly improves WE. When employees are emotionally invested in the organization, they are more likely to be engaged in their work, contribute innovative ideas, and put in discretionary effort to achieve the organization's goals. Thus,

H4: AC has a significant positive effect on WE

AC encourages employees to build strong relationships with their colleagues, leaders and overall organization. This can lead to improved teamwork collaboration, resulting in higher productivity and better outcomes (Semedo *et al.*, 2016; Udin *et al.*, 2022). AC significantly mediates the relationship between inclusive leadership and WE (Ly, 2023). Leaders who demonstrate respect and support for their employees can foster emotional attachment among employees to contribute positively to the organization's success. By showing empathy and fostering a positive work environment, servant leaders cultivate AC. When employees have a high level of emotional ties to the organization, they are more likely to be engaged in their work, contribute innovative ideas, and go beyond their basic job requirements. Therefore,

H5: AC significantly mediates the relationship between SL and WE

Job satisfaction

Job Satisfaction (JS) refers to an individual's overall cognitive and emotional evaluation of their job (Zhu, 2013). JS reflects how content, fulfilled, and pleased an employee is with their job (Batura *et al.*, 2016) and various aspects related to it. Employees who experience JS often report feelings of happiness, fulfillment, and contentment in their roles (Djastuti *et al.*, 2019). This emotional state is influenced by factors such as the nature of the work, opportunities for personal growth, and relationships with peers, colleagues and supervisors (Maryati *et al.*, 2019). Maslow's hierarchy of needs theory is often referenced in this context. According to this theory, JS is closely tied to the fulfillment of basic needs (like security, belongingness, and esteem) and higher-level needs (such as growth and self-actualization) through the job itself (Kian *et al.*, 2014). Jobs that offer opportunities for skill development and flexibility are more likely to contribute to higher level of employee satisfaction. JS in JD-R model functions as a crucial job resource that positively impacts WE (Wirawan *et al.*, 2020). The positive emotions and psychological resources associated with JS contribute to employees' willingness to invest themselves fully in their work, leading to enhanced overall well-being. JS serves as a foundational element that significantly nurtures WE (Garg *et al.*, 2018; Park and Johnson, 2019; Nemțeanu *et al.*, 2022; Zang and Feng, 2023). When employees feel satisfied with their jobs, they approach their work with a positive attitude to promote a conducive environment for WE. Also, when employees find their work enjoyable, they are naturally inclined to immerse themselves in their tasks, leading to higher levels of WE. Thus,

H6: JS has a significant positive effect on WE

JS often arises when employees perceive that their values, goals, and interests align with the organization. SL, therefore, can contribute to JS by providing employees with a sense of belonging and recognition (Al-Asadi *et al.*, 2019). When employees perceive that their leaders genuinely care about their well-being, it fosters a positive emotional connection to their job wholeheartedly (Farrington and Lillah, 2019). Also, employees who perceive their leaders as servant leaders are more likely to be satisfied with their jobs, which, in turn, leads to

increased WE (Aboramadan *et al.*, 2021). Thus,

H7: JS significantly mediates the link between SL and WE

According to previous studies, there still exists a gap in the literature on the link between SE and WE. Therefore, this study aims to investigate the relation between SE and WE by exploring the mediating role of AC and JS. Employees who experience SL are more likely to feel valued and appreciated, which in turn, leads to higher AC and JS because they become emotionally attached to a leader who genuinely cares about their well-being. When employees are happy and emotionally attached with their job, they are more likely to put in discretionary effort and be fully absorbed in their tasks. This current study was conducted in Central Java – Indonesia from March to June 2023.

MATERIALS AND METHODS

Sampling and data collection

This study employs a quantitative approach. Using a purposive sampling process, self-administered questionnaires were distributed to 255 employees working in public health institution in Central Java – Indonesia from March to June 2023, and 154 usable questionnaires were returned (with a response rate of 60.4%). The findings indicate that among the total sample, 106 respondents (68.8%) are women, while 48 (31.2%) are men. The data also suggests a higher participation of women in various activities compared to men. Additionally, the distribution of work experience reveals that individuals with 1-3 years of experience constituted 46 respondents (29.9%), whereas those with 4-6 years and over 7 years of experience accounted for 57 (37%) and 51 (33.1%) respondents, respectively.

Measures

The proposed model consists of four constructs, namely SL, AC, JS and WE. SL is measured by the 13-item scale adapted from Ehrhart (2004), Jaramillo *et al.* (2009), Choudhary *et al.* (2013). An example item is “I feel a sense of ‘ownership’ for my supervisor”. AC is assessed using 5 items adapted from Vandenberghe *et al.* (2004), Astuty and Udin (2020). An example item is “I am proud to be valuable part of the organization”. JS is measured by the six-item scale, which is adapted from Torlak

and Kuzey (2019), Yu *et al.* (2020). An example item is “I am very satisfied with my job”. WE is assessed using 6 items adapted from Schaufeli *et al.* (2008), Fletcher (2016), Udin *et al.* (2022). An example item is “I feel strong and vigorous at my job”. The survey comprises 33 question items sourced from existing research, and respondents provide ratings using a 5-point Likert scale. The scale ranges from 1, representing “strongly disagree,” to 5, indicating “strongly agree.”

Technique for data analysis

Partial least squares-structural equation modeling (PLS-SEM) with SmartPLS 3.0 software is utilized to analyze the data in this study. The SmartPLS software is acknowledged as a fitting choice for implementing PLS-SEM, as outlined by Sarstedt *et al.* (2014). PLS-SEM is commonly endorsed within the realm of business management research (Hair *et al.*, 2019) to investigate and validate intricate interconnections.

RESULTS AND DISCUSSION

The evaluation of the structural model in this study is carried out using the SmartPLS 3.0 software. The results indicate that due to low loadings of less than 0.5 as shown in Table 1, three items of SL (i.e., SL2, SL3, SL10) and two items of WE (i.e., WE4, WE7) are excluded from the model. The factor loadings falling within the range of 0.40 to 0.70 may be considered for elimination if their removal contributes to model enhancement (Hair *et al.*, 2019).

As shown in Table 1, the values of Cronbach’s alpha, composite reliability and AVE (average variance extracted) for SL in the current study are 0.799, 0.846, and 0.356, respectively; for AC are 0.724, 0.820, and 0.479; for JS are 0.760, 0.833, and 0.456; for WE are 0.741, 0.818, and 0.392, respectively. These results confirm internal consistency reliability and convergent validity of the scale items.

The assessment of discriminant validity in this study is confirmed using the Fornell-Larcker criterion and heterotrait–monotrait criterion (HTMT). The Fornell-Larcker criterion results in Table 2 indicate that the square root of AVE surpasses the correlation value between the construct and all other constructs. Also, the HTMT values for SL, AC,

Table 1: Measurement model

Variables	Items	Outer Loadings	Cronbach's Alpha	Composite Reliability	AVE
Servant Leadership	SL1	0.588	0.799	0.846	0.356
	SL4	0.574			
	SL5	0.574			
	SL6	0.643			
	SL7	0.546			
	SL8	0.634			
	SL9	0.618			
	SL11	0.521			
	SL12	0.693			
	SL13	0.559			
Affective Commitment	AC1	0.593	0.724	0.820	0.479
	AC2	0.717			
	AC3	0.796			
	AC4	0.720			
	AC5	0.615			
Job Satisfaction	JS1	0.601	0.760	0.833	0.456
	JS2	0.572			
	JS3	0.728			
	JS4	0.722			
	JS5	0.664			
	JS6	0.744			
Work Engagement	WE1	0.596	0.741	0.818	0.392
	WE2	0.691			
	WE3	0.615			
	WE5	0.626			
	WE6	0.587			
	WE8	0.607			
	WE9	0.654			

Table 2: Discriminant validity

Variables	Affective Commitment	Job Satisfaction	Servant Leadership	Work Engagement
<i>Fornell-Larcker Criterion</i>				
Affective Commitment	0.692			
Job Satisfaction	0.378	0.675		
Servant Leadership	0.321	0.429	0.597	
Work Engagement	0.653	0.518	0.330	0.626
<i>Heterotrait-Monotrait Ratio (HTMT)</i>				
Job Satisfaction	0.501			
Servant Leadership	0.422	0.512		
Work Engagement	0.883	0.663	0.439	

JS, and WE do not exceed the value of 0.90 (Gold et al., 2001), confirming the discriminant validity of the measurement model.

The results from PLS-SEM analysis in Fig. 1 and Table 3 reveal that no direct relationship between SL and WE ($\beta = 0.029$, $SD = 0.091$, t -statistic = 0.323, $p > 0.05$). Thus, H1 has to be rejected. Furthermore,

the results indicate that SL has a significant direct effect on JS ($\beta = 0.429$, $SD = 0.077$, t -statistic = 5.556, $p < 0.05$) and AC ($\beta = 0.321$, $SD = 0.100$, t -statistic = 3.226, $p < 0.05$). Hence, H2 and H3 are confirmed and supported by the data. Additionally, it is found that AC ($\beta = 0.527$, $SD = 0.062$, t -statistic = 8.518, $p < 0.05$) and JS ($\beta = 0.306$, $SD = 0.072$,



Fig. 1: Research framework

Table 3: Path coefficients

Relationship	Original Sample (β)	Standard Deviation (SD)	T Statistics	P Values	Decision
Direct effect					
Servant Leadership → Work Engagement	0.029	0.091	0.323	0.747	Rejected
Servant Leadership → Job Satisfaction	0.429	0.077	5.556	0.000	Supported
Servant Leadership → Affective Commitment	0.321	0.100	3.226	0.001	Supported
Affective Commitment → Work Engagement	0.527	0.062	8.518	0.000	Supported
Job Satisfaction → Work Engagement	0.306	0.072	4.275	0.000	Supported
Indirect effect					
Servant Leadership → Affective Commitment → Work Engagement	0.170	0.055	3.079	0.002	Supported
Servant Leadership → Job Satisfaction → Work Engagement	0.131	0.041	3.179	0.002	Supported

t-statistic = 4.275, $p < 0.05$) significantly affect WE. Hence, H4 and H6 are confirmed and supported by the data. This study, upon further investigation, reveals that AC ($\beta = 0.170$, SD = 0.055, t-statistic = 3.079, $p < 0.05$) and JS ($\beta = 0.131$, SD = 0.041, t-statistic = 3.179, $p < 0.05$) significantly mediates the relationship between SL and WE. Hence, H5 and H7 are confirmed and supported by the data.

The results of this study show that SL has no direct effect on WE. This finding confirms the previous studies, such as [Christianto \(2021\)](#), [Shim et al. \(2021\)](#), [Srimulyani \(2021\)](#) that SL has no significant effect on WE. Based on this finding, it is important to note that SL focuses on the leader's commitment to serving the needs of their employees and facilitating their personal and professional growth.

Nevertheless, the way SL is practiced can vary across different circumstances. If a servant leader does not effectively embody its principles, the impact on WE might be limited. Also, employees' personal characteristics and values can influence how they respond to SL. Some employees might thrive under SL, while others might prefer a more directive approach. PLS-SEM analyses reveal that SL significantly and directly affects JS and AC. Within the JD-R model, SL prioritizes the well-being and growth of employees, and this approach tends to foster positive relationships and supportive work environment to increased JS among employees (Isabel *et al.*, 2021; Vallina and Guerrero, 2018). Also, servant leaders build trust by showing respect for their employees' opinions, ideas, and contributions. This trust contributes to a positive work atmosphere and increased JS. Furthermore, servant leaders demonstrate empathy and understanding toward their employees' needs and concerns. This creates a positive emotional bond and a feeling of being cared for, which strengthens AC. The results also reveal that AC and JS have a significant direct effect on WE. In JD-R model, when employees are satisfied with their jobs and feel that their expectations are being met, they are more likely to experience higher levels of WE (Guglielmi *et al.*, 2016; Wirawan *et al.*, 2020). JS contributes to positive attitudes towards the organization and the work itself. Employees who feel positively about their jobs are more likely to engage with their tasks and the overall work environment. Additionally, employees with a high level of AC have a strong emotional bond with their organization. This emotional investment often translates into a greater sense of enthusiasm and energy towards their work, contributing to higher levels of WE.

The results further indicate that SL significantly impact WE through AC and JS as the mediator variables. When employees see their leaders actively demonstrating SL behaviors, it sets a positive example for the entire organization (Kiker *et al.*, 2019). This modeling of empathy and humility to others can inspire employees to reciprocate by becoming more engaged and committed to their work (Eva *et al.*, 2019). Furthermore, SL emphasis on creating a positive work environment, supporting employee growth, and prioritizing their well-being

leads to higher JS, which in turn positively influences WE.

CONCLUSION

This study reveals that SL is found to significantly influence JS and AC. However, the direct path of SL to WE is not significant. Additionally, it is found that AC and JS significantly affect WE. This study, upon further investigation, reveals that AC and JS significantly mediates the relationship between SL and WE.

In conclusion, the theoretical framework of SL aligns well with the positive outcomes associated with AC, JS and WE. SL behaviors, such as active listening, coaching, and providing resources, enhance employees' motivation and productivity. When employees feel their contributions are recognized and supported, they are more likely to invest greater effort into their work tasks. From a practical standpoint, adopting a SL approach leads to a more satisfied, committed, and engaged workforce, ultimately benefiting both employees and the organization as a whole. Similar to most field investigations, the present study exhibits a set of limitations that open avenues for further research endeavors. Firstly, it is crucial to exercise caution when attempting to generalize the findings of this research since it was conducted within a specific organizational and cultural context, specifically the public health institution in Central Java – Indonesia. Secondly, the utilization of cross-sectional data restricts the ability to draw definitive causal inferences. Nonetheless, forthcoming studies could consider employing longitudinal approaches to furnish more robust substantiation of the causal relationships identified herein. Lastly, the reliance on self-reported data for the study variables introduces the potential for common method bias concerns. Therefore, future research might expand on these findings by incorporating managerial input regarding their employees. Also, future research is needed to be systematically and fully explored to gain significant practical interpreting of effective leadership styles and their relationships with other variables.

AUTHOR CONTRIBUTIONS

U. Udin performed the literature review, data collection, and research findings. G. Rakasiwi

screened and analyzed the collected data. R. Dananjoyo helped in the review, conclusion, completing all sections.

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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.

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ABBREVIATIONS

AC	Affective commitment
AVE	Average variance extracted
JD-R	Job Demands-Resources

JS	Job satisfaction
HTMT	Heterotrait–monotrait criterion
PLS-SEM	Partial least squares-structural equation modeling
SL	Servant leadership
WE	Work engagement

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ORIGINAL RESEARCH PAPER

Analyzing spatiotemporal changes in urban green spaces' ecosystem service value and resilience

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ABSTRACT

BACKGROUND AND OBJECTIVES: *Urban ecosystem services are provided by a multitude of habitats, including green and water spaces. Such services are commonly under the control of heavy demand raised by the large number of beneficiaries. In this context, urban green spaces viz. parks and gardens supply these services for city residents. From this perspective, this study is to analyze the spatiotemporal changes in the ecosystem servicevalue of urban green spaces in Districts 1 and 14 (out of 22) of Tehran Municipality, Tehran, Iran. The level of resilience (namely, capacity and adaptability) of these districts, once confronted with climate change and environmental degradation, particularly carbon sequestration, is then investigated. As an innovation, the current study ultimately assesses the ecosystem services value of urban green spaces with higher accuracy to exert more actions to improve these spaces.

METHODS: *This library-based documentation study utilized spatiotemporal modeling with reference to software packages and field visits. In the first step, remote sensing was applied to create land-use maps using ENVI 5.3 software package and its formulas, algorithms, and extensions. In the second step, the InVEST software and model were used to model carbon sequestration in selected districts. To assess carbon sequestration and its changes over time, land-cover maps were generated for three 10-year periods (2003, 2013, and 2023) with 30 m accuracy via Landsat satellite-based program. The maps were classified in ENVI 5.3, and the net carbon sequestration in land, along with the market size of carbon sequestration, was estimated using the InVEST model, incorporating land-use maps, land-cover types, and carbon sequestration in reservoirs. Organic carbon content was determined based on other carbon reservoirs, previous surveys, and available data. Each carbon reservoir unit was valued in dollars, and discount rates and annual changes in carbon value were calculated based on global and local conditions surveys.

FINDINGS: *The study results obtained from land-cover/use maps produced during 2003, 2013, and 2023 in the selected districts, demonstrated a diminishing trend of green spaces and barren lands, while the area of built land has increased over time. The numerous changes in land use in the company of construction in green spaces and barren lands in District 1 from 2003 to 2013 had further led to 191401608 tons of emission, including 179114669 tons of carbon, valued 49056267 and 4636422 million Dollars, respectively. In District 14, the emission during 2003-2023 was also equal to 18.3644 tons of carbon, and that was 3444.14 tons of carbon for the period of 2013-2023, worth 1873871 and 1749769 thousand Dollars, in that order.

CONCLUSION: Indiscriminate construction and development of built-up areas in Tehran have undermined green spaces and barren lands, negating the benefits of green infrastructure efforts. This has resulted in a reduction in urban green spaces, hampering their capacity for carbon absorption and sequestration. Consequently, reduced carbon deposition will contribute to higher temperatures, diminishing the resilience of these urban areas.

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INTRODUCTION

Modern urbanization and high urban growth rates have brought about loads of challenges, including the destruction of natural ecosystems (Moarrab et al., 2022). As cities and natural environment systems are highly interconnected, they form socio-ecological systems. The interactions between the public and ecosystems are accordingly associated with the dependency of humans on natural environments for receiving vital Ecosystem Services (ES) (Torres et al., 2023). In this sense, such services have been generally explained as the benefits obtained by people from ecosystems that contain provisioning (e.g., food, water, and fiber), regulating (such as, climate regulation and pollination), cultural (like spiritual, aesthetic, and recreational values), and supporting (including, soil formation) services. In other words, rapid urbanization and the high rate of unplanned constructions have converted Urban Green Spaces (UGS) into the most vulnerable natural ecosystems in cities. In the era of global climate change caused by human activities, the loss of UGS has further led to an upsurge in temperature in these regions (Kong et al., 2016). As a result, urban heat stress has negatively affected the quality of life of city residents. As Schröter et al. (2017) state, the Greenhouse Gas (GHG) emissions per capita in North American cities were 25-50 times higher than those in low-income nations. As well, Livesley et al. (2016) and Sun, (2017) argued that urban resilience had reduced due to the destruction of wetlands and UGS, followed by a fall in thermal comfort and a rise in energy consumption for cooling purposes. As evidenced in previous studies, the heat wave in 2003 in many European cities could be partly attributed to insufficient UGS (Campbell, 2018). The rapid conversion of barren lands and parks into residential buildings along with commercialization in urban peripheries might further intensify temperature and produce Urban Heat Islands (UHIs) (De Luca, 2021; Amlor and Alidza, 2016). Of note, the survival of one-fifth of the world's population is contingent on the services provided by ecosystems and green spaces within rural and urban landscapes (Puplampu and Boafu, 2021). ES means the benefits that people take from ecosystems, and their main goal is to establish a connection with human well-being, placed in the four categories. Provisioning, regulating, supporting, and cultural services (Abdollahi, 2023). In this respect, the benefits

resulting from natural ecosystem regulation processes are labelled as regulating services, such as climate regulation (Makovníková et al., 2023). By removing GHGs, such as Carbon Dioxide (CO₂), from the atmosphere, ecosystems accordingly contribute to climate regulation as an ES. In fact, forests, pastures, and other dryland ecosystems store carbon four times more than that observed in the atmosphere (IPCC, 2006). Dry carbon storage and Carbon Sequestration (CS) have been thus introduced among the uppermost services, and studies have shown that the value of one ton of carbon stored has been equal to the damage avoided from not releasing one ton of carbon to the atmosphere (Stern, 2007; Balist et al., 2022). CS includes biophysical assessment tools and economic valuation (Lusardi et al., 2020). The carbon stored in a piece of land thus depends largely on four reservoirs, viz., above-ground biomass, below-ground biomass, soil, and Nonliving Organic Matter (NLOM). Dead carbon also consists of the soil layer and the standing dead wood. In this vein, one of the main regulating services with a leading role in maintaining an ecosystem and its functions is CS. Thanks to the removal of GHGs, such as CO₂, from the atmosphere; UGS thus play a vital role in climate regulation as an ecosystem-related service (IPCC, 2006). Among the major providers of regulating services are UGS and landscapes as human-environmental networks that meet diverse and valuable service needs of city residents (Mengist et al., 2020; Sinha et al., 2020). The World Health Organization (WHO) also introduces parks, sports fields, wetlands, forests, and pastures as examples of UGS, and considers them a vital part of urban ecosystems. Moreover, such spaces have been defined as any vegetation in urban environments, including parks, outdoor spaces, residential gardens, or street trees (Kabisch and Haase, 2013). According to Lindley et al. (2018), human activities, like land-use change, have significantly converted land cover on a global scale, with 25% of land use on the Earth's surface transformed which has also been noted by Pielke et al. (2011). Managing urban ecosystems for the resilient delivery of urban ES, such as maintaining resilience to respond to shifting demands, is thus part of sustainable urban ES. Despite this, socio-ecological ES seems to be context-dependent, which requires addressing the inherent complexity of not only ecological dynamics, but also human perceptions, values, and cultural traditions affecting their supply

and demand (Biggs *et al.*, 2012). To boost the resilience of the supply of ES on multiple spatial scales, it is of utmost importance to first better understand the manifold values of urban ES, and then recognize the context-dependent nature of ES, including sociocultural and ecological aspects (McPhearson *et al.*, 2015). Notably, not just disasters or climate change events, such as storm surges or heat waves, are likely to shape resilience in cities, but this is correlated with a larger set of urban ES that bring benefits to urban livelihoods and well-being (Sutikno *et al.*, 2023). All the more so, the aesthetic benefits of urban green infrastructure may alter the level of resilience to socioeconomic and ecological changes (Sanders *et al.*, 2015; Troy and Grove, 2008). Otherwise stated, urban resilience is the degree to which cities can stand change before being reorganized into a new collection of structures and processes (Qian *et al.*, 2023; Alberti *et al.*, 2004). UGS is accordingly a strategic issue to the extent that it can be regarded as one of the indicators of urban development and basic economy. With respect to multiple reasons, mainly the economic aspects, UGS have been changed into other uses, particularly more profitable residential ones. Of note, the process of changing the use of UGS within the city boundaries is common, so destroying UGS and changing their uses have given rise to excessive physical expansions (Golchubi Diva *et al.*, 2018). Among the key regulating services with an influential role in maintaining ecosystems and their functions is CS. Ecosystems accordingly contribute to regulating climate as an ES by adding and removing GHGs, such as CO₂, from the atmosphere (IPCC, 2006). The improper exploitation and destruction of UGS and barren lands has thus led to a quantitative and qualitative reduction of weather conditions, and subsequently lowered such services in cities. Therefore, the interactions between ES and CS should be taken into account and city managers need to be encouraged to develop UGS to make the most of their services. Tehran, one of the central provinces of Iran as the political-economic capital, has the largest population of city residents due to its important role. Every year, UGS in this city is being destroyed for various reasons, such as the development of industrial towns and the expansion of this megacity. During the past years, the urban population has further grown along with the area of Tehran. Unfortunately, the rising trend in the

population has not been accompanied by the development of UGS, that is, they have remained at a low rate as that in previous years (Safari & Sharifi, 2021). In view of population growth and the increasing number of vehicles, air pollution in Tehran has become one of the big challenges. Cars and factories are now the leading sources of air pollution, and the emissions of GHGs and air pollutants caused by fossil fuels, such as gasoline and diesel, are posing many problems, such as redoubling the concentrations of CO₂, Nitrogen Oxide (NO_x), and suspended particles in the air, which are remarkably evident in the cold seasons of the year (Ogunkunle and Ahmad, 2021), because the phenomenon of heat transfer between the air layers is weaker, and blocking airflow multiplies the pollutants in the air. As mentioned, the depletion of UGS is another important challenge facing Tehran. Following the increase in population and urban development, many green spaces, viz. parks, gardens, and lawns, have been reduced and replaced by buildings. For that reason, there is a lack of resources, such as oxygen, no biodiversity, and disturbance in climate regulation, which are directly and indirectly affecting quality of life of city residents. In this respect, CS, as one of the main components to protect the environment and combat climate change, has high economic values, help in sustainable economic development, and minimize the environmental impacts associated with climate change. Thus, investing in environmental protection and resilience measures and then diminishing GHG emissions are of great importance. Against this background, the present study is to analyze the spatiotemporal changes in the ES Value (ESV) of UGS in Districts 1 and 14 of Tehran Municipality, Tehran, Iran, and determine the effects of these spaces on urban resilience by calculating and analyzing CS. Here, urban resilience means the city's readiness and resistance in facing problems and events caused by climate change and air pollution. In this study, the relationship between UGS and urban resilience is accordingly investigated, and much focus is laid on the ESV of UGS, which plays an important role in evaluating the benefits and costs associated with the preservation and development of such spaces in the urban economy. These two components can further help city planners and officials in making effective decisions, among the innovations of this study.

Literature Review

Regarding previous research in this field, [Zhang et al. \(2023\)](#) investigated the impact of CS via terrestrial vegetation on economic growth based on satellite data in China and found that such services had a significant positive effect on economic growth in Northeast, Central, South, and Southwest China, but not in North, East, or Northwest parts. Following stability testing, this effect remained constant. CS using terrestrial vegetation had thus influenced economic growth, mainly through the improvement of industrial structures, resource allocation, and vegetation. This statistical model further elucidated the empirical evidence provided by CS for high-quality economic development and economic impacts on forestry and environmental protection. [Smith et al. \(2002\)](#) examined the CS potential of UGS in an urban area, using Remote Sensing data and field measurements to estimate the carbon storage capacity of various UGS, providing valuable insights into the importance of UGS for carbon reduction. As well, [Han et al. \(2018\)](#) identified urban ES; especially those produced by UGS and quantified their spatiotemporal changes on the regional scale in the southern part of Seoul, South Korea. At first, the changes in UGS were categorized, then a CS-related factor was selected as a trial case, and its spatial pattern was investigated using the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) model. The study results showed that the total CS potential decreased by 41.2% from 1975 to 2015, due to the reduction in the area of green and natural spaces. In addition, the drastic decline in the extent of urban forests and agricultural areas was introduced as one of the main reasons for the loss of CS. Moreover, [Ariuoma et al. \(2021\)](#) reflected on the role of CS and the potential of UGS in residential areas, and established that the simultaneous presence of trees and biochar (viz., charcoal from plant biomass and agricultural waste) in the environment could significantly increase CS. The CS potential of the study area was also 520 kg of CO₂ for each resident for 50 years. As well, biochar and tree biomass constituted 65% and 35% of the capacity, which could lead to the storage of 330,000 tons of CO₂ over 50 years, on a city scale. The findings additionally showed that green planning could help mitigate climate change by encouraging the use of biochar and tree planting, and further ensure optimal growing conditions. In 2019, [Jonsson et al.](#), investigated the potential of CS

for different land uses as nature-based solutions (NBS) to increase carbon storage and/or reduce GHGs. They concluded that most of the CS potential had occurred in conifer-broadleaf forests, covering approximately 60% of green infrastructure. Besides, the annual carbon storage potential would be thus lost with the rapid reduction of UGS due to the future land-use development from 2020 to 2040. By preventing development in areas with high CS potential, the losses could be accordingly reduced by 64.5%. [Gharibi et al. \(2021\)](#) correspondingly investigated the capability of UGS in providing ES for CS and confirmed that the largest area of green infrastructure was related to agricultural fields, gardens, parks, and abandoned lands, respectively. The highest CS potential in the city of Hamedan, Iran, was also soil (312047 tons), tree and shrub cover (90266 tons), grass cover (8383 tons), and litter (771 tons), in that order. In general, the results revealed that most CS could be met by the soil in the park use compared with other uses, so the development of UGS could be an option to reduce carbon in the atmosphere. [Pourtoosi et al. \(2017\)](#) studied the economic valuation of the ES of parks in the city of Mashhad, Iran, wherein the amount of gross carbon storage of trees was 9.2337 tons per hectare each year, and the major part was related to plantain species. The production of oxygen was also 1.0387 tons per hectare annually and the carbon storage in the urban parks was calculated as 761.22 tons per hectare. The removal of pollutants in one year and per hectare was further reported as 249.2 tons, and the value of regulating services (i.e., sequestration, oxygen production, and purification of urban pollutants) in parks in this city was shown as 4 million Dollars per hectare per year. The carbon reservoir of the parks in Mashhad was also valued at 1643 Dollars per hectare. Since the atmosphere was a huge reservoir of oxygen, this gas was not included in the Dollars valuation. The present study is to analyze the spatiotemporal changes in the ESV of UGS (here, CS) in Districts 1 and 14 of Tehran Municipality, Tehran, Iran. District 1, with a population of 480 thousand people has a green space area of 3799 thousand m² and the per capita of 10 m², as one of the districts rich in terms of UGS in this megacity. Given the population growth, indiscriminate construction has seriously threatened the UGS in this district, resulting in the reduction of green space ES and CS. Also, District 14, with a population of 333,484 thousand people, has a green space with an area of

2100 thousand m² and the per capita of 4 m², which is little as compared with other districts of Tehran Municipality. The construction in this district has been excessive since the past, UGS have faced much destruction, and this process continues.

The current study has been carried out in Tehran-Iran in 2023.

MATERIALS AND METHODS

Districts 1 and 14 of Tehran Municipality

Tehran, as the most populous city and the capital of Iran, is the first city of Tehran Province, with a population of 9,039,000 people according to the 2022 estimates and the 34th most populated city in the world and West Asia, as declared in 2018 by the United Nations (UN). The city of Tehran is divided into 22 districts and 122 urban areas. District 1 is located in the northeastern part of the city, as the northernmost district. It is bounded by the Alborz Mountain range from the north, the Evin neighborhood on the west, Shahid Chamran, Modares, and Shahid Sadr highways from the south, and Lavasanat on the eastern part. District 14 as the most densely populated one in the city of Tehran is also in the eastern-southeastern end parts of the city of Tehran, adjacent to District 12 from the west, District 13 on the north, and District 15 from the south. A region of study is shown in the Fig. 1:

The research process included two general steps,

first, the preparation and processing of satellite-based images, and then, the modeling of CS using the InVEST suite. The land-use map was further created utilizing satellite images. For this purpose, the images captured on June 2003, 2013, and 2023 were obtained from the Landsat satellite program, and then classified with reference to the Maximum likelihood estimation algorithm (Balist *et al.*, 2022; Lu and Weng, 2007), as one of the common methods for controlled classification in RS. Within this algorithm, the unknown pixels could be assigned to the most probable class with the assumption that the distribution of the training data of each class was normal. In the first step, based on the training samples of the classes, the mean value and the covariance table for the bands utilized during the classification were thus calculated. In the second step, the probability of the pixels belonging to each class was computed, and the pixels were classified and allocated to different classes at the highest probability. Statistical models based on normal distribution were further exploited to calculate the probability of each pixel belonging to each class, and then the pixels were assigned to the most likely ones (Jahandari *et al.*, 2022; Samimi and Nouri, 2023). Upon classifying the images and determining the land cover and use in each district, the accuracy of the results was checked, typically by comparing the reference map (land reality map) or the images with high spatial accuracy or the map

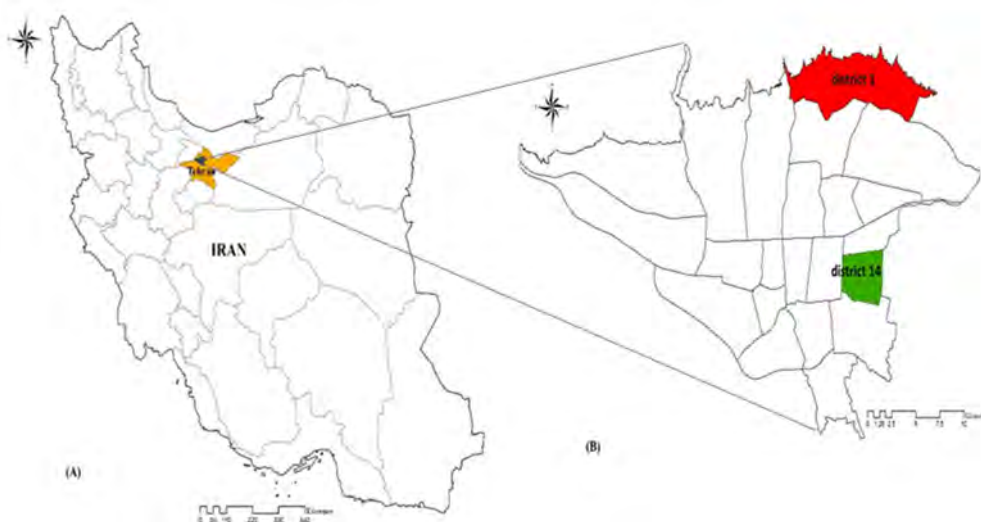


Fig. 1: Study area: (A) Iran and Tehran Province, (B) the city of Tehran and Districts 1 and 14

resulting from different classification methods and error matrix generation, though there were other methods for this purpose. A certain threshold of the correct classification probability was then respected. Afterward, random sampling was fulfilled by the Environment for Visualizing Images (ENVI) 5.3 software package, and the correctness of the classification was measured by Cohen's kappa coefficient to summarize the information obtained from the error matrix, recruiting all the elements of the error matrix to calculate the accuracy of the classification. This type of coefficient was a classification evaluation method to find the accuracy of the classification compared with a completely random one, indicating how different the classification was from chance, and the comparison showed agreement with the ground reality with no influence of randomness (Jahandari et al., 2022; Balist et al., 2022). The second step is comprised of modeling carbon storage and CS, using biophysical assessment tools and economic valuation (Jahandari et al., 2022). In this step, the InVEST 3.7.0 model was operated to estimate the effect of land-use changes on CS spatially on the urban land scale. In fact, this model could help calculate the total amount of carbon stored in four reservoirs, including above-ground biomass (tree leaves, branches, and trunks), under-ground biomass (e.g., plant roots), soil (soil organic carbon in the mineral horizon), and NLOM (leaf carcasses and branches) (Zhang et al., 2010). In this model, the inputs from land-use maps downloaded through the Landsat satellite program during the previous steps, were processed in the ENVI 5.3 software package, and prepared in the Geographic Information System (GIS) software, and then the amount of carbon stored in the mentioned reservoirs and the net amount of carbon stored in each area of land was estimated over time (of note, the amount of the fixed inputs of CS related to each land use per hectare had been previously determined by the researchers according to Table 2). The model outputs were further expressed as megagrams of carbon in cell grids or pixels. The land-use/land-cover (LU/LC) substrate for each pixel was each unique integer as a land-use class, indicating different land covers. For each LU/LC type, the model needed to estimate the amount of carbon in at least one of the four mentioned reservoirs, because the modeling results would be more complete if the data were available for more than one reservoir. This model

applies carbon estimates for each type of land cover and use to produce the maps of carbon storage in the existing reservoirs. If the current and future land cover and use maps were provided, the net changes of carbon storage over time (absorption and release) and its economic value could be calculated. To estimate the changes in CS over time, the model was simply applied to the existing maps and a projected future landscape, and then the difference in carbon storage between the pixels was calculated. If several future scenarios were available, the differences between the current scenario and each future one could be thus compared (Aalde et al., 2006). The calculations of the model were accordingly based on the application of the general equations of carbon measurement. CS could further occur when there was carbon storage over time. Based on this, if the carbon storage changes were positive, that is, from time t to T in the pixels examined, CS had occurred, and if they were negative, carbon had been lost between the two time periods, t and T (Mohaghegh et al., 2020). Employing land-use maps, land-cover types, and the amount of carbon stored in the reservoirs, the net amount of CS in a piece of land in Districts 1 and 14 of Tehran Municipality, during 2003, 2013, and 2023, as well as the market size of carbon stored in the remaining inventory were estimated via this model. Among the limitations of the model were an oversimplified carbon cycle, an assumed linear change in CS over time, and potentially wrong discount rates. The main biophysical conditions for CS, such as photosynthesis rate and the presence of active soil organisms, were not included in the model. This model could map carbon storage density to the LU/LC rasters, containing types, such as forests, pastures, or agricultural fields. It further summarized the results in the storage, separation, valuation, and total sum raster outputs. For each LU/LC type, the model needed to estimate the amount of carbon in at least one of the four main reservoirs introduced above. The modeling results would be thus more complete if the data were available for more than one reservoir. This model simply applied these estimates to the LU/LC map to create that of carbon storage in the existing reservoirs. If both current and future LU/LC maps were presented, the net change in carbon storage over time (sequestration and loss) and its social value could be calculated. To estimate this change in CS over time, the model was basically applied to the current

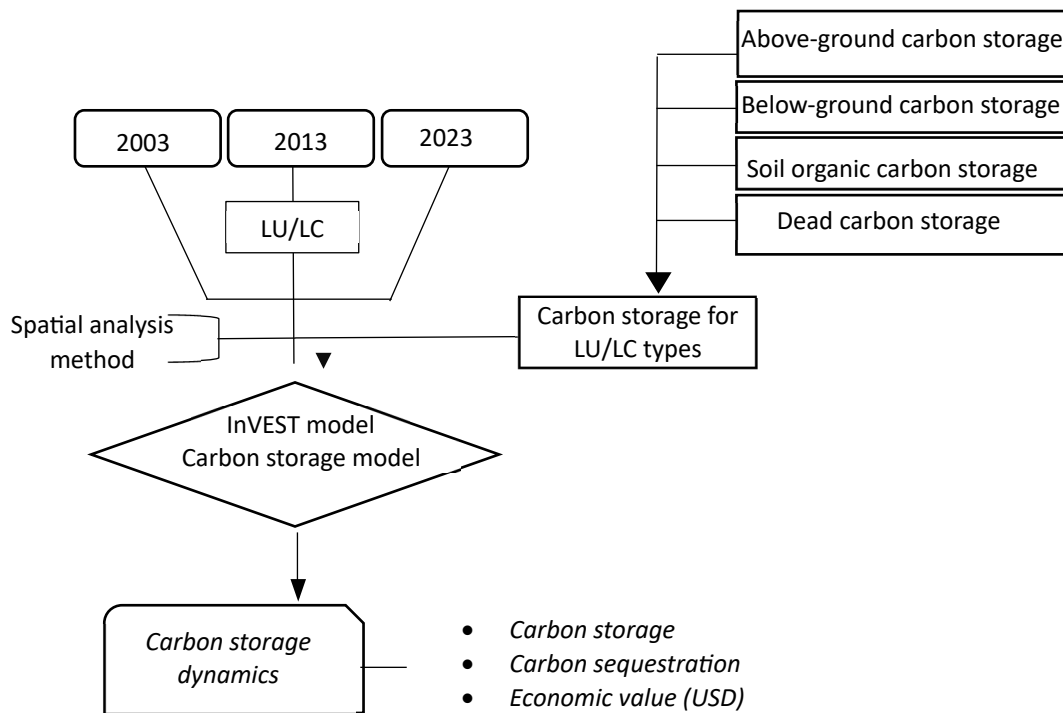


Fig. 2: Research Process

and the projected future landscapes, and the pixel-by-pixel storage difference was computed. If several future scenarios were available, the differences between the current scenario and each future one could be accordingly compared. The social value of one ton of separated carbon was social damage that could be avoided by not releasing each ton of carbon into the atmosphere. For the economic valuation of ES of CS, the value of each ton of carbon was considered equivalent to 35 USD with a discount rate of 3% and the annual changes of 2% of the carbon credit worth. The research process is illustrated in Fig. 2.

RESULTS AND DISCUSSION

The land-use changes in Districts 1 and 14 of Tehran Municipality were as follows. As mentioned in the research methods, the land-use map of these districts was first created using RS and satellite-based images. Figs. 3 to 8 show the land use maps of Districts 1 and 14 of Tehran Municipality for three time periods, 2003, 2013, and 2023. The land uses in these districts were further divided into four

types, and classified according to field surveys and the knowledge of each district. These uses included water spaces not available in District 1, very few water spaces between 2003 and 2013 in District 14, and water spaces in District 14 that will be removed in 2023. Green spaces, including parks, boulevards, and areas with vegetation and trees as spotted in the images, built-up uses, such as buildings, impervious surfaces, e.g., asphalt pavements, road networks, and areas manipulated by humans with no natural cover, and barren lands, namely, areas having no vegetation and construction, but bare soil.

District 1 of Tehran municipality with an area of 4661.2 hectares, was characterized by 26.55% of the area covered with green spaces, along with 56.24% and 17.21% of built-up lands and barren lands, respectively, in 2023. As well, District 14 with an area of 1455 hectares in 2023 also had water spaces, but green spaces, built-up lands, and barren lands accounted for 16.1%, 56.16%, and 27.57%, respectively. Table 1 shows the percentage of each land use in Districts 1 and 14 of Tehran Municipality

from 2003 to 2023.

Carbon Storage and CS and their changes

To model carbon sequestration and storage,

carbon reservoirs, which include 4 types of reservoirs on the ground, underground reservoirs, dead carbon reservoirs, and soil organic carbon reservoirs, were extracted and the data were introduced to the model

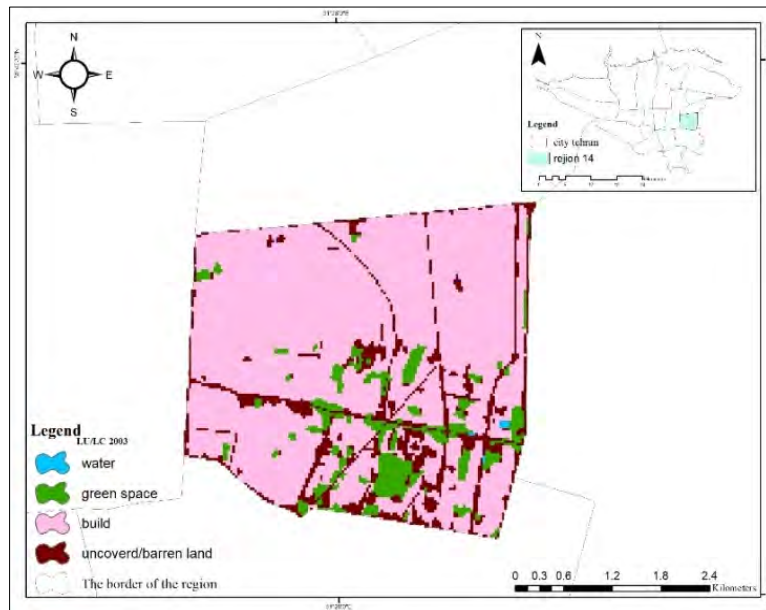


Fig. 3: Land use in District 14 of Tehran Municipality in 2003

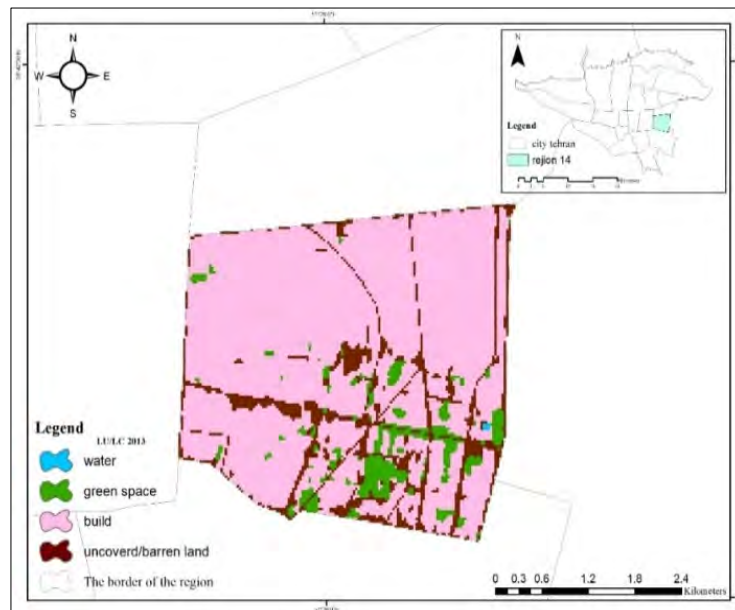


Fig. 4: Land use in District 14 of Tehran Municipality in 2013



Fig. 5: Land use in District 14 of Tehran Municipality in 2023

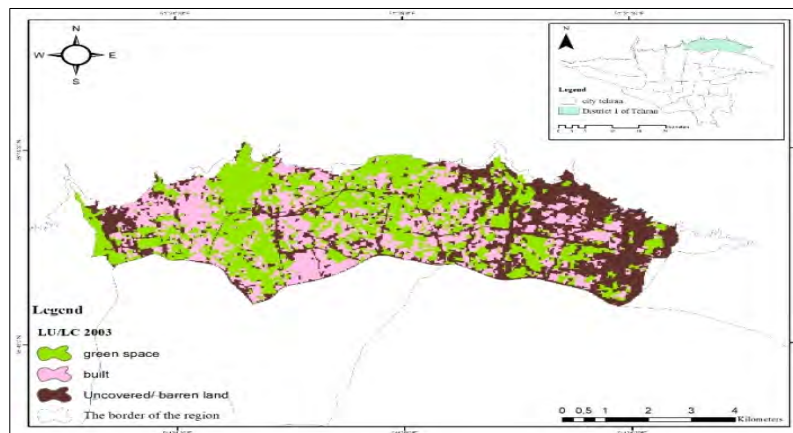


Fig. 6: Land use in District 1 of Tehran Municipality in 2003

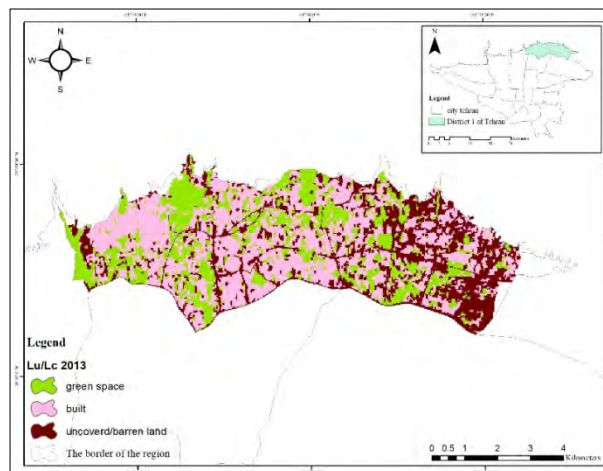


Fig. 7: Land use in District 1 of Tehran Municipality in 2013

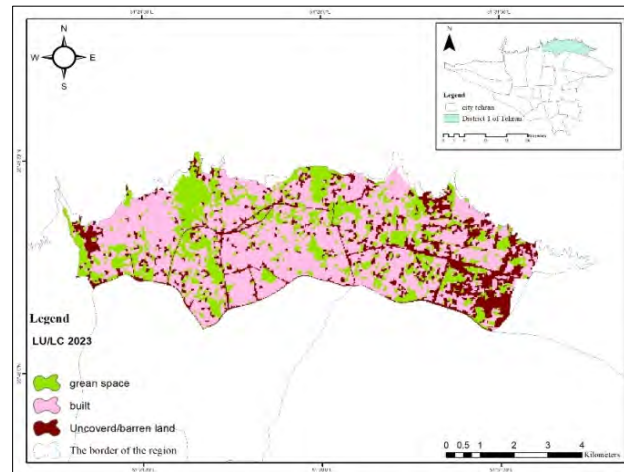


Fig. 8: Land use in District 1 of Tehran Municipality in 2023

Table 1: Percentage of land use in Districts 1 and 14 of Tehran Municipality from 2003 to 2023

Districts	Uses	2003 (percentage)	2013 (percentage)	2023 (percentage)
District 1	Green spaces	31	19.12	10.58
	Built-up lands	34.1	50.3	65.32
	Barren lands	34.9	30.58	24.1
District 2	Water spaces	0.1	0.055	0
	Green spaces	8	6.31	6.8
	Built-up lands	79	81.07	83
	Barren lands	12.97	12.55	12

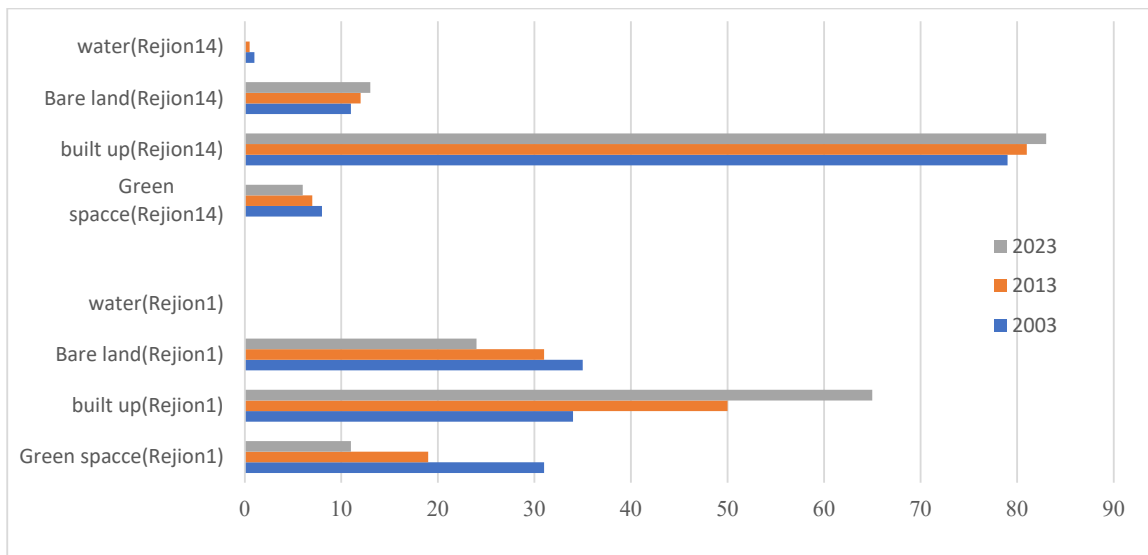


Fig. 9: Changes in land use in Districts 1 and 14 of Tehran Municipality during 2003-2023

Table 2: Carbon storage reservoirs in the city of Tehran (based on megagrams per hectare) (Mohaghegh *et al.*, 2020)

Uses / Carbon	Above-ground carbon	Under-ground carbon	Soil carbon	Dead carbon
Water spaces	0	5	0	0
Green spaces	10	2	62	1.1
Built-up lands	4	5	15	1
Barren lands	0.4	0.83	60	0

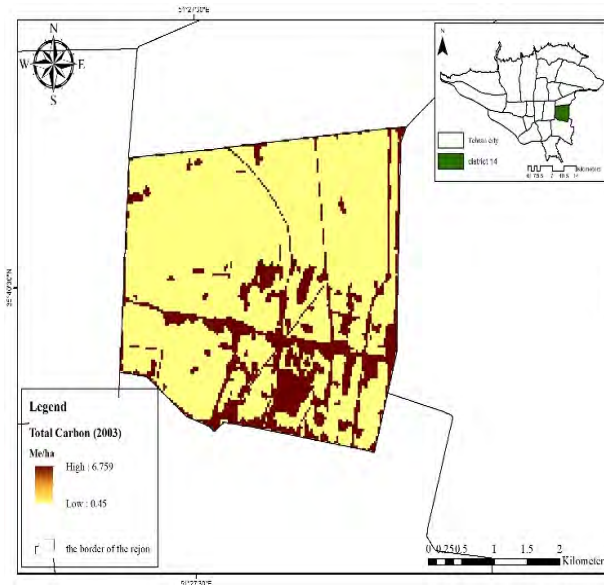


Fig. 10: Map of CS amount in District 14 of Tehran Municipality in 2003

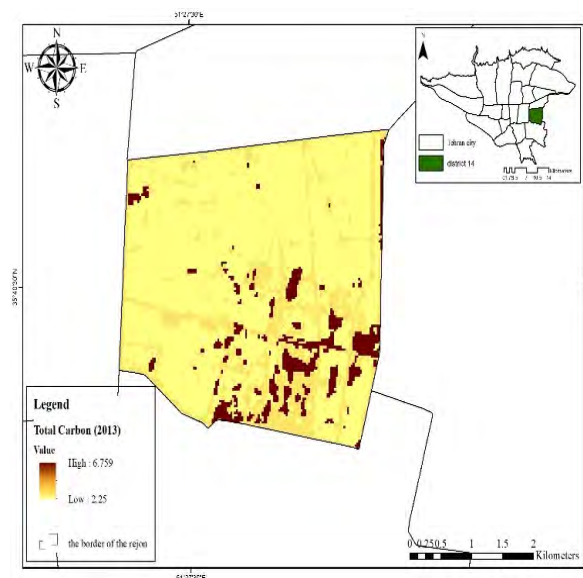


Fig. 11: Map of CS amount in District 14 of Tehran Municipality in 2013

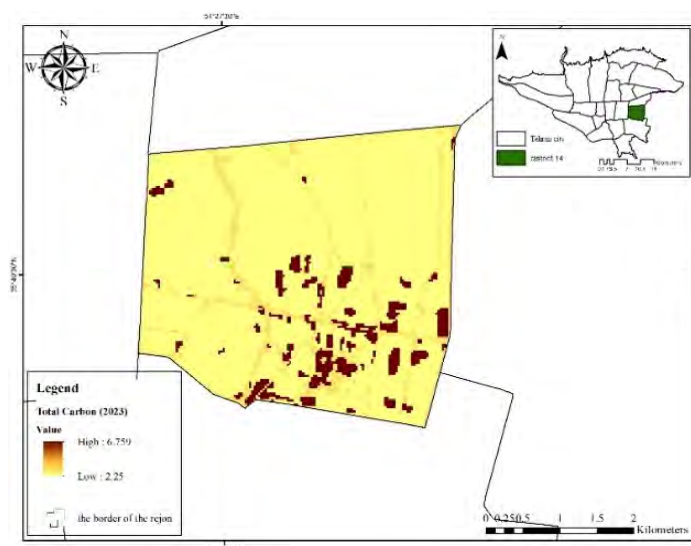


Fig. 12: Map of CS amount in District 14 of Tehran Municipality in 2023

Table 3. Amount of carbon storage in Districts 1 and 14 of Tehran Municipality during 2003, 2013, and 2023

Districts	Years	Minimum carbon storage (Tons per cell)	Maximum carbon storage (Tons per cell)	Total carbon storage (Tons per cell)
District 1	2003	0.45	6.759	21156415.4
	2013	0.45	6.759	19754807.7
	2023	0.45	6.759	18430138.5
District 14	2003	0.45	6.759	55006.68
	2013	0.45	6.759	51362.5
	2023	0.45	6.759	47918.36

Table 4: Changes in carbon storage in Districts 1 and 14 of Tehran Municipality during 2003, 2013, and 2023

Districts	Periods	Changes in carbon storage
District 1	2003-2013	-191401608
	2013-2023	-179114669
District 14	2003-2013	-3644.18
	2013-2023	-48229.8

in the form of a table with a specific format. Of note, the carbon reservoirs used in this study were extracted based on the review of previous research in this field in the city of Tehran and its surrounding environment. In this line, the carbon reservoirs were extracted for each class of use, and imported into the model.

Tables 3 and 4 displays carbon storage in the three time periods of this study, as well as the amount of changes in each period, compared with the previous

one. In District 1, the equivalent of 21156415 megagrams of carbon was thus stored in 2003, and this value reached 19754807 megagrams in 2013, with a decrease of 191401608 megagrams. In 2023, 179114669 megagrams of stored carbon have been released, as compared with the value in 2013. Figs. 10 to 12 present the amount of CS. In District 14, there were 55006 megagrams of carbon storage in 2003, which dropped to 51362 megagrams in 2013, that is, 3644.18 megagrams of carbon was lost over 10

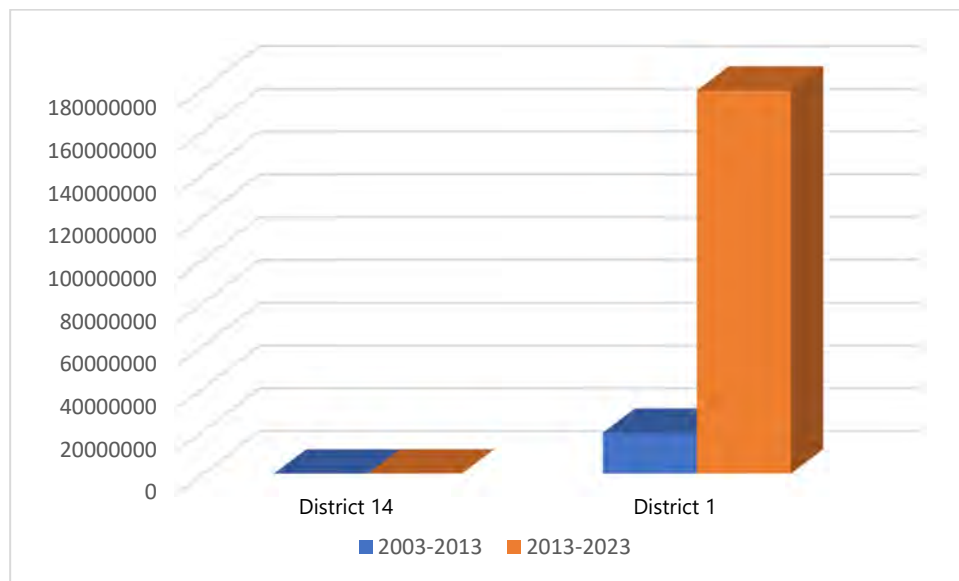


Fig. 13: Changes in carbon storage

years. In 2023, there has been 47918.36 megagrams of carbon storage in this district, namely, 47918.36 megagrams of carbon lost in comparison with the value in 2013.

Changes in Carbon Economic Value

According to the research methods, the value of each ton of carbon was considered to be 35 USD based on regional conditions and global references (Council, 2013). The discount rate of 2% and the annual carbon value change of 3% were also considered. As evidenced, different land-use changes in District 1 of Tehran Municipality resulted in the emission of 1401607.65 tons of carbon during 2003-2023, worth 49056267 USD, and 1324669.2 tons of carbon from 2003-2023, valued 46363422 USD. In District 14, various land-use changes also resulted in the release of 3644.18 tons of carbon in the period of 2003-2013, worth 1873871 USD, and 3444.14 tons of carbon during 2013-2023, valued 1749769 USD. Therefore, the unsystematic construction and development of built-up areas at the cost of destroying green spaces and barren lands, despite much effort and planning to develop UGS in this megacity overwhelmed the relative benefits of green infrastructure there, thereby making the resilience of ES of UGS unstable.

Natural-structural resilience has been

documented among the main dimensions of urban land-use resilience, accounting for various structural-natural capacities of a city to prevent destruction and quickly back to the original state following threats and demolition. Without structural-natural resilience, urban lands have a very low environmental quality and seem to be in a weak position to disasters. In comparison with domestic research in this field, the present study made it possible to examine and archive the changes in land use during 2003-2023, via the InVEST model, visualize the changes of CS on a regional scale, and represent its impacts on urban resilience. It also valued the amount of ES of CS in the study areas. In this line, Joneidi Jafari *et al.* (2015) had investigated the effect of changing the use of pastures in Eyvanki, Semnan, Iran, in terms of carbon storage and sublimation, and put emphasis on the sensitivity of the carbon storage of these lands to the effect of land-use change. In another study, Asadollahi *et al.* (2017) had further explored the impact of land-use change on CS, and reported that the role of green space coverage and CS was diminishing. Human activities in the form of land-use change have thus significantly transformed land cover on a global scale. With the growing recognition of ES, there is a need for the development of software packages and models to provide decision-makers with the required

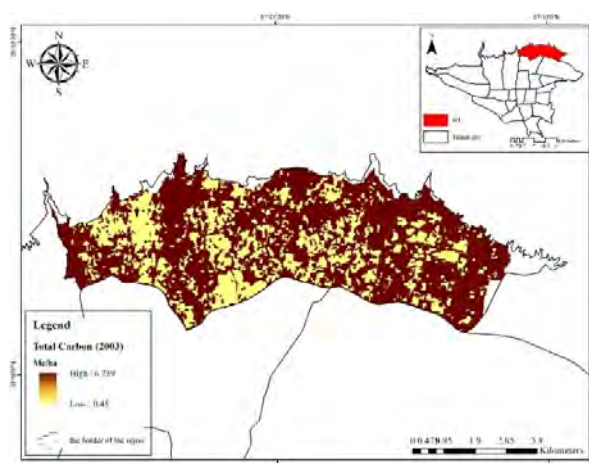


Fig. 14: CS amount in District 1 of Tehran Municipality in 2003

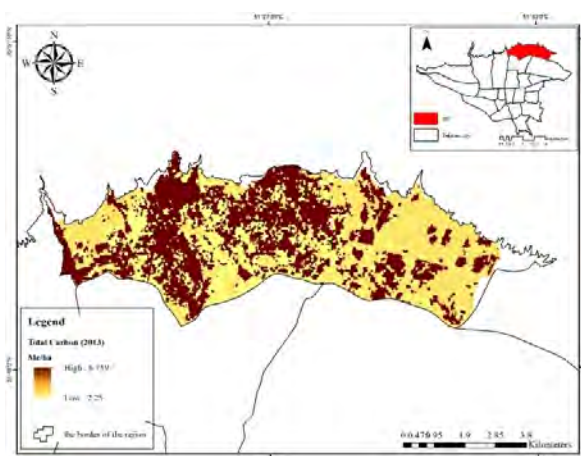


Fig. 15: CS amount in District 1 of Tehran Municipality in 2013

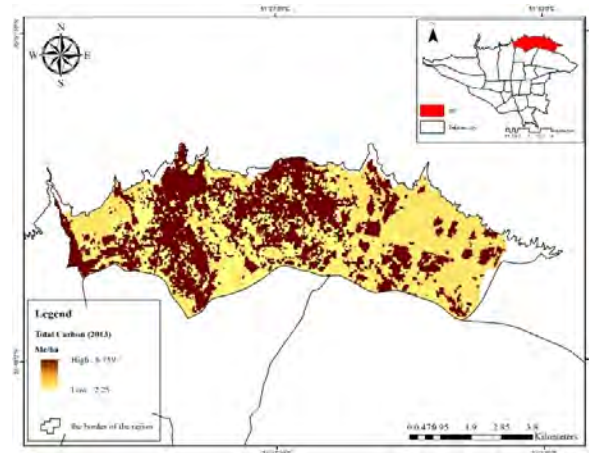


Fig. 16: CS amount in District 1 of Tehran Municipality in 2023

Table 5: Economic value of CS

Districts	Periods	Total CS (Mg* of carbon)	Periods	Change in carbon (Mg of carbon)	Net present value (USD)
District 1	2003	21156415.4	2003-2013	-1401607.65	-49056267.8
	2013	19754807.7			
	2023	18430138.5	2003-2013	-1324669.2	-46363422
District 14	2003	555006.68	2003-2013	-3644.18	-1873871.3
	2013	51362.5			
	2023	47918.36	2003-2013	-3444.14	-1749769.14

*Miligram

information on the supply of ES and examine the effects of land-use management on such services. To model the effect of UGS on CS, as well as the change of use on the change of carbon content, the InVEST model was applied, and its environmental benefits and losses were further delineated. To create land-use maps within the time periods of 2003, 2013, and 2023 in Districts 1 and 14 of Tehran Municipality, RS was recruited. As the results showed, the area of UGS and barren lands decreased over time in this megacity. However, the speed of this change in use was not constant during the 30 years of the study, and it was faster in the first two 10-year periods, implying the speed of population growth in Districts 1 and 14 from 2003 to 2023. A large area of barren lands has also undergone changes during these 20 years (particularly during the first 10 years) due to the increase in population and migration to the city along with subsequent demand for more lands to build residential areas and facilities. The speed of these changes eventually decreased for various reasons, including no capacity to load more constructions over the last 10 years of the study, as compared with the previous 20 years. CS among the most important regulatory services could thus reduce or adjust the speed of climate change through climate regulation from the local to the global macro-scales.

This study was thus an analysis of urban ES provided by multiple types of habitats, including green and water spaces. Such services are commonly under the control of heavy demand in cities raised by the large number of local beneficiaries. UGS, including parks and gardens, can thus provide various ES for city residents.

CONCLUSION

Urban ecosystem services are provided by various habitats such as green spaces and water bodies.

Such services are typically in strong demand from many service recipients. In this connection, urban green spaces, i.e. parks and gardens, provide these services to urban dwellers. The main objective in this study was to analyze the spatiotemporal changes in the ESV of UGS in two districts out of 22 municipal districts in Tehran, Iran. For this purpose, there were attempts to evaluate the resilience of these districts in the face of climate change and environmental degradation, especially the amount of CS. This study further provided an innovative tool to improve the ESV of UGS and take suitable measures to enhance such spaces, recruiting library and documentation studies, spatial analysis, modeling, software packages, and field visits. In the first step, land-use maps in the present and past were created using RS. In the second step, different software packages and models were utilized to model CS in the study areas. Upon analyzing the land use and cover maps, using different models, the amount of CS and their changes during three time periods were estimated. The study results showed that the indiscriminate construction and development of built-up areas had led to the depletion of UGS, and as a result, the reduction of their ecosystem resilience. Moreover, reduced CS and changes in land use could have a destructive effect on the ES of UGS, specifically in terms of resilience against climate change and temperature rise. This study was in line with previous research, except for examining the effect of CS of UGS on the economic and environmental issues of CS by vegetation and green spaces. In addition, it was implemented in various environments and laid focus on various aspects, including the significant positive effect of CS based on terrestrial vegetation on economic growth in urban areas, as one of the significant outcomes. Besides, the ESV of UGS as a resilience factor was considered. Other studies had correspondingly

evaluated the ecosystem effects of UGS on carbon reduction, but this study in a supplementary manner surveyed the effects of ecosystem on economic growth and spatiotemporal changes in the ESV of such spaces. The main goal was to evaluate the resilience of the study areas against climate change and environmental degradation, particularly CS. To achieve this goal, various steps were taken, and the findings revealed that CS in UGS decreased, and even vanished over time. This might be due to the changes in natural landscapes and the analysis of UGS. The study results can thus help city planners and officials in terms of proper planning and management of UGS. Creating and maintaining UGS not only helps in CS, but also brings other economic and environmental values, such as oxygen production, pollutant removal, and higher levels of resilience. These findings can further aid urban decision-makers to take advantage of the strengths and potential of carbon reduction in the design and development of UGS.

AUTHOR CONTRIBUTIONS

Sh. Hoseini performed the literature review, design, analyzed and interpreted the data, M.J. Amiri as the corresponding author, compiled the data and manuscript preparation. Y. Moarrab performed some of the remaining experiments and data.

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, falsification, double publication, submission, and redundancy, have been entirely witnessed by the authors.

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ABBREVIATIONS

CO_2	Carbon dioxide
CS	Carbon sequestration
ES	Ecosystem services
ENVI	Environment for visualizing images
ESV	Ecosystem services value
GIS	Geographic Information System
<i>InVEST</i>	Integrated valuation of ecosystem services and trade offs
LU/LC	land-use/land-cover
NLOM	Nonliving organic matter
NO_x	Nitrogen oxide
NBS	Nature based solution
RS	Remote sensing
WHO	World health organization

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ORIGINAL RESEARCH PAPER

Governance, ease of living, and citizens' perception: Components for quality-of-life assessment in mid-sized smart cities

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ABSTRACT

BACKGROUND AND OBJECTIVES: Smart cities are technology-driven urban agglomerations. Sustainability, competitiveness, and quality of life are the three cardinal principles for smart cities. The available studies specific to smart cities are related to smart technologies, innovations, smart infrastructure, etc., and limited studies are conducted from citizens' perspectives. The present study aims to assess the impact of governance, general well-being, also called ease of living of citizens, and citizens' perception of smart cities on their quality of life in mid-sized smart cities of India. The innovation and novelty of present study is that it attempts to fill the research gap in studies on smart cities by adopting the citizen-centric approach rather than infrastructure and technology-centric approach in developing countries.

METHODS: Three Indian mid-sized smart cities, Pune, Nagpur, and Indore were identified for the study. For the purpose of this study, a few hypotheses were developed and a structured questionnaire was prepared from the literature review. The data was collected from Pune, Nagpur, and Indore smart cities and it was analyzed by performing factorial analysis and Structural Equation Modelling using appropriate statistical package software.

FINDINGS: The findings from the statistical analysis validated the hypotheses. The results of the study indicate a strong positive impact of citizens' perception of smart cities on quality of life (Standardized Estimates = 0.66) while governance (Standardized Estimates = 0.11) and ease of living (SE=0.46) presented low to medium impact relationship with citizens' quality of life.

CONCLUSION: The findings of this study concludes that citizens' perception has highest influence on their quality of life. Considering these findings in the context of mid-sized smart cities, this study significantly contributes in existing research on tools and indicators of quality-of-life assessment in urban centers specifically in developing countries. This research article attempts to provide a substantial theoretical and practical contribution to urban studies.

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INTRODUCTION

A report by the United Nations states that around 55 percent of the world's population lives in urban centers and it is expected to increase up to 66 percent by 2050 (United Nations, 2018). As per the Census of India 2011, the urban population in India is about 31 percent which is projected to increase to about 40 percent by 2030 and to 50 percent by the middle of the 21st century (Sadashivam and Tabassu, 2016). This increase in the urban population in India may be attributed to various reasons such as the natural increase of population in existing urban centers, small settlements growing to urban centers, and migration from rural to urban areas (Das, 2016). This population growth implicit Indian cities to focus on the quality of life of people (De Guimarães *et al.*, 2020). Several realities confronting India have resulted in the development of a series of urban policies focusing on various aspects of urbanization (Kumar *et al.*, 2019). Some prominent policies in this series such as Integrated Development of Small and Medium Town (IDSMT-1995), Jawaharlal Nehru National Urban Renewal Mission (JNNURM-2005), and Atal Mission for Rejuvenation and Urban Transformation (AMRUT-2015) focused on the development of physical infrastructure and capacity building in Indian urban centers. The limitations and shortcomings in these policies shift the focus of policymakers from infrastructure-centric to citizen-centric urban policies (Smith and Pathak, 2018; Prasad and Alizadeh, 2020). The citizen-centric approach keeps citizens at the center of public policies and focuses on improving citizens' quality of life. The quality of life is a multifaceted, intricate concept that necessitates numerous approaches from various theoretical perspectives. There are three important theoretical perspectives to measure the quality of life (Diener and Suh, 1997). The first perspective is viewing the quality of life from normative angle such as religion, spirituality and philosophy. The second perspective is defining the quality of life through the satisfactions of priorities which can also be called as material well-being. The third perspective is defining the quality of life from the perception of the individuals which has been built over the period of time from their experiences. This individual perception can also be called as subjective well-being. The subjective as well as material well-being of citizens in urban centers is influenced by factors such as municipal governance,

livability, economic prospects, environment, public service quality, satisfaction, and citizen perception (Sharifi, 2019). With the objective of improving citizens' quality of life, the Government of India decided to transform 100 cities into smart cities under Smart Cities Mission.

Smart Cities Mission of Government of India

Smart cities are urban agglomerations that use cutting-edge technologies and Information and Communication Technology (ICT) to plan, develop, and manage urban affairs. In India, the concept of smart cities came into public discourse when the Prime Ministerial candidate of the Bharatiya Janata Party (BJP) Mr. Narendra Modi in the 2014 election manifesto announced his vision to transform 100 Indian cities into smart cities. After a landslide victory in the 2014 general elections, his government announced the Smart Cities Mission (SCM) aiming for the comprehensive development of physical, institutional, social, and economic infrastructure in Indian urban agglomerations. The primary objective of the SCM is "to promote cities that provide core infrastructure, clean and sustainable environment, and give a decent quality of life to their citizens through the application of smart solutions" (MoHUA, 2021). The Ministry of Housing and Urban Affairs of the Government of India has developed an Ease of Living (EoL) Index for the performance evaluation of 100 smart cities under SCM (MoHUA, 2021). The EoL Index aims to measure the ease of living of citizens in smart cities across three parameters- quality of life, economic ability, and sustainability. In 2019, the index has been expanded to include the Municipal Performance parameter to assess the performance of local urban government and their service efficiency. Smart cities have been studied extensively over the past few years. Most of the available studies on smart cities are related to smart technologies, innovations, smart infrastructure, etc., and limited studies are conducted from citizens' perspectives. The present study attempts to fill this research gap by adopting human-centric approach instead of technology-centric approach while studying the smart cities. Multiple studies have proposed many indicators and tools for smart city evaluation (Yadav *et al.*, 2019; Sharifi, 2019, 2020). However, limited studies are available that focuses exclusively on quality-of-life assessment indicators in smart cities.

The present study attempts to bridge this research gap by analyzing the components that influence citizens' quality-of-life in smart cities. It is also found that there is a great north-south divide in studies on smart cities across the world. Many researchers have focused their studies on smart cities in developed countries, and very few studies are available on smart cities in developing countries, particularly in India. The present study attempts fill this research gap by contributing in studies on smart urbanization efforts in developing countries and specifically on Smart Cities Mission of Government of India. The present study aims to assess the impact of governance, general well-being, also called ease of living of citizens, and citizens' perception of smart cities on their quality of life in mid-sized smart cities of India. Considering these findings in the context of similar mid-size smart cities in India, this study attempts to propose a conceptual framework for assessment of the citizens' quality of life in mid-sized smart cities. In the present study, the smart governance component includes the parameters such as citizen engagement in city affairs, quality of services provided by the smart cities, and the performance of the municipal administration. The ease of living component in the present study emphasizes the parameters such as citizens' satisfaction with public services, the natural environment, and economic ability in smart cities. The citizens' perception component includes their subjective understanding of smart cities and the associated quality of life. The current study aims at proposing the conceptual framework for the quality-of-life analysis of citizens in mid-sized smart cities of India. The study has been carried out in Nagpur city of Maharashtra state of India during the period of 2022-2023.

Theoretical background

Before presenting the hypotheses of the research, it is imperative to study the theoretical background that provides the necessary foundation for the formulation of the hypotheses (Samimi and Moghadam, 2024). This study is based on four components- governance, ease of living, citizen perception, and quality of life. These four components play a crucial role in making a city smart and its citizen smarter. This section in manuscript explains various sub-components of each component- governance, ease of living, and citizen perception focused in

present study to assess citizens' quality of life.

Governance

In its most basic form, public governance is defined as the intersection of administrative rules and regulations, legal positions, and norms that limit, decide, and authorise government functions. The concept of governance in cities relates to the ability of local government to manage its regions to accomplish growth, distribution, and efficient administration of public affairs (Lynn *et al.*, 2000; Odendaal, 2003). The components such as citizen engagement, public services, and municipal administration primarily influence public governance (Giffinger and Gudrun, 2010; Díaz-Cayeros *et al.*, 2014; Sharifi, 2019, 2020). The traditional model of governance underestimates citizen engagement and service quality while focusing on municipal administration. The modern concept of governance focuses on a system that aims to achieve mutual cooperation between the government and the forces of change (Bolívar and Muñoz, 2019). Citizen participation is an essential and indispensable component of smart governance where collaboration takes place between the public and various spheres of government (Odendaal, 2003; Ju *et al.*, 2019). In a study on US cities, (Portney and Berry, 2010) found a direct correlation between citizen participation and city sustainability and vice versa. Their study concludes that the cities which encourage citizen participation in civic matters also tend to frame sustainable civic policies. Similarly, the field of urban governance put significant emphasis on improving public service quality and delivery models in cities (Kelly and Swindell, 2002; Abid Aown *et al.*, 2018). The service quality framework depends on five significant dimensions – Tangibles, Reliability, Responsiveness, Assurance, and Empathy (Rolland and Freeman, 2010; Lam *et al.*, 2015; Kuo *et al.*, 2018). Together, all the above-mentioned dimensions of service quality determine the quality of governance. Another important component of urban governance is municipal administration. Municipalities play a pivotal role in urban governance as they are embedded in the framework of formal laws and rules, checks and balances, separation and division of powers, structures of resources, etc. (March and Olsen, 2010; Wittmayer *et al.*, 2017). Municipalities play the roles of promoters, enablers, and partners in advancing the knowledge of urban sustainability

through experimental governance (Kronsell and Mukhtar-Landgren, 2018).

Ease of living

Ease of living is a subjective concept. Earlier, it has been established that material well-being, which is grossly calculated in terms of Gross Domestic Product (GDP) is not capable of explaining the broader well-being of a population and region. Since the ultimate goal of smart cities is to improve liveability rather than simply improving the economic output of the general population, developing a robust, holistic measure of well-being becomes essential. The general well-being of the population is influenced by the factors such as the natural environment, economic opportunities, and satisfaction of citizens with the services and facilities provided by the urban administration (Honnakatti, 2020). In fact, various smart city assessment tools being used across the world have given significant emphasis on the public, economy, and environment components (Monfaredzadeh and Berardi, 2015; Sharifi, 2019). Citizen satisfaction assessment is the cornerstone of the citizen-centric approach. According to Stipak (1979), citizen satisfaction influences citizens' usage behavior patterns. Citizens' perceived satisfaction with services is crucial for all the stakeholders, whether policymakers, politicians, or citizens, because of the perception that service quality and citizen satisfaction are interrelated (Gendel-Guterman and Billig, 2021). The Ease of Living Index framework of SCM of the Government of India has three pillars—quality of life, sustainability, and economic ability (MoHUA, 2020). The sustainability pillar includes the natural environment, city resilience, and green spaces within the city limits. The sustainable environment and assured electricity supply are one of the 10 core infrastructural components of SCM. This also includes transition to sustainable energy systems with low CO₂ emission technologies and smart grids based on renewable energy sources (Kamyab et al., 2020). The present study incorporated sustainability and economic ability along with citizen satisfaction in the ease of living component of the quality of life assessment tool.

Citizen Perception

Citizens' perspective of smart cities varies from people to people, city to city, and country to country,

depending on the level of development, willingness to change and reform, resources, and aspirations of the city residents. In a study undertaken by (Praharaj and Han, 2019), citizens envisage smart cities as Information and Communication Technology-driven urban agglomerations with active, empowered, and informed residents that follow smart and sustainable behavioral practices. The citizens prefer to call the smart city 'sustainable city' and 'smart community' rather than 'wired city' or 'ubiquitous city.' Citizens' perception of smart cities determines the level of their participation in city affairs and engagement with the municipal administration (Belanche et al., 2016; Georgiadis et al., 2021).

Quality of life

Quality of life is broadly defined as the ability of an individual to survive and prosper in a particular area (MoHUA, 2020). The quality of life of citizens in urban centers is influenced by many factors such as municipal governance, livability, economic prospects, environment, public service quality, satisfaction, and citizen perception (Sharifi, 2019). Quality of life is a fundamental aspect of smart cities (Ismagilova et al., 2019). Over the period of time, the global concept of quality of life in urban studies has seen an expansion in its sphere of inclusion. The terms such as governance, urban service quality, economic ability, physical and natural environment, ease of living, citizen satisfaction and perception, etc. have been included and used as indicators for quality of life measurement (Peach and Petach, 2016; Papachristou and Rosas-Casals, 2019; De Guimarães et al., 2020). The concept of smart cities is not limited to technical issues but includes the development of urban policies that would contribute to the overall well-being of citizens and ultimately improve their quality of life (Meijer and Bolívar, 2016; Bibri and Krogstie, 2017). The primary objective of the Smart Cities Mission of the Government of India is to improve the quality of life of its citizens by providing participatory governance, core infrastructure, a clean and sustainable environment, and economic opportunities through the application of smart solutions (MoHUA, 2021).

Literature review and research hypotheses

A detailed literature review was conducted for the purpose of the present study. The kinds of

literature were focused on that would cover smart city governance, ease of living, citizen perception, quality of life, etc. in smart cities. Multiple studies have been undertaken across the globe on smart cities, particularly on smart technologies and smart innovations for smart cities but very few with a citizen-centric approach. The researcher witnessed a great north-south divide in the studies on smart cities. The researcher reviewed available literature that is pragmatic to the present study and would provide some insights into undertaking the research from citizens' perspectives. There are limited studies focused on smart cities in India. (Smith *et al.*, 2019) conducted a preliminary examination of the Smart Cities Mission by examining the quantitative and qualitative attributes of participating cities. (Prasad and Alizadeh, 2020) investigated Smart City Proposals (SCPs) of 20 Indian cities that are selected in the first phase of SCM and attempted to offer a typology of smart city approaches at the policy level. Ayona Datta, in a study on Dholera Smart City, calls smart cities as "new urban utopia of the 21st century" and concludes with the notion that Dholera smart city is being built on the fault lines of utopian imagining where urban centers are developed as business centers which she calls "entrepreneurial urbanization" rather than centers of social justice (Datta, 2015). Praharaj *et al.* (2017) studied the civic engagement component in SCM in India. The study measured civic engagement based on the number of comments and suggestions received by cities on their smart city proposals. Fig. 1 shows the conceptual framework of the present study.

Governance and quality of life

The citizens' quality of life in smart cities is influenced by various components of smart governance including municipal administration, citizen engagement, service quality, etc. (De Guimarães *et al.*, 2020). Smart city governance is seen to be capable of addressing a variety of urban issues while also promoting long-term growth and improved quality of life in urban areas (Lee *et al.*, 2013). A city is considered smart when it achieves economic and sustainable growth through investments in human and social capital as well as participatory governance that improves the quality of life (Caragliu *et al.*, 2011). The more the citizens use the urban services, the better the service quality, and the better the service

quality, the greater the life's quality (Zenker and Rütter, 2014; Georgiadis *et al.*, 2021). The individual studies analyze the impact of various elements of governance on citizens' quality of life. The present study comprehensively analyzes the impact of all the above elements of governance and hypothesizes that the governance of mid-sized smart cities positively influences the citizens' quality of life.

H1: Governance has a positive impact on the quality of life of citizens in mid-sized smart cities of India.

Ease of living and quality of life

The ease of living means the general well-being of an individual as well as society. General well-being includes life satisfaction with physical as well as mental health, employment, education, natural environment, liberty, safety and security, religious freedom, etc. (Honnakatti, 2020). Multiple studies have observed that ease of living positively influences the quality of life (Shoshani *et al.*, 2016; Stefansson *et al.*, 2018). In the field of medical sciences, the evaluation of ease of living and general well-being is actually an assessment of the quality of life (Vitman Schorr and Khalaila, 2018; Hanna and Strober, 2020; Alyami *et al.*, 2021; Nielsen *et al.*, 2022). The well-being of students is the primary concern of teachers as it directly influences the students' quality of life (Cegarra-Navarro *et al.*, 2014). While all these studies are pertaining to various aspects of quality of life, the present study attempt to understand the relationship between ease of living and citizens' quality of life in the context of mid-sized smart cities in India. The study hypothesizes that ease of living positively influences the citizens' quality of life in mid-sized smart cities of India.

H2: The ease of living has a positive impact on citizens' quality of life in mid-sized smart cities of India.

Citizen Perception and quality of life

Quality of life is both objective and subjective (Rasaizadi and Askari, 2020). The researchers suggest the citizen perspective studies for subjective analysis of quality of life (Macke *et al.*, 2018; Santos, 2023). The citizens' overall quality of life is a potential mediator between urban green spaces and citizens' perception of the environment, social inclusion, and urban management (Giannico *et al.*, 2021). The

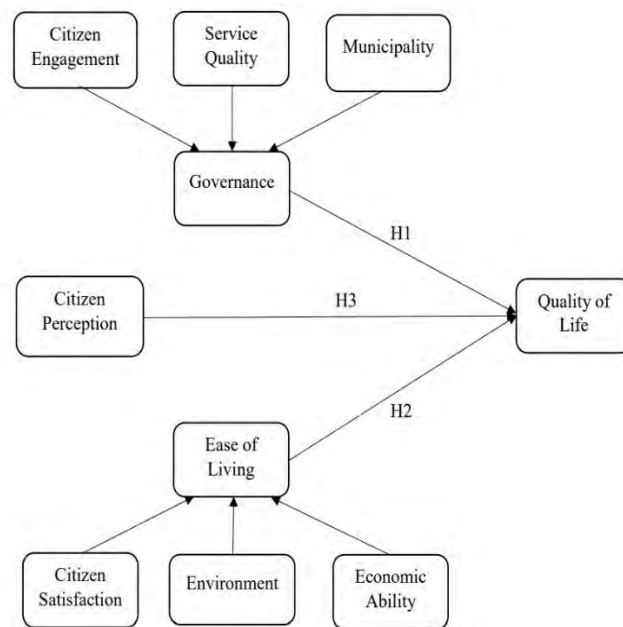


Fig. 1: Conceptual Framework

frequent review of citizens' perception of smart cities makes the community smart, creative, informed, and concerned and thereby improving liveability and life quality (Evans, 2009). The objective of the current study is to comprehend how individuals' perceptions of their respective smart cities affect the general quality of life. The study hypothesizes that the citizens' perceptions positively impact the citizens' quality of life in mid-sized smart cities.

H3: The citizens' perception has a positive impact on citizens' quality of life in mid-sized smart cities of India.

STUDY AREA OF RESEARCH

Pune Smart City, Smart City Nagpur, and Indore Smart City are study areas of the present research. Fig. 2 shows location map of India in the world and Fig. 3 shows the location map of three study smart cities in India. As per the Census of India 2011, Pune and Nagpur are two major cities in the Maharashtra state of India while Indore is the largest city in the Madhya Pradesh state of India in terms of population. Pune is the ninth-largest city in India in terms of population, having a population of 3.12 million approximately and it had grown with a decadal population growth rate of 7.8 percent during the period of 2005-2014

(Pune Municipal Corporation, 2021). Nagpur city is the 13th largest city in India and the third-largest city in Maharashtra state in terms of population. According to the Census of 2011, the population of Nagpur city is 2.4 million and is growing with a decadal population growth rate of 19.21 percent (Banerjee, 2011). Indore city is the 14th largest city in India in terms of population. As per the 2011 Census report, the approximate population of Indore city is two million (Indore Municipal Corporation, 2023). These cities are cultural, educational, economic, and industrial centers of India. Pune and Indore cities were selected in the first round, while Nagpur city was selected in the third round of SCM. Pune, Nagpur, and Indore smart cities are selected for the study as they share common grounds in multiple parameters such as historical and cultural backgrounds, the area under municipal corporation, population, demography, level of urbanization, economy, employment, education, health, municipal performance, quality of life, etc. As per the Smart Cities Mission dashboard, smart cities Pune, Nagpur, and Indore are performing better in terms of municipal performances, projects completed, and projects under progress compared to other similar mid-sized smart cities in India. The focus of the



Fig. 2: Location map of India

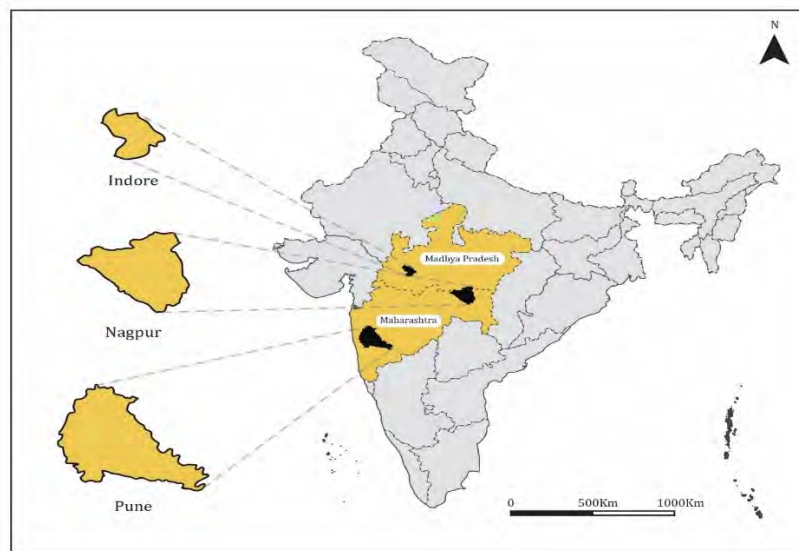


Fig. 3: Location Map of three study smart cities

present study is mid-sized smart cities. [Ramachandra and Aithal \(2013\)](#) have classified the Indian cities into large cities (population > 5 million), mid-sized cities (population 0.5-5 million) and small cities (population < 0.5 million). Large cities in India, such as Delhi, Mumbai, Bengaluru, Kolkata, Chennai, etc., have reached the saturation level in terms of urban sprawl growth, population, employment generation capacity, etc. that they cannot sustain more burden of urbanization. Therefore, policymakers are focusing on mid-sized cities as centers of regional development and limiting the influx of migrating

population to large cities. The mid-size cities play a pivotal role in the balanced regional development of any country and are likely to witness drastic urban growth as compared to large cities in the coming decades ([Chetty and Surawar, 2021](#); [Chetty, 2023](#)). To meet the demands of rapidly rising urbanization, the Government of India has decided to transform or set up 100 urban agglomerations into smart cities. According to the 2011 Census, India has around 84 mid-sized cities, out of which 56 cities are selected for prospective smart cities under the Smart Cities Mission of the Government of India.

MATERIALS AND METHODS

The study utilizes the hypotheses based on related literature and background studies. Two mid-sized Indian smart cities were selected for this study. A structured questionnaire was prepared and validated by using factor analysis. The data was collected from a total of 402 respondents from Pune, Nagpur and Indore smart cities. To test the hypotheses, the researcher performed Structural Equation Modeling on the collected data. Finally, the conclusion was drawn based on the results obtained. Fig. 4 illustrates the flow chart of research methodology that was followed in the present research.

Questionnaire

A brief literature review was carried out to frame the questionnaire. The survey questionnaire for this study contains 52 items, including items for demographic information (Table 1). The questionnaire was prepared using a five-point Likert Scale technique ranging from 1 (Strongly disagree/Very bad/ strongly dissatisfied) to 5 (Strongly agree/Very good/ strongly satisfied). The items in the questionnaire pertaining to the identified four components for this study. The items of the Governance component are related to various aspects of smart city governance such as citizen engagement, service quality, and municipal performance in smart cities. The items of the Ease of Living component are related to citizen satisfaction, environment, and economic ability. The items of citizens' perception component are related to the ease, feeling, and attitude of citizens while using the services offered by their smart cities, including IT-enabled services. The quality-of-life component includes the items related to various aspects of good quality of life such as personal achievements, self-actualization, self-reliance, aspirations of citizens and community, social and physical well-being, etc.

Data collection

The data from 402 respondents (61.2 percent male, 38.6 percent female, and 0.2 percent other) were collected from the cities of Pune, Nagpur, and Indore such that 139 respondents were from Pune, 136 respondents were from Nagpur, and 127 respondents were from Indore. The data was collected by visiting the cities of Pune, Nagpur, and Indore smart cities from October 2020 to April 2021. Apart from the field survey, the questionnaire

was distributed online to a few respondents from all three cities. The respondents were selected by using random sampling techniques. The focus was to incorporate citizens from all walks of life in the survey on smart cities. The questionnaire collected the demographic information of all the respondents. The respondents from all age groups participated in the survey. While collecting the data for this study, the researcher took the utmost care to include the respondents from diverse educational qualifications and varied professions to avoid any bias in the results. Out of 402 respondents, 2.7 percent had educational qualification secondary, 15.7 percent had higher secondary, 5.5 percent were diploma holders, 40.3 percent were graduates, and 35.8 percent were postgraduates with ages ranging below 18 years 4.73 percent, 18 to 30 years 50.25 percent, 31 to 40 years 12.94 percent, 41 to 50 years 10.68 percent, 51 to 60 years 8.46 percent and above 60 years 12.94 percent. The entire demographic scenario is shown in Table 2. The participants in our survey belonged to diverse professions and occupations such as Architectures (8), Chartered Accountant (5), Doctors (40), Engineers (77), Entrepreneurs (28), Government employees (17), Lawyers (8), Media personnel (12), Professor (13), Teachers (31), Scientists (5), Students (99), Workers/Labors (7), Housewives (14) and 38 participants belonged to some other profession/ occupation. Throughout our study, we met certain stakeholders in smart cities such as bureaucrats, and local political leadership involved in planning, implementing, and executing policies to discuss the outline of our study and collect information related to smart cities to maintain the generality which otherwise might get lost in conclusion (Podsakoff *et al.*, 2003).

Validation Method

The researcher performed the Confirmatory Factor Analysis (CFA) on collected data to validate the items in the questionnaire. CFA is used to determine the underlying relationship between the relatively large set of variables in this study. The factorial analysis is a multivariate approach to studying the interdependence of variables in which all the variables are evaluated concurrently, each related to the other, to study their interrelationship and minimize data (Hair *et al.*, 2019). Earlier research suggests that each of the values of loading factors should be greater than

Table 1: Constructs, measurements, and indicators

Construct	Indicator	Measurement	Sources
Citizen Engagement	CE1	Citizens of smart cities are socially engaged with different IT-enabled Services.	Cegarra-Navarro <i>et al.</i> (2014); Chatterjee and Kar (2018)
	CE2	The government uses e-governance mode to deliver different services to the citizens.	
	CE3	Citizens are well connected with the civil authorities via different e-governance services.	
	CE4	Community participation of citizens is well established using different modes of services	
	CE5	The government provides different sorts of information to the citizens using digital media	
	CE6	Citizens' usage of digital IT-enabled services in every sphere of life enhances their lifestyle.	
	CE7	Citizens are well-advised and trained to use IT-enabled services.	
Service Quality	SQ1	The system is reliable and it maintains its performance as per the requirements.	Zeithaml <i>et al.</i> (1990); Chatterjee and Kar (2018)
	SQ2	The information is continuously updated with the latest information in place.	
	SQ3	The services are efficient and user-friendly to the citizens of the smart city.	
	SQ4	The systems are well maintained providing quality services to the citizens.	
	SQ5	The functionalities are adequately designed to meet the needs of the citizens with full satisfaction.	
Municipality	MUN1	The smart city administration gives prompt service to citizens.	Gorla <i>et al.</i> (2010); Albino <i>et al.</i> (2015); Sofyani <i>et al.</i> (2020)
	MUN2	The smart city administration is always responsive to citizens' requests.	
	MUN3	The transparency of government information and actions is an instrument for the empowerment of citizens	
	MUN4	Availability of performance achievement report	
Environment	ENV1	Smart cities create and maintain attractive natural conditions for residents.	Gupta and Hall (2017); MoHUA (2021)
	ENV2	Smart cities ensure environmental protection and sustainable resource management.	
	ENV3	Physical infrastructure built under Smart Cities Mission helps in reducing pollution.	
	ENV4	Citizens find a green, clean, healthy Environment necessary for improving the ease of living in smart cities.	
Economic Ability	ECO1	A smart city environment facilitates entrepreneurship with an innovative spirit.	Gupta and Hall (2017); MoHUA (2021)
	ECO2	Smart cities provide more employment opportunities & improve employability.	
Citizen Satisfaction	CS1	Satisfaction with public health care infrastructure in your city?	Macke <i>et al.</i> (2018)
	CS2	Satisfaction with the quality & quantity of Municipality water supply services in your city?	
	CS3	Satisfaction with cleanliness, sanitation, and hygiene in your city?	
	CS4	Satisfaction with a solid waste management system in your city?	
	CS5	Satisfaction with the state of 24*7 assured electricity supply in your city?	
	CS6	Satisfaction with public education infrastructure in your city?	
	CS7	Satisfaction with the public transportation system in your city?	
	CS8	Satisfaction with the condition of gardens, green gyms, playgrounds, recreational centers, etc.	
	CS9	Satisfaction with affordable housing and slum rehabilitation in your city	
	CS10	Satisfaction with the state of law and order in your smart city?	
	CS11	Satisfaction with the level of pollution and quality of air in your smart city?	
	CS12	Satisfaction with the progress of the Smart City Project in your city?	
Citizens' Perception	CP1	How would you rate the community involvement efforts by your municipality?	Chatterjee and Kar (2018); MoHUA (2020)
	CP2	How would you rate the city's resilience to disasters?	
	CP3	How would you rate the government's efforts to address air/noise pollution?	
	CP4	The citizens have a positive attitude to use the services provided under Smart City Project.	
	CP5	The smart city project would have a positive impact on the quality of life of citizens in your city.	

Continued Table 1: Constructs, measurements, and indicators

Construct	Indicator	Measurement	Sources
Quality of Life	QoL1	Would enhance the quality of life through the use of green energy and ensure a pollution-free environment.	Harrison <i>et al.</i> (2012); Chatterjee and Kar (2018)
	QoL2	Would enable personal achievement, self-actualization, and success of achievement.	
	QoL3	Would improve the perceived ability to do things by citizens themselves enhancing self-reliance.	
	QoL4	Would improve the quality of social activities, more participation in community work, better social security as well as good relationships with others in society.	
	QoL5	Would improve perceived physical well-being, safety, security, healthy lifestyle, good avenues, etc.	
	QoL6	The valorization of joint work between government and citizens, with the aid of technology, allows prioritizing actions that directly impact the quality of life of citizens.	

Table 2: Demographic information of participants/respondents

City (%)	Gender (%)	Educational Qualification (%)	Age Groups (%)
Pune: 34.58	Female: 38.6	Secondary: 2.7	Below 18 Years: 4.73
Nagpur: 33.83	Male: 61.2	Higher Secondary: 15.7	18-30 Years: 50.25
Indore: 31.60	Other: 0.2	Diploma: 5.5	31-40 Years: 12.94
		UG: 40.3	41-50 Years: 10.68
		PG: 35.8	51-60 Years: 8.46
			Above 60 Years: 12.94

0.5, and that of cross-loading factors to be smaller than 0.5 (Žlender and Gemin, 2020). The items having a factor loading value less than 0.5 can be omitted (Goretzko *et al.*, 2023). Factor Analysis was performed using Statistical Package of Social Sciences (SPSS) v23 software. Along with factor loadings, the Construct Reliability (CR) should be greater than 0.7 to confirm that indicator components used in this study are reliable (Hair *et al.*, 2019). The CR is computed with the help of Eq. 1.

$$CR = \frac{(\sum \text{Standardized Factor Loading})^2}{(\sum \text{Standardized Factor Loading})^2 + (\sum e_i)} \quad (1)$$

Where e_i is the error. The reliability of measurements in the construct can be confirmed from the value of Cronbach's Alpha (α) which should be greater than 0.7 for the construct to be reliable (Kelarestaghi *et al.*, 2019). The values of Cronbach alpha are calculated using Eq. 2.

$$\alpha = \frac{N * \bar{C}}{\bar{V} + (N - 1) * \bar{C}} \quad (2)$$

Where,

N = number of measurements

\bar{C} = mean covariance between measurements.

\bar{V} = mean measurements variance.

Method for Hypothesis testing

Structural Equation Modelling (SEM) is a comprehensive statistical tool for testing the hypotheses and understanding the correlations/covariance among a set of variables (Suhr, 2006; Kock, 2023). Multicollinearity is one of the significant factors that can affect the SEM results. Multicollinearity refers to a situation where the measured variables are highly related to each other and are eligible for omission. The Pearson correlation test was performed to confirm whether there exists an issue of multicollinearity. Ideally, the Pearson correlation coefficient higher than $r = 0.85$ is a concern for SEM (Weston and Gore, 2006). After confirming that there did not exist an issue of multicollinearity, the SEM was performed using AMOS v23 software. The Pearson Correlation Coefficient is computed using Eq. 3.

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}} \quad (3)$$

Where,

r = Pearson correlation coefficient

x_i = values of x variable in sample (here e.g. variables of Governance)

\bar{x} = mean of the values of x variable

y_i = values of y variable in sample (here e.g. variables of Ease of Living)

\bar{y} = mean of the values of y variable

The SEM helps understand the overall acceptability of the model and the significance of various paths in the given model through various fit indices results (Li *et al.*, 2020; Kock, 2023;). The fit indices such as chi-square values and Root Mean Square Error of Approximation (RMSEA) are discrepancy functions adjusted for our sample size. The chi-square value describes the difference between observed covariance and the expected covariance matrix. The smaller chi-square value indicates little difference between observed and expected covariance matrices. The value of RMSEA ranges from 0 to 1, with the smaller the value, the better the model fit. The fit indices such as Goodness of Fit Index (GFI),

Adjusted Goodness of Fit Index (AGFI), Comparative Fit Index (CFI), Normed Fit Index (NFI), and Tucker Lewis Index (TLI) compare the observed model with the null model. The values of GFI, AGFI, CFI, NFI, TLI, etc., range from 0 to 1, with values greater than 0.9 indicating better model fit.

RESULTS AND DISCUSSION

A Principal Component Analysis (PCA) was performed on 45 variables. The Kaiser-Meyer-Olkin (KMO) measure confirmed the sample adequacy for the analysis, KMO = 0.950 which is “superb” according to (Field, 2009) and Bartlett’s Test of Sphericity, X^2 (1275) = 13946.067, $p < 0.001$, indicating that correlation between the measurements was sufficiently significant for PCA. Table 3 shows the factor loadings above 0.5 (Kock, 2023). Table 3 shows that Cronbach’s Alpha values (α) are 0.858, 0.951, 0.839, and 0.903 for GOV, EOL, CP, and QL respectively, which are well above 0.7. It appears from table 4 that Pearson Correlation Coefficients with reference to all the components lie in the range of 0.60 and 0.83. The path analysis for our research framework is shown in Fig. 5. It illustrates the results obtained by performing SEM. The results obtained from SEM indicate that the research model is within the acceptable range of

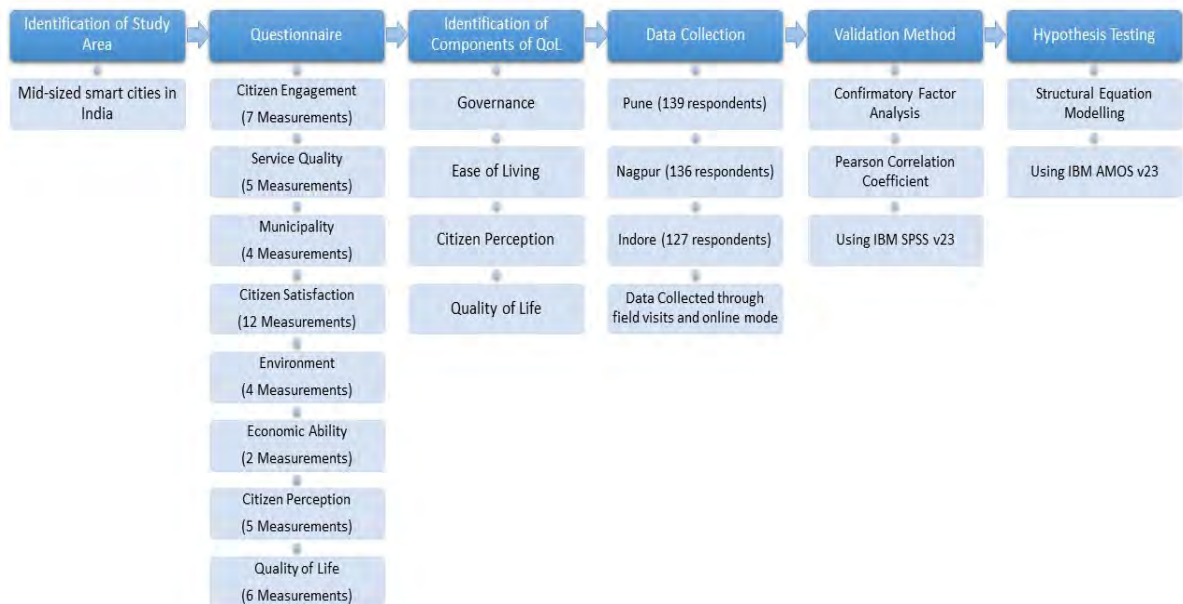


Fig. 4: Flow chart of research methodology

Table 3: Confirmatory factorial analysis

Constructs	Factor Loadings	Communality	Mean	Standard Deviation	AVE	Cronbach's Alpha	KMO	CR
Governance (GOV)								
CE1	0.757	0.637	3.54	1.116	0.571	0.858	0.875	0.942
CE2	0.801	0.686	3.51	1.076				
CE3	0.753	0.622	3.68	1.087				
CE4	0.217	0.144	3.93	1.042				
CE5	0.708	0.581	3.54	1.057				
CE6	0.743	0.714	3.89	1.083				
CE7	0.686	0.681	3.68	1.118				
SQ1	0.749	0.685	4.02	0.880				
SQ2	0.809	0.741	3.95	0.890				
SQ3	0.797	0.700	4.00	0.866				
SQ4	0.821	0.724	3.98	0.853				
SQ5	0.799	0.682	4.06	0.921				
MUN1	0.687	0.533	2.77	1.188				
MUN2	0.791	0.646	3.26	1.009				
MUN3	0.683	0.620	3.03	1.027				
MUN4	0.757	0.642	3.47	0.966				
Ease of Living (EoL)								
CS1	0.696	0.660	3.06	1.022	0.509	0.957	0.960	0.951
CS2	0.657	0.551	3.37	0.980				
CS3	0.712	0.677	3.69	1.102				
CS4	0.716	0.597	3.80	1.019				
CS5	0.626	0.441	3.98	0.958				
CS6	0.662	0.592	3.04	1.043				
CS7	0.723	0.664	3.88	1.010				
CS8	0.722	0.642	3.72	1.108				
CS9	0.835	0.734	3.56	1.074				
CS10	0.780	0.669	3.68	1.053				
CS11	0.789	0.656	3.57	1.143				
CS12	0.768	0.658	3.80	1.014				
ENV1	0.650	0.564	3.19	1.034				
ENV2	0.526	0.466	4.03	0.977				
ENV3	0.640	0.490	3.64	1.054				
ENV4	0.682	0.639	3.76	1.016				
ECO1	0.807	0.721	3.13	1.091				
ECO2	0.772	0.599	3.39	1.009				
Citizen Perception (CP)								
CP1	0.766	0.587	3.67	0.970	0.610	0.839	0.842	0.717
CP2	0.794	0.631	3.77	0.982				
CP3	0.825	0.681	3.74	0.964				
CP4	0.805	0.647	3.60	0.966				
CP5	0.709	0.503	3.60	0.999				
Quality of Life (QoL)								
QoL1	0.817	0.667	3.67	1.027	0.674	0.903	0.894	0.721
QoL2	0.840	0.706	3.55	0.970				
QoL3	0.850	0.722	3.54	1.068				
QoL4	0.795	0.633	3.53	1.092				
QoL5	0.791	0.626	3.55	1.054				
QoL6	0.831	0.691	3.54	1.073				

fit indices. From Fig. 5, it appears that all the path coefficients of interaction between GOV and QoL, EoL and QoL, and CP and QoL are significant at the confidence level of 99 percent. The researchers

used the values of various fit indices obtained after performing the SEM to evaluate the quality of conceptual framework. Most of these fit indices are derived from chi-square values: i) Chi-square value

Table 4: Pearson correlation coefficient

Components	Governance	Ease of Living	Citizen perception	Quality of Life
Governance	1			
Ease of Living	0.81	1		
Citizen perception	0.77	0.60	1	
Quality of Life	0.76	0.72	0.83	1

Table 5: Hypothesis tests

Components		Research Model	
		Unstandardized Estimates (UE)	Standardized Estimates (SE)
H1	Governance (GOV) → Quality of life (QoL)	0.18	0.11
H2	Ease of Living (EoL) → Quality of life (QoL)	0.53	0.46
H3	Citizens' Perception (CP) → Quality of life (QoL)	0.74	0.66

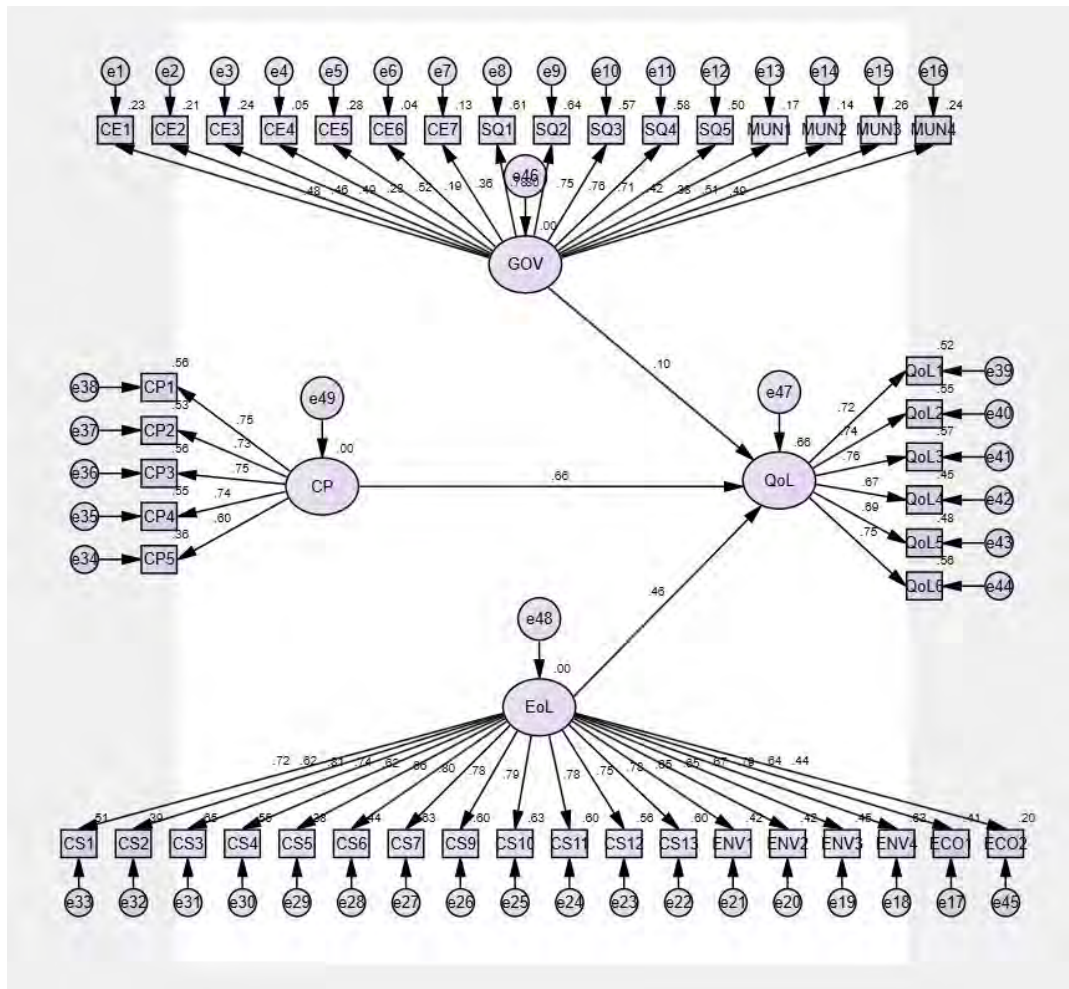


Fig.5: Path analysis of conceptual framework

divided by the degree of freedom (CMIN/DF) with a value of 4.09; ii) CFI = 0.735; iii) NFI = 0.683; iv) GFI = 0.782; v) AGFI = 0.767; vi) RMSEA = 0.081. The values of fit indices interpret that the conceptual model can be enhanced, with the inclusion or exclusion of certain items employing statistical standards. It should be emphasized that the ideal fit indices do not necessarily illustrate the strength of path relationships among the variables in research frameworks (Chatterjee and Kar, 2018). Table 5 shows the values of Unstandardized Estimates (UE) and Standardized Estimates (SE) of hypothesis tests which indicate the impact of various components in smart cities on citizens' quality of life residing in smart cities. It is observed that all the values of unstandardized estimates and standardized estimates are positive and statistically significant. The relation between components CE \rightarrow QoL (H1), and EoL \rightarrow QoL (H2) shows positive and medium impact relationships as standardized estimates are smaller than 0.5 while CP \rightarrow QoL (H3) shows positive and high impact relationships as standardized estimates are greater than 0.5 (Suhr, 2006).

Discussion

This study has aimed on ascertaining the impact of governance, ease of living, and citizens' perception on the citizens' quality of life in mid-sized smart cities in India. Results of CFA show that the loading factor of measurements in all the constructs is greater than 0.5, and that of cross-loading factors is smaller than 0.5. Therefore, the results respond affirmatively to the convergent validity and discriminant validity of the components. Both convergent and discriminant validity are subcategories of component validity, and both together confirm the component validity (Brown and Chin, 2004; Chatterjee and Kar, 2018). After confirming the component validity, the SEM was performed on the research model using AMOS Graphics version 23 software (Zhu et al., 2022). One of the important issues that can influence the SEM results is multicollinearity. The Pearson correlation test was used to determine whether there exists a problem of multicollinearity. All the correlation coefficients in the Pearson correlation test are found to be in the range of 0.60 and 0.83 which infers that there does not exist an issue of multicollinearity, and the data is fit to feed to SEM. The results of fit indices obtained from the SEM indicate that the conceptual

model is valid but can be improved further by incorporating other factors that can influence the quality of life. The Standardized and Unstandardized estimates obtained by performing SEM and shown in Table 5 validate all the hypotheses and reiterate the results so obtained. The outcome of the conceptual framework present important findings regarding the impact of governance, ease of living, and citizen perception on the citizens' quality of life in smart cities. The results show that governance has a low but positive impact on citizens' quality of life in smart cities (SE=0.11) since good governance promotes citizen engagement, and makes service quality, and municipal administration efficient, effective, and reliable resulting in improving the quality of life of citizens in smart cities. These findings corroborate with the findings of Vázquez et al., (2018) which found that smart governance component is least associated with citizens' quality of life as compared to components like economy and people. The findings also corroborate with the findings of Capdevila and Zarlenga (2015) which highlights that smart citizens and not smart governance of smart cities should be the focus to improve living standards of the citizens. The findings of the study contribute an additional dimension to findings of Bovaird and Löffler (2003) which emphasizes on the role of awards, incentives, and rankings to public governance bodies for their performance in improving the citizens' quality-of-life. The ease of living component which include citizen satisfaction with smart city services, environment and economic ability presented a medium positive relation with citizens' quality of life in smart cities (SE=0.46). The findings corroborate with the study conducted by Macke et al. (2018) which states that overall well-being which encompasses the satisfaction with municipal services and natural environment along with socio-structural relation and community integration determine citizens' quality of life in smart cities. The study conducted by Diener and Suh (1997) imply that economic well-being, subjective well-being and social indices together ensures better quality of life for citizens in society. This study aligns with the findings of present study. The citizens' perception component has a highly positive impact on the quality of life of citizens living in smart cities (SE=0.66). The findings support the study conducted by Giannico et al. (2021) which states that citizen perception of objective greenness

in the neighborhood has positive influence on their quality of life. The findings are novel and contribute additional dimensions to the findings of [Weziak-Białowolska \(2016\)](#) which states that citizens are tend to satisfy with their quality of life when they “feel” safe and secure with their place of living as oppose to other parameters such as municipal services, public administration, natural environment etc. which otherwise influence their material well-being. It confirms that citizens’ quality of life is influenced by their subjective understanding of experiences in smart cities.

CONCLUSION

This research article attempts to provide a substantial theoretical and practical contribution to urban studies. The hypotheses test reveals that citizens’ quality of life in Indian mid-sized smart cities is positively influenced by the components such as city governance, ease of living, and citizens’ perception of smart cities. Among the three components focused on in the present study, the citizens’ perception component has the highest influence relationship over the citizens’ QOL in mid-sized smart cities. This finding highlights the contribution of citizens’ perception of smart cities in improving their QOL. The study reveals that the citizens’ subjective understanding of smart cities is influenced by various factors such as their city’s resilience to pollution and disaster management, efforts of the municipality in involving the citizens in city affairs, and the ease of using the services and facilities in smart cities. The positive perception of the above factors has a positive influence on their QOL. The crucial advantage of citizen perspective component in quality of life assessment is that it based on the experiences of the individuals. When significant population have positive experience with the smart cities, it reflects on their overall quality of life. The ease of living component in the present study shows a medium positive impact on citizens’ quality of life in mid-sized smart cities. This finding highlights the importance of citizen satisfaction, the natural environment, and the economic ability of citizens to fulfill their aspirations, etc. in enhancing their QOL. The study reveals that cities that focus on the factors such as sustainable resource management, pollution-free natural green,

and a clean environment, ensure employability and entrepreneurship with an innovative spirit to ensure a significant QOL for their citizens. The governance component in the present study which includes citizen engagement, quality of services provided by the smart city, and the role of the Municipal Corporation shows little positive impact on the quality of life of citizens in smart cities. The findings reveal that the factors such as service quality, the performance of local urban government and administration as well as citizen engagement in city affairs do not significantly influence the citizens’ living standards. But the findings can be summarized as citizens are consumers of services and engaging citizens in urban affairs would ensure constant feedback from the users on the services, thereby improving the service quality. The proactive response of the municipality to the feedback from the citizens and timely redressed of the grievances expedite good and smart governance. Thus, from the study, it can be concluded that the QOL is more a psychological construct than a social one. Smart cities are perceived differently by different people. Some pursue smart cities as tall high rising buildings while some pursue smart cities as technologically driven urban agglomerations. Similarly, the quality of life is perceived differently by different people. The citizens of smart cities strongly believe that smart city projects in their respective cities enhance their quality of life. Considering these findings in the context of mid-sized smart cities, this study significantly contributes in existing studies on tools and indicators of quality-of-life assessment in urban centers specifically in developing countries. This research article provides a substantial theoretical and practical contribution to urban studies. By applying this conceptual framework to mid-sized smart cities, policymakers and administrators can frame and implement the policies for enhancing the citizens’ quality of life through citizens’ perspectives. As the study is conducted from the citizens’ perspective, its managerial contribution is focused on the targeting strategic drivers that can assist policymakers in the formulation of public policies and initiatives of the municipal executive that involve the populace from the perspective of the components of smart governance, ease of living, and citizens’ perception to improve the QoL.

Limitations and future scope

The study is limited to three components- governance, ease of living and citizen perception, which influences the quality of life. The quality of life is a multifaceted, intricate concept that necessitates numerous approaches from various theoretical perspectives. Future studies are suggested to investigate more components that influence citizens' quality of life in smart cities. While we tried to incorporate the respondents-participants in the survey from all walks of life, various educational qualifications, professions, and occupations, as the genders and different socio-cultural backgrounds, it is necessary to admit that our study is not a true representative of the whole population residing in smart cities which is spread across all 100 smart cities in India. All the respondents-participants in the survey belong to Pune, Nagpur, and Indore cities, representing mid-size smart cities in India. The results of this study therefore cannot be applied to both large and small cities in India. The results of this study cannot be applied to all 100 prospective smart cities in India, which are located in the country's northern, eastern, western, southern, and central regions and have different cultures, belief systems, and political environments, etc. These are some limitations to our research that future researchers need to address. It is also crucial to study the governments of smart cities in terms of various policies and programs to improve citizen participation, quality of services, overall satisfaction of citizens, and their quality of life in smart cities. A comprehensive study on all the smart cities in India and separate studies on other smart cities in India and various aspects related to those smart cities can also be conducted.

AUTHOR CONTRIBUTIONS

M. Vikrant Dhenge performed the conceptualization, literature review, data collection, analysis and interpretation of the data, prepared the manuscript text, and manuscript edition. G.N. Nimbarte performed the literature review, compiled the data and manuscript preparation.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. 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.

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ABBREVIATIONS

<i>AVE</i>	Average Variance Extracted
<i>CR</i>	Composite Reliability
<i>CE</i>	Citizen Engagement
<i>CS</i>	Citizen Satisfaction
<i>CP</i>	Citizens' Perception
<i>ECO</i>	Economic A
<i>EoL</i>	Ease of Living
<i>ENV</i>	Environment
<i>GOV</i>	Governance

<i>KMO</i>	Kaiser-Meyer-Olkin
<i>MUN</i>	Municipality
<i>p-value</i>	Probability value
<i>QoL</i>	Quality of Life
<i>r</i>	Pearson correlation coefficient
<i>r-value</i>	Pearson correlation coefficient
<i>RMSE</i>	Root Mean Square Error
<i>SCM</i>	Smart Cities Mission
<i>SE</i>	Standardize Estimates
<i>SQ</i>	Service Quality
<i>UE</i>	Unstandardized Estimates

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ORIGINAL RESEARCH PAPER

Analysis of the challenge of urban management from the viewpoint of experts and executive managers

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ABSTRACT

BACKGROUND AND OBJECTIVES: The importance of integrated urban management has become increasingly evident in today's world, particularly for large cities facing physical, spatial, and demographic growth and complexity. In Iran, the lack of effective citizen participation and integrated management has posed a significant challenge to the urban management system. To address this issue, this research focuses on the role of citizens and urban activists in various levels of Tehran metropolis management, including policy making, planning, supervision, and control. It also evaluates the legislative and executive layers to emphasize their importance in achieving effective urban management.

METHODS: The present study adopts a qualitative research design, with a practical orientation in terms of its objectives, and an analytical-exploratory approach for data collection. The study focuses on experts and city managers as the statistical population of interest. To gather data, a questionnaire was developed and distributed among the target community. The reliability of the questionnaire was assessed using Cronbach's alpha coefficient, which yielded a high value of 0.97. Data analysis involved the use of descriptive statistics, including frequency, frequency percentage, mean, and standard deviation, as well as inferential statistics, specifically the one-sample t-test. The statistical analysis was conducted using the SPSS software package.

FINDINGS: According to the findings, 31.4% of the responses identified the citizens and 25.7% of the responses identified the municipality as the owner of the city. 68.6% of the answers have identified the municipality as the manager of Tehran city. Also, 80% of the respondents said that management fragmentation is the biggest challenge of urban development in Iran. The most influential institutions in the process of urban management are Tehran Municipality at the policy-making level, self-governing experts and researchers at the planning level, the Tehran Islamic Council at the monitoring and control level, the Islamic Council at the legislative level and Tehran Municipality at the executive level, while the citizens are the last.

CONCLUSION: The present urban management approach faces significant obstacles in the form of fragmentation and inadequate coordination among decision-making entities. These challenges result in disarray, duplication of efforts, and squandering of resources. Consequently, the absence of transparency and lucidity in the roles of city proprietors and managers, coupled with the lack of precise delineations for the engagement of organizations, individuals, and institutions in the urban management process, could impede the attainment of sustainable development objectives and curtail the capacity of civil society to comprehend and partake in effective urban governance.

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INTRODUCTION

Separation of citizens, who are the owners and users of the urban environment and space, from the process of preparing and implementing urban projects and plans, is one of the critical issues in the current urban development of Iran (Tanku and Woldetensae, 2023). Governments cannot do everything, so they give tasks to local organizations (Ebdali et al., 2018). This helps to solve problems and meet citizens' needs (Soroushan et al., 2021). Modern approaches to city management, such as involving citizens in decision-making, implementing effective city governance, and prioritizing long-term planning, differ from the traditional centralized control method (Alavian et al., 2022). These concepts become meaningful when used in conjunction with other concepts, such as social and sustainable development, civilized society, citizen participation, and human rights (Beidaghi et al., 2023). Thus, it is necessary to determine the levels of application and the practitioners responsible for implementing these concepts and understanding their significance. In this case, determining the roles of the main agents in urban management makes it possible to identify a suitable framework for developing infrastructure for urban management and reaping the benefits of good urban governance (Ziari et al., 2020; Rasaizadi and Askari, 2020). Thus, it is essential to determine who should be involved in decision making and the capacity to implement the desired urban management approaches (Eftekhari et al., 2018). The government of Iran has a significant influence on the management of cities. This is because of several reasons, such as the centralization of authority, the influence of external factors on plans and designs, and the economy's dependence on oil. Urban management in Iran is not organized or integrated because of these factors. It focuses too narrowly on specific areas and fails to address the issues arising from urban development. It is also controlled by a top-down approach, meaning that decisions are made by the government and not by the people who live in the cities (Hekmatnia et al., 2017; Boochani et al., 2020). In Iran, urban management does not have an integrated and single management system; therefore, many institutes and municipalities influence urban administration (Ebdali et al., 2018). Such a lack of integrated urban management would result in parallel work, friction, conflicts between departments, a lack of coordination in duties, and

failure to take responsibility (Haji and Hayati, 2022). Tehran is an important metropolitan area in Iran. This is the administrative and political capital. However, this city faces many problems and challenges in managing its affairs at national, regional, and local levels (Hajilo et al., 2019). The reason is that Tehran Municipality has limited control over urban management, and the lack of integrated urban management hinders the provision of urban services in an organized and efficient manner. This leads to wastage of city resources and disrupts the delivery of urban services (Vahidnia, 2022). This study examines the influence of urban owners and managers in Tehran, and specifically how they impact urban management. This research looks at many aspects of urban management and shows why mayors need more power to run cities, even big cities. It also analyzes the current governance system. In addition, it offers a unique perspective on urban management and emphasizes collaboration, transparency and accountability with practical solutions. To achieve these objectives, the research was conducted in Tehran, Iran in 2023.

Theoretical Foundations

City is the biggest community in the world. Efficient processes and informed decisions by city management aid development. Public interest in sustainable development can improve a city's life (Ebdali et al., 2018). Urban management in developing countries requires a consistent and integrated approach to urban issues (Shojarazavi et al., 2023). Understanding integrated urban management requires an understanding of the relationship between three key aspects: the various actors involved in urban management (such as decision makers, urban planners, policymakers, city executives, and urban stakeholders such as citizens and the private sector); the different layers of urban management (including policy-making, organizing and planning, and the executive layer); and the various instruments used in urban management (such as human resources, organizations, financial resources, and rules and regulations) (Talebpoor and MojahidDini, 2018). Experts believe that integrity is crucial to urban management. This includes integrating management tasks, integrating various contexts of urban planning and geography, and integrating relationships between influential institutions such as the city council,

central government, and the local state (Sarvar *et al.*, 2019; Mousavi and Ziyari, 2017). Therefore, the concept of integrity opposes that of multiplicity and fragmentation. Multiplicity and fragmentation may occur in politics, planning, and other issues (Hajilo *et al.*, 2019). Hence, coordination is required to prevent the adverse effects of multiplicity and fragmentation (Shahidasht *et al.*, 2022). Commentators categorized urban management into three groups: Model (A) provides a solution for managing cities and regions by integrating planning and governance. This sentence is about fragmentation in planning policy and includes two types of fragmentation in function and territory (Rivolin and Faludi, 2005; Barakpour and Asadi, 2009; Rahmani, 2012). The divisions in model (B) include functional, political-programmatic, territorial and political-government divisions. Fragmentation occurs due to the presence of multiple stakeholders. To solve these problems, there is a need to change and control the decision-making process in the management of cities; in this regard, it is necessary to focus on supporting local organizations (Kazemian and Mirabedini, 2011; Karami, 2019; Hajilo *et al.*, 2019). Model (C) is divided into physical, social, functional, visual, spatial-ecological, theoretical, planning policy, political government analysis, and benefit sharing. There are also divisions based on the ecology. To deal with these challenges is the use of strategic spatial planning (Barakpour and Asadi, 2009; Nadin, 2006; Rivolin and Faludi, 2005; Ghalibaf *et al.*, 2012).

Urban Management System in Iran

The first experience of urban management in Iran dates back to the constitutional era when urban associations emerged. One of the most significant achievements of the First Constitution Era was the evolution of the structure of social institutions, which faced crises for various reasons, such as the mistrust of citizens in all governmental entities (Abadian and Bitarafan, 2012). Overall, urban management levels are classified into three categories: excellent (central government), average (provincial government), and operating (local government) (Moghimi, 2019). In Iran, these levels include national, provincial, and local (city) (Ebdali *et al.*, 2018). Fig. 1 presents the primary institutes and organizations involved in establishing interorganizational relationships in urban complex management. This describes their tasks and authority. In the categorization, urban

management is considered at three levels: mayors with limited authority, mayors with moderate authority, and mayors with extensive authority. Iran is a regional power with limited authority. In this category, the mayor has limited authority, and the central government typically plays a significant role in urban management, which leads to minimal citizen participation. In this method, the mayor must have a wide range of authorities to administer to cities, especially megacities (Arzani-Birgani and Kohzadi-Seifabadi, 2021).

Urban Management System in Tehran Metropolis

As a strategically located and densely populated city, the Tehran Metropolis holds a significant position (Taghvaei *et al.*, 2021). Tehran Metropolis, which has many activists and actors at various management levels, faces numerous conflicting barriers, such as the degradation of environmental resources and the unplanned increase in activity and residential development in metropolitan and peri-metropolitan areas (Soroushan *et al.*, 2021). There is currently no established system or protocol in place for facilitating coordination between the various organizations involved in managing Tehran, as depicted in Fig. 2. Several institutions have a significant influence on the administration of the city, including the Islamic Council Assembly, Government Board, Ministry of the Interior, and Governorate. Furthermore, public institutions such as the Tehran Municipality and Governorates, as well as private companies and organizations, also play a role. The involvement of foreign embassies, representative offices, and international organizations further complicates the system (Khandan and Sobhani, 2021; Boochani *et al.*, 2020; Ashtianiaraghi *et al.*, 2020; Hajilo *et al.*, 2019, Karami, 2019).

Literature review

Experts and researchers have conducted studies on urban development issues in Iran from various perspectives. These studies have examined the challenges faced by urban development organizations in Iran, considering factors from outside, inside, and within a group. According to the current study's focus, various sources have been investigated, including Yadgarzadeha and Noorian (2022), who highlighted that urban development groups in Iran face external, internal, and intra-group factors that

Urban management challenges from the viewpoint of executives

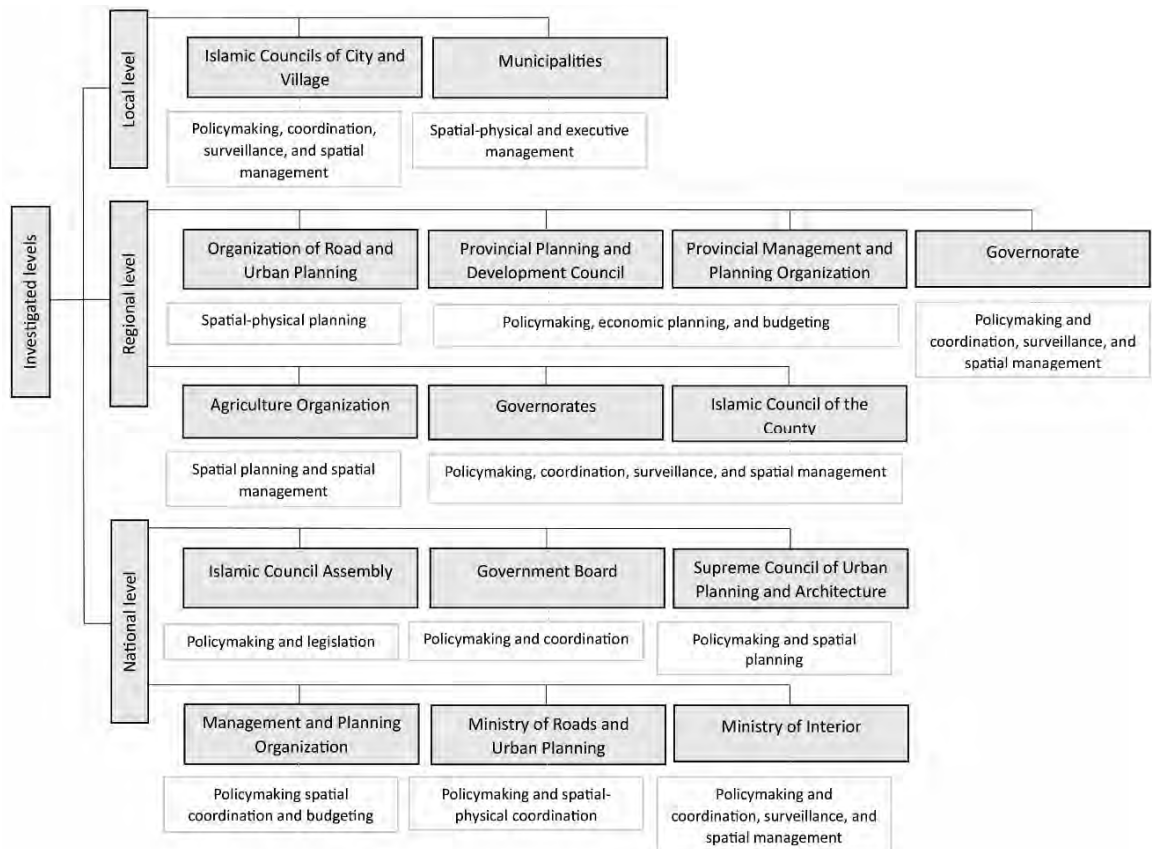


Fig. 1: Main institutes and organizations in the field of urban complex management (Asgari and Kazemian, 2006)

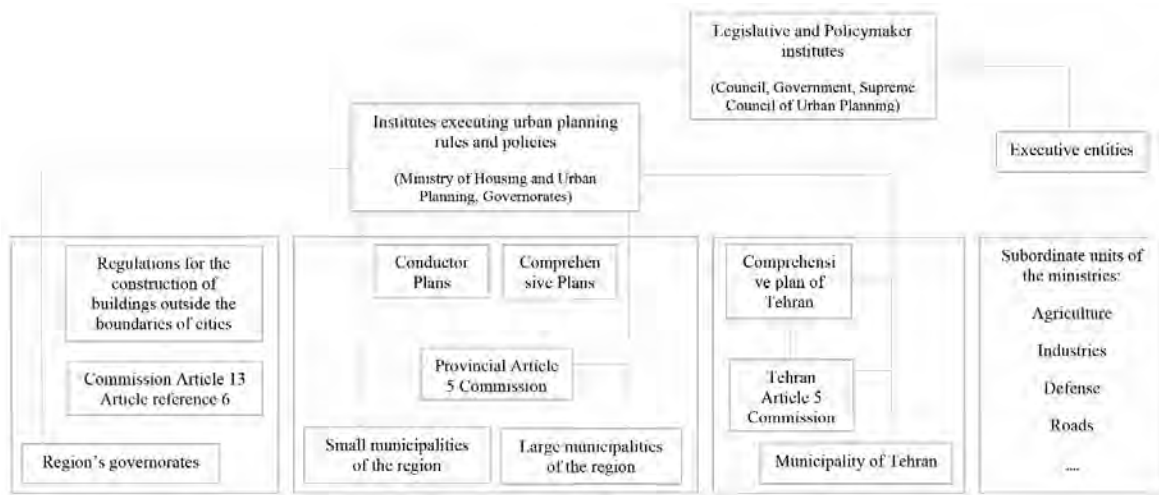


Fig. 2: The model of communication between different institutes in urban management of Tehran (Faraji Rad, 2017)

impede effective organizational functioning. This article does not address the challenges faced by urban development groups, but rather focuses on the construction engineering organization. It also does not discuss the impact of various factors on urban development, nor does it include the views of experts from different urban development organizations. Akhoundi *et al.* (2006), focused on the challenges of political and functional fragmentation in the metropolitan area of Tehran and the centralized planning system, emphasizing the necessity of a new method for urban management and suggesting the use of a good system to address the challenges of the Tehran Metropolitan Region (TMR). This article does not discuss the limitations of the study on TMR governance, but suggests that more institutional and functional studies be conducted on TMR organizations to improve governance in the Tehran Metropolitan Region (TMR) through laws, money, and politics. Tabari and Mousavi (2019) described how rentier networks dominate urban management in Tehran. This leads to conflicts and elites who do not use the proposed solutions. However, it does not explain how rentier networks affect the progress and growth of the city, does not point to the limitations of the grounded theory method, and does not analyze how to disrupt rentier networks in Tehran. It also failed to guide the creation of a fair and transparent urban management system. Maghsoodi Tilaki *et al.*, (2014) have identified five significant obstacles, including the lack of proper plans and regulations, inadequate public participation, and limited financing, that impede urban planning in Iranian cities. The authors recommend that the urban planning system in Iran be compared with contemporary planning ideas, such as the City Development Strategy (CDS), and that greater cooperation be established among city stakeholders and more authority be granted to local authorities to promote effective urban planning. This study focuses on the strengths and weaknesses of comprehensive planning but does not address the challenges faced by Iranian cities in urban planning, the impact of urban development programs on Iranian cities, or the perspectives of urban planners, managers, and experts. To address these gaps, this research examines the role of the city owner, city manager, and other institutions and organizations in the management process of the city of Tehran. The study also draws on the experiences of executive

managers and urban planning specialists to present practical strategies for effective urban planning. The research was conducted in Tehran, Iran in 2023.

MATERIALS AND METHODS

This research underscores the imperative for transparency and clarity in delineating the roles of various organizations, individuals, and institutions involved in Tehran's urban management due to the significance of effective urban governance and decision-making. The research is a qualitative and analytical-exploratory study that employs library research and field techniques to gather data. Researchers have utilized the views of experts, managers, and professors who have shaped Tehran's plans and programs. The data were analyzed using descriptive statistics such as frequency, mean, and standard deviation, as well as inferential statistics from a single-sample t-test with SPSS software. The one-sample t-test is a parametric method and one of the types of community average tests. The researchers used this test to study ideas and answer related questions using a Likert scale, and a five-point Likert scale was employed to measure attitude. The study aims to understand whether experts and managers in the field of urban planning perceive the division in urban management as a challenge for urban planning in Iran. To this end, a questionnaire was devised and distributed to the target community. Thirty-five questionnaires were completed and received. The research implementation stages were designed using two models (Fig. 3). Urban development experts evaluated and confirmed the validity of the questionnaire's form and content. The questions were divided into two parts, with Section A asking about personal characteristics and Section B discussing work-related topics. Part B consists of three parts, with the questions in Section B.1 being open-ended to allow for diverse responses, and Section B.2 offering multiple choices to obtain accurate information. Finally, Section B.3 utilizes a five-point scale to measure the influence of urban activists on Tehran's management levels. Unfavorable components have a mean value that is lower than the average Likert scale rating of 3. Components with a rating higher than the average represent the optimal scenario. If the significance level is below 0.05, the mean value can be applied to the entire population (Samimi, 2024). The t-test was compared to the

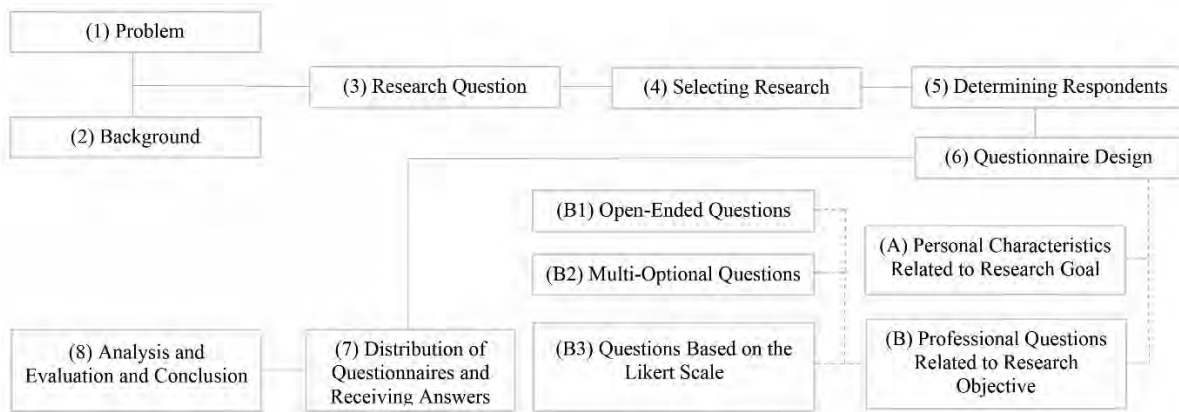


Fig. 3: Research implementation steps

critical value of 1.96. If the test value is greater than 1.96 or less than -1.96, the null hypothesis is rejected and the opposite hypothesis is accepted. However, if the test value falls within the range of $[-1.96, +1.96]$, no conclusion can be drawn regarding the mean value. If the upper and lower limits are positive, the component's status is above the average, indicating favorability. Negative constraints, on the other hand, indicate that the component's state is unfavorable. This study aims to investigate the degree of influence of urban activists in different layers of policy, planning, supervision and control, legislation, and executive policies. The questionnaire consists of 80 questions, with 16 related to the policy layer, questions 17-32 related to the planning layer, questions 33-48 related to the monitoring and control layer, questions 49-64 related to the legislative layer, and questions 65-80 related to the executive layer. Cronbach's alpha was used to calculate and analyze the questionnaire's reliability, yielding a result of 0.97, which is higher than 0.7. Therefore, the questionnaire showed good internal consistency and reliability. This study will determine the penetration rates of different organizations and which organizations have the highest and lowest penetration rates.

RESULTS AND DISCUSSION

Among the respondents, 17.1% were female and 82.9% were male. Among the participants, 37.1% selected urban development, planning, and design as their major field of study. The remaining participants studied various subjects such as construction, architecture, geography, economics, sociology,

law, management, environment, engineering, and plant physiology. Among the respondents studied, 71.4% held a Ph.D. or higher degree or were Ph.D. researchers. Additionally, 62.8% of the respondents were employed by the municipality. Regarding the question of who owns Tehran, the responses indicated that a variety of entities are considered to be the owner, including citizens, municipalities, city councils, governments, and ministries. Of the respondents, 31.4% identified citizens as the owners and 21.6% identified the municipality as the owner of the city. The majority of the participants in the survey believed that citizens play an important role in urban planning and that the Tehran Municipality, as the owner of the city, has a significant role in city management. However, there were differing opinions regarding the ownership of Tehran. Some experts have introduced citizens as the owners of the city, while others have named other institutions or organizations. In terms of the management of Tehran, the survey results showed that the majority of experts identified the municipality as the manager of the city, with 68.6% of respondents selecting this option. Only 2.9% of respondents identified the leader as the city manager, while 5.7% each identified the city council and the government as the managers. Two respondents (5.7%) named the governorate as the manager, and one respondent (2.9%) named the president as the manager of Tehran. The majority of respondents emphasized the municipality as the primary city manager of Tehran, with only a small number of individuals suggesting other organizations and institutions. This information can be utilized by

Table 1. The answer to the question of management fragmentation as a challenge of urban development in Iran

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	28	80.0	80.0	80.0
	No	7	20.0	20.0	100.0
	Total	35	100.0	100.0	

Table 2. Answer to the question of urban development in Iran

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Renter oil-dependence political economy	10	28.6	28.6	28.6
	The low level of public participation in the administration	7	20.0	20.0	48.6
	Multiplicity in legislation and surveillance	8	22.9	22.9	71.4
	Managerial fragmentation	10	28.6	28.6	100.0
	Total	35	100.0	100.0	

policymakers and urban managers to understand the perspectives of experts on the responsibilities of urban institutions. As shown in [Table 1](#), 80% of respondents agreed that management dispersion is the primary challenge in the urban management process in Iran, with 20% disagreeing. Most participants in the survey believed that managing Iranian cities is a complex process.

This survey underscores the need for collaborative efforts among decision-makers in urban management in Iran. The current fragmented management structure is hindering sustainable development, and the dependence on oil rents in the political economy is also a significant challenge. The participants in the survey were asked to identify the primary challenges facing urban development in Iran, and the options included managerial fragmentation, low public participation, a political economy dependent on oil rents, and excessive regulation and oversight. The most frequently chosen options were managerial fragmentation and dependence on oil rents. In Tehran, the low level of public participation in city management was cited as a significant issue by 20% of respondents, while multiplicity in legislation and supervision was identified as a challenge by 22.9% of respondents ([Table 2](#)). Respondents believed that the lack of collaboration among managers and the reliance on oil are major impediments to urban growth in Iran. Only 20% of respondents considered low public participation to be a significant problem, and a significant number of respondents (22.9%) identified excessive regulation and oversight as a challenge. This survey highlights the need to address

the issue of fragmented management and reduce dependence on oil rents in the Iranian economy. The lack of public participation in urban management is also a challenge that needs to be addressed, and citizens should be encouraged to participate in urban development. To ensure the successful development of cities in Iran, the issues must be addressed through effective laws and supervision. Additionally, the impact of different institutions and organizations was evaluated across various layers of policymaking, planning, supervision, and control, legislation, and implementation.

[Table 3](#) indicates the organizations that influence policy making. The results show that governmental institutions, non-governmental organizations, public sector institutions, and international institutions are the influential institutions. The findings of this study can assist policymakers in understanding how to incorporate these organizations into monitoring and management. In the planning layer, non-governmental organizations, public governance organizations, governmental institutes, citizens, private sector institutes, and international institutes are the influential institutions. The research also found that independent experts and researchers from non-governmental organizations, the Tehran municipality from the group of governance-public institutes, and the Supreme Council of Urban Planning and Architecture from the governmental group had the highest effectiveness. In the surveillance and control layer, the Islamic Council of Tehran, along with the Ministry of Interior and the governorate, has the highest effectiveness among the governance-

Table 3. One-sample t-test results of the influence of the mentioned organizations on the desired layers

Layers Organizations	The Policymaking Layer	The Planning Layer	The Surveillance and Control Layer	The Legislation Layer	The Execution Layer
Islamic Council Assembly	6	6	6	1	12
Ministry of Interior and Governorate	4	4	3	4	3
Ministry of Road and Urban Planning	5	5	5	5	4
Supreme Council of Urban Planning and Architecture	3	3	4	3	6
National Land and Housing Organization	7	8	10	7	8
Urban Development and Improvement Organization	8	7	8	8	5
The General Inspection Organization of the Country	10	13	7	10	10
Policymaking Council of Joma Imams	11	15	12	12	15
Tehran Municipality	1	1	2	6	1
Islamic Council of Tehran City	2	2	1	2	2
Organization of endowments and charity affairs	14	14	14	13	14
Association of Consultant Engineers	9	9	11	9	9
Independent Experts and Researchers	16	12	12	14	13
Service Organizations in the Private Sector	13	11	15	15	7
International Institutes such as the UN	15	16	16	16	16
Citizens	12	10	9	11	11

public institutes. The research also found that the Islamic Council and the Supreme Council of Urban Planning and Architecture have more influence. The Ministry of Roads and Urban Development has less supervision over this layer. The Islamic Council Assembly and the Islamic Council of Tehran have the highest average values. The Islamic Council, the Ministry of Interior, and the Governorate have the most influence, and independent experts and researchers have the least influence in the legislative layer. At the executive level, public governance institutions, state governance institutions, private sector institutions, citizens, non-governmental organizations, and international institutions are the influential institutions. The Tehran Municipality, which is in the group of governmental institutions, the Ministry of Interior, and the Governorate in the subgroup of governmental institutions and consulting engineers, which is in the group of non-governmental organizations, have the most influence in this layer.

According to the findings of this research, the level of citizens' participation in the administration of city affairs remains low and their influence in the urban management layers is minimal. This indicates a multiplicity of institutions and organizations involved in the urban management process, with

no similar or constant influence rates across different layers. [Yadgarzadeh and Noorian \(2022\)](#). confirm these findings, identifying three groups of challenges including external factors, internal factors, and intergroup factors. Organizations contribute the most, followed by a wider variety of in-group agents, reflecting urban developers' critique of their professional community. Internal factors, including interorganizational relationships, pose a challenge due to the lack of coordination and clear definition of the roles of organizations in the urban management process. [Ahmad Akhouni et al. \(2006\)](#) discussed in a scholarly article the significant challenge that integrated policymaking faces in the metropolis of Tehran. The authors noted the presence of numerous government and administrative territories, leading to fragmentation, alongside a centralized planning system that promotes sectionalism. Given the unique circumstances of Tehran, it becomes crucial to reassess its governance structure. The research findings also indicated a lack of cooperation and participation among key stakeholders involved in the administration of Tehran metropolis. Furthermore, the study highlighted the insufficiency of public participation mechanisms in the decision-making and implementation processes. According to the study

conducted by [Tabari and Mousavi \(2019\)](#), closed rentier networks possess significant economic and political influence that impacts macro policies and decision-making within the city. These networks prioritize projects for maximum profit, regardless of the detrimental effects on the city. The political economy of basic rent continues to be a challenge in urban management. Iranian urban experts consider the management of urban buildings in Tehran as a form of institutional capital in the urban space, involving multiple stakeholders in the management of urban spaces, whose actions can be evaluated to ensure the interests of the public are met. [Maghsoudi Tilaki et al. \(2014\)](#) identified five major obstacles to the feasibility of the urban planning process, including contextual factors, the structure of urban planning, relevant laws and regulations, public participation, and financial resources, and the fragmentation of urban management layers. In the current research, the study aims to examine the extent of influence exerted by different organizations in achieving development by analyzing various layers of urban management. The control of urban management units in Iranian cities is not centralized, with multiple offices, departments, and agencies involved in decision-making for urban development. The lack of integrity in urban management is also evident in the current research.

CONCLUSION

The investigation focused on the impact of urban owners and managers in Tehran on urban management. Research findings indicate a lack of transparency in determining the ownership and management of Tehran, with various organizations, individuals, and institutions failing to define their roles in urban management. A minority of respondents acknowledged that citizens possess ownership of Tehran, yet their influence on urban management remains limited. Experts highlight the absence of coordination among managers as the primary obstacle to city development in Iran. The dispersion of urban planning in Iran poses a significant challenge, impeding the formulation of effective solutions. The management process of Tehran City is primarily overseen by Tehran Municipality and the Supreme Council of Urban Planning and Architecture. Collaboration among experts, researchers, municipalities, and the

Supreme Council occurs at the planning level. The Tehran Islamic Council, Tehran Municipality, and the Ministry of Interior are responsible for supervision and handling of affairs, while the Islamic Council and the Tehran Islamic Council enact relevant legislation. The management of cities involves numerous institutions and organizations, including the executive layer consisting of Tehran Municipality, Tehran Islamic Council, Ministry of Interior, and Governor's Office, which hold significant sway over urban management. However, this fragmentation poses a major challenge to achieving sustainable development and a civil society. To address this issue, local organizations must be empowered with greater decision-making power, which can be achieved through citizen participation. These organizations should also establish horizontal relationships and coordinate with one another to create an integrated urban management system. Unfortunately, there is a lack of transparency in the introduction of the owner and city manager, and citizens are not sufficiently involved in city management. To overcome these challenges, good governance practices can be implemented, and strategies can be developed to encourage citizen participation in urban governance. By doing so, an integrated urban management system can be established, which will benefit all stakeholders involved.

Suggestions

Strategies for citizen participation

- Using participatory budgeting methods
- Moving towards participatory planning at the neighborhood level
- Raising awareness of citizens' ability to choose suitable individuals for city council
- Facilitating the involvement of city stakeholders in planning and executing urban projects
- Encouraging engagement with communities and promoting good citizenship
- Improving services for citizens, with a focus on poor areas and the provision of necessary infrastructure
- Attending meetings with city officials by sharing information and helping people to build trust

Strategies for integrated urban management system

- Encouraging collaboration between different levels of government

- Increasing transparency and accountability
- Promoting public-private partnerships
- Fostering innovation and creativity in urban planning and management.
- Establishing a council to supervise organizations led by the mayor
- Integrating local organizations and increasing their authority
- Transferring urban management to the municipality

AUTHOR COUNTERBUTIONS

S. Mahdinezhad conducted the research, which involved gathering materials, developing the methodology, collecting and analyzing data, interpreting the findings, and drafting and finalizing the article. M.H. Boochani was responsible for conceptualizing, supervising, orienting, collecting data, and revising the article. A.A. Malekafzali contributed to the research methodology, techniques, and modeling, as well as project management.

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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.

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ABBREVIATIONS (NOMENCLATURE)

<i>CDS</i>	City Development Strategy
<i>df</i>	Degrees of Freedom
<i>Fig</i>	Figure
<i>Ph.D.</i>	Doctor of Philosophy
<i>SD</i>	Standard Deviation
<i>t</i>	Test Statistics
<i>TMR</i>	Tehran Metropolitan Region

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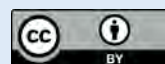
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ORIGINAL RESEARCH PAPER

Human resource analytics: A novel approach to bridge the gap between human resource functions and organizational performance

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ABSTRACT

BACKGROUND AND OBJECTIVES: Human resource analytics played a vital role in human resource practices like training, selection and performance management and other function of human resource management. The objective of this study is to identify the major challenges by understanding when, how and why human resource analytics leads to enhancement of performance of organization and unveil the methods that increase organization performances. The aim of stud is identifying the types of human resource decisions that can benefit from analytics and understanding the challenges and opportunities associated with incorporating data into decision-making. Impact on human resource functions: examine the specific areas within human resource management where analytics can have a significant impact. This may involve studying talent acquisition, employee engagement, performance management, training and development, and other human resource functions to assess how data-driven approaches can enhance efficiency and effectiveness.

METHODS: The present study is mainly based on the primary data which is collected from human resource management personal of top 10 private life insurance company is considered for data collection of research. The data were collected from 194 employees of the human resource department. Quantitative methods are used to examine primary data gathered from the companies. The data is collected through a questionnaire-based survey. The questionnaires were distributed to the target population, it is a closed questionnaire. Multiple regression analysis and t-test were applied to analyze the data. The statistical package for the social sciences software was used to process the data. Validity and reliability test along with one sample t-test, independent sample t-test are conducted in this research.

FINDINGS: The study found that the benefits of human resource analytics such as quick and reliable information processing, helping managers to draw meaningful patterns in the data, deeper insights in the employee data. Human resource analytics on organizational performance, multiple regressions were applied. The study found that the model explained 59% of the variance (R square = .593). The digitalization of human resource functions refers to the process of leveraging technology and digital tools to automate, streamline, and enhance various human resource processes and activities. It involves using digital platforms, software applications, and data-driven approaches to improve efficiency, accuracy, and effectiveness in managing human resources. Digitizing human resource processes reduces complexity within the department while also improving administrative quality and human resource flexibility.

CONCLUSION: The results demonstrated the importance of these fast decision making, better and improvement in the quality of decision-making significantly affects the human resource organizational performance and human resource functions. The study is helpful for human resource professionals to concentrate more on duties that are relevant to their work. In terms of efficiency, it is found that digitizing human resource procedures leads to an increase in administrative quality and human resource flexibility, as well as a decrease in bureaucracy within the function. Digitalization is a tool that speeds up the communication process while lowering costs, allowing companies to be more productive and perform more effectively and efficiently.

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INTRODUCTION

The concept of “Human Resource (HR) analytics” is still a new impression. Interest in human resource analytics has been exceeded in different disciplines of management, together with human resources management that has been witnessed by increasing number of human resource departments adopting “human resource analytics” to enhance decision making process. Technological innovations like artificial intelligence machine learning and cognitive computing enable human resources practitioners to handle complicated human resources issues and make smarter decisions by analyzing vast volumes of data (Chowdhury *et al.*, 2023). Human resource analytics procedure is becoming popular day by day. Human resource analytics is always found as a part of human resource practices like training, selection and performance management that has long olden times in social sciences, together with organizational and industrial psychology, human resource and organizational behavior (Mishra *et al.*, 2016; Javed, *et al.*, 2020). Human resource analytics also support in analyzing organizational performances by evaluating employee’s performances time to time. Human resource analytics support in establishing the road to analyze the employee’s performance as it helps in indicating low and high performances in an organization. It provides improvements in present performances for further development. Human resource analytics use statistical procedures that support in obtaining information to reflect the influence on the organization. It created form that supports futuristic sites to look for gap in performances, factors that boost or decrease productivity (Allam and Malik, 2020). With the amalgamation of development of technologies and industries advancement, organizations have adopted human resource analytics that increases effectiveness among organizations. Moreover, the noteworthy enlargement of human resource technology access, involving cloud apps and platforms, human resource information systems (HRIS), has supported departments of human resource the ability to gather, administer and evaluation of huge amount of employee information as compare to early inheritance systems of Information Technology (IT). Such shifting act as an encouragement of human resource analytics and adoption level increases within departments of human resource. Advancement in human resource

technologies supports in collection and evaluation of employees and candidate information. Human resource analytics in google has built a proof-based method to enhance its selection and recruitment process by exploring various elements of better performance that may forecast employee’s success in future (Malik and Allam 2021). Likewise, along with selection and recruitment, human resource analytics supports companies with the ability to identify various challenges of human resource together with engagement of employee, inclusion and diversity, and returns. Human resource analytics is still at developing stage and therefore, practitioners and scholars are hovering to carry out researches showcasing digitization of human resource and handling of increasing amount of employee’s information can influence decision making of human resource and organizational returns (Pape, 2016). Human resource analytics leads to companies to achieve its objectives and insights by obtaining and translating huge quality employee’s information. In comparison to human resource, the use of data is extensively used in other application areas of an organization. In order to deal with this extensive data, the organizations are popularly using human resource analytics, frequently promising not less than the revolving of the “human resource management” (McCartney and Fu, 2022). The importance of human resource analytics is highlighted in the situation of pandemic where the organizations are raising details about remote work culture, employee engagement, and well-being in order to have a good picture of employee’s individual needs. Basically, the situation had offered number of different types of new data sources that particularly promotes the quality of human resource analytics (Bryce *et al.*, 2022). Crucial roles are played by human resource analytics in solving issues related human resource. It is responsible to assist human resource to solve the issues and ensure to follow the policies and objectives of the organization as well. Employments are increased, process of decision making is fastened and the productivity is improved by the use of human resource analytics. Big data is not helpful for the company; therefore, it is systematically extracted with the help of right technology from different sources. This can also find the pattern, trend and also correlate with the data. It is found that actionable insights are provided by the analytics into the behavior of the user which assist to reduce the cost, drives the

revenue and provide good experience as well (Nagpal *et al.*, 2022). The methods used in earlier research on digitalization of human resource functions are more analytical and exploratory, where secondary sources of information have been given greater significance and the conclusions have been drawn based on the available data and literature. There is a lack of descriptive research that is grounded on empirical evidence and that particularly derives its conclusions from primary data.

Aims of study

1. To know the role of “human resource (HR) analytics” to bridge the gap between human resource functions and “organizational performance.”
2. To know the impact of human resource (HR) analytics on human resource functions.
3. To know the impact of human resource (HR) analytics on organizational performance.

To achieve these objectives, the research survey was conducted in Lucknow, India in 2023

Literature review

Cartney and Fu (2022) explored that to adopt proper human resource analytics and to carry out value addition; companies must possess high quality of information, analytical potential and the planned ability to take action. Gupta and Sadique (2020) examined that department of human resource must optimize the method and human resource analytics is very important to take fast and better decisions to match with people capabilities and requirements along with decrease in costs. Tomar and Gaur (2020) explored that as companies are globally rising, they possess huge amount of data in each department. Therefore, it has become difficult to collect and analyze human resource information, so it is important to have human resource analytics also in human resource department. Angrave *et al.* (2016) examined that specific approach or policy brings enhancement or improvements in employees' performance. Hence analytics has the capability to optimize the performances which can effectively resource the talents needed in coming future. Rasmussen and Ulrich (2015) explored that human resource analytics was adopted to set up an association among quality of leadership and low level of turnover that leads to high level of operative competency that further lead to few or a smaller

number of miss-happenings and low time for maintenance and high satisfaction among customer. Douthit and Mondore (2014) explored that human resource information system (HRIS) software involves employee's face graphical user interfaces that are built to design to support in performance management, career planning, knowledge sharing and learning enrolments. Its main objective is to enhance the operations and process of human resource by making it easy and quick to understand. Momin and Mishra (2015) explored that human resource analytics involves complicated project with multi stage including formulation of questions, data organization, research design and statistical modeling of various level of complications and rigor. This complicated method then changed to simplest form by human resource analytics which helps in future management actions. Hota and Ghosh (2013) examined that human resource analytics help organizations to make strategic Decisions which ultimately helps in final analysis of decision making. Verma and Mehrotra (2017) explored that human resource analytics helps in efficiency, accurateness, and overall development of human resource functions which ultimately give worth to human resource department. Lochab *et al.* (2018) explored that human resource analytics possess association with the company's performance. Making decision is a difficult part in every company. It is a tool to enhance the decision-making performance associated to workforce in the company (Allam *et al.*, 2021; Srivastav and Mittal, 2021). George and Kamalanabhan (2016) explored that the biggest factor to accept human resource analytics in a company needs Analytical skill of a person. The adoption of “human resource analytics” is more when the technology accepted for analytics is user friendly. Ramanathan *et al.* (2017) examined that when human resources and companies' leaders work together to deal with main reasons of issues experiment new methods to solve them, at that moment human resource analytics become successful which ultimately help companies to grow. Sharma *et al.* (2014) explored that human resource analytics enhance organizational as well as an individual performance. It also improves the quality of decisions taken by company. The worth of prognostic analytics is more and hence relevant in all areas related to human resource. Lakshmi and Pratap (2016) examined the various purpose of human

resource analytics and apparatus that results in better opportunities for human resource and support in strategic planning of employees in a company, for example compilation of human resource investments, computation, actions and determines the influence of practice and program of human resource on bottom line. [Anam and Haque \(2020\)](#) found that human resource analytics is data driven and supports in taking better decisions starting from recruitment to retaining the finest talent in the company. It supports organizations to recognize talented employees and take decisions on the basis of facts and figures. [Kale, Aher and Anute \(2022\)](#) have focused on human resource practices that has the ability to change the “traditional roles to transformational roles” in organizations, like improvement of quality of recruitment, talent management, employee productivity and decreasing employee turnover. [Kiran et al. \(2022\)](#) examined the relation between “human capital management, human resource analytics and organizational performance” through systematic literature survey. It is found that the human capital management is easily tracked with the help of human resource analytics in the organizations. [Kaur and Dhawan \(2021\)](#) revealed it is difficult for the human resource practitioners to practice analytics due to “lack of necessary expertise and understanding to use the human resource analytics technology, and there may be information security or data management concerns.” [Rao and Vaidya \(2018\)](#) examined that execution of human resource policies and strategy is a major challenge and is human resource professional ready to use and implement various tools and technique such as artificial intelligence, intelligent assistants chat box, etc. [Stefan \(2020\)](#) explored that it is not only aligning digital technologies but strategically executing the technology which helps to create value to the organization and to also observe and evaluate that both are balanced. [Baykal \(2020\)](#) revealed that Electronic Human Resource Management (EHRM) helps human resource professional to focus more on strategic human resource activities rather than the procedural work, it helps in all human resource function and even change the behavior, think pattern, attitude towards work. [Gigauri \(2020\)](#) explored that covid-19 had made organization to switch to digitalization aspect which is the now a most demanding skill of an employee and what effect it has

on work life balance of an employee, up skilling of an employee is very important for sustainability ([Malik, 2023](#)). [Majid \(2019\)](#) found that due to the shift in digitalization and human resource analytics human resource professionals are undergoing a tremendous change in their mindset as well as in technological aspect and a shift from service provider to solution facilitator. [Fernandez and Gallardo \(2019\)](#) found that there is a lot of confusion in concept of human resource analytics i.e. it is not going to replace the traditional method rather it will help in decision making and leveraging value from the data which provide different ways to solve problems effectively and more efficiently. [Suvalova et al. \(2020\)](#) studied human resource field is now changing its trends towards digitalization and human resource analytics and chat bots are helping in solving lots of accounting and compensations calculation, which analyze the effectiveness, only concern is how these changes will be implemented. [Chytiri \(2019\)](#) observed that digital skill gap should be filled by digital technologies and human resource managers have to work as a change agent who promotes human resource analytics and digitalization among all employees of an organization. [Das and Sureshkrishna \(2019\)](#) observed that to remain competitive organization has to adopt new technologies in coordination with human resource and they cannot escape from it. [Sinha and Mishra \(2014\)](#) found that all the tools which were used by human resource professionals are not fully utilized in line with human resource analytics and digitalization, for this training, information, and awareness has to be imparted. [Prakash et al. \(2019\)](#) observed that digitalization has pushed all the departments in the organization to fall in line which help to deliver best result which is expected and if not the purpose will be defeated. [Pushpalatha and Pandian \(2021\)](#) observed that human resource managers have to play a more active role and give their contribution towards the era of digitalization to ensure that the human capital is skilled as well as educated in order to meet the demand of digitalization. [Raghavendra et al. \(2018\)](#) revealed that the system of e-recruitment is very convenient and helpful for many organizations because it's not just hiring the people its hiring the right candidate so the role of human resource analytics and digitalization is very pivotal. [Bala \(2015\)](#) observed that the transformations begin and end on the basis of the demand and dominance of

digitalization and now it's time to call it as a "digital age" and human resource technologies needs to enhance in order to survive in this era of human resource analytics and digitalization. [Samson and Agrawal \(2020\)](#) explained that digitalization not only help in filtering good talent but also helps in keeping a close track on the performance as well to understand is there any need of training or not and for this to happen human resource professional has to be more strategic and proactive. [Okoronkwo \(2021\)](#) studied that human resource management has transformed the traditional style of business model with digitalization; digital approach in line with human resource plays a key role in up-gradation and being competitive in the market and business. [Mohammed \(2019\)](#) observed that it is the human resource which is responsible for the success of any organization and how they have been selected is a matter of great concern and human resource analytics along with digitalization plays a key role in this which helps to build a great organization. [Rani et al. \(2019\)](#) observed that there is a lot of difference in digitalization and implementation of human resource analytics in private sector organization and public sector organization which will affect the growth of the industry as a whole so irrespectively all should be on same page to give best output. [Nivlouei \(2014\)](#) observed that EHRM simplifies the usage of the human resource marketplace and also offers more self-services' to its employees and provide an advanced business solution which is more reliable and efficient. [Malika et al. \(2021\)](#) observed that convergence- divergence theory is very important and useful if it is developed with a collaborative partnership perspective in the global information technology (IT) industry. [Yipeng et al. \(2020\)](#) observed that there is a much more need of such type of human resource and its functions which take a lead role in bicultural individuals in cross cultural mergers and acquisition with the help of human resource analytics and digitalization. [Varma et al. \(2019\)](#) explored that human resource analytics helps in measuring performance of different functions and gain insights of employee effectiveness and efficiency. Human resource analytics has emerged as an important tool which helps identify factors which has deep intervention and helps build understanding of employee behavior and create a sustained and high-performance ecosystem. [Opatha \(2020\)](#) observed

that human resource analytics has emerged as a new trend and challenge in the business context emphasizing the strategic value and find solutions or to make sustainable decisions relating to issues based on evidences. [Jana et al. \(2022\)](#) examined that high-end technology is being applied in all departments like marketing, finance, operation, production, logistics and adoption of technology in human resource function. The results suggested that technological, organizational and environmental factors play a key role in the adoption of human resource analytics in companies. [Vargas et al. \(2018\)](#) explored that high performing organizations are using analytics for evidence-based decision-making. [Gurusinghe et al. \(2021\)](#) examined that digitization, new technologies and artificial intelligence demand organizations for new ways of working with a different skill set to accomplish strategic objectives. Human resource analytics is the scientific solution enabling organizations to make significant human capital and strategic business decisions and thereby gain a competitive advantage. [Muhammad et al. \(2023\)](#) investigates the impact of external factors on the adoption of human resource analytics. The finding obtained from the study confirms that social influences are the significant factors that influence the adoption of human resource analytics among human resource professionals. [Ellmer et al. \(2021\)](#) explored that human resource analytics are said to create value when providing analytical outputs that are relevant to decision-makers' immediate business issues. [Ratnam et al. \(2023\)](#) observed that in the competitive world, organizations are facing many pressures that demand organizational excellence. This paper sheds light on the reasons for the slow adoption of human resource analytics and provides inputs to human resource development professionals of early majority and late majority adopting organizations in terms of how to overcome the challenges and gear up for effective human resource analytics adoption and implementation. [Philipp et al. \(2022\)](#) observed that many firms still make business critical decisions intuitively, despite clear evidence that analytics-based decision-making is likely more effective in creating corporate and social value. [Giermindl et al. \(2022\)](#) explored that technological advances in the field of artificial intelligence are heralding a new era of analytics and data-driven decision-making. Recent progress in the field of AI

and ever-increasing volumes of digital data have raised expectations and contributed to a very positive image of people analytics (Joo et al., 2022). Mohammed et al. (2023) examined the cross level effects of 2 prevalent contextual elements human resource systems and relational climates on individual and team creativity. The results suggested that relational climates represent more effective positive predictors of creativity at both levels, above and beyond the effects of human resource systems.

Hypothesis

Ha1 There is no significant impact of HR analytics on Human resource functions.

H01 There is a significant impact of HR analytics on Human resource functions.

Ha2 There is no significant impact of HR analytics on organizational performance.

H02 There is a significant impact of HR analytics on organizational performance.

Based on the above review and the hypotheses, following aim will be achieve and this study will help the human resource management department to utilize human resource (HR) analytics as an integral policy in the current technological environment.

- To know the role of human resource (HR) analytics to bridge the gap between human resource functions and organizational performance.
- To know the impact of human resource (HR) analytics on human resource functions.
- To know the impact of human resource (HR) analytics on organizational performance

The current study has been carried out in city of Lucknow, India in March, 2023.

MATERIALS AND METHODS

The present study is mainly based on the primary data which is collected from human resource management personal of top 10 private life insurance company is considered for data collection of research. The data were collected from 194 employees of the human resource department by using simple random sampling method. Quantitative methods are used to examine primary data gathered from the companies. The data is collected through a questionnaire-based survey. Employees from human resource department holding different designations were considered for the survey of present study. Total 194 respondents were surveyed with the help of a structured questionnaire

(Hota and Ghosh,2013; Anam and Haque,2023; Baykal, 2020; George and Kamalanabhan, 2016) to know the role and importance of human resource analytics to bridge the gap between human resource functions and Organizational performance. Multinational human resource company was targeted to get the data in city of Lucknow, India in 2023. The total number employees are around 290. A Simple random sampling method was used to collect the primary data. Validity and reliability was checked and found above 0.60 for all items (Drost, 2011). The statistical tools like mean, t-test and multiple regressions were applied to analyze and evaluate the data to get the appropriate end results. Multiple regressions were run on statistical package for the social sciences (SPSS) 20 software (Sanie Jahromi et al., 2023).

RESULT AND DISCUSSION

Table 1, is showing demographic details in which, it is found that in total 194 respondents 67.5% are male and 32.5% are female. Among them 30.4% are below 36 years of age, 34.5% are from the age group 36-43 years and rest 35.1% are above 43 years of age. 21.1% of the respondents are working as human resource directors, 27.3% are human resource managers, 30.9% are human resource information specialist and rest 20.6% are working on the post of recruiters in human resource department of different companies.

Table 2, demonstrating the different roles of "human resource analytics" that bridge the gap between human resource functions and organizational performance. The respondent says that human resource analytics uplifts the status of human resource profession and become a core source for competitive advantage among companies with mean value 4.01 and supports to take fast and better decisions that match with people capabilities and requirements at effective cost with the mean value 3.98. In google human resource analytics has built a proof-based method to enhance its selection and recruitment process with the mean value 3.91 and human resource analytics support human resource department to analyze the employee's performance with the mean value 3.89. Human resource analytics support organizations to recognize talented employees and take decisions on the basis of facts and figures with the mean value 3.86 and

Table 1: Demographic

Variable	Respondents	Percentage
Gender		
Male	131	67.5
Female	63	32.5
Total	194	100
Age		
Below 36 years	59	30.4
36-43 years	67	34.5
Above 43 years	68	35.1
Total	194	100
Designation		
HR Director	41	21.1
HR Manager	53	27.3
Human resource information specialist	60	30.9
Recruiters	40	20.6
Total	194	100
Work Experience		
Less than 5 years	55	28.4
5-8 years	71	36.5
More than 8 years	68	35.1
Total	194	100

Table 2: Role of “human resource (HR) analytics” to bridge the gap between “human resource functions” and “organizational performance”

Item No.	Statements	Mean value	t value	Sig.
1.	Human resource analytics support human resource department to analyze the employee’s performance	3.89	5.528	0.000
2.	Human resource analytics support to get information to reflect the influence on the organization through statistical procedures	3.65	2.139	0.017
3.	In Google human resource analytics has built a proof-based method to enhance its selection and recruitment process	3.91	5.941	0.000
4.	Human resource analytics identifies challenges of human resource together with engagement of employee, inclusion and diversity, and returns	3.73	3.266	0.001
5.	Human resource analytics helps company to attain its objectives and insights by collecting and transferring employee’s information	3.62	1.732	0.042
6.	Human resource analytics supports to take fast and better decisions that matches with people capabilities and requirements at effective cost	3.98	6.810	0.000
7.	Human resource analytics collect and analyze human resource information	3.70	2.864	0.002
8.	Human resource analytics support organizations to recognize talented employees and take decisions on the basis of facts and figures	3.86	5.179	0.000
9.	Human resource analytics along with human resource support in strategic planning of employees in a company	3.67	2.416	0.008
10.	Human resource analytics uplifts the status of human resource profession and become a core source for competitive advantage among companies	4.01	7.375	0.000

human resource analytics identifies challenges of human resource together with engagement of employee, inclusion and diversity, and returns with the mean value 3.73. The respondent also says that human resource analytics collect and analyze human resource information with the mean value 3.70 and human resource analytics along with human resource

support in strategic planning of employees in a company with the mean value 3.67. It is also found from the [Table 2](#), that human resource analytics support to get information to reflect the influence on the organization through statistical procedures with mean value 3.65 and human resource analytics helps company to attain its objectives and insights by

Table 3: Coefficients

Model	Un standardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-.103	.144		-.716	.475
Human resource analytics support Quick and Reliable Information Processing	.193	.066	.194	2.931	.004
Human resource analytics enables the managers to draw meaningful patterns in the data	.589	.068	.573	8.635	.000
Human resource analytics helps to get deeper insights in the employee data	.104	.045	.101	2.334	.021
Human resource analytics supports to take fast and decision making better	.107	.047	.109	2.261	.025
Human resource analytics improves the quality of decision making	.041	.021	.056	1.939	.054

Dependent Variable: Human resource (HR) analytics improves the human resource function

Table 4: Coefficients

Model	Un standardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.134	.257		.522	.602
Human resource analytics support Quick and reliable information processing	.323	.118	.298	2.745	.007
Human resource analytics enables the managers to draw meaningful patterns in the data	.364	.122	.324	2.980	.003
Human resource analytics helps to get deeper insights in the employee data	.169	.080	.149	2.116	.036
Human resource analytics supports to take fast and decision making better	.050	.085	.046	.587	.558
Human resource analytics improves the quality of decision making	.073	.038	.092	1.936	.054

Dependent Variable: Human resource (HR) analytics improves the Organizational Performance

collecting and transferring employee's information with mean value 3.62. To know the significance of the statements, t-test was applied. In this study, to measure the impact of all the statements related to human resource analytics on human resource function, multiple regressions were applied. It is found that the model explained 84% of the variance (R Square = .848).

Table 3, shows that all the statements like human resource analytics support quick and reliable information processing, human resource analytics enables the managers to draw meaningful patterns in the data, human resource analytics helps to get deeper insights in the employee data. Human resource analytics supports to take fast and decision making better and human resource analytics improves the quality of decision making which are related to human resource analytics significantly improves the human

resource Function as the value under significant column is below 0.05 for all the statements except, human resource analytics improves the quality of decision making. This variable is significant at 10% level of significance; however, others are significant at 5%. Further in this study to measure the impact of all the statements related to human resource analytics on organizational performance and multiple regressions were applied. It is found that the model explained 59% of the variance (R Square = .593).

Table 4, shows that all the statements like human resource analytics support quick and reliable information processing, human resource analytics enables the managers to draw meaningful patterns in the data, human resource analytics helps to get deeper insights in the employee data. Human resource analytics improves the quality of decision making which are related to human

resource analytics significantly improves the human resource function as the value under significant column is below 0.05 (Samimi and Nouri, 2023) for all the statements except human resource analytics supports to take fast and decision making better. Through its capability to do statistical and predictive analysis, human resource technology makes the process of turning employee data into information easier for executives, Rasmussen and Ulrich, 2015; Douthit and Mondore, 2014; Ramanathan *et al.*, 2017) human resource specialists, and managerial staff to use to make critical personnel decisions (Anam and Haque, 2023; Baykal, 2020). Additionally, human resources professionals are now able to aggregate data and carry out predictive analyses, which would not be possible without technology for human resources (Malika *et al.*, 2021). Access to human resources technology is essential for giving human resources professionals the tools they need to collect, analyze, and visualize data so that senior management can make better decisions (Rao and Vaidya, 2018) Rasmussen and Ulrich, 2015; Douthit and Mondore, 2014; Ramanathan *et al.*, 2017).

CONCLUSION

Human resource analytics is of significant importance in building a strategic plan for workforce that support in decreasing rate of attrition and establish a data-driven culture in a company. Human resource analytics is an immense prospect for the human resource department to be a main driver in a company. However, the accurate appliance and appropriate utilization of human resource analytics are important to understand its advantages in the company. Hence it is important that human resource professionals must proceed in further practical responsibility to conquer the gap of awareness so that official training will be more dependable with the assumption by the companies. With human resource analytics, human resource professionals are able to raise the precise questions, evaluate the precise actions and metrics and grant confirmation to the decision makers to take correct and strategic decisions among alternative courses of practices and policies of human resource. When human resource analytics is applied and used accurately, it develops more in present ever-changing areas and business perspectives. Hence, human resource analytics is important for organizations to provide precise and

real time data to have more competitive advantage over their competitors. The study concludes that there are different roles of human resource analytics that bridge the gap between human resource functions and organizational performance such as it uplifts the status of human resource profession and become a core source for competitive advantage, supports to take fast and better decisions, enhance selection and recruitment process, support human resource department to analyze the employee's performance, talented employees and take decisions on the basis of facts and figures and also identifies challenges of human resource together with engagement of employee, inclusion and diversity, and returns. It is also found that human resource analytics significantly improves human resource function and organizational performance. It was found that, the benefits of human resource analytics such as quick and reliable information processing, helping managers to draw meaningful patterns in the data, deeper insights in the employee data fast and decision making better and improvement in the quality of decision-making significantly affects the human resource organizational performance and human resource functions.

Suggestions

The findings of the study suggest that it is very important for the organizations to understand and evaluate the problems of their workforce for its success and this possible by adopting human resource analytics in their company. They can use human resource analytics to enhance organizational performance by identifying the major challenges. The organization need to develop their interest in human resource analytics so as to exceed in different disciplines of management including human resources management. The study also suggests the organizations to make human resource analytics as a part of human resource practices like training, selection and performance management in their company. This study recommends using human resource analytics in the organization so as to have better and improved decision-making process. It is recommended to choose correct human resource analytics technology as per organization's requirements. It is better to develop a feedback culture in the organization support organizations to recognize talented employees and take decisions accordingly.

The study also recommends using “human resource analytics” to get information to reflect the influence on the organization through statistical procedures. A comparative study on employee performance after adopting “human resource analytics” in the organization has a good scope for researchers to conduct their study. The studies may also investigate the factors that determine employee’s contribution to accomplish the strategic plans using human resource analytics.

AUTHOR CONTRIBUTION

N.A. Khan did research design, and manuscript text and manuscript preparation. A.A. Khan help in literature review, data collection and analysis and interpretation. A. Malik helped in preparing manuscript, reviewing data and interpretation of data.

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CONFLICT OF INTEREST

The authors of this article do not declare any conflict of interest with the publication of this article. Various ethical issues such as plagiarism, fabrication, data forgery, informed consent, duplication, submission and redundancy have been controlled.

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ABBREVIATIONS

<i>EHRM</i>	Electronic human resource management
<i>HRIS</i>	Human resource information system
<i>IT</i>	Information technology
<i>Sig</i>	Significance value
<i>SPSS</i>	Statistical package for the social sciences
<i>T</i>	T-test value

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ORIGINAL RESEARCH PAPER

Assessing user's satisfaction in innovation centers with industrial heritage renovation

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ABSTRACT

BACKGROUND AND OBJECTIVES: Adaptive reuse of heritage buildings is important because of their impact on preserving the city's identity and urban integrity, as well as their hidden capabilities and values. In recent years, one of the adaptive reuse projects in existing factories around the world and also in Iran is transforming them into innovation centers. Thus, it is necessary to investigate the effective indicators of designing innovation centers and adapting the industrial heritage buildings to these criteria. This study aims to investigate and prioritize the criteria and indicators of designing innovation centers with industrial heritage renovation.

METHODS: The current study is performed in two phases. First, the related literature was studied and criteria regarding industrial heritage and innovation centers were distinguished. In the next phase, post-occupancy evaluation of two cases of innovation centers in Tehran and Mashhad (Azadi innovation factory and Mashhad innovation factory) was carried out and the results were gained by applying structural equation modeling method using SmartPLS software. Thus, users' satisfaction level of these criteria and the importance of each criterion from the users' point of view were investigated.

FINDINGS: The results revealed that, for designing innovation centers in industrial heritage sites, four main criteria such as environment, technology and energy, aesthetics and socio-cultural could be discussed. According to the presented structural equation modeling, according to users' opinion, environment criteria with Path coefficients of 0.4 in both cases is the most important factor while technology criteria with Path coefficients of 0.3 ranks after it. The factor loadings show that attention should be paid to the appropriate dimensions of work spaces (0.8), flexible and appropriate furniture (0.7-0.9), and providing service areas (0.8). Also, creating a sense of place and increasing productivity and improving social interactions were very important from the users' point of view while designing adaptively reused heritage as innovation centers.

CONCLUSION: For designing innovation centers the environment criteria are more important in users' opinion and more attention should be paid to greenery, space and mass and access to the complex. The environmental comfort factors for users are also of high importance and the users' satisfaction level reveals that in these two cases users are almost satisfied with the design.

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INTRODUCTION

In the second half of the 20th century, after the industrial era, significant changes were made in urban design. Many industrial complexes in the core of the cities lost their use and were abandoned (Rezaei Ghahroodi and Mahdavinejad, 2019). For the first time in history, the need to preserve the values of heritage buildings was noticed after the destruction of several industrial buildings in England (Sulimowska-Ociepka, 2021). The explanation of heritage values begins with the Athens Charter, which is the first global document establishing fundamental guidelines for a code of practice for conservation and the issue of international charters after it (Chatzi Rodopoulou 2023). After revising the principles of Athens Charter, the Venice Charter was proposed in 1964 (ICOMOS, 1964), and after that, the Nizhny Tagil Global Charter was issued in 2003 (TICCIH, 2003). In this regard, in 2011, a protocol was approved to develop the principles of heritage protection under the title of Dublin principles (ICOMOS-TICCIH, 2011). Industrial heritage should be preserved since they have tangible and intangible values (Nejadebrahimi et al., 2014) and in other words, social, economic, cultural, aesthetic, original and special values (Hanachi and Khani, 2021). As the city's infrastructure grew over time, many industrial zones were built, but some of them are not fully operational now. This caused the quality of life to deteriorate: there were more slums and health problems, and the social and economic situation declined (Potseshkovskaya and Soroka 2021). Studies about industrial heritage show that they are the result of interaction between culture and industry and contain valuable information about science and technology of their time. Industrial heritage forms part of the identity and memories of cities. Creating memories is a way of preserving the past in the present or preserving the present in the past, so it is needed to reuse and adapt these buildings to the current uses required in cities (Bahramipناه, 2022; Ghanbary, 2018; Shahhosseini and Moulaii, 2019). The authenticity, environmental values, urban image and vision for urban development are the other aspects that emphasize on importance of preserving industrial heritage for urban integrity (Oevermann, 2015). Local community's feeling towards heritage is essential for their regeneration and if the heritage sites are abandoned, they can cause negative memories. Vice versa, reusing the

heritage buildings can increase social integrity and strengthen local identity (Martinovic and Ifko, 2018). Besides protection of industrial sites for future generation, they bring a new life to the city environment (Gharaati et al., 2023). Thus, it is vital to comprehend how industrial heritage is locally used and understood for its preservation (Galaz-Mandakovic and Rivera, 2023). According to Leus cited in Ranjkesh and Fadaei Nezhad Bahramjerdi, (2020), preservation of industrial heritage is only possible through "adaptive reuse". By adaptive reuse and by creating a new usage, the industrial heritage buildings are modernized for contemporary use. Adaptive reuse is a method to adjust the new use to the abandoned building in four aspects such as function, architecture, structure and infrastructure, which is also in line with sustainable development, from an environmental point of view (Heidari et al., 2019; Bahramipناه, 2022). Some suitable reuses for industrial heritage include garden nurseries, markets, tertiary education, arts and creative industries, and new business incubators (Clark, 2013). In recent years, more attention has been paid to innovation centers in Iran and the need to support start-ups. Innovation centers are referred as science and technology park or innovation center or incubator. Incubators are centers that help start-ups and new innovative companies to increase success and reduce the risk of failure (Dupal et al., 2017). Creating innovation centers is one of the methods to preserve industrial heritage during the process of reuse, which has been implemented in recent years. Due to the formation of a number of innovation centers in Iran and reuse of industrial heritage as innovation centers in several cities, it is necessary to examine the criteria required in the adaptive reuse of heritage in order to design innovation centers in accordance with the users' needs.

Research background

Industrial heritage and adapting heritage use

Heritage can be considered as a memory of the past that people live with it now, and then leave it to the next generations to learn from and enjoy it (Jopela, 2011). The International Committee for the Conservation of the Industrial Heritage (TICCIH) in The Nizhny Tagil Charter for the industrial heritage has defined Industrial heritage as "The remains of industrial culture which are of historical, technological,

social, architectural or scientific value. These remains consist of buildings and machinery, workshops, mills and factories, mines and sites for processing and refining, warehouses and stores, places where energy is generated, transmitted and used, transport and all its infrastructure, as well as places used for social activities related to industry such as housing, religious worship or education” (TICCIH, 2003 cited in Clark, 2013; Sulimowska-Ociepka, 2021). Industrial heritage sites are an important part of the landscape and built environment around us. These landscapes illustrate the interplay between humans and machines, and also between nature and architecture (Meng *et al.*, 2023). They establish tangible and intangible connections with our past and have the potential to play an important role in cities and suburbs (Clark, 2013), they can even affect movements of urban citizens (Bazazzadeh *et al.*, 2022). There are different theories regarding the value of heritage protection. In Cesare Brandi’s classification, the three main aspects of place, time and authenticity are the basis of the value evaluation framework. The parameter of place is divided into six sub-components including interventions, social, political, economic, functional and structural. And the time parameter is divided into two sub-components of identity and value. The authenticity parameter is divided into nine subcomponents such as original, natural, exceptional, impressive, referential, technical, artistic, practical, and rare (Mahdavinejad *et al.*, 2017). In another category, heritage values are classified in five aspects including historical, technological, economic, educational and psychological values (Jie, 2009). One way to preserve these values is the adaptive reuse of heritage (Alavi *et al.*, 2021). Adaptive reuse includes changing the use of existing structures or buildings based on new needs of users aiming to achieve economic, social and environmental sustainability with an emphasis on saving material, reducing costs and preserving the inherent values of heritage (Ferretti *et al.*, 2014). In research about adaptive reuses in Australia, the criteria including the age of the building and its conditions, height, depth, building envelope and cladding, structure, facilities, interior design, flexibility for various uses, type of construction, location, values, dimensions, Accessibility, proactive legislation, acoustic isolation, user demands and site orientation are reviewed (Wilkinson *et al.*, 2009). To achieve a framework for

sustainable heritage management industrial heritage sites in England were studied. Research shows that for sustainable heritage management, while analyzing the situation, strategic orientation, holistic planning and long-term sustainability perspective, the active participation of stakeholders and their values should also be considered (Landorf, 2009). In adaptive reuse capabilities in a research information such as identity, location, context, use, ownership, building features, architectural details, and heritage materials were examined through record cards, image collections, and building dimensions (Fuentes, 2010). Another research about the silos of Spain, investigated the impact of comparative use of these buildings in their context and the impact on the landscape of the surrounding urban context (creating an urban sign or urban public space) by examining the primary information about case examples (sites and images) (Garrido-Cifuentes *et al.*, 2017). In a study on the comparative use of grain silos in Italy, based on the multi-criteria decision analysis method, after reviewing the information of the existing situation, the new use was determined by considering the number of changes in levels, openings, mass and view (Giuliani *et al.*, 2018). Reviewing 25 cases of Iran’s industrial heritage shows flexibility as an important feature in adaptive use. This feature has four criteria including “adaptability”, “dismantle and reuse of materials”, “assembly and disassembly” and “durability” (Bazazzadeh *et al.*, 2021). Based on the value of heritage and functional building service life model (building functional cycle), users’ behavior in the urban space and choosing routes were investigated using DepthmapX software. Also, parameters such as facade dimensions and pedestrian access and facade alignments and building height and visibility and permeability were investigated (Pizarro-Reyes *et al.*, 2022). Esmailian Toussi and Etesam, (2019) studied the textile factories of Isfahan and Yazd using the combined method of typology and analytic form. In this research, the sub-criteria of the cases have been examined by describing the interpretative-historical characteristics. Then, based on the physical characteristics, the physical-spatial, semantic, and physical parts, the case samples were parameterized and the data was analyzed through inductive and analogical reasoning. In a research on change in function and green application of Ray cement industrial complex, the importance of using

industrial heritage capacities for green adaptive reuse with the aim of productivity, reducing consumption, and recycling had been discussed (Bahramipanah, 2022). Another research on improving the energy performance in historical buildings shows that interventional and non-interventional methods are ways of protecting the heritage. These methods are applied in facade, cooling-heating and lighting systems (Gholami *et al.*, 2021). Mahdavinejad *et al.*, (2016) investigated the factors of the formation of spatial identity such as memories, orientation, spatial order and figure and appearance and individual identity in the historical area of Dezful city. The criteria discussed in mentioned researches are summarized in Fig. 1.

Innovation Center

Work spaces are somewhat different from each other according to the type of work and activities performed in them. Due to the changing nature of these spaces, there is no clear distinction between them. Accelerators, incubators, co-working spaces, pilots, startup spaces, and urban innovation centers are types of innovative workspaces. One of the parts of every innovation center is the co-working space. In 2005, the first co-working space started in San Francisco by Brad Newberg (Merkel, 2015; Spinuzzi, 2012). A study about the successful examples of

innovation centers in Melbourne, Sheffield and Cardiff, mentions the criteria for an innovation center such as the spaces with different functions and with different dimensions, flexibility of the spaces, easy access to the building for all groups, the use of open plan and suitable natural or artificial lighting (Montgomery, 2007). Another study, suggests that besides easy access to the building and having rooms for concentration, a work space needs to be open 24 hours a day to create a greater sense of belonging (Spinuzzi, 2012). Based on the users' opinion at the design and innovation center of Aalto University, values such as cooperation, openness, interactions, accessibility and sustainability have been considered for a co-working space. To achieve this purpose, criteria such as an inviting lobby, multiple spaces with different functions, flexible spaces and flexible furniture on wheels, relaxing and intimate spaces, decorative and interesting elements, bright colors and cozy corners were mentioned. Using different materials in interior design and a space for displaying prototypes and posters can also fulfill these values (Kojo and Nenonen, 2014). In a study in Wales, the presence of meeting spaces, private offices, and rest spaces, along with flexible spaces, are listed as essential elements for employees' satisfaction, and co-working spaces should have a happy atmosphere and lively social connection. It is also necessary to

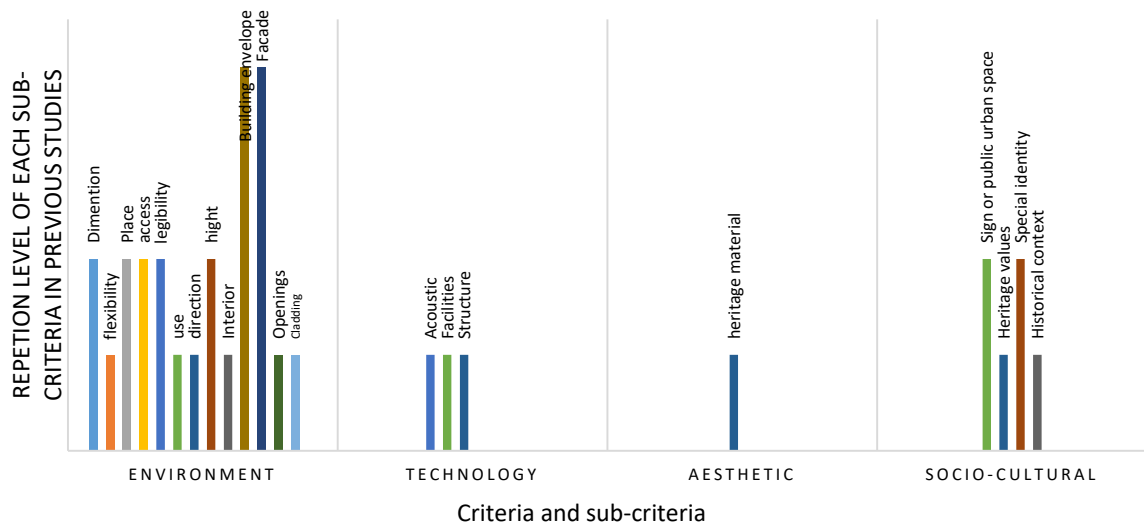


Fig. 1: The components studied in previous research (Giuliani *et al.*, 2018; Garrido-Cifuentes *et al.*, 2017 ; Pizarro-Reyes *et al.*, 2022; Esmaeilian Toussi and Eteessam, 2019; Mahdavinejad *et al.*, 2016; Fuentes, 2010; Wilkinson *et al.*, 2009)

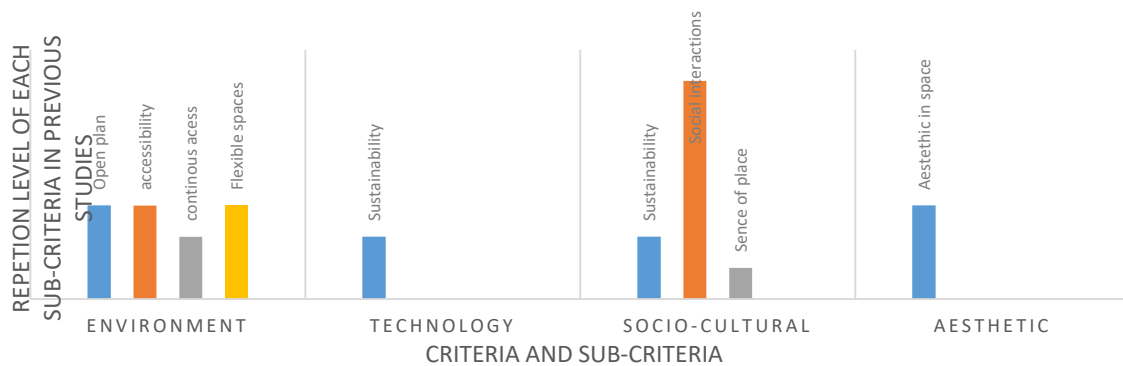


Fig. 2: Characteristics studied in the innovative work spaces based on previous researches (Montgomery, 2007; Spinuzzi, 2012; Kojo and Nenonen, 2014; Merkel, 2015; Fuzi, 2015; Kojo and Nenonen, 2016; Brown, 2017; Micek, 2020)

have spaces that inspire and stimulate creativity (Fuzi, 2015). In the study of co-working spaces in Finland, the typology of these spaces is divided into three categories: public, semi-public and private. Also, the importance of the built space from the access perspective is pointed out (Kojo and Nenonen, 2016). Brown, (2017) states that one of the reasons for motivating people to work in innovation and co-working centers is having an open-plan space with multiple uses, as well as flexibility and aesthetic design, which also increases social interaction. Adjacency and friendly social relations in innovation centers have been found as the reason for strengthening cooperation and achieving innovation, and also open and multi-use spaces as criteria for achieving it (Micek, 2020). Fu et al., (2023) in a research conducted in two platforms served as enterprises discovered a positive relationship between space utilization and social interactions and that making a sense of identity will thrive incubators. In a user experience survey about co-working spaces in Nigeria, more than 50% of the respondent's declared that visual and thermal comfort as well as social and relaxation spaces are very important. The findings also show that various furniture design and accessibility are the important factors for designing co-working spaces (Memud and Tabibi, 2023). Irrespective of user and place, in designing co-working spaces, considering accessibility and half-open layouts is beneficial (Appel-Meulenbroek et al., 2021)

Fig. 2 summarizes the components examined in the mentioned studies about innovation centers.

Post-Occupancy Evaluation (POE) in similar uses

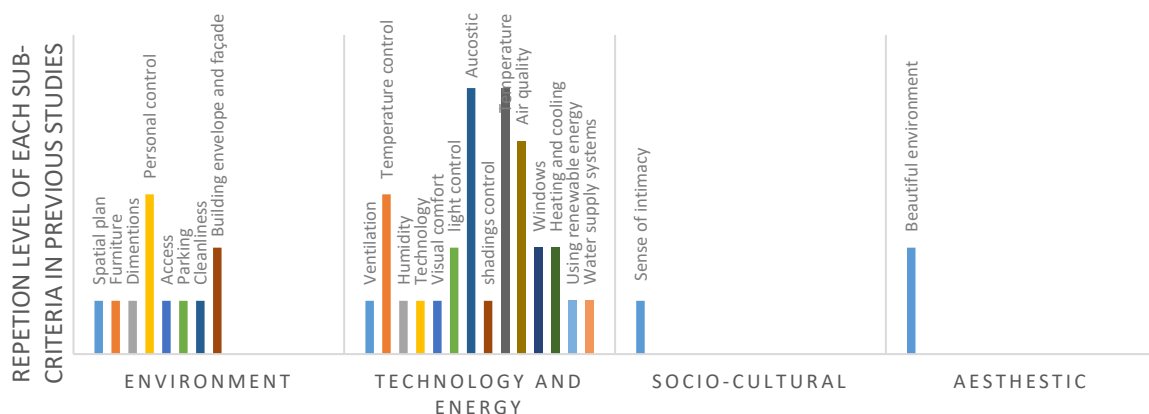
POE is an effective way to find design solutions for productivity and user satisfaction (Motalebi et al., 2021). For more than half a century, post-occupancy evaluation has been used as a method to determine how well a building was designed to meet the needs and goals of its users. One of the tools for POE is preparing a questionnaire that can be classified and implemented by three methods as Building Use Studies (BUS), Design Quality Indicator (DQI) and Overall Liking Score (OLS) (Bordass and Leaman, 2005). Several parameters of POE such as privacy, acoustics, lighting, temperature, ventilation, comfortable furniture, cleanliness, visual comfort are questioned to check the quality of the indoor environment. In post-occupancy evaluation of 20 office buildings in USA, considering factors such as age and gender, the results showed that the quality of air temperature was the most important factor in employees' satisfaction (Choi et al., 2012). Hua et al., (2014) have investigated the effect of various factors such as building facade, thermal comfort, indoor air quality, sound privacy, visual comfort and personal control on users' satisfaction and its effect on the spatial map of users. Another study compared the post-occupancy evaluation of two green office buildings in China to investigate the level of user satisfaction with environmental factors such as acoustics, thermal and visual comfort, and indoor air quality (Pei et al., 2014). Park et al., (2018) in a study that investigated satisfaction in 64 office buildings through post-occupancy evaluation

found that factors such as temperature, space size and quality of windows and temperature control are the most significant factors in satisfaction with thermal quality. A research on the characteristics of co-working spaces, based on the users' preference, states that criteria such as accessibility (by public transport or private car), spatial plan (semi-open plan), having multiple work groups and a sense of intimacy were the priorities of most users (Weijss-Perree et al., 2019). Pastore and Andersen (2019) in a research in Switzerland evaluated post-occupancy of four green office buildings by collecting information about the dimensions, year of construction, number of users and the amount of control over the awnings and windows. The findings state the effect of factors such as temperature, light and air quality on users' satisfaction. In the study of work spaces in seven buildings in Singapore, eighteen parameters were investigated and users were most dissatisfied with parameters such as cleanliness, sound privacy, personal control and temperature (Cheung et al., 2020). Another research examined a green building in Korea and the technologies used in it to evaluate post-occupancy and user satisfaction with components such as parking lots and the possibility of charging electric cars, efficient water supply system, building envelope. Also, use of renewable energy and factors affecting comfort and environmental control such as ventilation, heating and cooling, lighting and awnings were examined (Kim and Kim, 2020). Asojo

et al. (2021) examined twelve categories of indoor environment quality indicators in a work space in Minnesota. They found that the level of light control, humidity, visibility and technology in the building has a direct relationship with the level of users' satisfaction and the employees are the most dissatisfied with controlling heat, furniture, visual and acoustic privacy and the aesthetics. The impact of adjustable and changing facades on the users' experience and criteria such as acoustics, visual features, aesthetics, air quality, control and heating were examined based on the users' preferences and existing conditions (Koyaz and Ünlü, 2022). Cited in Hassanain and Mahroos, (2023) other POE studies of office buildings also conducted by Deuble and de Dear, (2012), Akashah et al., (2015), Choi and Moon, (2017) and Middlehurst et al., (2018) gathered information on users' satisfaction with indoor environment quality (IEQ) in work spaces. Jailani et al., (2015) conducted a POE to identify the gap between users' preferences and the building's performance and conclusion showed no significance relevance between user's expectations and building's performance (Jailani et al., 2015 cited in Hassanain and Mahroos, 2023).

The main criteria investigated in post-occupancy evaluation in mentioned studies are shown in Fig. 3.

In order to discover criteria of designing innovation centers with industrial renovation, the mentioned factors were analyzed from two perspectives: importance from the users' point of



Criteria and sub-criteria

Fig. 3: investigated components of each criteria in POE of work spaces based on previous researches (Koyaz and Ünlü, 2022; Asojo et al., 2021; Cheung et al., 2020; Kim and Kim, 2020; Pastore and Andersen, 2019; Weijss-Perree et al., 2019; Park et al., 2018; Pei et al., 2014; Hua et al., 2014; Choi et al., 2012)

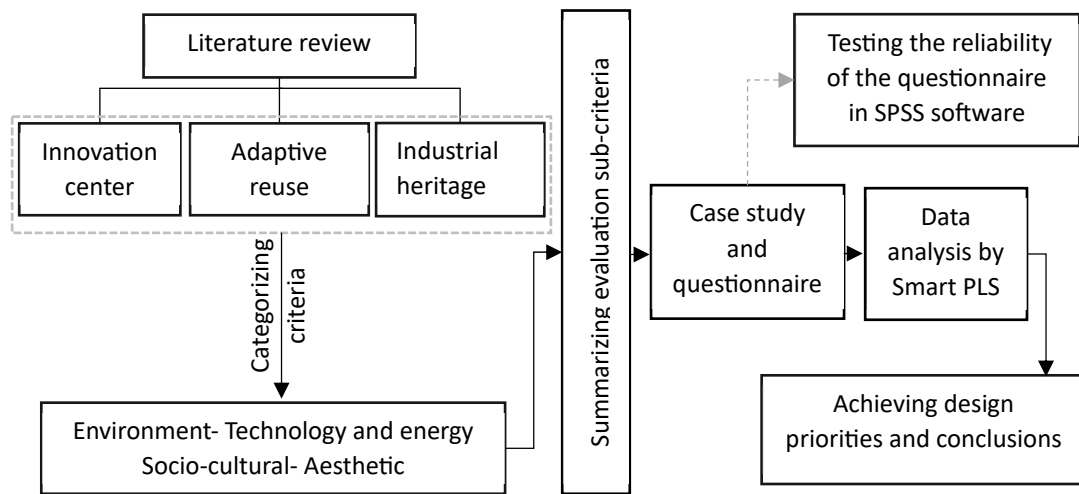


Fig. 4: Theoretical research model by: Authors)

view and the user's satisfaction. Therefore, at first, this research has extracted the effective factors and common cases in innovation centers and industrial heritage by considering the different dimensions of industrial heritage according to the literature review about the three topics of innovation center, industrial heritage and adaptive reuse. In the next step, according to the literature and principles and models studied in [Liu et al. \(2018\)](#) research and [Nili et al. \(2017\)](#) research according to five Broadbent's criteria, these factors were categorized into four main criteria such as aesthetics, socio-cultural, environment and technology and energy and then the sub-criteria, observed in literature review, were placed under the four criteria. Then, by post-occupancy evaluation, these factors were analyzed in two existing factory cases in terms of importance from the users' point of view and the users' satisfaction, and the Structural Equation Model (SEM) was analyzed in Smart PLS3 software.

The research hypotheses include the following:

- Among the four examined criteria, environment and technology and energy are more important than the other two criteria from the users' point of view.
- Socio-cultural criteria are more important than aesthetic criteria for users.
- Users are most satisfied with environment criteria.

The research questions are as follows:

1. Which design sub-criteria in these four

categories has a greater impact on users' satisfaction?

2. Do the environment criteria affect users' satisfaction more than technology?

3. Which of the environment sub-criteria are more important for users?

The process of this research is shown in [Fig. 4](#).

As mentioned in the literature, previous research on industrial heritage were conducted in terms of assessing the buildings characteristics but not for a specific use as work spaces and the articles about innovation centers or offices which observed users' needs were not cases of industrial renovation nor adaptive reuse. Another novelty aspect of the research is that the POE is not only assessing users' satisfaction with the building but also it investigates the users' expectations by asking the importance of factors from users' opinion. So, the importance and level of satisfaction could be compared to find the gap in current designed innovation centers and be considered in future design. Thus, the result of the article shows a new aspect of post occupancy evaluation of heritage buildings which is the users' needs and opinion on how to design innovation centers in these heritage buildings. Two achieve this, the study was conducted in Mashhad and Tehran innovation centers in Iran in 2023.

MATERIALS AND METHODS

Case study

In Iran, innovation as concept of research and

development started with Pasteur Research Institute, which was established for medical research in 1920 (Ansari *et al.*, 2016). In the field of innovation, since 2007, innovation centers have been established in Iran. The first industrial heritages in Iran were built in Qajar period, and reached the peak in Pahlavi period. Till then, more than 270 factories were established, and by 1952, this number reached 347 factories, most of which were located in Tehran (Samadzadehyazdi *et al.*, 2019). Buildings such as Behshahr textile factory, administrative and technical railway buildings in Tehran, Mashhad, Tabriz and other cities, also some factories in Qazvin, Yazd, Isfahan, Rasht, Rey and Qom were built during the Pahlavi era. Among the existing industrial heritage, Ama Electrode Factory (Azadi Innovation center) and Coca-Cola Factory (Mashhad Innovation center) are two examples of industrial heritage remained from the Pahlavi II era, which are adaptively reused innovation centers. Fig. 5 shows the geographic location of the cases.

The reason for selection of these two cases is their former use as factory and construction time with an interval of two years, also their new use as innovation centers during 2016 to 2019. More information about the buildings' attributes is provided in Table1.

After examining the characteristics of the two cases and the commonalities obtained from studies on industrial heritage and POE, the suggested criteria for preparing the questionnaire were divided into the general categories of environmental, technology and energy, socio-cultural, and aesthetic. The criteria and sub-criteria for preparing the questionnaire are shown in Table 2. The online questionnaire was designed based on the five-point Likert scale, for each of the factors, based on two indicators of satisfaction and the importance of the factor from the users' point of view. Then, the relationship of each factor with user satisfaction and the importance of the factor in the design of each case was investigated using structural equation model in Smart PLS3 software.

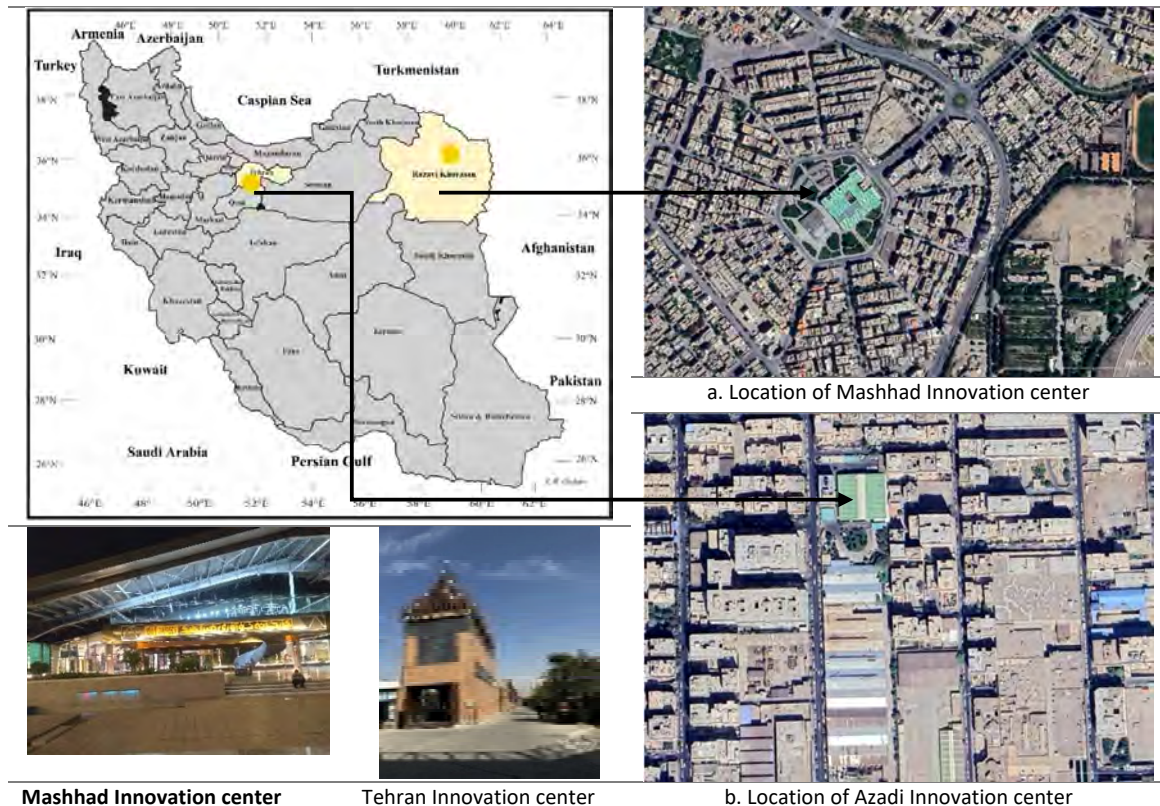
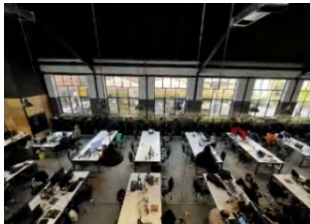



Fig. 5: Geographic location of the case studies

Table 1: Information about innovation centers in Mashhad and Tehran

	Ama Electrode Factory	Coca-cola factory
Location	Tehran, Lashgari Expy	Mashhad, Pajuhesh square, Kosar boulevard, Mashhad
Age	Pahlavi II	Pahlavi II
Ownership	Hamava Company (A branch of Pardis Technology Park)	Mashhad Municipality
Area	18500 square meters	3.7 hectares
Built area	Around 12000 square meters	Around 10000 square meters
Previous function	Factory	Factory
Establishment	1960	1958
Architectural space	Ten niches plus the central building and 4500 square meters office space	Two niches with four-part brick and steel arches
Decoration	No decoration except the remained bricks from the old factory	No decoration
Type of adaptive reuse	Tehran innovation center	Mashhad innovation center
	Accelerator, Innovation Studio, co-working space, Cafe, Botanists Production, Contemporary Architects Center, Sports Club, Tech-shop, Lobby, Conference Hall, export exhibition, management	Dining hall, exhibition hall, classrooms, winter and summer courtyard, two co-working spaces (small and large), office space, spaces for conversation, amphitheater, studio and content production, innovation laboratory, reception, warehouse and safe deposit box, management, Special innovation spaces for children
connection with the urban spaces	Connecting through entrance	Connecting through park and playground
Privacy	Fences	No fence
Interior photo		

Structural equation modeling (SEM), segregates measurement errors from the scores of factors, so it provides a methodology for modeling the latent variables directly. SEM has developed since 1970, and is now widely applied. Multiple indicators for a latent variable in form of factor analysis is the idea for SEM. Several widely used statistical models are covered by SEM methodology (Yuan and Bentler, 2006; Samimi and Nouri, 2023).

Therefore, 60 questionnaires were collected from Mashhad Innovation Factory users and 60 questionnaires from Azadi Innovation Factory users in Tehran. The total number of respondents was 120. The respondents were of different age groups but were mostly between 18 to 25 years old and almost 66.7 percent of them were men. 42.5% of the

respondents were working in co-working spaces and the rest were working in private offices, management and other parts of the centers. The presented model based on the four presented criteria for each of two cases was conducted separately from two aspects of satisfaction and importance in Smart PLS3 software. In order to check the reliability of the questionnaire and the presented model, Cronbach's alpha was also checked in SPSS software. Reliability in each of the criteria is acceptable. (Cronbach's alpha is higher than 0.7). Also, the construct cross-validated redundancy and the construct cross validated communality, was checked and the quality of the structural model is acceptable because of the positive values. Also, the results of Bartlett and Kaiser-Meyer-Olkin (KMO) test show appropriate values as shown in Table 3.

Table 2: Classification of criteria and sub-criteria for preparing questionnaire (Nili et al., 2017; ;Liu et al., 2018)

Criteria	Factors	Questions
environment	Greenery	Using greenery in interior and exterior environment Legibility of entrance Providing parking spaces for cars, motorbikes and bicycles Work space flexibility and the multi-functionality of the spaces Flexibility and possibility to change the use of service spaces for future development Separation of work space in order to provide privacy Interior furniture design to provide general order in spaces Providing service spaces such as gyms, coffee shops, restaurants and rest areas
	Mass and space	Providing additional spaces (such as group work space, meeting space, space for talking on the phone and communal spaces, conference/video conference room, space for hosting customers, thinking space and study space) Suitable dimensions of the work spaces (large and small) Appropriate height of work spaces Compliance with rules and standards in communication and movement spaces (proper width and height, stairs, ramps, elevators) Access to public transportation (metro, bus and taxi)
	Access	
	Building technology and specialty in structure and facility	Providing comfortable temperature in winter (heating) Providing comfortable temperature in summer (cooling) Provide adequate ventilation and fresh air Providing appropriate relative humidity in spaces Providing sound comfort in spaces and controlling annoying sounds from nearby spaces
		Use of suitable natural and artificial light in spaces Ability to control light in spaces (such as canopy, shader, curtain, etc.) Using modern air purification systems (purifying algae) in order to create fresh air in spaces Using new materials and new building systems
		Applying and using new energies (such as solar panels, wind turbines, etc.) in order to reduce the use of fossil fuels
	Effect of technology on other contexts	
Socio-cultural	Place identity and memories	Designing spaces in order to create a sense of belonging and interest in the work environment
	different aspects of social life	Designing spaces in such a way that social interactions are possible Possibility of using the space for other members of the community
	Cultural impact	Monitoring and taking care of spaces and creating a safe place for users The effect of designed spaces to increase job productivity
Aesthetics	Artistic value of building such as form, shape, material, color and decoration	Good view and perspective Harmony in colors of the spaces and furniture with the use of space Using the existing materials in the old factory in order to preserve them

RESULTS AND DISCUSSION

Design and adaptive use of industrial heritage is increasing in the contemporary era, especially in recent years. With respect to the government's support policies for knowledge-based companies and start-ups, the creation of innovation centers in cities, especially in metropolitan cities like Tehran and Mashhad, is increasing. For this reason, in the projects of changing the industrial heritage of factories to innovation centers, it is necessary to examine the design criteria. Therefore, the results of this research,

considering the use of the POE method in examining the indicators and criteria of user satisfaction and interest, can be effective in future designs. The first hypothesis: According to the results of the research, the criterion of environment with loadings of 0.47 in Mashhad model and 0.46 in Tehran model and technology and energy with loading of 0.32 and 0.31 in Mashhad and Tehran were the most important from the users' point of view. Therefore, the first hypothesis of the research is confirmed. The second hypothesis: The loadings caused by the aesthetic

Table 3: measures of Bartlett and KMO test

Bartlett and KMO test						
case		criteria	KMO	Approx. Chi-Square	df	Sig.
Mashhad	importance	Technology and energy	0.872	450.803	45	<0.01
		environment	0.932	719.996	78	<0.01
		Socio-cultural	0.788	164.740	10	<0.01
		Aesthetic	0.638	34.588	3	<0.01
	Satisfaction	Technology and energy	0.854	341.713	45	<0.01
		environment	0.813	393.787	78	<0.01
		Socio-cultural	0.810	130.014	10	<0.01
		Aesthetic	0.670	37.387	3	<0.01
Tehran	importance	Technology and energy	0.831	342.977	45	<0.01
		environment	0.901	499.290	78	<0.01
		Socio-cultural	0.817	139.410	10	<0.01
		Aesthetic	0.657	41.461	3	<0.01
	Satisfaction	Technology and energy	0.801	307.707	45	<0.01
		environment	0.862	451.764	78	<0.01
		Socio-cultural	0.793	113.495	10	<0.01
		Aesthetic	0.648	47.834	3	<0.01

Table 4: Path coefficients

Criteria in each case-importance and satisfaction	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics	P Values
Aesthetics -> importance in Tehran factory	0.101	0.106	0.019	5.408	0.000
Socio-cultural -> importance in Tehran factory	0.182	0.181	0.015	11.847	0.000
Technology -> importance in Tehran factory	0.315	0.318	0.021	14.828	0.000
Environment -> Importance in Tehran factory	0.460	0.462	0.019	23.670	0.000
Aesthetics -> satisfaction with Tehran factory	0.132	0.132	0.013	10.294	0.000
Socio-cultural -> satisfaction with Tehran factory	0.205	0.203	0.016	12.583	0.000
Technology -> Satisfaction with Tehran factory	0.282	0.280	0.045	6.314	0.000
Environment -> Satisfaction with Tehran factory	0.481	0.479	0.030	16.192	0.000
Socio-cultural -> importance in Mashhad factory	0.171	0.172	0.009	19.083	0.000
Technology -> importance in Mashhad factory	0.326	0.322	0.016	20.577	0.000
Aesthetics -> importance in Mashhad factory	0.081	0.083	0.011	7.552	0.000
Environment -> Importance in Mashhad factory	0.470	0.474	0.022	21.833	0.000
Socio-cultural -> Satisfaction with Mashhad factory	0.227	0.225	0.019	11.796	0.000
Technology -> Satisfaction with Mashhad factory	0.361	0.375	0.031	11.831	0.000
Aesthetics -> satisfaction with Mashhad factory	0.113	0.112	0.016	6.994	0.000
Environment -> satisfaction with Mashhad factory	0.407	0.410	0.030	13.647	0.000

criterion in Tehran and Mashhad were 0.10 and 0.08, respectively, based on its importance from the users' point of view. While the loadings of the importance of socio-cultural criterion in Tehran and Mashhad were 0.18 and 0.17 respectively. Therefore, socio-cultural criterion was more important than aesthetic criterion for users, and the second hypothesis of the research is also confirmed. The third hypothesis: By examining the level of satisfaction with environmental criterion, according to the evaluated model, it can be stated that the loading of environmental criterion was more than

other criteria. Therefore, it can be said that users are more satisfied with the environmental criterion than other criteria. Therefore, the third hypothesis of the research is also true. In Table 4, the positive impact of the criteria and the significance of the relationship between the criteria and satisfaction and importance are shown.

Fig. 6 illustrates the weight of attributes as histogram graphs. The correlation between each pair of variables is demonstrated using heat map matrix in Fig. 7.

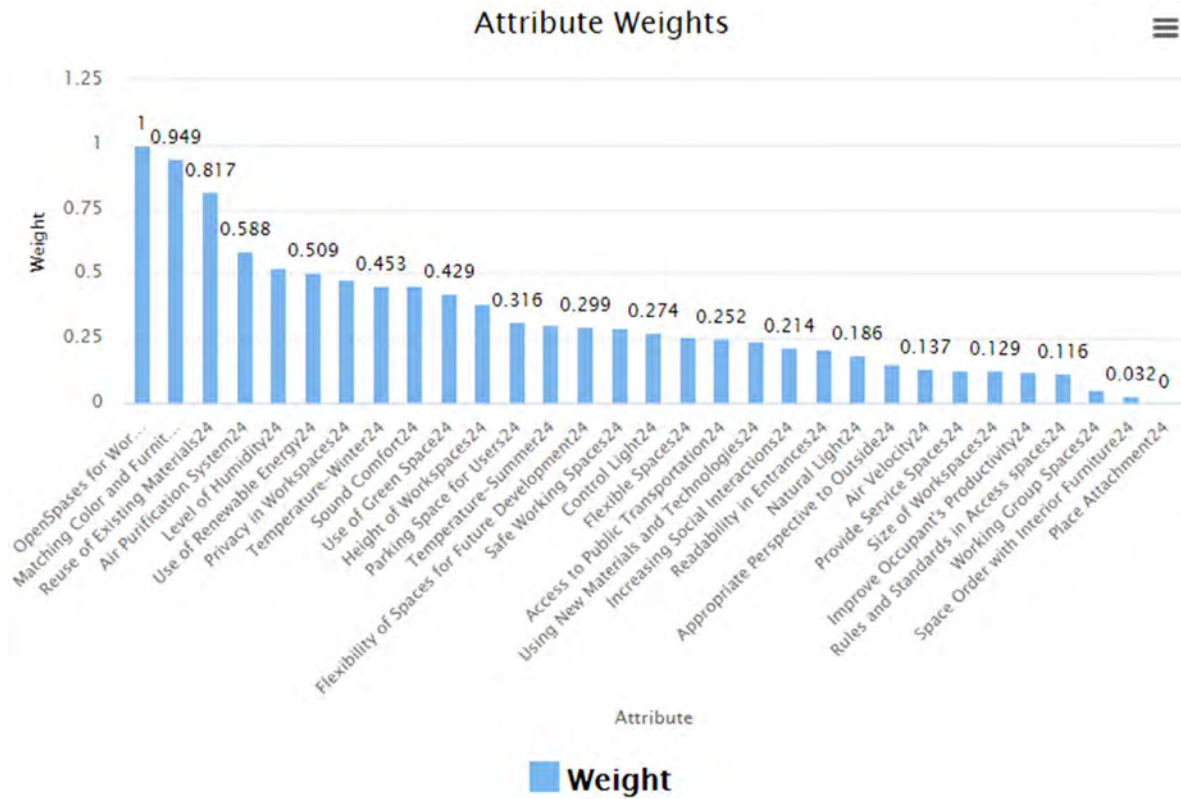


Fig. 6: Weight of attributes

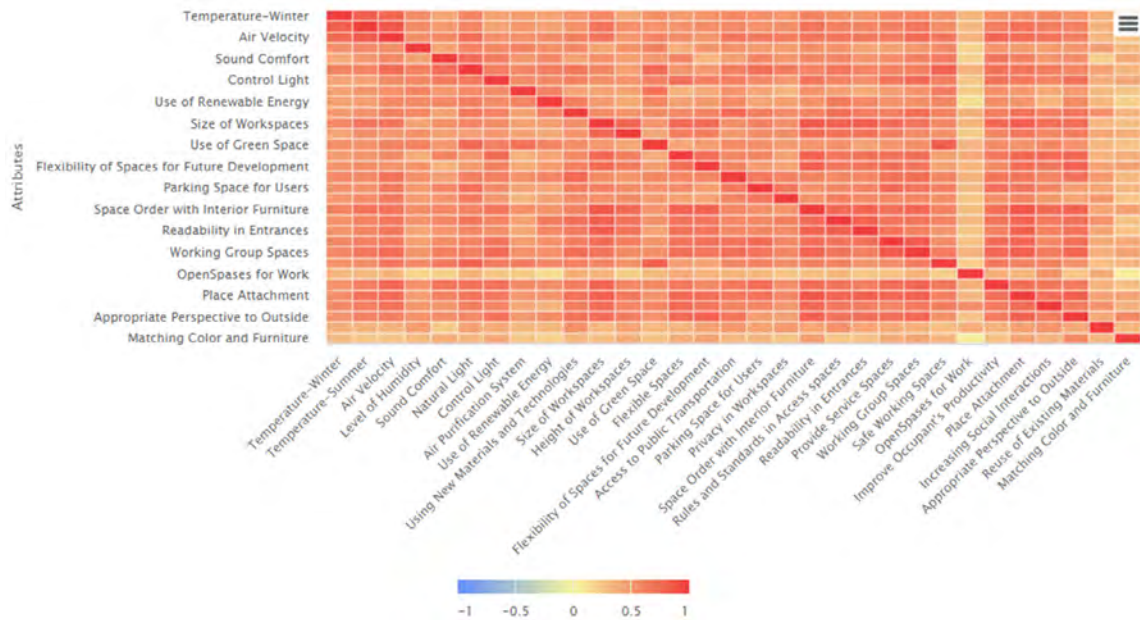


Fig. 7: Data correlation map

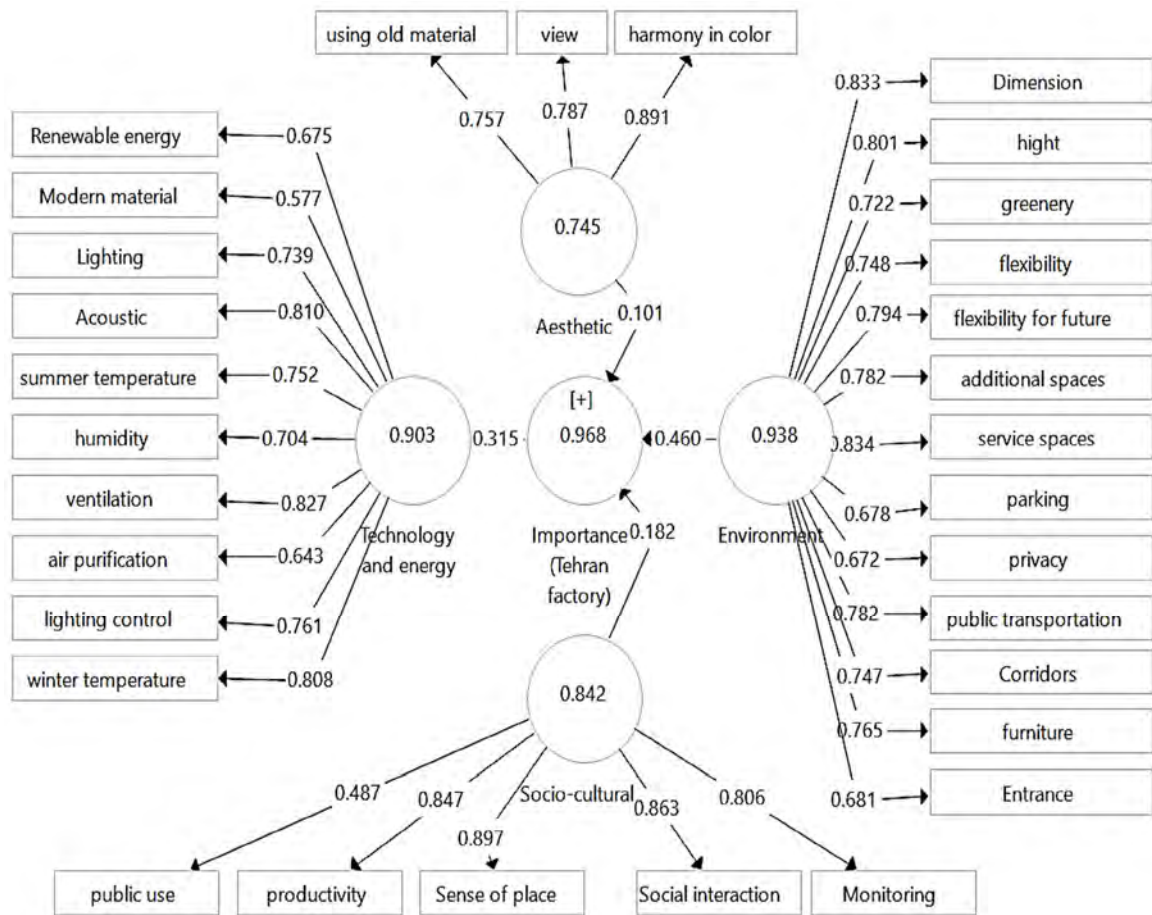


Fig. 8: PLS algorithm for the importance of factors in innovation center in Tehran

In response to the first question of the research, it should be said that in Mashhad Innovation Factory, in terms of environmental criteria, the two sub-criteria of dimensions of working spaces and furniture design for creating order in the spaces have caused the most satisfaction. In Tehran Innovation Factory, in the same criterion, the provision of additional spaces such as group work space, meeting space, space for talking on the phone and collective spaces, conference and video conference room, space for hosting customers, thinking space and space for study has created satisfaction in users. In terms of aesthetics, harmony in colors of the spaces and furniture with the use of space in Tehran Innovation Factory, and the perspective and view in Mashhad Innovation Factory have caused the most satisfaction. In Mashhad, the effect of spaces designed to increase job productivity

and in Tehran, the design of spaces to establish social interactions, have caused the greatest satisfaction from the socio-cultural criterion. This is in line with research by [Weijs-Perree et al., \(2019\)](#). In relation to the technology and energy criterion in Tehran, the provision of adequate ventilation has been found to be more satisfactory. Conversely, in Mashhad, the provision of appropriate relative humidity has been deemed more successful. This observation aligns with the researches of [Cheung et al., \)2020\(](#), [Park et al., \)2018\(](#) and [Asojo et al., \)2021\(](#). In response to the second question of the research, while examining the factor loadings of the technology and environment criteria, it can be stated that in Mashhad Innovation Factory, overall satisfaction with the environmental component is more than technology and energy criterion, but in three sub-criteria (access, provision

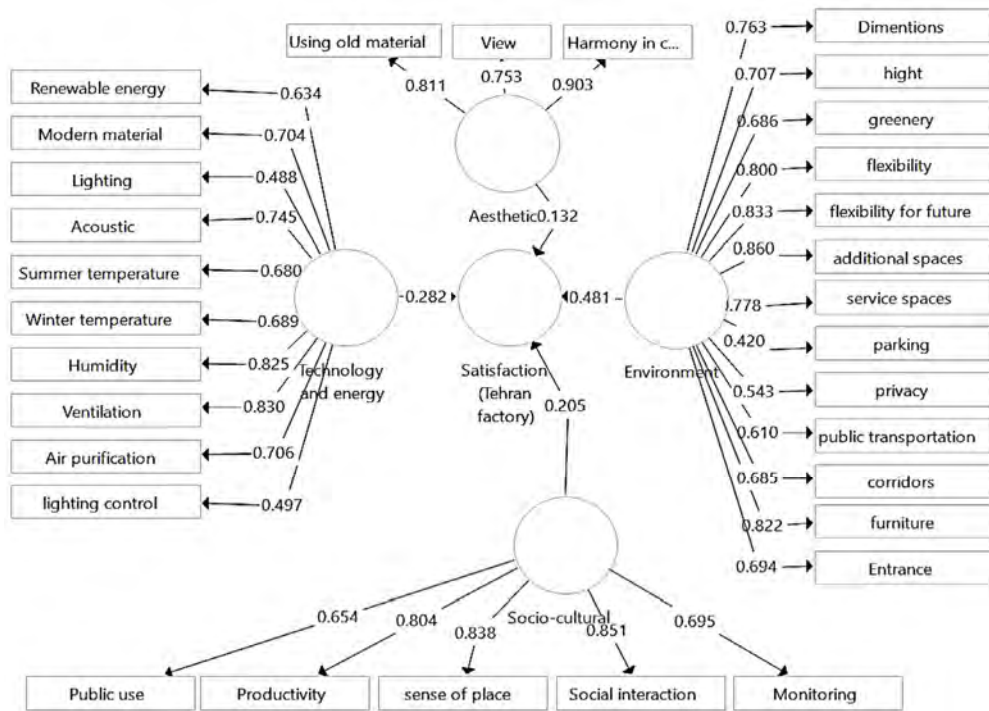


Fig. 9: PLS algorithm for the satisfaction with the factors in innovation center in Tehran

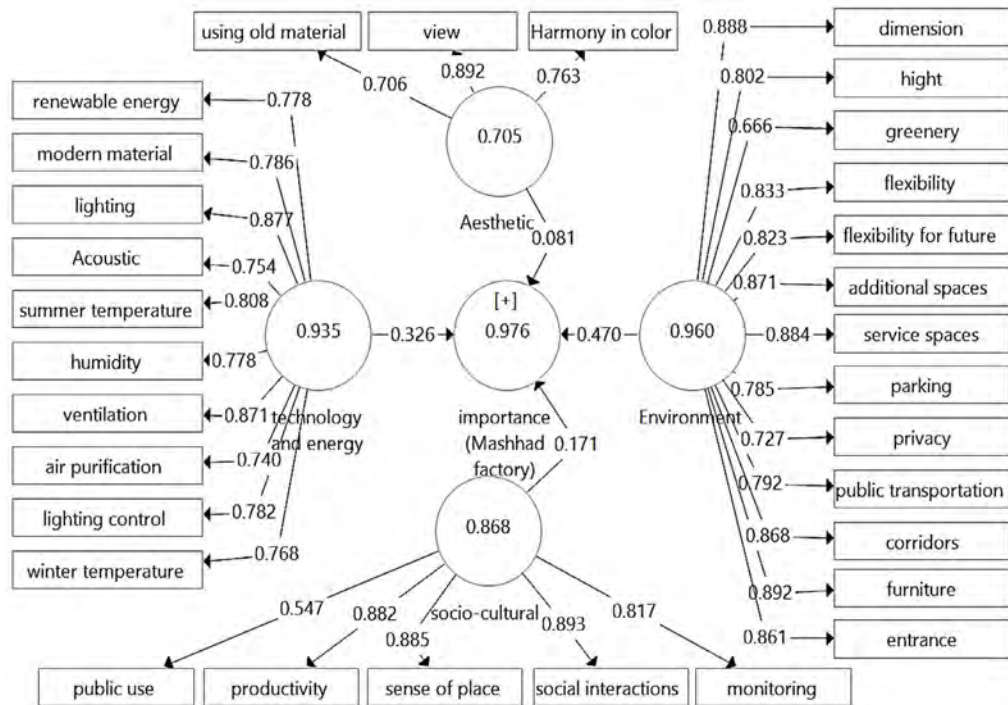


Fig. 10: PLS algorithm for the importance of factors in innovation center in Mashhad

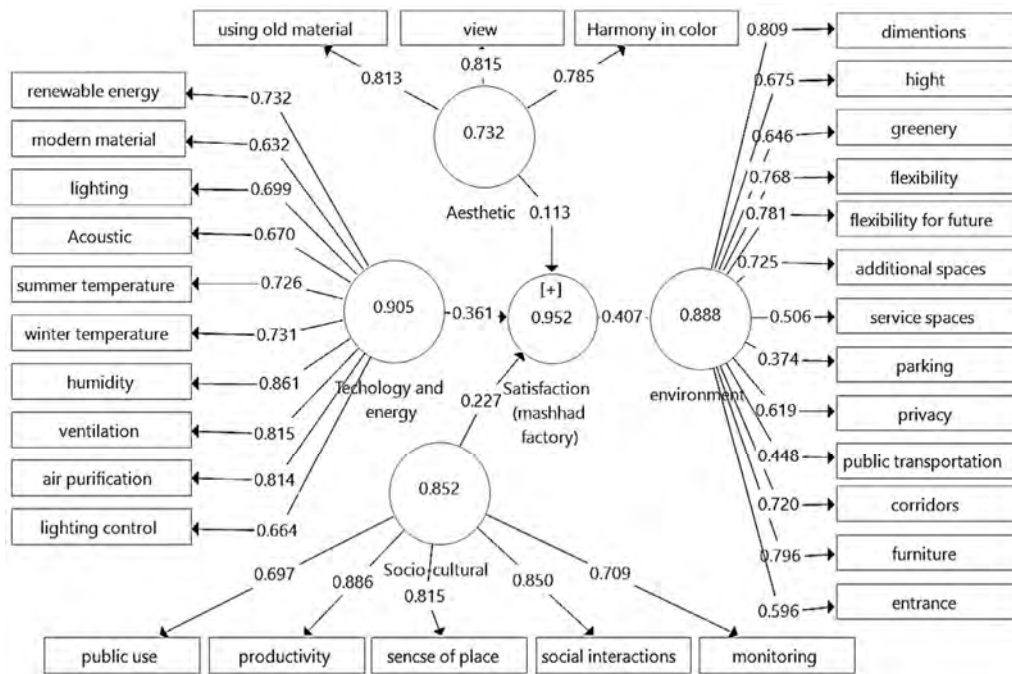


Fig. 11: PLS algorithm for the satisfaction with the factors in innovation center in Mashhad

of parking and service spaces) factor loadings are less than the other sub-criteria. Based on the objective assessment and talking with the users of Mashhad Innovation Factory, one of the main problems of the users was the lack of service areas such as restaurants or coffee shops and the weakness of additional services. Also, the distance to the metro station and the lack of parking space for the members of the center indicates the relative level of dissatisfaction with the three mentioned factors. In Tehran, the factor loading of all components is higher than 0.50, except for the factor of providing parking space (0.42). According to the factor loadings and the coefficients of the two criteria, in general, satisfaction with the factors of the environmental criterion is more than that of the technology criterion. The insufficiency of available parking facilities for patrons of center constitutes a conspicuous factor contribution to their discontentment. In the environmental criterion, dimensions of work spaces, interior furniture design and provision of service spaces have been more important from the point of view of the users, which is also in line with [Asojo et al., \(2021\)](#). The results of the algorithm are briefly shown in [Figs. 8 to 11](#).

CONCLUSION

Industrial heritages have various values and form a part of the identity and common memories of citizens, so the adaptive reuse of these buildings to the current uses is important. By using post-occupancy evaluation, in Mashhad and Tehran innovation centers, criteria for future design and important indicators can be achieved to be used in future. According to the findings of the research, the need for service spaces in innovation centers to facilitate the activities of companies and start-ups should be noticed more in future designs. Also, flexibility for future developments is one of the factors that requires more attention for adaptive change of the industrial heritage to innovation centers. Considering the capabilities of the structure and the possibility of having large spaces in the factories, it is possible to build flexible spaces for the convenient moving and changing them for future uses. Using wheeled furniture is another practical recommended method of flexibility that has been applied in Mashhad and as users stated their satisfaction it is proved to be a desirable method. Also, factors such as the use of renewable energies and modern air

purification systems are important according to the users' opinion, but they have been less noticed in the existing cases except few microalgae purifiers used in Mashhad center. Furthermore, the opinion of users regarding dissatisfaction with green space in Tehran innovation center shows the importance of dealing with green space and its impact on increasing productivity in the workplace. So, by creating more green spaces and adding more plants preferred by users in indoor environment besides improving indoor environmental quality a sense of belonging to the working environment could be improved. Also, the sound comfort is important in working environments and co-working spaces. In Azadi Innovation Factory, due to having larger spaces and larger shared co-working spaces, despite the use of sound insulation and hemp furniture, which reduce the echo of sound, the level of satisfaction is evaluated less than Mashhad center. Therefore, paying attention to the separation of spaces and sound control in shared work spaces especially in large areas is one of the effective factors in design. According to the analyzed data, surveillance and control is one of the important factors in social criterion based on users' opinion. Therefore, as discussed in the previous studies, control on windows and transparency is a key factor for designing co-working spaces to have more surveillance. Using transparent separators is also another way.

As the findings of the research shows, creating a sense of place is ranked as one of the highest socio-cultural sub-criteria which opens a novel aspect towards innovation center design with adaptive reuse. To create a suitable work space as well as creating a sense of place to both heritage building and the new designed place is important. Thus, further research could be done on technics of creating a sense of place and belonging in working spaces of innovation centers. The sense of belonging and creating collective memories in cities is created by recognizing the cultural, individual and social values of the citizens of each city. Another important factor from the users' point of view in these industrial heritage buildings (innovation centers) is the possibility of creating social interactions. According to the analyzed data, users were satisfied with this sub-criterion (possibility of improving social interactions) and the results shows that working in the designed environment and co-working spaces helps the individuals to

communicate more with other companies. The links between the buildings mass and the semi-open and open spaces help improve these interactions. Although previous articles on POE of working spaces were mostly conducted on environmental factors and indoor quality except few cases that mention social interactions in co-working spaces, current research investigates satisfaction of users about social interactions and productivity which has been ranked as important sub-criteria of designing innovation centers from users' point of view which is also in line with previous research. Thus, one of the topics for future research can be how to design and use buildings adaptively to improve productivity. Also the design factors for improving social interactions in working spaces is another future topic for POE. This research was done only in two available cases in Iran which were in Mashhad and Tehran cities due to the limitations of cost and time for publishing the questionnaire in other cities or other countries. So future research could be done in different places and different age groups. The results may vary in some factors as the social and cultural norms differ in other locations. Another limitation of the research was access to the innovation center and the people who work there due to the secret aspects of innovative ideas and control over the area. Therefore, the number of filled out questionnaires were limited to 120 totally. It is suggested that future researchers conduct a greater number of questionnaires.

AUTHOR CONTRIBUTIONS

S. Madani performed the literature review, questionnaire and data gathering, analyzed and interpreted the data, prepared the manuscript text, and manuscript edition. H. Kamelnia helped in the literature review and questionnaire preparation. A. Ghalenovi helped in questionnaire preparation and data analysis and manuscript edition.

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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.

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ABBREVIATIONS

<i>IEQ</i>	Indoor Environment quality
<i>BUS</i>	Building Use Studies
<i>DQI</i>	Design Quality Indicator
<i>OLS</i>	Overall Liking Score
<i>POE</i>	Post Occupancy Evaluation
<i>SEM</i>	Structural Equation Modeling
<i>TICCIH</i>	International Committee for the Conservation of the industrial Heritage

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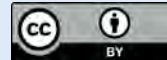
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ORIGINAL RESEARCH PAPER

An elucidation of comparative political ecology in urban areas regarding the allocation of urban green infrastructure

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ABSTRACT

BACKGROUND AND OBJECTIVES: As an integral component of urban space, green space assumes a pivotal role in the purification and filtration of air, provision of recreational opportunities, and augmentation of the aesthetic allure of the urban landscape. In contemporary urban settings, the significance of urban green spaces is widely acknowledged and embraced as an indispensable facet of the city. The consequences of urban expansion and the resulting environmental problems have indefinitely made the presence of green spaces and their proper distribution essential. Meanwhile, it is necessary to pay attention to achieving spatial balance in the distribution of urban parks, as they are an important component of urban green spaces, particularly in large cities. The population in Karaj city in Iran, has experienced an excessive increase, particularly in the last three decades. This has resulted in the rapid expansion of urban areas the destruction of the natural landscape and the structural pattern of both natural and artificial ecosystems. The city of Karaj, formerly known as Baghshahr, has transformed into a metropolis, with only a few traces of its once abundant urban green spaces remaining. This research aims to evaluate the demand for green space and the distribution capacity among the districts of 3 and 8 of Karaj city. The objective of the current study is to provide solutions based on spatial justice to increase the use of green space.

METHODS: The current research utilizes a combination of descriptive-analytical and critical methods, as well as documentary and survey methods. To analyze and evaluate the condition of green spaces and their mapping, information, and data from relevant organizations and satellite images have been utilized within specific spatial-temporal scales and GIS software.

FINDINGS: The results showed that the highest weight obtained was related to participation, with a weight of 0.118. This was followed by social capital, with a weight of 0.116 percent. The lowest weight was related to public services, with a weight of 0.040.

CONCLUSION: District 3 has more green space than District 8 due to the presence of gardens and trees planted by the municipality on the outskirts of the district. Additionally, the political ecology in these neighborhoods has not been impacted by District 3. However, Jahanshahr and Molana neighborhoods in District 8 have a high per capita population due to their small population and large areas of parks. Additionally, the presence of Family, fruit, Fateh and small Iran Gardens, contribute to the high population density in these neighborhoods. However other areas in the district experience a significant shortage of urban green spaces and are

DOI: [10.22034/IJHCUM.2024.02.08](https://doi.org/10.22034/IJHCUM.2024.02.08) affected by the influence of political ecology at both the neighborhood and regional levels.



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INTRODUCTION

One of the primary catalysts in the Anthropocene epoch is the escalating proliferation of urban regions, which, particularly following the advent of the Industrial Revolution, has assumed a pivotal and highly consequential role in the alterations of the natural environment (Shoorcheh, 2022). From the perspective of numerous researchers in this field, the world has entered a new era in geological history, commonly referred to as the Anthropocene (Steffen et al., 2007; Kolbert, 2011; Steffen et al., 2011; Purdy, 2015; Bonneuil and Fresco, 2016). The defining feature of the Anthropocene epoch is the conversion of natural landscapes into anthropogenic landscapes. The concept of “first nature” pertains to the pristine state of Earth’s ecosystems, while “second nature” encompasses the geographical environments that have been shaped through human alterations and interventions (Gandy, 2015; Smith, 2010; Harvey, 1996; Swyngedouw, 1996; Heynen et al., 2006). The loss of green infrastructure networks, which serve as vital life support systems for cities, is a significant challenge arising from population growth and land use. Given the multitude of ecological services these infrastructures offer to urban areas, they have become a focal point of interest for contemporary urban planners (Yazdan Panah et al., 2015). Urban green spaces possess specific attributes that render them conducive environments (Jennings and Bamkole, 2019) for enhancing the overall well-being of individuals. The presence of parks, trees, and bodies of water within urban settings offers a variety of social, psychological, and aesthetic ecosystem services, which are crucial in creating livable cities. However, the effectiveness of these spaces in fulfilling their designated functions relies on their quantitative and qualitative structures and characteristics (Aram et al., 2022). Hence, it is essential to establish criteria and guidelines for the development of urban green spaces before any planning takes place. In response to the increasing urbanization and technological advancements, there is a need for dynamic green spaces to preserve ecological balance. Urban green spaces offer both social and ecological advantages. The primary benefit of green spaces in cities is their environmental functions, which create a livable environment for humans and mitigate the negative impacts of urbanization and technology (Nasehi et al., 2016). During the urbanization of a city, the

dynamic changes in green infrastructure have a significant impact on urban ecological processes (Chang et al., 2013). Green infrastructure refers to the presence and arrangement of natural elements, such as forests and wetlands, within a specific geographical area. Similar to man-made infrastructure, such as transportation systems and utilities, green infrastructure also serves a vital function by providing ecosystem services that are essential for human well-being. The depletion of green infrastructure incurs hidden costs for society (Weber et al., 2006; Yazdan Panah et al., 2015). Despite the efforts made by cities to develop and improve urban infrastructure, numerous urban challenges continue to emerge in significant numbers. These challenges encompass issues such as air and water pollution (Samimi and Nouri, 2023), rainwater runoff, biodiversity loss, population growth, and the formation of urban heat islands. All of these factors have detrimental effects on the urban environment. Furthermore, the influence of climate change is increasingly exacerbating these problems (Kwak, 2016). The city of Karaj, located near Tehran, has undergone rapid and unprecedented urbanization, resulting in a lack of spatial harmony between key urban functions, especially residential areas and green spaces. This research aims to assess the current state of urban green spaces in the ten regions of Karaj, considering population, per capita calculation, and the utilization of green spaces, with a specific focus on urban parks. The study will analyze the social, economic, and physical impacts on citizens and explore the relationship between the distribution of green spaces and population. Strategies will be proposed to achieve social justice in the distribution and accessibility of green spaces, presenting a vision for a city within the city of Karaj. The city of Karaj, along with its seven subordinate cities, is currently grappling with challenges pertaining to pollution and the degradation of its green areas. To prevent future crises, it is crucial to preserve and expand the city’s green spaces and establish a green belt around it. In the past, Karaj was renowned for its vast gardens, but urbanization has since turned it into a bustling metropolis. Without proper planning and management of green spaces, as well as the establishment of ecological networks, the social and ecological structure of the city is at risk. The current plan estimates a green space of 0.7 square meters

per capita, but the revised plan suggests increasing it to 6 square meters within the legal limits of the city ([Detailed plan of Karaj green space, 2013](#)). Based on the analysis of various sources such as surveys, maps, personal data, and on-site visits, it is clear that urban development has had a significant impact on the green spaces in Karaj. The green areas have either been diminished, compressed, or completely eradicated. Consequently, the overall condition of green spaces in Karaj city can be considered unsatisfactory. Given the political and ecological context, this study aims to explore two ecological regions in the city of Karaj, taking into consideration economic, social, and physical factors. Specifically, the investigation focuses on the role of political ecology in the distribution of green spaces between disadvantaged and affluent areas of Karaj city. Regions three and eight have been selected for examination, and the research criteria within these regions have been analyzed. Parks and urban green spaces play a crucial role in fostering social sustainability and are regarded as key indicators of societal progress. These spaces provide individuals with a sense of security and tranquility ([Annabestani and Hosseini, 2018](#)). Parks and urban green spaces play a crucial role in fostering social sustainability and are regarded as key indicators of societal progress. These spaces provide individuals with a sense of security and tranquility ([Miraibi Moghadam et al., 2019](#)). In essence, an urban park can be described as a large area with a forest-like structure, consisting of diverse plant species, and designed to be environmentally and ecologically sustainable, adapting to the existing environmental conditions within the city ([Rahimi Sardo, 2019](#)). Urban parks hold significant importance in the overall landscape of a city, and their presence is crucial for promoting the well-being and health of its residents ([Ayala-Azcárraga et al., 2019](#)). Green space is a crucial component of urban ecosystems and a fundamental requirement for urban societies. The provision of green space in cities should be both quantitatively and qualitatively appropriate, taking into account the city's physical size and ecological conditions ([Farrokhian and Mayedzadeh, 2020](#)). Urban green spaces contribute significantly to the overall landscape of cities. Notably, squares and boulevards are potential areas for creating green spaces within cities. Given their relatively large size, these spaces play a vital role in meeting the per capita

needs of citizens and present valuable opportunities for establishing green spaces in urban areas ([Miraei et al., 2018](#)). Urban green spaces serve as a valuable platform for fostering social connections and promoting cultural values within society ([Haidari et al., 2022](#)). These spaces play a multifaceted role, encompassing social, economic, and ecological dimensions. They are recognized as a key factor in enhancing the quality of urban living environments and fostering community development ([Mirzadeh Tabatabai et al., 2018](#)). Urban green spaces refer to designated areas within urban settings that are adorned with trees, flowers, grasses, and other vegetation, either naturally or artificially. These spaces are subject to human oversight and management in accordance with relevant regulations, laws, and expertise. These spaces are established, maintained, or constructed with the aim of improving the living conditions and well-being of both urban residents and non-rural populations ([Rahimi Sardo, 2020](#)). The term "ecology" originates from the Greek words "Oikos" and "Logos," which respectively mean dwelling, habitat, or living place, and knowledge, science, or understanding. Its literal definition pertains to the study of living organisms within their natural habitats ([Ardakani, 1400](#)). Urban ecology is an emerging field of study that aims to comprehensively understand the interplay between the environment, economy, politics, and cultural-social factors, guided by ecological principles. Its ultimate goal is to facilitate human flourishing and achieve a state of stability and harmony with nature ([Hanaee et al., 2022](#)). Urban ecology offers a platform for examining the societal implications of the environmental movement, specifically the interplay between communities and their surrounding environment. Additionally, it prompts us to consider the potential long-term effects on our understanding of cities and the dynamic between humans and their environment. This raises whether urban ecology aims to establish communities solely influenced by ecological factors or if it can contribute to the development of significant environmental ideas and concepts in response to various ecological crises ([Hudson and Mervin, 2018](#)).

Literature review

[Movahed et al. \(1401\)](#) in a study titled analysis of the sustainability of urban neighborhoods with an emphasis on social-spatial justice, a case study:

Maragheh city, quantified special natural virtue and social capital and their relationship at the level of Maraghe urban neighborhoods. Their findings revealed that the amount of social capital in new and marginalized neighborhoods is nearly identical to the per capita distribution of urban services. Finally, in order to analyze the spatial relationship between spatial justice and social capital, Pearson correlation and weighted geographic regression methods have been used. Also, the results of the geographic regression showed that with the increase in the number of users, especially in the marginal areas, the social capital of these areas will increase. [Rajabi et al. \(2022\)](#) in research entitled analysis of the spatial distribution of urban public services from the perspective of social justice in the spatial structure of Tabriz metropolis, with the aim of evaluating and analyzing the distribution of urban public services from the perspective of social justice, determined that the districts 6 and 8 have the highest points and districts 5 and 4 have lower points. The research's findings indicate that the high scores in certain areas were attributed to their economic and commercial significance, which necessitates focusing on all aspects of health, open space, education, technology and urban amenities instead of just quantity and quality and it is necessary to enhance access to social justice indicators in the urban areas of Tabriz. [Taduon et al. \(2021\)](#) in an article titled impact of social inequality on the quality of green space in Kashan city, aimed to study the impact of social inequality in the enjoyment of urban green space. Analysis of results using structural equation modeling shows that there is a significant relationship between the social status of areas and the quality of green space in the city, as well as between variables related to Quality index of green space. The results also determined that the landscape factor has the highest loading factor with 0.98. [Kumar \(2022\)](#), in an article titled environmental justice elements and strategies in organized urban green space development, found that the following five key components contribute to economic injustice environment, including: community characteristics and infrastructure related to organized green spaces; economic development and organized green space management; connecting green space with environment and health; spatial development, land use, land access and availability and management of green space provision. Strategies

such as community management, green space development and management; fair and equitable distribution of green space; improve accessibility; linking green spaces with health benefits; and the mandatory link between built infrastructure and the provision of green spaces will ensure environmental justice. [Xu et al. \(2022\)](#) in the article titled research on the comparative relationship between the supply of Urban Ecological Recreational Space (UERS) and the demand of residents - a case study of an urban development area in Wuhan with the purpose of research on the relationship between green space supply and people's needs determined that the quality of UERS in the Wuhan urban development area varies widely and its distribution is very uneven. Service delivery and demand levels vary widely, and overall performance tends to decrease from the city center to the surrounding areas. UERS' overall supply-demand mix is not ideal, and more than half of communities are experiencing supply shortages or no services. [Nasri and Hosseini \(2022\)](#) conducted a study titled evaluating the correlation between urban green space provision and economic and social inequality in Tehran - Iran regions. Study data were extracted from official statistical and spatial data and analyzed using Arc GIS. The results show an uneven distribution of Urban Green Spaces (UGS). However, areas with higher socioeconomic status had the optimal level of UGS justice among the 22 areas. But the results do not confirm a direct correlation between areas of lower socioeconomic status. [Roy et al. \(2021\)](#), in a study aimed at studying and assessing the ecosystem health of three different types of urban settlements in urban areas, developing peripheral cities, and emerging cities, found that construction levels are increasing in peripheral cities (11%) and urban areas (23%) which shows increasing pressure on the ecosystem in the form of reduced in permeable levels. Increases in water turbidity, land surface temperature and the number of aerosols (tiny solid and liquid particles in the air) in the air indicate high pressure points that require corrective and preventative action. [Vano et al. \(2021\)](#) conducted research using urban green infrastructure as a research perspective to critically evaluate Slovakia's planning processes at the national, regional and local levels, by analyzing the planning documents and interviews with green space practitioners and evaluate appropriate local performance. The findings reveal weak instrumental

support for urban green infrastructure planning, as well as other systemic and administrative barriers to such infrastructure. [White et al. \(2021\)](#) conducted research using the proposal of an integrated conceptual framework that expands the benefit-service relationship to include solutions. There are different types of services (ecosystem services, technology-based services, and labor services). The results presented a method for ranking nature-based solutions, in which they calculated the relative contribution of ecosystem services compared to technology and labor services. The methodology and framework are applied to projects addressing water pollution issues and demonstrate their applicability and operationalization. [Kaproška \(2019\)](#) considered environmental justice in the context of the availability of urban green spaces, with the aim of assessing and considering the spatial justice of public services in the use of green spaces. The results showed that urban green spaces influence the health and well-being of urban residents, but access can be unequal in terms of socio-spatial heterogeneity. The increasing challenges posed by urban living, such as climate change, densification, expansion of development, and urban heat islands, necessitate the sustainable management of green spaces and the equitable distribution of their benefits. It is crucial to ensure socially fair access to these spaces. Furthermore, an important aspect of this discourse is the consideration of planning decisions that have the potential to be beneficial, such as increasing the availability of urban green spaces, as well as those that may contribute to gentrification and exacerbate social inequality, with their long-term consequences. A review of previous studies reveals that most of the research conducted thus far has primarily focused on assessing the current state of urban ecosystem services in relation to land use change, land cover, landscape, urban growth, and the economic valuation of ecosystem services. Consequently, factors pertaining to the capacity to provide ecosystem services have not been adequately addressed from the perspective of characteristics, socio-economic factors, and local attributes of urban areas. This issue highlights the need to enhance the ability to provide ecosystem services associated with nature-based solutions that enhance the quality, health, and well-being of people's lives, while simultaneously promoting sustainable development, urban resilience, and the

development of urban green infrastructure through scenario building. The current study has been carried out in Karaj, Iran in 2023.

MATERIALS AND METHODS

The current study combines descriptive, critical, documentary, and survey methods. The purpose of this study is to evaluate the demand situation and allocation capacity for green space use in the districts of 3 and 8 of the Karaj metropolitan area, and to provide solutions for increasing green space use based on spatial equity of green space use. In order to conduct a comprehensive analysis and assessment of the state of green spaces, it is imperative to utilize pertinent information and data obtained from various organizations such as the municipal organization, governorate, and police force organization. Additionally, satellite imagery at appropriate spatial-temporal scales and Geographic Information System (GIS) software should be employed to map the aforementioned green spaces. Furthermore, it is crucial to consider the social characteristics of the residents in districts three and eight of Karaj metropolis, specifically their economic status. This can be achieved by utilizing information and data derived from the [National Statistics Organization \(2015\)](#). Moreover, the municipal areas map of Karaj metropolis should be consulted to ensure accurate spatial representation. To further enhance the analysis, statistical information pertaining to crime levels and addiction rates, which have been compiled and utilized by the police organization, should be incorporated. By integrating these various sources of information and data, a comprehensive evaluation of the condition of green spaces and the economic well-being of the citizens in districts three and eight of Karaj metropolis can be achieved. In addition, the discourse surrounding political ecology within the realm of green spaces during the period spanning from the 1991s to the 2021s has been subject to scholarly inquiry. The present study employed a field survey approach to assess the state of spatial justice in green spaces across eight and three districts of Karaj metropolis. To this end, the opinions of 30 experts in the field of urban development and urban planning were solicited using the Dimtel questionnaire. Additionally, the study utilized linear regression to examine the relationship between independent social, economic, and political variables of citizens'

characteristics and their access to green space, which served as the dependent variable. To prioritize the impact of independent variables on the distribution of green space, the critic method was employed. The normalization of data is presented in Eq. 1.

$$r_{ij} = \frac{x_{ij} - x_j^{\min}}{x_j^{\max} - x_j^{\min}} \quad (1)$$

Eq. 2 illustrates the initial weight assigned to the criteria.

$$c_j = \sigma_j \sum_{i=1}^m (1 - r_{ij}) \quad (2)$$

Eq. 3 presents the values denoting the initial and ultimate weight of the criteria.

$$w_j = \frac{c_j}{\sum c_j} \quad (3)$$

In an academic context, the weight of criterion j is denoted as W_j , while C_i represents the cumulative amount of information encompassing a total of k criteria. The range of k criteria begins at $k=1$ and extends until $k=m$. The amount of information extracted from criterion j , denoted as C_j , is obtained through the utilization of the subsequent equation. In accordance with relationships 2 and 3, criteria possessing a greater value of C_j will be accorded significant weight. Additionally, relationship 3 stipulates that σ_j represents the standard deviation of the j th criterion, while r_{ij} denotes the correlation between two criteria, i and j . Drawing from the aforementioned analysis, it can be inferred that C_j holds greater value and furnishes more information than the criterion under consideration, thereby rendering the relative importance of the criterion crucial in a decision-making scenario. The Normalized Difference Vegetation Index (NDVI) is a metric used to assess the health of vegetation by analyzing the manner in which plants reflect specific wavelengths of the electromagnetic spectrum. In essence, the NDVI index serves as an indicator of plant health by evaluating the plant's response to various light waves. The electromagnetic spectrum plays a crucial role in comprehending plant health as it enables the determination of a plant's well-being based on its energy and light reflection patterns. To compute the NDVI index, it is necessary to compare the levels

of red-light absorption and near-infrared reflection, which provide insights into the plant's vitality. The subsequent mathematical formula calculates the NDVI, thereby transforming raw satellite data into vegetation indices. This formula amalgamates information from the red and near-infrared bands to generate a single, representative value. It achieves this by diminishing the reflectance in the red spectral band from the near-infrared, subsequently dividing it by the sum of near-infrared and red reflectance. The NDVI index value always falls within the range of -1 to +1. Values between 0 and 1 denote deceased plants or inorganic objects such as rocks, roads, and houses. For living plants, the NDVI index values range from 0 to 1, with 1 representing optimal health and 0 indicating the least healthy state. Each pixel in an image can be assigned a singular value.

The study area

The study area under consideration is Karaj, which is situated approximately 36 kilometers west of Tehran. It is positioned on the western bank of the Karaj River and on the southern slope of the Alborz Mountain range. Karaj is bordered by Mazandaran province to the north, Tehran city to the east, Shahryar city and Central province to the south, and Savojblag city and Qazvin province to the west (Fig. 1). The geographical coordinates of Karaj are approximately 51 degrees 0 minutes 30 seconds east longitude and 35 degrees 48 minutes 45 seconds north latitude. Its altitude is recorded at 1297 meters above sea level, specifically at the railway station. Karaj is located 48 kilometers northwest of Tehran. The city covers an area of 4.175 square kilometers, while the entire region encompasses 9.178 square kilometers. Karaj serves as the central hub of the region and is situated on the slopes of the central Alborz Mountain range. As of the 2015 census, the population of Karaj city was recorded at 1,592,492 individuals, which increases to 1,973,470 individuals when including the population residing in the outskirts of the city. For the purposes of this study, District 3 and 8 were selected due to their distinct social, economic, and physical characteristics. The specific locations of these regions are depicted in Figure 1, as outlined in the Strategic Structural Plan of Karaj City in 2015.

RESULTS AND DISSCUSION

Initially, the map of Karaj city was divided into three

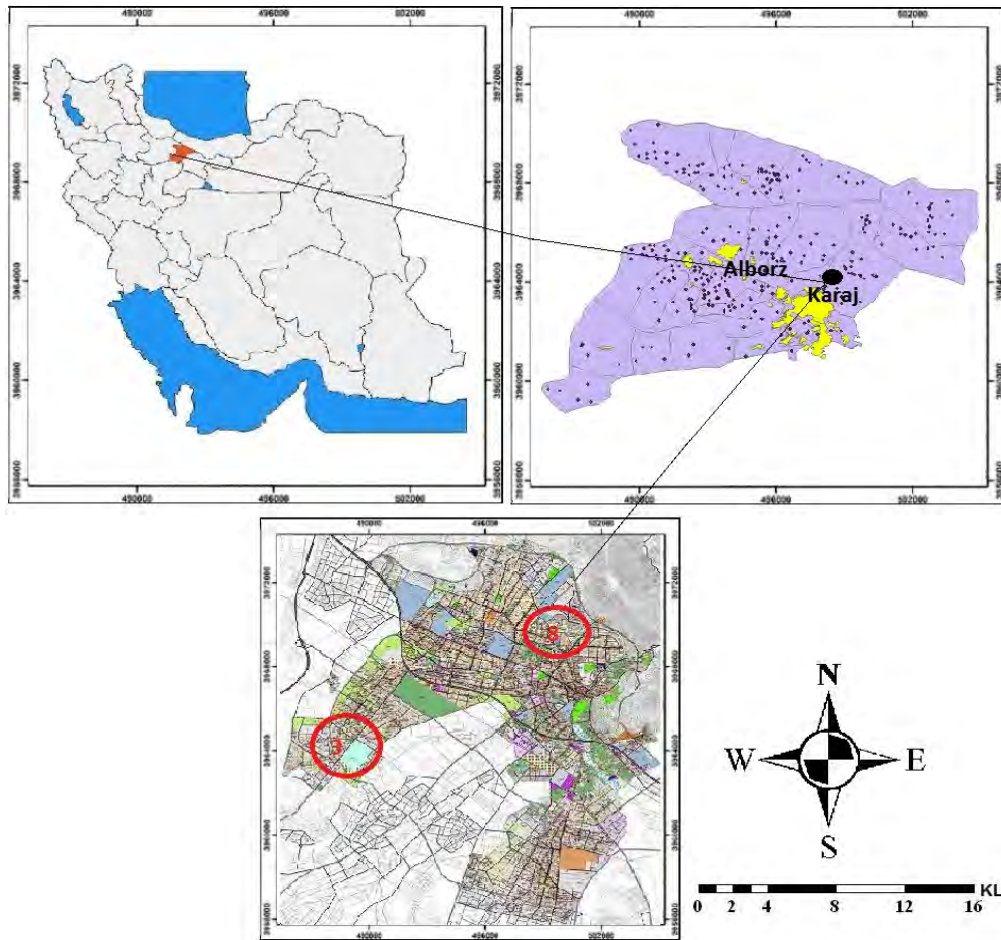


Fig. 1: The geographical location of the Karaj in relation with the map of Iran

and eight regions, which were determined through a combination of research, questionnaires, and census data provided by the Statistics Organization. The indicators for each region were then calculated, taking into account information on crime, divorce, criminality, and addiction obtained from the police organization. Additionally, data on urban capital and social services were acquired from the governorate. Subsequently, the regions were ranked based on each index using Dimtel's questionnaire, resulting in scores ranging from 0 to 9. In the next step, normalization was carried out by considering the impact of each indicator on the potential for political ecology of green space. For instance, if an indicator such as literacy positively influenced the presence of green space, its frequency was linearly increased. The values were

then divided by the maximum value of each index. Conversely, for indicators with a negative effect, such as addiction, the values were calculated using the formula 1 minus the values divided by the maximum. The outcome of this process was the normalization of all indices between 0 and 1. This information is visually represented in Figs 1 to 13, where the values of each index can be observed based on color.

Based on the findings presented in Table 1, it is evident that the variable exhibiting the highest weight is participation, with a weight of 0.118. Subsequently, social capital emerges as the second most influential factor, with a weight of 0.116. Conversely, the variable associated with the lowest weight is public services, which obtains a weight of 0.040.

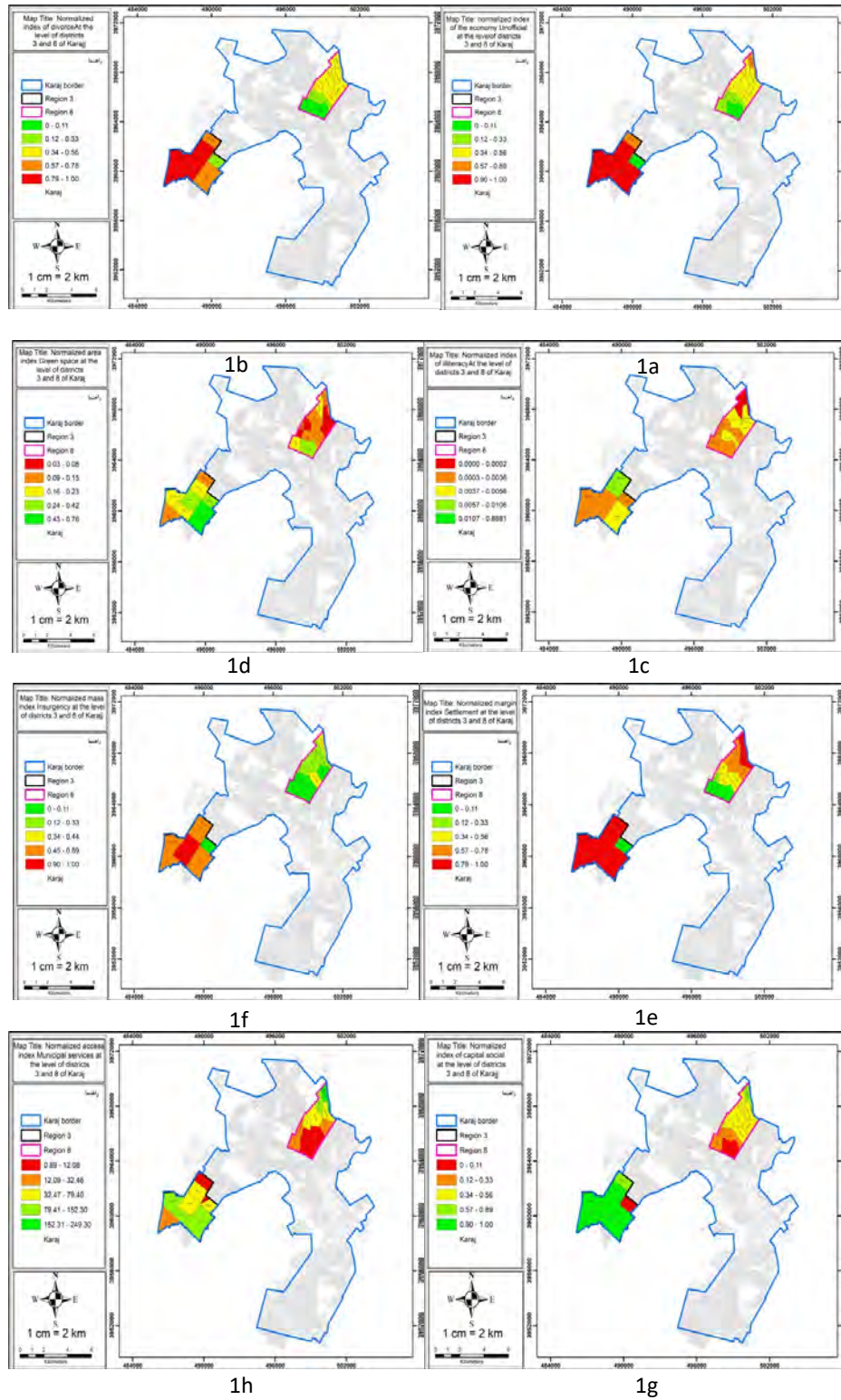
Based on the findings presented in Fig. 1a, it

Table 1: Weight of the criteria

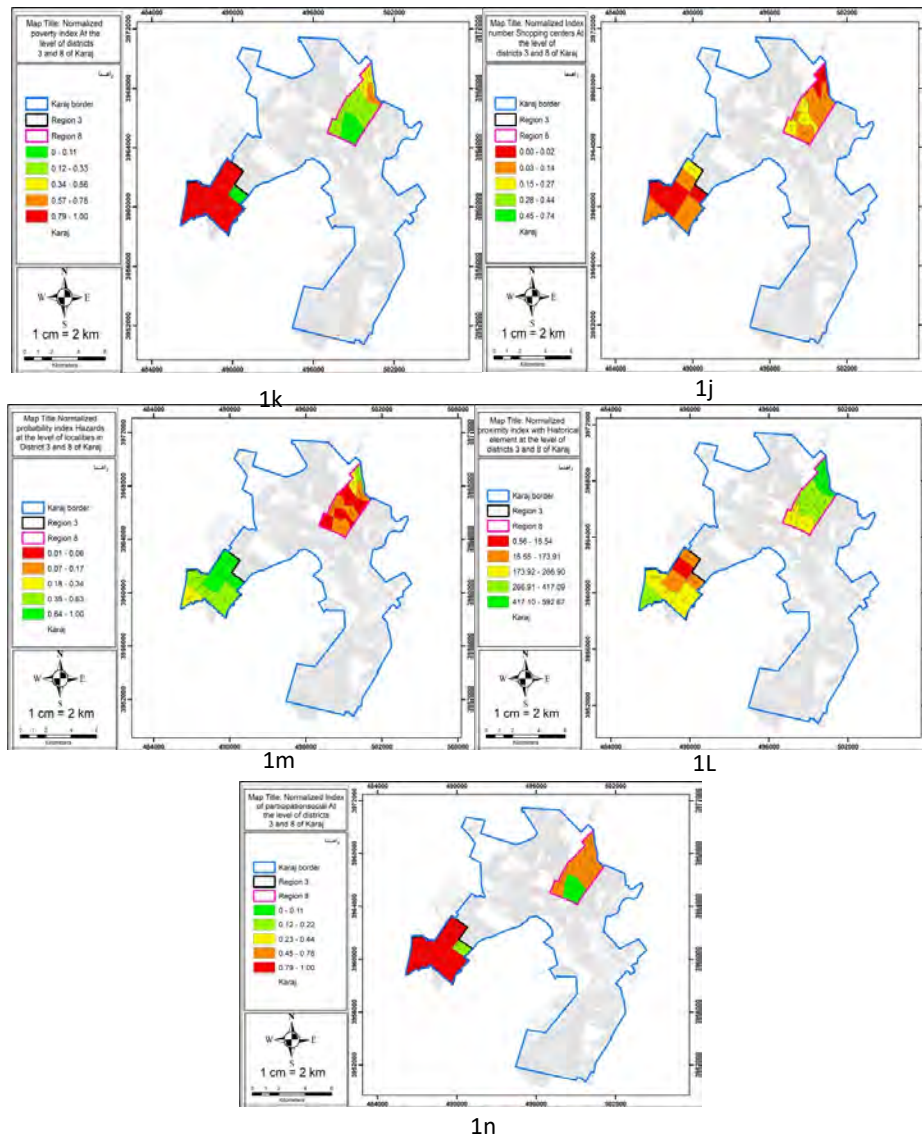
Index	Contrast matrix	Standard deviation	multiplication	Weight
Crime	11.11341565	0.273034982	3.03	0.062
Urban poverty	10.8977055	0.241612595	2.63	0.054
Unemployment	11.52769574	0.244961989	2.82	0.058
Divorce	10.88357019	0.238370147	2.59	0.053
Illiteracy	12.89595501	0.202241939	2.61	0.053
Marginalization	10.50849822	0.320213482	3.36	0.069
Addiction	11.09068663	0.295335542	3.28	0.067
Participation	18.50535282	0.313066039	5.79	0.118
Economy	10.83206191	0.297750988	3.23	0.066
Social capital	19.16793809	0.297750988	5.71	0.116
Risks	15.90143646	0.224661476	3.57	0.073
Public services	13.05777571	0.15122585	1.97	0.040
Historical	14.20222248	0.227802365	3.24	0.066
Purchase	14.05763092	0.198471376	2.79	0.057
Green space	12.95225198	0.186924161	2.42	0.049

can be observed that the level of informal economy in District 3 of Karaj is significantly high. This phenomenon can be attributed to a multitude of factors, including but not limited to low levels of education and income. Furthermore, Fig. 1b indicates that the rate of divorce in District 3 surpasses that of other neighborhoods in Karaj. It is noteworthy that the rate of divorce in underprivileged areas is considerably lower than that of affluent regions within the city of Karaj. Additionally, the illiteracy rate in the neighborhoods of Aghtape, Akhtarabad, Golestan, and Koie Mehr three is substantially higher than that of other neighborhoods. This can be attributed to the low income of the residents and their early employment. In Districts 8, the prevalence of low-income neighborhoods such as Nuclear Power Plant, Molana, and Hajiabad is notable. This can be attributed to the financial constraints faced by the residents of these areas. In terms of green spaces, District 3 boasts a significantly higher number of such areas compared to District 8. The decrease in green spaces in District 8 can be attributed to the destruction of southern gardens and increased construction activities. Conversely, the increase in agricultural land in the western and southern parts of the district has led to an increase in green spaces in this area. The map indicates that marginalization is prevalent in District 3, the nuclear power plant, and Mahmoud Abad in District 8. This is due to the low cost of land and rent, lack of facilities and urban services, and limited access to amenities such as transportation. The level of crime is also high in neighborhoods such

as Koie Mehr and Agtape, which are characterized by high levels of unemployment and urban poverty. The social capital map reveals that neighborhoods such as Jahanshahr, Molana, and Mehrshahr have low levels of social capital. Conversely, less privileged and marginalized neighborhoods in the district exhibit higher levels of social capital due to increased interactions, social trust, and participation in social affairs. The urban services map indicates that Karaj city has relatively equal distribution of urban services, although central areas have higher access to such amenities due to the concentration of power and wealth in these areas. In summary, the analysis highlights the disparities in income, green spaces, marginalization, social capital, and urban services across different districts and neighborhoods in Karaj city. Based on the cartographic representation, it is evident that the accessibility to shopping centers is significantly greater in the Molana, Nubuvat, and Rajai Shahr neighborhoods compared to other regions within the vicinity. Conversely, the urban poverty rate map reveals that Golestan, Koie Mehr, Kianmehr, Agtape, Akhtarabad, Ahadabad, and Baharan neighborhoods exhibit a higher prevalence of urban poverty. It is worth noting that areas lacking spatial justice exhibit diminished access to shopping centers and an augmented incidence of urban poverty. Furthermore, the map indicates that District 8 neighborhoods possess a substantially greater abundance of historical elements in comparison to the aforementioned regions, owing to the age and formation of the city of Karaj. In terms of risks,



Figs. 1a-1n: The normalized maps illustrating the research criteria in Districts 3 and 8



Continued Figs. 1a-1n: The normalized maps illustrating the research criteria in Districts 3 and 8

District 3 experiences a heightened level of risk due to the presence of non-compliant constructions. Additionally, the neighborhood proximate to the atomic power plant, in conjunction with non-compliant constructions, is geologically situated in close proximity to the Eshtehard fault, thereby amplifying the risk level. Moreover, the level of social participation is markedly higher in region three as opposed to region eight, attributable to the solidarity and robust neighborhood relations prevalent in the former. In the subsequent phase, a set of four

Landsat satellite images spanning the years 1991, 2001, 2011, and 2021 were obtained (Figs. 2 to 5). Given the historical availability of Landsat images over the past two to three decades, Landsat 5 and 7 images were utilized for the years 1991 and 2001, respectively. These images possess a spatial resolution of 30 meters. For the year 2001, images with a finer resolution of 15 meters were employed, while for the years 1990 and 1400, Sentinel 2 satellite images with a resolution of 10 meters were utilized. These images underwent pre- and post-processing procedures, as

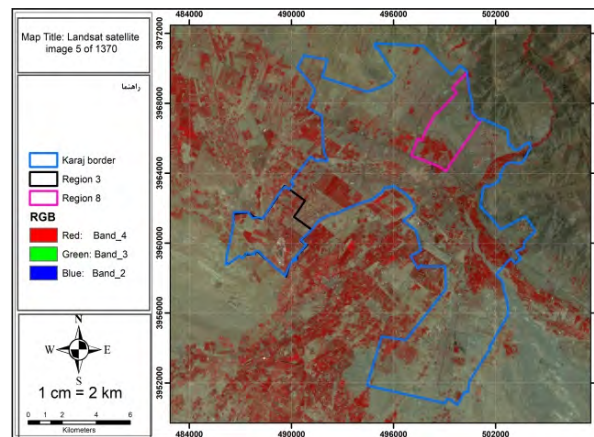


Fig. 2: Satellite image of Esther 1991

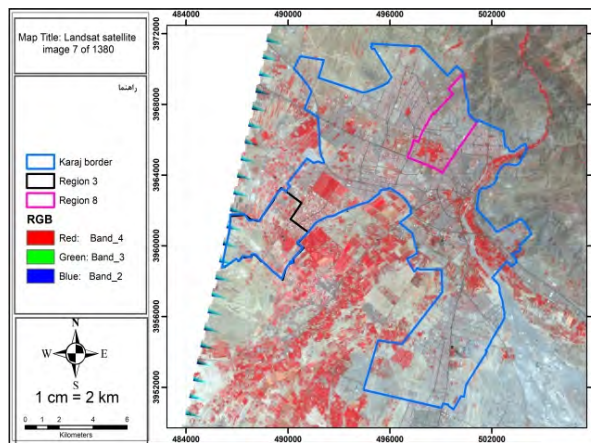


Fig. 3: Satellite image of Esther 2001

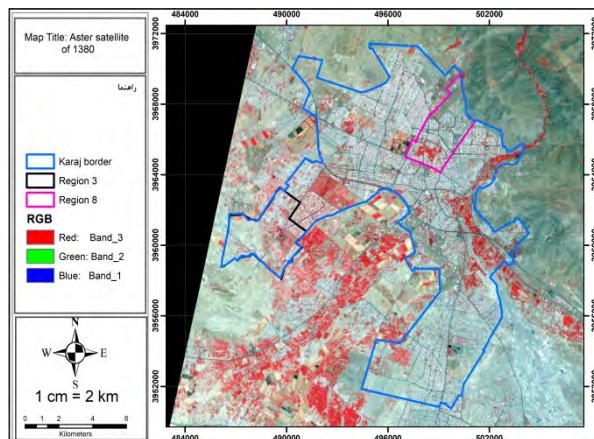


Fig. 4: Satellite image of Esther 2011

well as radiometric and atmospheric corrections, to enhance the accuracy of the Normalized Difference Vegetation Index (NDVI) in order to identify areas of vegetation. The study focused on a specific urban area.

According to the aforementioned information, the green space was segregated (Figs. 6 to 9) from other land uses subsequent to the computation of an index derived from the understanding of the district and the establishment of a threshold. Notably, the index encompasses all urban green spaces, encompassing trees situated within boulevards. To ensure comparability, the index was standardized by dividing the data by the maximum green space area.

In the subsequent phase, the statistical association

between green space as the dependent variable and other indicators as the independent variable was determined through relevant calculations and statistical analyses. The outcomes, ranging from 0 to 1, indicated that as the weighted linear combination (WLC) approaches 1, a positive correlation exists between the indicators and the existence of green space (Fig. 10), and conversely.

Based on the analysis of green space in the years 1991, 2001, 2011, and 2021, it is evident that the Golestan neighborhood of Mehrshahr and Aghatape in District 3 has witnessed a gradual expansion of its green areas. This growth can be attributed to the increased presence of gardens and agricultural lands. Additionally, the municipality and the

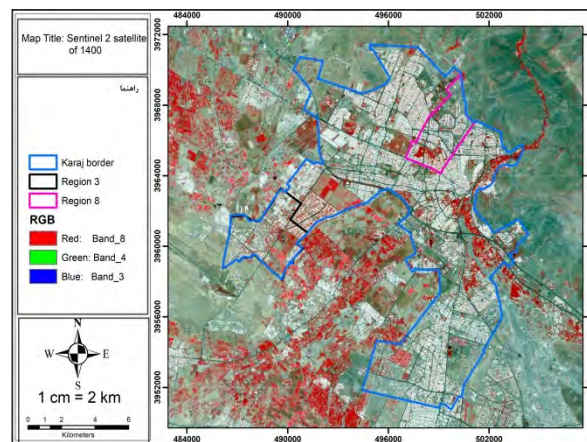


Fig. 5: Satellite image of Esther 2021

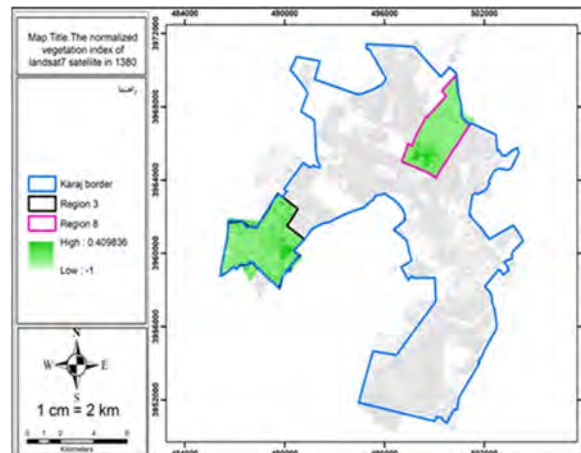


Fig. 6: The normalized vegetation cover in 2001

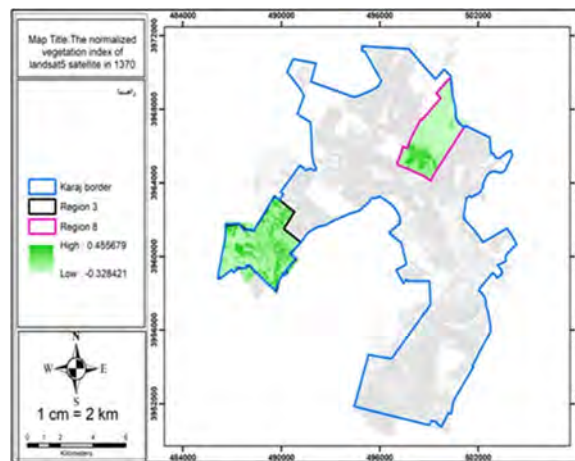


Fig. 7: The normalized vegetation cover in 1991

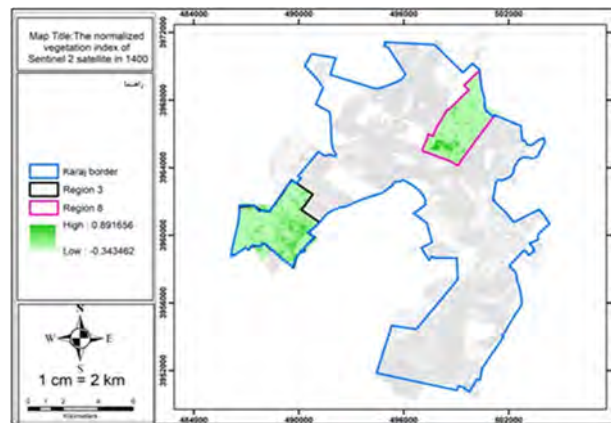


Fig. 8: The normalized vegetation cover in 2021

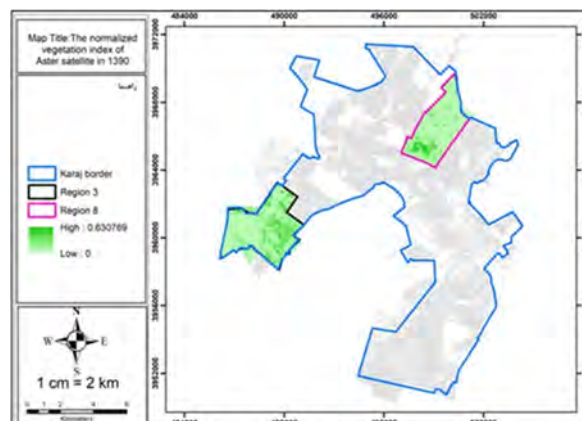


Fig. 9: The normalized vegetation cover in 2011

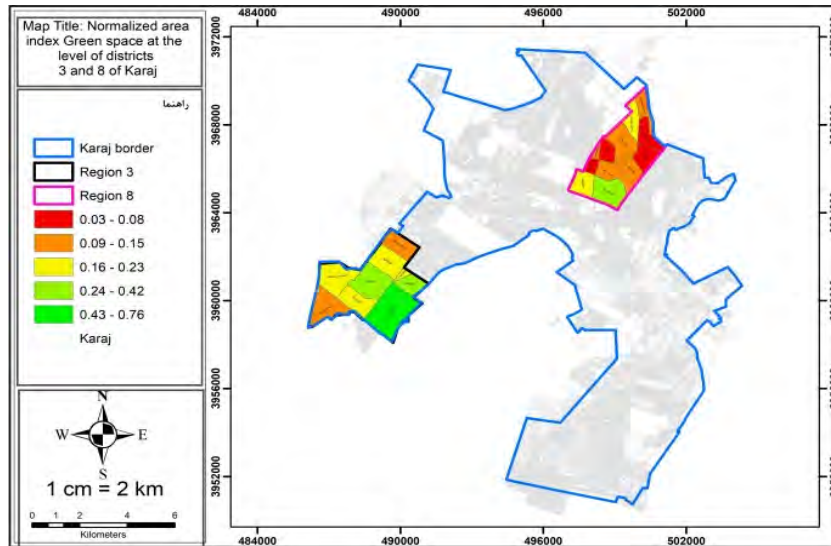


Fig. 10: The verdant expanse encompassing Districts 3 and 8

pastures and forestry organization have contributed to this development by planting vegetation in the surrounding lands and outskirts of the neighborhood. As a result, the neighborhood now boasts a dominant natural landscape characterized by this vegetation cover.

At the neighborhood level, the variety of plant species remains limited. Furthermore, a notable disparity exists between the western and eastern halves of the neighborhood in terms of vegetation density, with the former exhibiting significantly higher and denser vegetation. It is worth mentioning that the municipality has recently undertaken commendable initiatives, such as planting multiple tree trunks along the roadside. This measure not only enhances the neighborhood's aesthetic appeal but also serves to fortify the soil alongside the road. Overall, the expansion of green space in the Golestan neighborhood of Mehrshahr and Aghtape, driven by the proliferation of gardens and agricultural lands, coupled with the efforts of the municipality and the pastures and forestry organization, has resulted in a prominent natural ambiance. In the southeastern regions of Karaj, specifically in the Mehrshahr neighborhood, the presence of fruit gardens and limited green spaces and gardens in District 3 has resulted in the absence of political ecology influence. However, in District

8, the existence of Fateh Garden, Family Park, and Iran Garden green spaces has led to the emergence of political ecology in these neighborhoods. The concentration of wealth and literacy in these areas has played a significant role in the increase of green spaces. Since 1941, Karaj has remained a large village with a population of 3000 people. Surrounding this village were beautiful gardens abundant with water and favorable weather conditions, making it a popular vacation destination for residents of Tehran. In 1946, the first general census recorded a population of 14,526 people in Karaj city, residing in three separate municipal areas: Karaj, Gohardasht, and Mehrshahr, which represented Baghshahr entirely. As the population grew and Karaj gained acceptance, its proximity to Tehran, favorable climate, affordable housing, and employment opportunities in the metropolis led to intentional or unintentional changes in land use, resulting in the conversion of many gardens into construction sites. Currently, the city's infrastructure does not meet the needs of its residents, and the per capita green space is significantly below the national average. In the past, the city boasted several times the national average of green space per capita, but this has drastically declined. The city of Karaj is confronted with numerous challenges as a result of its close proximity to Tehran, and it is often referred to as a

metropolis lacking in infrastructure. Karaj possesses limited authority in urban management and heavily relies on the provincial center for decision-making. Some of the issues faced by Karaj include densely populated areas, disruptions caused by immigration and unemployment, and inadequate facilities for sports, recreation, and leisure activities, despite a significant proportion of the population being young. Additionally, poverty and social inequality are prevalent, as highlighted in the second master plan of Karaj, which was approved in 1989. This plan serves as a guide to assess the successes and failures of its implementation, as well as to determine whether any shortcomings in achieving the set goals are attributed to the plan's structure or the inadequacies in the execution methods. Owing to its close proximity and adjacency to Tehran, Karaj has experienced substantial population growth in recent decades. In this study, the adequacy of per capita urban green space in Karaj has been evaluated in relation to national and international standards, revealing that the current state of per capita green space in the examined areas of Karaj is highly unsatisfactory. In general, the findings indicate that District 3 exhibits a significantly higher per capita urban space compared to the desired standards, thus earning the highest rank. Conversely, District 8 possesses a smaller proportion of green spaces in comparison to district 3. The per capita and standards of the remaining eight regions are not in line with the established benchmarks, and in other regions, there is a notable decline and imbalance when compared to the existing standards outlined in other scientific sources. Overall, it can be concluded that the third region boasts a high per capita population due to its small population size and extensive park areas. However, District 8, in contrast to District 3, suffers from a severe deficiency of urban parks at both the neighborhood and regional levels, necessitating the creation of such parks based on the population of each region and in accordance with accepted standards in the field of urban green spaces per capita. Particularly with regards to parks, appropriate measures should be implemented to establish parks in the areas of Karaj city. Based on the obtained results, it is evident that political ecology has not played a significant role in District 3 of Municipalities of Karaj, as evidenced by the formation of Agtape and Akhtarabad

neighborhoods which have arisen spontaneously on the outskirts, owing to the presence of municipal gardens, agricultural lands, and tree plantations. On the outskirts of the district, political ecology has not influenced the neighborhoods, resulting in a greater abundance of green spaces compared to other neighborhoods. However, in Jahanshahr, Molana, and Rajaeeshahr neighborhoods, political ecology plays a substantial role due to the concentration of wealth and power in these areas, as well as the presence of fruit gardens, family gardens, small Iran garden, Fateh Garden, Jahan Garden, Molana boulevard, green spaces, and wide boulevards. Finally, it can be stated that the results of the present study are in agreement with the findings of [Kaproška, \(2019\)](#); [Hu et al. \(2021\)](#); [Ayala-Azcárraga et al. \(2019\)](#); [Maleki et al. 2021](#)), [Tadayon et al. \(2021\)](#), [Mahmoudzadeh et al. \(2022\)](#) and have all reached similar conclusions, providing further support for the findings of the current research.

CONCLUSION

One of the significant challenges posed by urban growth and population increase is the alteration of land use and the subsequent loss of green infrastructure. In recent decades, the urban green infrastructure in the Karaj metropolis, which experiences the most rapid urban growth among cities in the northwest region of the country, has suffered from economic exploitation and the proliferation of non-environmentally friendly land uses. This situation can be attributed to a variety of factors, including the actions of city administrators and, at times, the citizens themselves. The present study investigates the political ecology of Karaj city and its connection to the city's green spaces. The findings reveal an imbalanced distribution of green space infrastructure in Districts 3 and 8 of Karaj city, which has the potential to undermine spatial justice in these areas and disrupt the urban ecology. The majority of these issues can be attributed to the following factors: inadequate access to urban green infrastructure in the rural areas of Karaj, a lack of neighborhood parks, an uneven distribution of green infrastructure in the urban landscape (as evidenced by satellite imagery), and a weak spatial hierarchy and insufficient connectivity between green spaces at various levels. Consequently, urban planning should prioritize increasing the number of

green spaces per capita in areas with low per capita access, thereby ensuring optimal access to this essential urban element.

In the urban areas of Districts 3 and 8, the creation of green spaces should be based on functional radius and proper service to prevent overlap with existing parks and to provide tangible benefits to citizens. In recent years, the metropolis of Karaj has sacrificed green infrastructures, particularly green spaces in urban planning and physical development, for economic gain. It is imperative to prevent the fragmentation and shrinking of green infrastructures in areas with higher per capita. To achieve this, the number and area of green spots should be increased in areas with discrete spots and small areas, and continuity should be created between these areas and those with low per capita. This will improve the status of the green infrastructure of the city of Karaj. As the Satellite images of vegetation cover (NDVI) from 1991 to 2021 indicated a decrease in the use of green spaces, which have been converted into residential and commercial areas were apparent. Based on the findings, it can be concluded that political ecology has not exerted a significant influence within District 3 of Karaj municipality. This assertion is supported by the fact that certain neighborhoods within this district have emerged in an unplanned and unlawful manner, primarily driven by the existence of gardens, agricultural lands, and municipal tree plantations located on the periphery of the district. Notably, political ecology has failed to manifest its impact within these neighborhoods, which paradoxically exhibit a greater abundance of green spaces compared to their counterparts. However, District 8 exhibits a notable per capita population density owing to its relatively small population size and expansive parklands. Moreover, the prevalence of Family, fruit, Fateh, and small Iran Gardens further contributes to the substantial concentration of green spaces within the district. Conversely, other regions within District 8 encounter a considerable dearth of urban green spaces, thereby being subject to the impact of political ecology at both the neighborhood and district scales.

AUTHOR CONTRIBUTIONS

N. Izadbin, performed the original draft, methodology, the literature review and prepared the

GIS maps. H. Mahmoodzade, revised the manuscript from the academic point of view and edited the maps. R. Ghorbani, critically revised the manuscript.

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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.

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ABBREVIATION

GIS Geographic Information System

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ORIGINAL RESEARCH PAPER

Examining the role of green human resource management practices on environmental behavior with the environmental knowledge mediation effect

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ABSTRACT

BACKGROUND AND OBJECTIVES: Green human resource management contributes to developing an eco-friendly culture by influencing employee green behavior. This study intends to examine the role of green human resource management on voluntary and innovative work eco-friendly behavior using the mediating effect of environmental knowledge. This study examined the direct relationship between Green human resource management practices (recruitment, training and development, compensation, performance appraisal, and employee involvement) and green employee behavior (voluntary and green innovative work behavior). This addresses the growing environmental challenges and the need for sustainable business practices. In order to promote environmentally conscious behavior at work, employers can benefit from the study's implications.

METHODS: This study evaluated how environmental knowledge mediates the connection between the green human resource management practices and environmental behavior. Data was drawn from 15 firms in the Indian service sector. To analyze a quantified data set collected through a survey method using structured questionnaire and sent to all respondents through Google forms online survey by using simple random sampling technique. All analyses were conducted using "Partial Least Squares Structural Equation Modeling.

FINDINGS: The analysis showed that green human resource management practices positively affect employee green behavior. Specifically, the results indicate that green recruitment, compensation, and employee involvement were positively related to one dimension of employee green behavior (green innovative work behavior). Green Performance appraisal was also found to affect green voluntary behavior positively. The path coefficients were positive, when the model's path coefficients (β) and t-statistics were used to evaluate the relationship between the independent and dependent variables, t- value should greater than 1.96 and p value should be greater than 0.05, in this study the following hypotheses are statistically significant (H1c: $\beta=0.392$, $P<0.000$; H2a: $\beta=-0.391$, $P<0.044$; H2d: $\beta=0.348$, $P<0.000$; H2e: $\beta=0.255$, $P<0.001$; H3b: $\beta=-0.297$, $P<0.000$; H3de: $\beta=0.239$, $P=0.049$; H3e: $\beta=0.545$, $P=0.000$).

CONCLUSION: This study examined how employees' environmental knowledge can affect their employee green behavior through green human resource management practices. Environmental knowledge cannot mediate the association between a few green human resources management practices and Employee green behavior, according to the outcomes of the study. Effective green HRM strategies can influence employees' green knowledge, affecting their employee green behavior. The significance of green human resource management in greening businesses, especially in the service sector, is highlighted, especially in an emerging country like India. This research presents an overview of the study's findings, limitations, and implications.

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INTRODUCTION

Convergence on environmental issues related to ecological emissions, increased carbon dioxide (CO₂), technological affluence, etc., pushed business organizations to greener ecological practices to reduce the adverse effects on the ecosystem (Tirno *et al.*, 2023). Environmental injustice, the impact of climate change, environmental ethics, social responsibility, and the exclusion of ecological problems have all contributed to increased environmental awareness in society (Islam *et al.*, 2020; Nawafleh, 2020). Green Human Resource Management (GHRM) refers to this initiative's endeavor to promote human resource practices that more substantially help society, business, and the environment (Tirno *et al.*, 2023). It incorporates HRM policies and procedures by including eco-friendly HR principles for efficient and sustainable resource utilization (Moghadam and Samimi, 2022). To encourage eco-friendly behavior, it also emphasizes waste reduction, job-related attitude promotion, an appropriate balance between work and life, the adoption of conveyance pooling programs, online filing, teleworking simulated conferences, training through the internet, recycling of materials, energy-effective office space, and other factors (Srividya *et al.*, 2022; Samimi and Moghadam, 2024). The terms "green recruitment and selection," "green training," "green performance management," "green pay and reward," and "green involvement" are only a few examples of scholarly works that have included GHRM initiatives (Arulrajah and Opatha, 2016; Ren *et al.*, 2020). Literature suggests that GHRM boosts employee behavior and attitude by encouraging individualized ecological initiatives during hiring and selection, training, and disseminating information about the company's environmental stewardship (Tang *et al.*, 2018). As a result of having work and job designs that face environmental standards, ecological training fosters employees' participation in green activities by enhancing knowledge, skills, and competence (Yong *et al.*, 2020). The impact of green human resources management methods (green involvement and training, ecological performance, and ecological employment, as well as remuneration) on environmental results was stressed by several scholars (Zhang *et al.*, 2021). These measures exhibit the business's commitment to ecological protection, which could improve its commitment to sustainability and credibility over time (Tang *et al.*, 2018). As

stated, cognitive abilities, human skills, and talents are critical for organizations to acquire a competitive edge (Shang and Yang, 2022). According to Ahmad *et al.*, (2022), people either possess particular talents naturally or learn them through education, with the latter eventually developing human capital if it provides enough focus. Green behavior also referred to as eco-friendly behavior, is the conduct of staff members who are considerate of the environment (Fawehinmi *et al.*, 2020). Employees with more excellent ecological knowledge (EK), awareness, and substantial involvement in environmental protection are more effectively engaged with ecological problems (Munawar *et al.*, 2022). Furthermore, GHRM swayed employees' efficiency and morale concerning organizational goals, for example, eco-efficiency programs. Understanding and evaluating how actions affect the environment is known as environmental knowledge (Steg and Vlek, 2009). Numerous studies have demonstrated a strong connection between GHRM and employees' ecological knowledge. The authors claim that firms can promote eco-friendly employee behavior by incorporating ecological aspects and making precise green tasks in HRM like job design, performance evaluations, and rewards while appreciating GHRM actions (Watson *et al.*, 2017). Irani and Kilic, (2022) stated that green knowledge-based training programs would enhance the skills in organizations by hiring eco-conscious people to teach others successfully (Munawar *et al.*, 2022). Finding, acquiring, creating, and applying information to improve organizational performance and competitiveness is what environmental knowledge comprises. Therefore, studies should investigate how green knowledge influences voluntary and innovative green behavior by adopting green human resource management techniques. Though one of the most vital components (Brookes and Altinay, 2017), employees who must be aware of environmental challenges cannot adopt the attitudes and behaviors necessary to deal with them. The research aims to establish how GHRM practices affect environmentally friendly and innovative green behavior through EK. The following factors contributed to creating the research model: First, from a GHRM standpoint, HR functions may encourage environmentally friendly behavior. Second, according to the knowledge theory, GHRM is associated with practical environmental knowledge, which

promotes environmentally friendly behavior in the sector. Thirdly, HRM practices in industries that deal with ecological concerns significantly influence the application of organizational environmental exercises that eventually encourage green behavior (Abid *et al.*, 2020). The objective of this study is to investigate the intermediary function of environmental knowledge in relation to the previously mentioned connections. Consequently, this study aims to ascertain the impact of Green HRM on Employee Green Behavior (EGB) by means of environmental knowledge. The purpose of this study is to analyze the impact of green human resource management practices on green voluntary and green innovative behavior. This study carried out in Indian service sector. The current study has been carried out in India in 2023. The remaining part of the article is organized as follows: The theoretical underpinnings, a survey of literature on green HRM, environmental knowledge, EGB, and the procedures involved in developing hypotheses. Next, details on the research technique are provided and the results and analysis are presented. Finally, discussion and theoretical ramifications, limitations, prospects for further research, and conclusion are covered in the last section.

Underpinning theory

The theory of “Ability, Motivation, and Opportunity” (AMO) framework, which Bailey *et al.* (1993) initially proposed, is supported by this study. The AMO theory describes how HRM practices enhance HR capabilities to guarantee discretionary actions of employees by inspiring and promoting involvement. Three ideas are connected to the AMO theory: Employees must possess the necessary skills, be encouraged to act discreetly, and be given the authority they need to achieve company goals (Ramkissoon *et al.*, 2022). According to the AMO theory, HRM practices improve organizational performance by enhancing employees’ capacity, motivation, and chances of executing EGB aligned with the organization’s strategic goals (Marin Garcia and Tomas, 2016). This suggests that employees contribute to achieving organizational goals based on their performance if their capacity is raised through recruiting and training or if employees are given opportunities to participate in collaboration and decision-making processes. In general, HRM practices will enhance the business’s conservation

efforts when workers have the knowledge, motivation, and opportunities to operate in an environmentally conscious manner (Fawehinmi *et al.*, 2020). Employees would feel duty-bound towards an initiative on ecological management while sharing knowledge and providing feedback on the company’s ecological actions. Therefore, AMO’s nexus should motivate employees to engage in EGB.

Research Question1: Do GHRM practices affect EGB?

Research Question2: Does employee green knowledge mediate with GHRM practices and EGB?

Green HRM practices and Green behavior

There is a need to incite environmentally conscious behavior by providing knowledge, opportunities, training, and motivation to step in and promote more thoughtful behavior. According to research by Blok *et al.* (2015), employee views of organizational support for nature significantly influence EGB. This assistance may include eco-friendly policies, eco-performance-based evaluations, Green Training (GT), promoting staff involvement, etc. According to research, engaged, motivated, and well-trained employees are likelier to act in ways that promote a business’s environmental sustainability (Shen *et al.*, 2018). It is widespread that AMOs rely on each other and cannot operate appropriately in ensuring that personnel perform to EGB (Bos-Nehles *et al.*, 2013). It means that when employees gain adequate skills through Green Recruitment and Selection (GRS) and GT, Green Performance Management (GPM) and Green Rewards (GR) are desirable to motivate them to achieve strategic goals (Fawehinmi *et al.*, 2020). Additionally, Green Employee Involvement (GEI) will provide opportunities for employees to be involved in decision-making and provide input that will simplify promoting an ecologically sustainable program through carrying out EGB (Fawehinmi *et al.*, 2020). Employees will have a greater emotional propensity to realize what is expected of them and what benefits they can derive from it, which can boost their dedication and inspire them to execute EGB to promote sustainable development efforts when businesses demonstrate their support for sustainable development through the execution of GRS, GT, GPM, GR, and GEI. Finally, GHRM practices show employees how strongly a company supports them regarding ecological beliefs, commitments, training,

performance evaluation, and asking for feedback on improving ecological management by implementing GHRM and ecological knowledge. As a result, this leads to employee-friendly behavior toward the workplace environment. Research has demonstrated that GHRM profoundly impacts EGB (Kim *et al.*, 2019; Saeed *et al.*, 2019; Shen *et al.*, 2018). Green workplace behavior indicates an individual's commitment to the environment (Norton *et al.*, 2015). It includes voluntary and innovative behaviors. Voluntary green behavior refers to extra-role green behavior, which is not the formal duty of an employee and is not considered in their performance assessment (Xiao *et al.*, 2020). Innovative work behavior is believed to comprise idea generation, promotion, and realization of employees' advantage (BosNehles *et al.*, 2013; West and Farr, 1989). Innovation is very essential to compete with competitors (Tajpour, 2018). Green innovative work behavior (GIWB) refers to employees' behaviors devoted to generating, promoting, and realizing green-based ideas by adopting environmental management to innovative work behavior. Empirical studies show that GHRM is typically connected to eco-friendly task behavior, employee empowerment, eco-friendly work design, and enterprise environmental stewardship (Chaudary, 2019; Fawehinmi *et al.*, 2020; Ramkissoon *et al.*, 2022; Renwick *et al.*, 2013; Shen *et al.*, 2018).

Green HRM and Green Knowledge

Knowledge regarding the environment is an understanding of human connections, environmental threats, and the various relationships in the ecological system (Scholar *et al.*, 2015). This type of knowledge might encompass the capability to lessen the impact that detrimental consequences have on environmental systems, which would result in an action that is beneficial to the environment. According to Levy and Marans (2012), pro-environment behaviors are influenced by problem awareness and mitigation techniques. Recent research has shown that, despite initiatives to spread the word about environmental sustainability, there still needs to be more people's understanding and sensitivity to environmental problems (Burchett *et al.*, 2015). When people share their knowledge, skills and expertise among members of an organization, performance improves and organizations become more innovative (Tajpour and Razavi, 2023). It could

be attributed to inefficiency in linking GHRM with ecological management within the organization. Mazzi *et al.*, (2016) claimed that connecting GHRM with environmental management is crucial because it motivates employees to participate in ecological management endeavors by cultivating knowledge and attitude. According to studies, green HRM practices should affect employees' environmental understanding (Ren *et al.*, 2020). This is necessary that GRS, GT, GPM, GR, and GEI all GHRM practices work together to improve employees' environmental knowledge (Moraes *et al.*, 2014; Renwick *et al.*, 2013). A company may boost its employees' green knowledge, alertness of ecological security, and understanding of the value and importance of greening the workplace by promoting the conservation of the environment, training and framing policies for green hiring and selection, management of performance, rewards, and employee involvement (Renwick, 2018; Zhang *et al.*, 2019). A case study of employees at a "Toyota technical development corporation" revealed that HRM practices endorse knowledge creation and transmission within employees and setting up efficient training techniques, interpersonal interactions, input, involvement, and knowledge stock development. As a result, the hypothesis is proposed:

The mediating effect of green knowledge

To "train (ability), stimulate (motivation), and engage employees (opportunity)" in environmentally friendly programs and to motivate them to act according to the strategic objectives of the organization is a notion of effectual GHRM proposed by Appelbaum (2000). These are found to have an impact on employees' EGB. However, research into the fundamental causes of this association is still in its infancy.

According to Renwick *et al.*, (2013) literature analysis, environmental knowledge is essential in the association between GHRM and EGB. Susan *et al.*, (2020) emphasized the need for research examining the mediating function among GHRM and EGB. This is due to the lack of knowledge about these interactions' mechanisms. Employee skills here stand in for green knowledge. Green Human Resource Management is an exterior force that guarantees employees align their behavior with the ecological goals of the firm. These factors affect employees' cognitive abilities and internal traits, which affect EGB performance (Ren *et*

al., 2018). This involves hiring and selecting employees committed to the environment and ensuring they receive the proper GT. When GRS chooses personnel with green values, providing GT to employees improves their awareness of the environment, and their skills make them psychologically prone to participate in EGB (Chaudhary, 2019). According to Saeed et al. (2019), green knowledge enhances the influence of green human resources management on EGB. Furthermore, Rayner and Morgan (2018) stated that an organization might improve environmental knowledge by increasing employees' skills, motivation, and the opportunity to do EGB. Employee cognition affects green HRM performance by impacting EGB performance to promote EMS, according to Ren et al., (2018) research. Higher-order cognitive and social skills and abilities, such as knowledge of the environment, are essential for green HRM procedures to impact the effectiveness of green employment (Rayner and Morgan, 2018; Susan et al., 2020). As a result, growing environmental awareness through GHRM equates with promoting environmental behavior, and this behavior reflects the level of ecological knowledge. Therefore, this argument assumes that GHRM methods will impact employees' green knowledge. As a result, the following hypotheses are proposed:

H1. GHRM practices positively affect EGB.

H1a. Green recruitment has a significant impact on EGB

H1b. Green training and development has a substantial impact on environmental knowledge

H1c. Green performance positively relates to environmental knowledge

H1d. Green compensation positively relates to ecological knowledge

H1e. Green employee involvement positively correlates with environmental knowledge

H2. GHRM practices positively affect Environmental Knowledge.

H2a. Green recruitment has a significant impact on EK

H2b. Green training and development has a substantial impact on EK

H2c. Green performance positively relates to EK

H2d. Green compensation positively relates to EK

H2e. Green employee involvement positively correlates with EK

H3. EK positively mediates between GHRM and EGB

MATERIALS AND METHODS

Survey design and Data collection

Information was gathered from Indian service sectors like banks, healthcare, communication, Hospitality and IT. This industry has been selected as one that will grow significantly both in India and globally. Furthermore, in recent years, this vast industry has focused on green transformation. The responders were chosen from businesses in prominent south Indian cities like Bangalore, Chennai, and Hyderabad. A total of 15 service firms were surveyed to get responses from 400 people, regardless of gender or age. The study relied on a non-

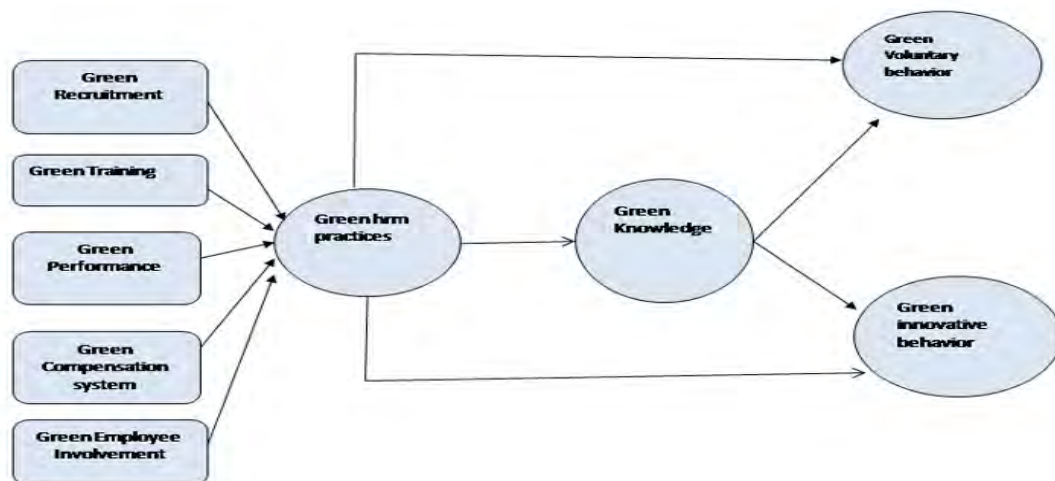


Fig 1: Proposed conceptual framework

probability purposive sampling technique to acquire primary data. This method is helpful for field research or behavioral sciences study since it generates valid data (Cooper *et al.*, 2014; Edeh *et al.*, 2023). In the purposive sample approach, the overall behavior or viewpoint of the respondents is virtually collected through Google Forms. Thus, researchers can choose responders based on judgment and willingness (Masykuri and Pritasari, 2022). In addition, the non-probability technique can be used when the whole population is unknown or infinite (Salman, 2020). Four hundred online survey forms were mailed out, and the data-gathering period spanned in India from July 2023 to September 2023.

Measurement

The first section of the study contained questions about GHRM practices in various service industries. The 21 items were adapted from Tang *et al.* (2018); Jenny Dumont and Shen (2017). The second section of the questionnaire focuses on EGB in the workplace. The researcher measured voluntary green behavior consisting of seven items adapted from Garavan *et al.* (2022) extensively used and well-validated scale. The behavior of employees that consists of idea creation, promotion, and implementation is regarded as innovative work behavior. Scott and Bruce (1994) created a six-item gauge to assess innovative work behavior. Following the study objectives, this scale was changed by adding green-related terms. Green knowledge was considered using four items from Gillani *et al.*, (2018) that set the level of environmental knowledge. A five-point Likert scale varies from “strongly disagree” (point one) to “strongly agree” (point five) and was used to measure each variable.

Data analysis

Several recent studies have used the Smart PLS tool for analyzing the data of “Partial Least Squares Structural Equation Modeling” (PLS-SEM) (Sarstedt *et al.*, 2021). This option was preferred due to the software’s advanced estimate techniques and extensive application within GHRM (Ringle, 2016). According to Hair *et al.* (2020), PLS is better for analysis because the research aimed to anticipate and define the constructs. According to PLS-SEM, the study used a two-step methodology to analyze the findings (Anderson and Gerbing, 1998; Henseler *et al.*, 2015; Siyal *et al.*, 2019; Yap *et al.*, 2012). First,

it evaluated reliability, Convergent Validity (CV), and internal consistency reliability; then, the structural model was investigated to test hypotheses (Henseler *et al.*, 2015).

Measurement model assessment

The researcher adopted (Anderson and Gerbing, 1998) the two-step method to analyze data. Outer loadings (Table 1), Convergent Validity and reliability (Table 2) and Discriminant Validity (Table 3) were assessed in this study. CV can be proven if the loadings exceed 0.50 (Bagozzi and Yi, 1988), the composite reliability values exceed 0.7 (Gefen, 2000), and the extracted average variance exceeds 0.5 (Fornell and Larcker, 1981).

RESULTS AND DISCUSSION

Outer model and CV were calculated using alpha and factor loadings, with loadings exceeding the recommended value of 0.60. Accordingly, CR values are more than the suggested value of 0.7. In addition, the constructs’ AVE values exceeded 0.5. In the Table 1 all the outerloading values exceeds the 0.7 where it meets the threshold values of outer loading 0.7. VIF values are analysed to test the multi collinearity issue in the scale, the VIF threshold values are less than 0.5 as per hair *et al.*, 2017, in the study VIF values are satisfied.

According to the above Table 2, the values of Cronbach’s Alpha for green recruitment, green training, green performance, green rewards, green employee involvement, green knowledge, green voluntary behavior, and green innovative work behavior are all 0.818, 0.766, 0.786, 0.767, 0.843, 0.829, 0.872 and 0.868 respectively. The Composite Reliability of all the variables is superior to 0.9. As a result, the Cronbach alpha (.850), rho_A (.900), CR (.900), and AVE (.5) threshold values were satisfied, so the internal consistency was achieved.

The “Fornell-Larker criterion” was one of the prominent effective approaches for evaluating particular scenarios; nonetheless, the approach needs to show the lack of Discriminant Validity (DV) (Henseler *et al.*, 2015). Values in Table 3 show below 0.9, which means there is no issue of multi-collinearity because the square root of AVE for each construct is greater than each established correlation coefficient. Thus, the measurement model set satisfactory CV and DV.

Table 1: Outer Loadings

Items	Green Recruitment	Green Training	Green Performance	Green Compensation	Green Employee involvement	Green voluntary behavior	Green innovative behavior	Green Knowledge	Variation Inflation Factor(VIF)
GR1	0.795								1.790
GR2	0.794								1.679
GR3	0.796								1.587
GR4	0.827								1.746
GT1		0.805							1.589
GT2		0.819							1.549
GT3		0.848							1.535
GP1			0.797						1.750
GP2			0.755						1.550
GP3			0.619						1.442
GP4			0.885						1.631
GC1				0.727					1.459
GC2				0.798					1.656
GC3				0.811					1.628
GC4				0.731					1.417
GEI1					0.827				1.786
GEI2					0.832				2.708
GEI3					0.815				2.663
GEI4					0.800				1.729
GEI5					0.772				1.373
GVB1						0.815			2.023
GVB2						0.875			2.166
GVB3						0.885			2.402
GVB6						0.817			2.062
GIB1							0.838		2.190
GIB3							0.844		2.130
GIB4							0.823		2.129
GIB5							0.796		1.903
GIB6							0.783		1.704
							0.771		
GK1								0.815	1.882
GK2								0.804	1.570
GK3								0.794	2.278
GK4								0.802	1.845

Table2: Reliability and Validity

Constructs	Cronbach's Alpha	rho_A	Composite Reliability	(AVE)
Green recruitment	0.818	0.826	0.879	0.645
Green training	0.766	0.777	0.864	0.679
Green performance	0.786	0.921	0.852	0.593
Green compensation	0.767	0.775	0.851	0.589
Green employee involvement	0.843	0.848	0.889	0.616
Green Knowledge	0.829	0.855	0.885	0.660
Green innovative behavior	0.868	0.869	0.905	0.655
Green voluntary behavior	0.872	0.903	0.911	0.720

Table3: Discriminant Validity

Constructs	Green compensation	Green employee involvement	Green innovative behavior	Green Knowledge	Green performance	Green recruitment	Green training	Green voluntary behavior
Green recruitment	0.803							
Green compensation	0.050	0.767						
Green Employee Involvement	0.021	0.657	0.785					
Green Involvement Behavior	-0.034	0.641	0.625	0.809				
Green Knowledge	0.087	0.660	0.740	0.613	0.813			
Green Performance	0.554	0.100	0.001	0.046	0.108	0.770		
Green Training	0.962	0.029	0.015	-0.022	0.088	0.477	0.824	
Green Voluntary Behavior	0.657	0.097	0.057	0.082	0.088	0.633	0.607	0.849

Structural Model Assessment (Inner model)

After evaluating the measurement model in Fig. 2 the direct effect in Table 4 and indirect effect in Table 5, an inner model was created to test the hypothesis's t-value, standard errors, and path coefficient to explain the importance of this model. The path coefficient values were used to determine the acceptance or exclusion of hypotheses using a bootstrapping approach in Smart PLS. As shown in Table, green performance management has a favorable relationship with green voluntary behavior ($\beta = 0.392$, LL = 0.224, UL = 0.572, $t = 4.354$). Thus, H1c is accepted. Green recruiting, pay, and employee involvement correlate positively with green innovative behavior. Thus, H2a, H2d and H2e are accepted ($\beta = -0.391$, LL = -0.734, UL = 0.033, t

= 2.023; $\beta = 0.348$, LL = 0.205, UL = 0.503, $t = 4.733$; $\beta = 0.255$, LL = 0.103, UL = 0.401, $t = 3.432$). The findings revealed that green knowledge is positively related with green compensation, green training and green employee involvement ($\beta = -0.297$, LL = 0.196, UL = 0.413, $t = 5.201$; $\beta = 0.239$, LL = -0.015, UL = 0.455, $t = 1.974$; $\beta = 0.545$, LL = 0.434, UL = 0.638, $t = 1.508$) are significant; therefore, H3b, H3d and H3e are supported ($\beta = 0.107$, LL = 0.345, UL = 0.446, $t = 2.633$).

Theoretical Implications

The results of this study significantly advance the field of literature; this research adds to a foundation of knowledge, especially concerning the AMO theory. First, it adds to the AMO hypothesis that little is being

Table 4: Direct effect

Constructs	B*	Mean (M)	STDEV	T	P	LL	UL	Decision
Green recruitment -> Green innovative behavior	-0.391	-0.359	0.193	2.023	0.044	-0.734	0.033	Supported
Green Recruitment -> Green Knowledge	-0.216	-0.206	0.132	1.631	0.104	-0.459	0.041	Not supported
Green recruitment -> Green voluntary behavior	0.458	0.398	0.373	1.228	0.220	-0.505	1.009	Not supported
Green Compensation -> Green innovative behavior	0.348	0.356	0.074	4.733	0.000	0.205	0.503	Supported
Green Compensation -> Green Knowledge	0.297	0.304	0.057	5.201	0.000	0.196	0.413	Supported
Green Compensation -> Green voluntary behavior	0.031	0.032	0.053	0.581	0.562	0.067	0.141	Not supported
Green Employee involvement -> Green innovative behavior	0.255	0.255	0.074	3.432	0.001	0.103	0.401	Supported
Green Employee Involvement -> Green Knowledge	0.545	0.540	0.052	10.508	0.000	0.434	0.638	Supported
Green Employee involvement -> Green voluntary behavior	0.081	0.079	0.061	1.323	0.187	-0.037	0.201	Not supported
Green knowledge_ -> Green innovative behavior	0.196	0.188	0.076	2.577	0.010	0.031	0.324	Supported
Green knowledge_ -> Green voluntary behavior	-0.073	-0.074	0.058	1.260	0.208	-0.187	0.040	Not supported
Green performance -> Green innovative behavior	0.068	0.066	0.057	1.191	0.234	-0.046	0.176	Not supported
Green performance -> Green Knowledge	0.084	0.086	0.049	1.708	0.088	-0.010	0.179	Not supported
Green performance -> Green voluntary behavior	0.392	0.400	0.090	4.354	0.000	0.224	0.572	Supported
Green training -> Green innovative behavior	0.291	0.262	0.181	1.613	0.107	-0.112	0.596	Not supported
Green training -> Green Knowledge	0.239	0.226	0.121	1.974	0.049	-0.015	0.455	Supported
Green training -> Green voluntary behavior	-0.016	0.041	0.396	0.041	0.967	-0.571	0.974	Not supported

B* = Beta coefficient; STDEV= Standard error; T= Statistics; LL = lower limit; UL = upper limit; P = Probability value.

done to use green HRM to predict environmental knowledge, particularly within the service sector. The results demonstrate that employees will have “declarative knowledge” to fully understand the situation of the environment and “procedural knowledge” to put that knowledge into practice to mitigate ecological issues when given the essential capability, adequate motivation, and opportunities to perform. [Saeed et al. \(2019\)](#) theory, which contends that the successful adoption of GHRM methods in guaranteeing environmental sustainability depends on improving employees’ ecological knowledge, lends credence to this conclusion. Second, this study adds to previous research by [Marin-Garcia](#)

[and Tomas \(2016\)](#) that revealed that environmental awareness might strengthen AMO regarding behavior by mediating between GHRM practices and EGB. This demonstrates that when staff members have adequate “training, awareness, motivation, and engagement” in achieving sustainability, their ecological knowledge will spark environmentally responsible behavior in the institutions. The results confirm [Rayner and Morgan’s \(2018\)](#) hypothesis that green knowledge influences the EGB of employees with support from upper management. The findings of this research are likely to be used to gain additional insight into how to encourage employees to adopt environmentally friendly behaviors and convince

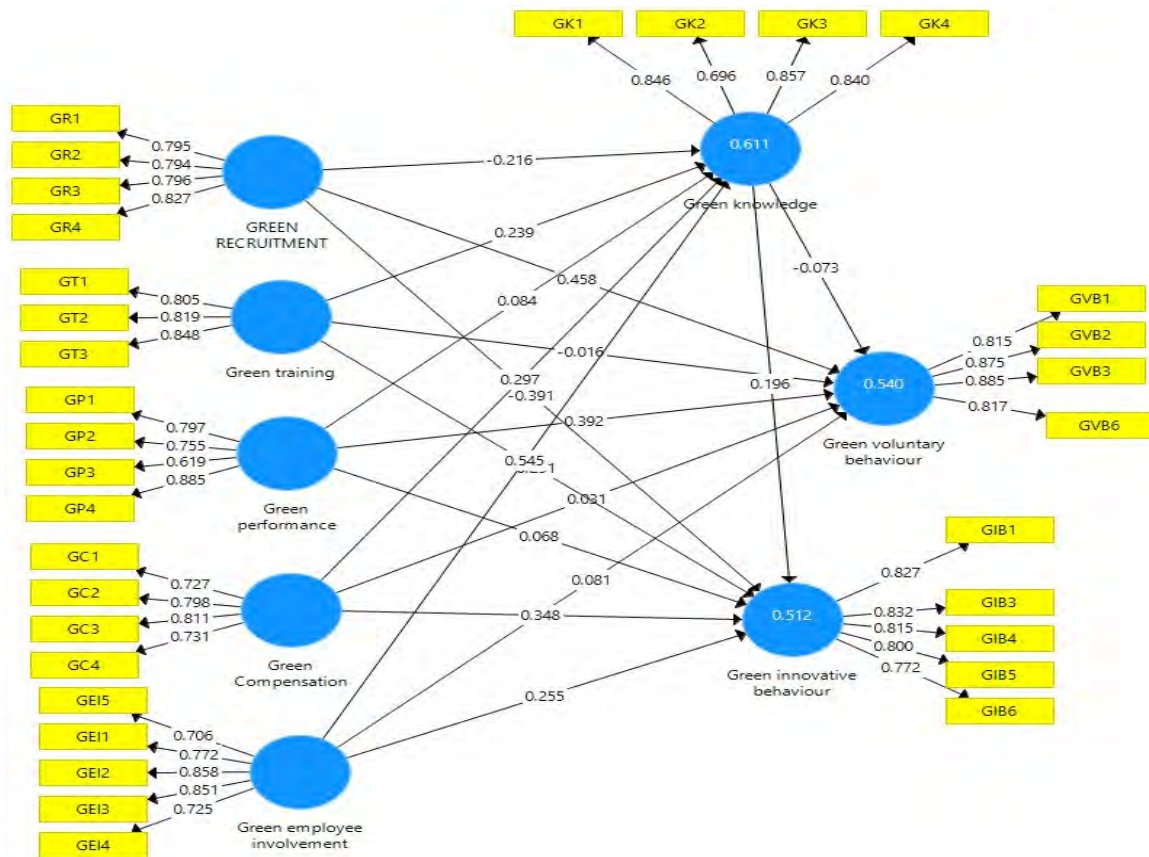


Fig. 2: Measurement model

Table 5: Indirect effect Path coefficient and hypotheses

Constructs	β	Mean	STDEV	T	p	Decision
Green recruitment -> Green knowledge_ -> Green innovative behavior	-0.042	-0.040	0.032	1.309	0.191	Not Supported
Green Compensation -> Green knowledge_ -> Green innovative behavior	0.058	0.057	0.025	2.363	0.019	Supported
Green employee involvement -> Green knowledge_ -> Green innovative behavior	0.107	0.102	0.043	2.474	0.014	Supported
Green performance -> Green knowledge_ -> Green innovative behavior	0.016	0.016	0.012	1.396	0.163	Not Supported
Green training -> Green knowledge_ -> Green innovative behavior	0.047	0.043	0.031	1.502	0.134	Not Supported
Green recruitment -> Green knowledge_ -> Green voluntary behavior	0.016	0.015	0.017	0.914	0.361	Not Supported
Green Compensation -> Green Knowledge_ -> Green Voluntary Behavior	-0.022	-0.023	0.019	1.129	0.259	Not Supported
Green employee involvement -> Green knowledge_ -> Green voluntary behavior	-0.040	-0.039	0.031	1.276	0.203	Not Supported
Green performance -> Green knowledge_ -> Green voluntary behavior	-0.006	-0.007	0.007	0.871	0.384	Not Supported
Green training -> Green knowledge_ -> Green voluntary behavior	-0.017	-0.016	0.017	1.021	0.308	Not Supported

them that doing so is one of their most important responsibilities in both the workplace and society. This research aimed to evaluate the effect of

GHRM methods on EGB in India's service industry. Additionally, an effort was started to investigate the basis of the above correlations by analyzing

the internal processes at play, and environmental knowledge was examined as a mediator. Surprisingly, the findings demonstrate that GHRM practices such as green recruitment, remuneration, and employee involvement are significantly associated with green creative behavior. In contrast, green performance significantly directly impacts environmentally voluntary behavior. Surprisingly, the findings demonstrate that green HRM practices such as green recruiting, pay, and employee involvement are related considerably to green innovative behavior. In contrast, green performance significantly directly impacts green voluntary behavior. This implies that implementing GHRM within an organization does not guarantee the willingness of employees to engage in environmentally beneficial behavior. Therefore, properly implementing green HRM practices is crucial to incentivize employees to engage in EGB. This result confirms the need for underlying variables for GHRM to impact EGB. Out of 5 practices, only three supported green innovative behaviors; the remaining significantly impacted voluntary environmentally friendly actions. The implementation of green training did not yield statistically significant effects on voluntary or inventive behavior. The study's results support an indirect and significant relationship between GHRM practices, compensation, employee involvement, and ecological innovative behavior. This relationship is mediated by green knowledge. The remaining green HR practices had no discernible impact on green voluntary and innovative behavior, and green knowledge had no mediation impact. This conclusion adds to existing research on the issue of how HRM may affect employee working outcomes via underlying processes, including environmental knowledge (Su *et al.*, 2021). This finding is backed by evidence from other research indicating that employees tend to evade topics about which they lack enough knowledge (Chan and Hsu, 2016; Saeed *et al.*, 2019), regardless of whether an organization implements Green HRM practices. This demonstrates the significance of developing environmental knowledge to fully comply with GHRM practices, resulting in environmentally conscious behavior inside the workplace. Research has indicated that a higher degree of ecological knowledge enhances the association between GHRM and EGB (Khan *et al.*, 2022; Saeed *et al.*, 2019). To our knowledge, no study has used green knowledge to mediate GHRM

and employee green behavior among employees in the Indian context.

Limitations and Future research

Due to limited resources and time, the investigation still has subsequent flaws. This research exclusively focuses on the mediating role of green knowledge. Future studies should investigate additional potential mechanisms of influence and refine the existing research framework. Hence, it is anticipated that future studies will investigate whether there exist alternative variables that serve as more effective mediators in addition to knowledge. Second, GHRM practices are impacted by the executors and the environment; however, this study solely considers the employee as the implementation factor. Future research can consider environmental factors and address their moderating effects and the interactions between individual and environmental variables. Future research would yield more intriguing results if these restrictions were considered. To assure representative and impartial samples, future research should broaden the survey's reach to include more survey samples of various organizational characteristics, including industry, city, and size.

CONCLUSION

This study aims to examine the influence of green human resource management practices on employee green behavior, specifically through the mediating role of green knowledge. Additionally, the current research emphasizes the significance of environmental knowledge in influencing the association between environmentally conscious human resource management (HRM) practices and voluntary engagement in environmentally friendly behavior, as well as the adoption of innovative practices that promote environmental sustainability. This study examined how employees' environmental knowledge can affect their EGB through green Human Resource Management practices. Environmental knowledge cannot mediate the association between a few green human resources management practices and EGB, according to the outcomes of the study. Competent GHRM practices may determine employees' ecological knowledge, influencing their EGB. Effective GHRM strategies can influence employees' green knowledge, affecting their EGB.

The significance of GHRM in greening businesses, especially in the service sector, is highlighted, especially in an emerging country like India. The examination of GHRM within the individual setting is at an early stage, especially in India. As a result, this study educates various industry categories on the importance of GHRM and its benefits to an organization and environment by promoting eco-conscious behaviors in the workplace.

AUTHOR CONTRIBUTIONS

Vanisri.K conducted the research materials, conceptualization, technique, software, literature review, reference editing, and article preparation and undertook the entire process of creating this manuscript. P.C. Padhy worked on data correction, original draft preparation, composing reviews, and responsibility for revisions and finalizing the paper, ensuring its accuracy and coherence.

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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.

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ABBREVIATIONS

<i>AVE</i>	Average extracted value
β	Regression co efficient
<i>EGB</i>	Employee green behaviour
<i>EK</i>	Environmental knowledge
<i>GHRM</i>	Green Human Resource Management
<i>GRS</i>	Green Recruitment & Selection
<i>GT</i>	Green Training
<i>GC/GR</i>	Green compensation/ Green Rewards
<i>GP</i>	Green Performance
<i>GEI</i>	Green Employee Involvement
<i>EMS</i>	Environmental Management System
<i>LL</i>	Lower limit
<i>N</i>	Sample size
<i>p-value</i>	Probability value
R^2	Coefficient of determination
$R^2 adj$	Adjusted coefficient of determination
<i>STDEV</i>	Standard Error
<i>T value</i>	T statistic
<i>UL</i>	Upper limit
<i>VIF</i>	Value inflation factor

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ORIGINAL RESEARCH PAPER

Development of accounting information system quality in local government:
mediating role of accounting competency

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ABSTRACT

BACKGROUND AND OBJECTIVES: Several investigations were previously conducted on the crucial role of Accounting Information System in enhancing organizational performance and accountability. However, there is a limited amount of knowledge regarding the factors that influence the quality of Accounting information system, especially when considering their application in local government settings in developing countries. Therefore, this study aimed to investigate the factors determining Accounting information system quality in local government of Indonesia, including availability and functions of network, hardware, and software. The mediating role of accounting competency was also explored using resource orchestration theory.

METHODS: This study adopted a questionnaire survey method and conducted statistical hypothesis testing using Structural Equation Modelling-Partial Least Square (SEM-PLS) method. The data were obtained from local government organization staff in Yogyakarta Special Region, selected based on involvement in using software.

FINDINGS: The results showed that availability and functions of network and software, as well as accounting competency, were positively correlated with accounting information system quality, with p-values of 0.000, 0.023, and 0.000, respectively. Meanwhile, availability and functions of hardware did not show a significant correlation, as evidenced by p-value of 0.375. Accounting competency significantly mediated the relationship between availability and functions of network, software, and Accounting information system quality, with p-values of 0.032 and 0.001, respectively. Moreover, Adj. R² was 0.467 (medium level), and the SRMR value assessed the model fit at 0.079 (good model fit).

CONCLUSION: This study contributed a novel framework related to the determinants of improving Accounting information system quality in local government setting and addressed the debate surrounding the role of accounting competency in the system development. Moreover, there were emphases on the significant mediating role of accounting competency as a prerequisite for other determinants (availability and functions of network, hardware, and software) to promote better Accounting

DOI: [10.22034/IJHCUM.2024.02.10](https://doi.org/10.22034/IJHCUM.2024.02.10) information system quality.



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INTRODUCTION

E-government era is responsible for influencing Accounting Information System (AIS) development in local government of developing countries such as Indonesia (Chung, 2017). There has been a consistent emphasis on new technology investments, particularly hardware and software, to support AIS development (Utama, 2020). For instance, data sourced from the Indonesian Ministry of Communication and Information Technology showed that from 2019 to 2022, the budget allocated for IT investment to support E-government initiatives reached 75 trillion Rupiahs. Starting at approximately 7 trillion rupiahs in 2019, the investment increased to 10 trillion rupiahs in 2020 and surged to 25 trillion rupiahs in 2022 (Kominfo, 2022). Despite the substantial investments in E-government, including AIS, government accountability and performance continue to face widespread criticism. According to Ombudsman (2022), local government received 150 complaints in January-June 2022, of which 82 reports (54%) pertained to issues with public services. In the context of E-government, the low level of government accountability can be related to the inadequate AIS quality (Al-Hattami *et al.*, 2021). AIS plays a crucial role in providing relevant and up-to-date information concerning local government performance targets. It enables swift and well-informed decision-making to address performance and accountability challenges in local government (Nurhayati *et al.*, 2023). AIS development in Indonesia is occasionally viewed as misguided by government officials. According to observations, many leaders in Indonesian local government institutions who overly prioritize AIS advancements believe that a well-established system is sufficient to ensure accountability in local government organization without the need for employees with accounting competency. For instance, individuals without an accounting background can record transactions and automatically generate financial reports after receiving training on AIS software (Sofyani *et al.*, 2023). However, accountability in this context is limited to financial reporting. Local government should be held accountable not only for reporting but also for the efficiency and productivity of budget utilization (Jann and Læg Reid, 2015). In the absence of accounting competence staff, AIS can provide vast amounts of basic information at a rapid

pace, but it may not deliver the relevant, accurate, and valuable data needed for effective decision-making. As a result, the resolution of performance and accountability issues can be hindered. The filtering, processing, and interpretation of available information to formulate accurate and timely decisions requires individuals who have a holistic understanding of information technology and accounting system (Asadi *et al.*, 2021). In conclusion, accounting competency is essentially an orchestrator in creating AIS quality. Studies focusing on the determinants of AIS quality remain limited (Nurhayati *et al.*, 2023), specifically in the context of local government. Thoa and Nhi (2022) found that availability and functions of network, hardware, and software, as components of AIS architecture, had a significant impact on the quality of financial accounting information in the public sector of Vietnam. Fitriati *et al.* (2020) argued that the quality of accounting information is indeed, determined by AIS quality. Therefore, to produce high-quality financial accounting information, AIS architecture should first prioritize quality. To address the empirical gap, this study examined the architecture as a determinant of AIS quality, with a specific focus on the mediating variable of accounting competency. The mediating role of accounting competency aims to address the pros and cons mentioned above, regarding the important accounting competency in AIS development. This is related to the perspective of resource orchestration theory, suggesting that to achieve excellence, management should be competent in orchestrating the internal resources of organization (Sirmon *et al.*, 2011). The mobilization of resources in an integrated and harmonious manner is also crucial (Asiaei *et al.*, 2021). Based on the perspective to develop the theoretical framework, the role of the orchestration can be attributed to accounting competency, which represents the necessary knowledge for orchestrating hardware, software, and network resources to enhance AIS quality. Specifically, the information generated by AIS software may not always be compatible, relevant, or complete. Addressing such issues requires the development and adjustment of AIS, a process that benefits from input from competent staff, particularly those with expertise in accounting field. In this context, staff serve as agents orchestrating AIS architecture. The current study has been carried out

in Local Governments in Yogyakarta Special Region, Indonesia, in 2022. This study offered various contributions, firstly, it practically addressed the debate surrounding the role of accountants in the advancement of AIS in the public sector. Secondly, novel insights were provided regarding the role of accounting competency as a mediating factor in AIS development, particularly within the context of local government. Thirdly, resource orchestration theory was applied in relation to public sector accounting, tenets previously and widely addressed in the context of corporate strategic management for achieving competitive advantage.

Theoretical Foundation

The theoretical framework of this study was underpinned by the theory of resource orchestration proposed by Sirmon *et al.* (2011). Resource orchestration comprises all aspects of asset management and the strategic coordination of resource allocation to generate benefits for organization (Sirmon *et al.*, 2007). This framework is influenced by three key factors, firstly, organization should have a clear vision of how to be structured to identify and capitalize on opportunities. Secondly, enhancing competencies is essential for the effective management of existing resources and improvement of organizational performance. Thirdly, effective and efficient coordination of these

resources is crucial (Sirmon *et al.*, 2011). These key elements are outlined in Fig. 1.

Resource orchestration theory specifically focuses on the responsibility of individuals in structuring, bundling, and leveraging resources in organization efficiently. One of the key challenges in resource orchestration is synchronizing process (Helfat (2007). Achieving harmony in generating stakeholder value requires balancing various elements in this process. Based on the theory perspective, individuals with accounting competency play a crucial role in enhancing organizational ability and improving the effectiveness, efficiency, and integration of resources in developing AIS. To enhance the process of achieving organizational performance, the use of information and communication technology, combined with competent individuals, is essential (Sofyani *et al.*, 2023). Based on these insights, accounting competency functions as a mediator (orchestrator) of the relationship between other determinants and AIS quality (Fig. 2).

Hardware, Software, Network, and AIS Quality

A high-quality AIS is essential for creating quality financial accounting information (Thoa and Nhi, 2022). The system is constructed by applying hardware and software components, which enhance the ability to efficiently gather, process, and store data. Furthermore, communication network system,

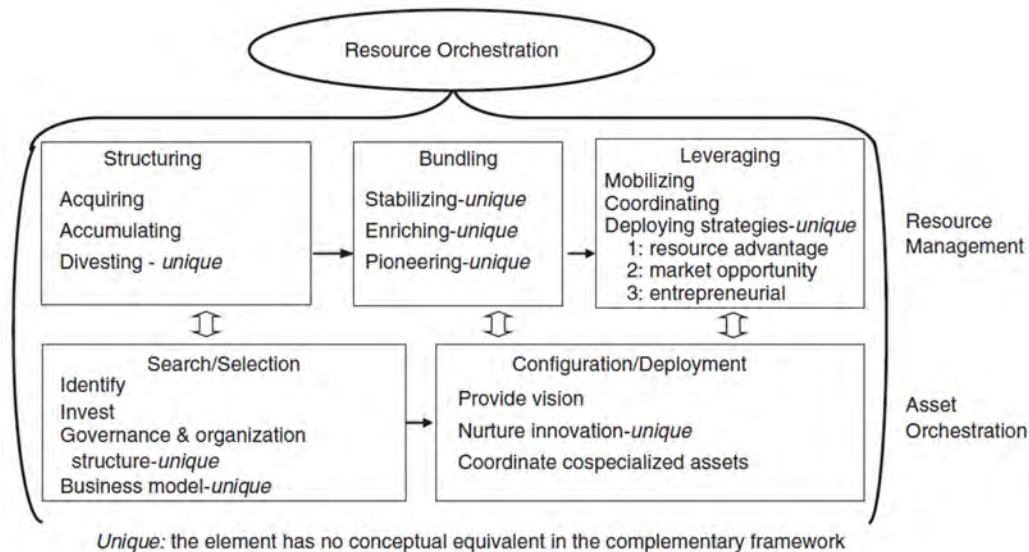


Fig 1: Resource Orchestration Theory (Sirmon *et al.*, 2011)

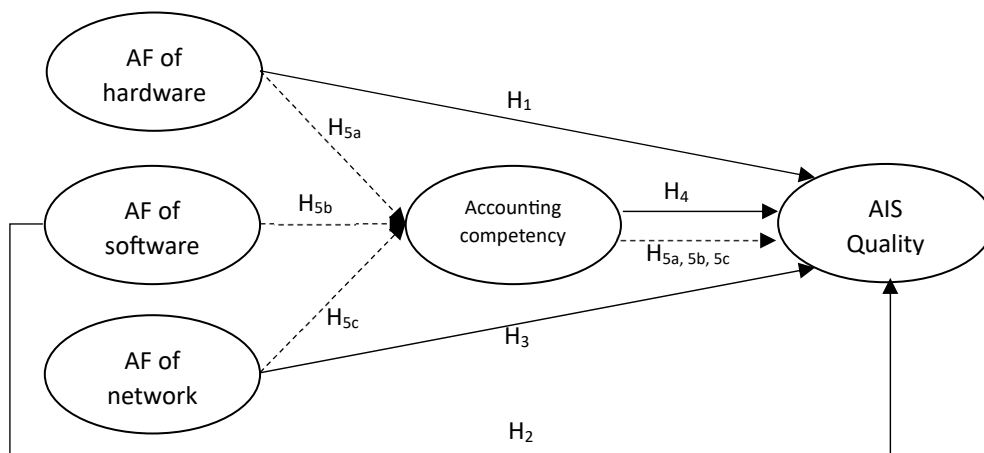


Fig 2: The theoretical framework

such as the Internet, facilitates data exchange and connects information across various departments in organization (Qasaimeh *et al.*, 2022). It can promote increased interaction and active participation of individuals and departments in various organizational management activities, including decision-making and coordination (Wu *et al.*, 2022). The system also facilitates access to information and public services for relevant users (Taipale, 2013). Since AIS in Indonesian local government operates on a website-based (online) platform, the presence of a well-functioning network is crucial. The following hypotheses were formulated based on the discussion above:

H1: Availability and functions of hardware positively influence AIS quality.

H2: Availability and functions of software positively influence AIS quality.

H3: Availability and functions of network positively influence AIS quality.

Accounting competency and AIS quality

Accounting competency refers to the competence, knowledge, and skills required to fulfill accounting tasks (Nurhayati *et al.*, 2023). According to orchestration theory (Sirmon *et al.*, 2011), internal resources can only provide added value to organization when there are individuals capable of harmoniously integrating the resources (Asiaei *et al.*, 2021), based on organizational

management. However, this crucial aspect has not received adequate exploration, leading to a common misconception where the roles of certain actors in organization are sometimes ignored or underestimated. In the context of AIS development, the significance of accounting competence is rarely addressed. This issue gains particular relevance in the public sector, where some perceive the roles as no longer essential due to the advanced era of e-government (Sofyani *et al.*, 2023). However, the perspective has raised debate, as several studies continue to investigate the crucial role of accountants in the digitalization age of business processes (Coman *et al.*, 2022). Adopting the perspective of resource orchestration theory, the role of competent accountants in developing AIS is crucial. This study contended that effective utilization of Information Technology/Information System (IT/IS) equipment, such as hardware, software, and network in AIS development, significantly relies on the involvement of accountants. Nurhayati *et al.* (2023) showed that the knowledge of system users significantly influenced AIS quality in institutions. Mujiono (2021) also suggested that the functional role of accountants in the digital era was expanding, not only in financial reporting system proficiency but also in strategic business analysis using business intelligence for decision-making. With the involvement of accountants, hardware, software, and network can be orchestrated harmoniously and integrated to achieve desired objectives

Table 1: The Operationalized definition of variables

Variable	Indicator	Source
Availability and Functions of Hardware	1. Availability of hardware facilities (AFH1); 2. Hardware facilities that function properly (AFH2); 3. Hardware specifications have been updated to facilitate accounting system operations (AFH3).	Thoa and Nhi (2022)
Availability and Functions of Software	1. Availability of accounting software operations (AFS1); 2. Functions of accounting software operations (AFS2); 3. Availability of accounting system operations (AFS3); 4. Functions of accounting system operations (AFS4).	Thoa and Nhi (2022)
Availability and Functions of Network	1. The communication network facilitates coordination between units (AFN1); 2. The communication network enables accounting system operation (AFN2); 3. Offices rarely experience communication network interruptions (AFN3).	Thoa and Nhi (2022)
Accounting Competency	1. Accounting-related staff understand financial administration procedures (AC1); 2. Accounting-related staff make financial reports that prevent mistakes (AC2); 3. Accounting-related staff at the office understand the used AIS well (AC3).	Thoa and Nhi (2022)
AIS Quality	1. AIS contributes to the integrity of the financial reporting process following applicable regulations (AISQ1); 2. AIS can mention local government assets (AISQ2); 3. AIS can shorten data collection time (AISQ3); 4. AIS improves the quality of financial reports (AISQ4); 5. AIS simplifies local government transaction process (AISQ5); 6. AIS accelerates the process of preparing financial statements (AISQ6); 7. AIS can address human weaknesses in data processing (AISQ7).	Kwarteng and Aveh (2018)

(Sirmon *et al.*, 2011), such as enhancing AIS quality. Accountants aim to determine how software should be developed, what hardware is required, and how IT/IS should be designed. Situations where AIS does not correlate with specific accounting standards or regulations and fail to mitigate risk can also be identified (Zybery and Rova, 2014). The following hypotheses were formulated based on the discussions above:

H4 : Accounting competency positively influences AIS quality.

H5a : Accounting competency mediates the relationship between availability and functions of hardware and AIS quality.

H5b : Accounting competency mediates the relationship between availability and functions of network and AIS quality.

H5c : Accounting competency mediates the relationship between availability and functions of software and AIS quality.

MATERIALS AND METHODS

This study conducted a questionnaire survey and hypothesis testing at Local Government

Organization (LGO) in Yogyakarta, Indonesia. A purposive sampling method was adopted, with staff utilizing AIS software selected as the sampling unit (respondents). A study permit validation letter was obtained from the competent authority before the questionnaires were distributed to respondents. The study experts personally distributed and collected the questionnaires during visits to respondent offices, ensuring a relatively high response rate and adherence to specified criteria. Consultation and validation with five relevant experts, and a pilot study were conducted prior to data collection. Both analyses confirmed that the questionnaire indicators of all variables validly and reliably measured the variables under investigation (Hair *et al.*, 2022). This study incorporated five variables, namely availability and functions of network, hardware and software (independent variables), accounting competency (mediating variable), and AIS quality (dependent variable). The operationalization of all variables is presented in Table 1. The central focus of discussion is AIS quality, which is operationally defined in line with Kwarteng and Aveh (2018), as the system ability to manage data and generate information that is

Table 2: Characteristics of Respondents

Information	Description	Total	Percentage (%)
Level of Education	Diploma	45	32
	Undergraduate	65	46
	Postgraduate	4	3
	No Answer	26	19
Gender	Female	93	66
	Male	47	34
Time Using AIS software	1-5 Years	11	8
	6-10 Years	29	21
	11-15 Years	45	32
	16-20 Years	30	21
	21-25 Years	19	14
	>25 Years	3	2
	No Answer	3	2
	Total	140	100

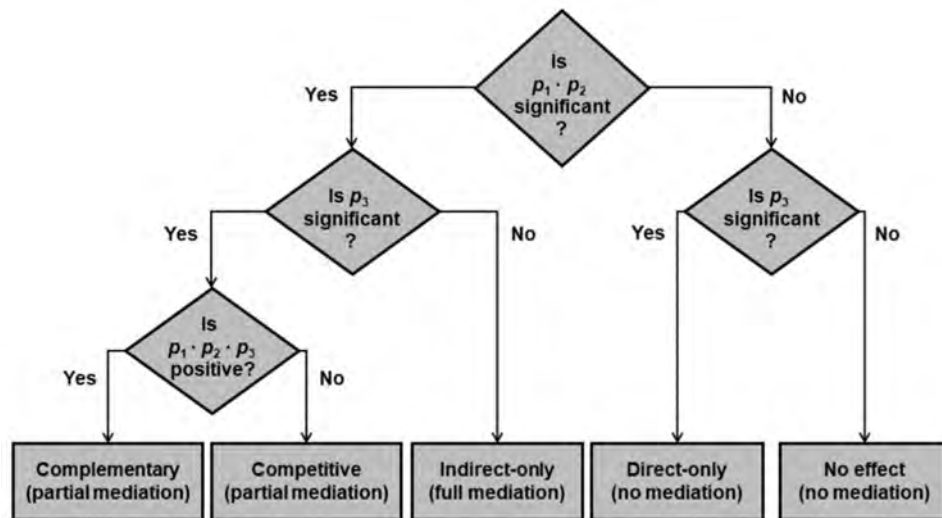


Fig 3: Mediation Assessment (Zhao et al., 2010)

useful, economical, reliable, timely, and flexible. All variables were measured on a Likert scale ranging from 1 to 5, with 1 showing “strongly disagree” and 5 signifying “strongly agree.” This scale adheres to the standard measurement method commonly used in Indonesia, allowing respondents to easily comprehend the questionnaires and provide accurate responses.

This study adopted Partial Least Square (PLS) method, and the number of respondents was determined based on the recommendation of Memon et al. (2020). The minimum sample size was typically obtained by multiplying the maximum

number of indicator links pointing to latent variables in the model by 10. Regarding AIS quality, a latent variable with the highest number of indicators (seven), the minimum sample size should be 70 (10 x 7). A total of 200 questionnaires were distributed, out of which 20 were not returned, and 40 were filled out by relevant respondents. As a result, 140 usable questionnaires were obtained, exceeding the minimum sample recommended (Hair et al., 2022). Table 2 shows the characteristics of respondents.

The collected data were analyzed using SPSS application (Mehdinavaz Aghdam and Roustae, 2023) to generate outputs such as Common Method Bias

(CMB) and descriptive statistics. Subsequently, PLS was adopted to assess the validity and reliability of measurements as well as the relationship among variables (Hair *et al.*, 2022). This study adopted the latest relevant literature to assess mediation models compatible with PLS and examine the mediating role of accounting competency, as proposed by Zhao *et al.* (2010) and endorsed by Hair *et al.* (2022) (Fig. 3).

RESULTS AND DISCUSSION

Bias Detection

Harman single-factor test was conducted as an initial step before examining data to identify the presence of CMB, which was crucial for self-reported survey data. Podsakoff *et al.* (2003) claimed that CMB could be problematic when a single latent component accounts for most of the explained variance or when the score exceeds 50%. The results of the Common Method Variance (CMV) test, particularly the unrotated factor analysis, showed that the first component only explained 36% of the

variation. This showed that CMV did not significantly influence the current results.

Measurement Model Assessment

In PLS analysis, the measurement model was assessed to evaluate the validity and reliability of the construct. This was necessary to determine how well the measurement correlated with the underlying concepts (Sekaran and Bougie, 2019). As a general guideline, a loading and cross-loading threshold of 0.5 was applied (Hair *et al.*, 2022). In the initial assessment, certain indicators showed lower loadings, specifically IFN3 and AFS4. This adversely affected the Cronbach Alpha, Composite Reliability, and Average Variance Extracted (AVE) scores, and led to the removal of the indicators (Hair *et al.*, 2022). In the subsequent evaluation, all remaining items had satisfactory loading and AVE scores (Table 3), theoretically showing the existing indicators effectively measured the intended constructs, namely convergent validity (Hair *et al.*, 2022).

Table 3: Loadings and AVE Scores

Construct	Indicator	Loading	AVE*
Availability and Functions of Hardware	AFH1	0.904	0.728
	AFH2	0.867	
	AFH3	0.785	
Availability and Functions of Software	AFS1	0.716	0.718
	AFS2	0.926	
	AFS3	0.886	
Availability and Functions of Network	AFN1	0.962	0.921
	AFN2	0.958	
	AC1	0.849	
Accounting Competency	AC2	0.877	0.752
	AC3	0.876	
	AISQ1	0.791	
AIS Quality	AISQ2	0.785	0.627
	AISQ3	0.722	
	AISQ4	0.768	
	AISQ5	0.866	
	AISQ6	0.862	
	AISQ7	0.736	

*AVE = Average Variance Extracted

Table 4: Discriminant validity test result using result Fornell-Larcker method

Construct	1	2	3	4	5
AIS Quality	0.792				
Availability and Functions of Hardware	0.446	0.853			
Availability and Functions of Network	0.564	0.594	0.960		
Availability and Functions of Software	0.552	0.575	0.546	0.848	
Accounting Competency	0.619	0.454	0.531	0.609	0.867

Table 5: The Results of Construct Reliability Test

Construct	Cronbach's Alpha	Composite Reliability	Initial (final) indicator
Availability and Functions of Hardware	0.815	0.889	3 (3)
Availability and Functions of Software	0.809	0.883	4 (3)
Availability and Functions of Network	0.914	0.959	3 (2)
Accounting Competency	0.835	0.901	3 (3)
AIS Quality	0.900	0.921	7 (7)

Table 6: The Results of Structural Model Assessment

Association	β	SD	t	Supported?
Direct Effect				
AFH \rightarrow AIS Quality (H_1)	0.023	0.072	0.318	No
AFS \rightarrow AIS Quality (H_2)	0.165	0.083	2.001*	Yes
AFN \rightarrow AIS Quality (H_3)	0.263	0.071	3.714**	Yes
Accounting Competency \rightarrow AIS Quality (H_4)	0.371	0.101	3.681**	Yes
Indirect Effect (Accounting Competency as Mediator)				
AFH \rightarrow Accounting Competency \rightarrow AIS Quality (H_{5a})	0.014	0.026	0.529	No
AFS \rightarrow Accounting Competency \rightarrow AIS Quality (H_{5b})	0.164	0.053	3.081**	Yes
AFN \rightarrow Accounting Competency \rightarrow AIS Quality (H_{5c})	0.099	0.053	1.856*	Yes
Adj. $R^2 = 0.467$ (medium level); SRMR = 0.079 (good model fit)				

Note: ANH = Availability and Functions of Hardware; AFN= Availability and Functions of Network; AFS = Availability and Functions of Software;

* $P < 0.05$; ** $P < 0.01$

Discriminant validity was carried out by examining the correlations between the measurements of potentially overlapping constructs. Based on Table 4, the correlation scores between internal constructs (root of AVE) were higher than for other external constructs (Gefen and Straub, 2005). This showed that discriminant validity was successfully established (Hair *et al.*, 2022).

Inter-item consistency was assessed using Cronbach alpha and composite reliability ratings (Table 5). The assessment results showed that each alpha score exceeded the recommended threshold of 0.6, as specified by Chin *et al.* (2003). According to Fornell and Larcker (1981), composite reliability levels of 0.70 or higher were considered acceptable. Therefore, the scores obtained in the current study were considered reliable.

The study instruments and data were deemed valid, reliable, and suitable for use in the structural model assessment and the testing of hypotheses, since the measurement model assessment standards were met (Hair *et al.*, 2021).

Structural Model Assessment

Table 6 presents the results of the structural model test, showing the relationships between variables, and the acceptance of H_2 , H_3 , and H_4 .

Availability and functions of software and network, as well as accounting competency were the primary keys to promoting AIS quality. The results of the indirect effect test showed that both H_{5b} and H_{5c} were supported, implying the mediating role of accounting competency in the relationship between the variables. According to Zhao *et al.* (2010), this type of mediation is characterized as complementary. The adjusted R^2 for the study model was moderate, specifically 0.467, showing that exogenous factors could explain 46.7% of endogenous variables, while the remaining variance was explained by external variables (Chin, 1998). PLS analysis was not aimed at assessing model fit, even though the results were presented. Moreover, SRMR value, which was less than 0.10, signified the model was "fit" (Henseler *et al.*, 2014).

PLS prediction was conducted to assess the predictive performance of the proposed model (Table 7). This evaluation was carried out by comparing the Root Mean Square Error (RMSE) with the Mean Absolute Error (MAE) in PLS and linear regression models (LM). The predictive power is considered strong when RMSE and MAE values in PLS are lower than those in LM (Shmueli *et al.*, 2016). This statement was evidenced in the analysis results in Table 7, showing the model had a moderate level

Table 7: The results of PLS Predict test

Indicator	PLS		LM	
	RMSE	MAE	RMSE	MAE
AISQ1	0.514	0.418	0.503	0.414
AISQ2	0.554	0.416	0.579	0.438
AISQ3	0.549	0.416	0.575	0.417
AISQ4	0.505	0.408	0.525	0.405
AISQ5	0.471	0.353	0.497	0.369
AISQ6	0.522	0.399	0.559	0.418
AISQ7	0.586	0.411	0.572	0.414
CA1	0.504	0.341	0.515	0.341
CA2	0.549	0.349	0.540	0.327
CA3	0.518	0.330	0.494	0.350

Table 8: The Results of Nonlinear Effect Test

Correlation	β	SD	t	P
Quadratic Effect 1 (AFH) → AIS Quality	0.056	0.060	1.208	0.114
Quadratic Effect 2 (AFS) → AIS Quality	0.046	0.026	0.999	0.159
Quadratic Effect 3 (AFN) → AIS Quality	-0.044	-0.039	0.879	0.190
Quadratic Effect 4 (AC) → AIS Quality	-0.001	0.020	0.018	0.493

Note: ANH = Availability and Functions of Hardware; AFN= Availability and Functions of Network; AFS = Availability and Functions of Software; AC = Accounting competency

of predictive power (Shmueli et al., 2019).

Robustness Check

The viability of various projects was analyzed based on previous studies to validate empirical method and results (Deb et al., 2022). Based on the recommendations of Hair et al. (2019), additional methods were introduced to assess the robustness of PLS results, focusing on the resilience of both the structural and measurement models. The methods included Confirmatory Tetrad Analysis (CTA) to empirically confirm measurement model definitions, whether reflective or formative. Sarstedt et al. (2020) suggested that nonlinear effects of the structural model should be investigated. CTA was adopted to test the robustness of the measurement model (Vickers, 2017). A formative model is presumed when the confidence interval of the model tetrad does not include zero (Hair et al., 2019). However, this study provided empirical evidence for the reflective mode of the construct measurement model, as CTA results showed that the confidence intervals included zero. This necessitated the analysis of data using a reflective method. A quadratic analytic method was also adopted for the nonlinear test (Samimi and Nouri, 2023). The results showed that all exogenous factors had insignificant P values (Table

8), showing a linear relationship between external and endogenous factors, as well as the robustness of the study model (Hair et al., 2019).

Discussions

In the context of E-government development in emerging economic countries, investigations on the determinants of AIS quality remain limited. Moreover, debates have risen regarding the relevance of accounting competency when AIS software is developed in local government organization. To address the gaps, this study extended the conceptual framework proposed by Thoa and Nhi (2022) concerning AIS architecture and the relationship with AIS quality. A theoretical framework was also introduced, positioning accounting competency as a mediating or orchestrating factor, in line with the principles of resource orchestration theory (Sirmon et al., 2011). This study presents a novel model for determining AIS quality in local government. AIS quality in the context of local government refers to the ability to swiftly, comprehensively, and accurately prepare financial reports in compliance with regulations, while simultaneously mitigating errors and enhancing the report quality (Kwarteng and Aveh, 2018). This current study showed that the AIS quality was influenced by availability and

functions of software and network components, as well as accounting competency. This was supported by [Thoa and Ni, \(2022\)](#), showing the significant technical contributions of software and network to the production of high-quality financial information, which facilitated better decision-making. There was more emphasis on the importance of knowledge and competency required to manage information technology-based system, as these attributes were dynamic and influenced by the extent of exposure to the system, skills, and training ([Han et al., 2023](#)). The results showed that availability and functions of hardware did not determine AIS quality. This observation was quite reasonable, as hardware-related aspects in local government organization of Indonesia were generally well-equipped, with government agencies having adequately upgraded computers, printers, and other essential hardware ([Kominfo, 2022](#)). Issues related to hardware did not affect quality through accounting competency, as these typically fell under the purview of IT/IS technicians. Accounting competency played a crucial role of a mediator in AIS quality, in accordance with [Mujiono \(2021\)](#), [Daff \(2021\)](#), and [Han et al., \(2023\)](#), indicating the continued need for individuals with accounting competencies in the era of accounting digitalization. Network and software serve as essential tools for supporting accounting system. It is crucial to orchestrate them to obtain added value, specifically improve AIS quality ([Sirmon et al., 2011](#)). Current accountants are expected to possess the acumen and skills to process data, identify errors, analyze information, and provide meaningful contextual decisions ([Mujiono, 2021](#)). It is essential to be sensitive to AIS compatibility that may lag as business processes evolve with new transaction types ([Jackson et al., 2022](#)). Therefore, determining how new types of financial transactions should be handled through AIS software necessitates judgment from accountants.

Practical and theoretical implications

The implications of this study are twofold. Practically, software and network issues are considered a top priority for local government in developing countries aiming to improve AIS quality. Software and network issues often create challenges in remote areas, such as Papua, Nusa Tenggara, and Kalimantan. These areas occasionally experience

disruptions in AIS software functions due to network problems. Based on the online operation of software for local government, interruptions in network connectivity can disrupt recording, reporting, data integration, and information production processes. Therefore, it is essential to expand network infrastructure to underdeveloped areas through collaboration with state-owned telecommunications company. The need for accounting competency remains essential in the pursuit of AIS quality. [Daff \(2021\)](#) argued that graduates should possess a strong foundation in accounting, understanding how transactions flow through accounting process to evaluate data accuracy. This is crucial because information generated by AIS can be inaccurate due to errors in data input and financial reporting. Errors from software caused by virus or malware and the emergence of new types of transactions not previously covered by software, can render software incompatible and compromise quality. Staff with accounting competency play a crucial role in identifying these deficiencies and promptly updating software version in coordination with IS/IT department personnel. This proactive method ensures the maintenance of AIS quality ([Han et al., 2023](#)), consequently upholding the quality of financial reports ([Thoa and Ni, 2022](#)). Theoretically, this study filled a gap in the conceptual framework proposed by [Thoa and Nhi \(2022\)](#), which focused on the direct effects of some determinants such as software availability, hardware, and network functionality on AIS quality. These determinants essentially constitute AIS architecture, which influences the AIS quality ([Fitriati et al., 2020](#)). Therefore, the primary objective was to investigate the role of these determinants on AIS quality rather than the quality of accounting information, while also introducing the novel concept of accounting competency as a mediating factor. From a theoretical perspective, this study confirmed the theory of resource orchestration in the context of public sector. The underlining premise was that, to achieve a competitive advantage, organization needed to acknowledge the actors capable of orchestrating internal resources ([Sirmon et al., 2011](#)). Regarding AIS development in the public sector, accounting personnel play a crucial orchestrating role, as configurations and adjustments will be constantly required when accounting system is integrated with

IT/IS. Therefore, accounting staff help in selecting, acquiring, accumulating, and releasing architecture resources, ensuring that AIS requirements conform with organizational governance. Configuration, mobilization, coordination, and implementation of the architecture are also facilitated in accordance with organizational strategy and objectives. This orchestration optimizes the production of AIS quality, generating high-quality accounting information for strategic and innovative decision-making, particularly for government accountability.

CONCLUSION

In conclusion, this study investigated the key determinants of AIS quality, focusing on the role of hardware, software, and network availability and functions, with accounting competency as a mediator. Mediation test was carried out to address the importance role of accounting competency in the context of evolving AIS, particularly in the public sector of developing countries. The responses from users in local government of Yogyakarta showed that availability and functions of network and software, as well as accounting competency, were significant factors associated with AIS quality. However, there was no significant impact on hardware availability and functions. The results showed the significant role of accounting competency as a mediator in the relationship between AIS quality and its two critical determinants, namely network and software. Moreover, accounting competency played a crucial role, since software and network support primarily served as tools. Human involvement (Brainware) for orchestration is essential for the development of AIS quality. This study introduced a novel framework for the design of AIS quality determinants, while empirically testing the tenets of resource orchestration theory, commonly discussed in the private sector, to elucidate how sustainable competitive advantages could be achieved. The theoretical discourse was also extended to the public sector literature with the introduction of resource orchestration theory. This study had several limitations, firstly, it was exclusively conducted in local government organization of Yogyakarta, limiting the scope of the results. Further studies in diverse regions were recommended to validate and extend the current results. Secondly, in-depth investigations were not conducted on the

nuanced contributions of accounting competency to AIS quality. This limitation was inherent to the quantitative method adopted. Therefore, future studies were recommended to explore this aspect more comprehensively using qualitative method. With the importance of accounting competency in AIS quality, it was crucial that Higher Education Institutions considered incorporating relevant competencies into curriculum for AIS development in the public sector.

AUTHOR CONTRIBUTIONS

H. Sofyani, conducted and managed all aspects of this study, including the proposal preparation, grant application, study execution, manuscript drafting, and submission to an academic journal.

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CONFLICT OF INTEREST

The author declares no potential conflict of interest regarding the publication of this work. This study adhered to ethical principles, including the prevention of plagiarism, obtaining informed consent, addressing misconduct, avoiding data fabrication or falsification, preventing double publication, and avoiding redundancy.

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ABBREVIATIONS

<i>Adj R²</i>	Adjusted Coefficient of determination
AC	Accounting Competency
AFH	Availability and Functions of the Hardware
AFH	Availability and Functions of the Software
AFN	Availability and Functions of the Network
AIS	Accounting Information System
AISQ	AIS Quality
AVE	Average Variance Extracted
CMB	Common Method Bias
CMV	Common Method Variance
LGOs	Local Government Organizations
LM	Linear Regression Model
MAE	Mean Absolute Error
<i>p-value</i>	Probability value
PLS	Partial Least Square
RMSE	Root Mean Square Error
SD	Standard Deviation
SRMR	Root Mean Square Residual
β	Coefficient

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ORIGINAL RESEARCH PAPER

Urban development scenarios on flood peak discharge in an arid urban watershed using the WinTR-55 hydrologic model

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ABSTRACT

BACKGROUND AND OBJECTIVES: Land use change can directly affect rainfall-runoff relationships. The change in land use is an essential factor in runoff production. This research evaluated the effect of urban development scenarios of land use change on runoff in Gonabad city of Iran. The innovation and importance of this work are to determine which land use changes have the greatest impact on the flood discharge in this urban area. Also, determine how much the minimum development of urban green space is to control and reduce peak flood discharge in this city that is located in a dry area.

METHODS: The effect of urban development scenarios on runoff was evaluated by the WinTR-55 model in 5 sub-basins of Gonabad city. The main data required for inputting to the WinTR-55 model are sub-area and reach characteristics, curve number, and storm data. The storm data in TR-55 are 24-hour rainfall amounts in a return period of 2, 5, 10, 25, 50, and 100 years. The changes in the maximum flood discharge and flow hydrograph in each sub-area and return period were calculated by the WinTR-55 model under existing land use conditions and 9 scenarios of urban development.

FINDINGS: The greatest increase in runoff production was related to the conversion of abandoned fallow and agricultural lands to residential. Also, the most effective increase or decrease of land cover change in peak flow discharge and total flow volume was at the 2-year return period. The decreased effect of the development of green spaces and urban gardens on peak flow discharge and total flow volume was seen only if their development was more than 50%. The average maximum decrease in peak discharge and total flow volume was 22.7% and 16.1%, respectively. While the average maximum increase in peak discharge and total flow volume was 84.4% and 53.9%, respectively.

CONCLUSION: The effect of increasing green spaces and urban gardens on the reduction of peak discharge and volume of runoff was also evident in the study area. Land management and preventing the conversion of permeable land uses such as agricultural, gardening, fallow lands, and rangeland will be much simpler and less costly. Urban land use management to prevent urban floods requires the expansion of permeable surfaces, especially green spaces, and urban gardens. These are the important novelty of this research that can be beneficial for future urban developments

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INTRODUCTION

In 2012, the United Nations reported that the world's urban population is growing increasingly as estimated that 53% of the world's population will be settled in cities (United Nations, 2012). This increase in population requires urban development. The development of residential areas is due to the development of roads, houses, and buildings (Torres Navas et al., 2021). This development can lead to negative ecological and environmental effects (Samimi and Shahriari Moghadam, 2020). Increased residential areas change ground surface responses to precipitation. It reduces rain infiltration and the lag time of runoff which increases peak flows and floods (Feaster et al., 2014). Flood is a natural phenomenon that can happen almost anywhere it rains (Eshghizadeh, 2017). Floods are one of the main damaging natural disasters that occur more frequently under the influence of human interventions, especially urbanization development (Zhou, 2022). One of the main effecting factors on floods is land use changes (Gholamian and Ildoromi, 2020). The change in land use and land cover is an essential factor in runoff production and flood estimation (Hashim et al., 2022; Li et al., 2019; Vaziri, 2021). The increase in urban areas can trigger river peak discharge (Barasa et al., 2014). Urban development is usually accompanied by the loss of agricultural lands and rangelands that convert to urban lands (Shehu et al., 2023). These changes increase the potential for runoff and sedimentation in cities (Torres Navas et al., 2021). To determine the effect of the land use change on the peak flow in an urban watershed, many hydrologic models were developed that predict runoff amount from rainfall with acceptable accuracy (Alkan 2016; Muhammad and Khan, 2015). Apollonio et al. (2016) evaluated the impact of spatio-temporal changes in land use on the hydrological response of the Cervaro basin in Southern Italy, from 1984 to 2011. They used Landsat imagery and a physically-based lumped approach for infiltration contribution to produce a land use map and estimate flood peak. Dang and Kumar (2017) investigated the effect of the rapid growth of urban development on the increase of flood risk in Ho Chi Minh City, Vietnam. They used QuickBird imagery to create a land use change map and a TR-55 model to estimate flood risk in this urban area. Shrestha (2019) analyzed the changes in land cover in the Pampanga River basin of the Philippines

for the years 1996 and 2016 and the effect of them on the flood, the results showed that these changes can increase the flood risk in urban areas in the future. Recanatesi and Petroselli (2020) evaluated the impacts of land cover changes on the runoff in rainfall events in Rome. They analyzed land cover and flood risk changes in 1954, 1967, and 2018 by a hydrological-hydraulic model as a result of urban development. Also, Berkessa et al. (2023) showed rapid urbanization has caused vegetation cover in the wetland the decrease over the past decades. This area was converted to urban areas and the surface storage areas of precipitation are decreasing, which can lead to an increase in floods. One of the widely used and reliable methods for estimating peak discharge and flow volume in small and urban watersheds is the TR-55 model. Technical Release 55 (TR-55) is a simplified method to calculate runoff volume, the peak of discharge, and hydrographs of rain storms, especially in urban watersheds. TR-55 was introduced by the Natural Resources Conservation Service (NRCS) in 1975. In 1998 NRCS revised a Windows-based model of Tr-55 as Win TR-55 and computer software for estimated runoff of rainfall events in agricultural and urban watersheds (NRCS, 2005). Many studies have confirmed the ability of this model to estimate runoff in urban and agricultural watersheds (Blair et al., 2014). The studies conducted with this model also confirmed the use of this model for estimating runoff in urban areas. Alkan (2022), evaluated the peak flow in the agricultural watershed of the Kirklareli Vize and Samsun Minoz Stream watersheds. The peak flow is calculated by the WinTR-55 model. The results showed that WinTR-55 can be used for the predicate of flood in the watersheds. Corbin et al. (2021) used WinTR-55 and the Regional Regression Equations (RREs) models to assess their accuracy for the peak flow of runoff in the WS80 area. Sutjningsih et al. (2015) simulated the discharge using a WinTR-55 model to estimate the annual sediment yield in a small urban watershed at the outskirts of Greater-Jakarta. Henning (2009), showed that the Win TR-55 model can be used to determine peak flows for storm return periods of 2, 5, 10, 25, 50, and 100 years. Due to the lack of surface water resources in arid regions, the concentration of vegetation covers and other aspects of life are around the water resources, such as the city of Gonabad, where the concentration of population and agricultural lands were due to the

existence of qanats (as Qasabeh qanat of Gonabad) in these areas, a decrease in vegetation cover can have a negative effect on their micro-climate. One of the main reasons for the reduction of vegetation in these areas is the conversion of current lands into residential lands due to the development of the city. One of the main urban problems is the occurrence of floods and urban flooding, which has increased in frequency in recent years. Estimation of the flood peak flow is one of the most important factors in managing the runoff in urban areas (Alkan, 2022). The destructive floods in May 2021 and 2022 have caused a lot of damage to this city, and so far, no research has been done on the effects of land use changes on floods in this city. There is little information about the effects of land cover changes on runoff, peak flows, and flooded areas in many arid urban watersheds spatially in Gonabad city. The main purpose of this study is to evaluate the effect of urban development scenarios of land use change on runoff by the WinTR-55 model in Gonabad city as an arid urban watershed. For this purpose, changes in the maximum flood discharge and flow hydrograph in 5 sub-basins of Gonabad city for events with a return period of 2, 5, 10, 25, 50, and 100 years were evaluated under existing land use conditions and possible land use change scenarios. The innovation and importance of this work are to determine which land use changes have the greatest impact on the flood discharge in a dry urban area. Also, determine how much the minimum development of urban green space is to control and reduce peak flood discharge in a city located in a dry area. The current study has been carried out in Gonabad city in 2023.

MATERIALS AND METHODS

This study evaluated the effect of land use change on runoff in an arid urban watershed. The main hypothesis was that urban development can increase the flood in this watershed. This hypothesis was examined by the WinTR-55 model and possible land use change scenarios. Changes in the maximum flood discharge and flow hydrograph were evaluated for rainfall events with a return period of 2, 5, 10, 25, 50, and 100 years in the study area.

Study area

The study area is the city of Gonabad in the northeast of Iran (center coordinate 34°21'28", N;

58°42'2", E). The area of the study area is 3619.1 ha and a population of about 40773 in 2016. The general slope is from south to north. The average height of the area is 1150 meters above sea level. The climate of Gonabad city is predominantly arid with a mean annual precipitation equal to 140.3 mm and a mean annual temperature of 17.6°C. According to the drainage conditions of the area, five sub-areas can be determined for this urban area with a total area of 3,626.4 hectares. Fig 1 shows the study area and sub-area.

WinTR-55

WinTR-55 is a single-event rainfall-runoff model. In this model, a watershed is divided into subareas and reaches. A subarea is a surface of the land that has land use and land cover special characteristics, and according to these characteristics, it responds against rainfall events, and the runoff produced on it is drained by a reach. Reaches are flow paths that discharge runoff of the subarea to its outlet. A hydrograph can be generated for each subarea. Also, for each reach, hydrographs can be routed based on the physical characteristics of the channel, or as a reservoir based on temporary storage and outlet characteristics. An accumulated flow can be calculated by combined sub-areas and reaches at the watershed outlet (NRCS, 2005). The TR-55 utilizes the SCS runoff equation to convert rainfall to runoff and predict the peak and total volume of the runoff. The TR-55 to generate the runoff hydrographs uses a simplified tabular method based on land use, land cover, and climate characteristics. The calculations of the tabular method are performed with TR-20. The WinTR-55 is based on the TR-20 (NRCS, 2002) model, and all calculations are done for hydrograph generation, combining hydrographs, channel routing, and structure routing based on it (WinTR-55 User Guide, 2009).

Data collection, input, and analysis

The data was inputted into WinTR-55 through several windows. The main data required for input are sub-area and reach characteristics, curve number, and storm data. For each sub-area be defined name, area, flows to reach/outlet, curve number, and time of concentration. In the TR-55 the weighted CN is calculated by land use details. The land use details can be defined for sub-areas to determine the area of each

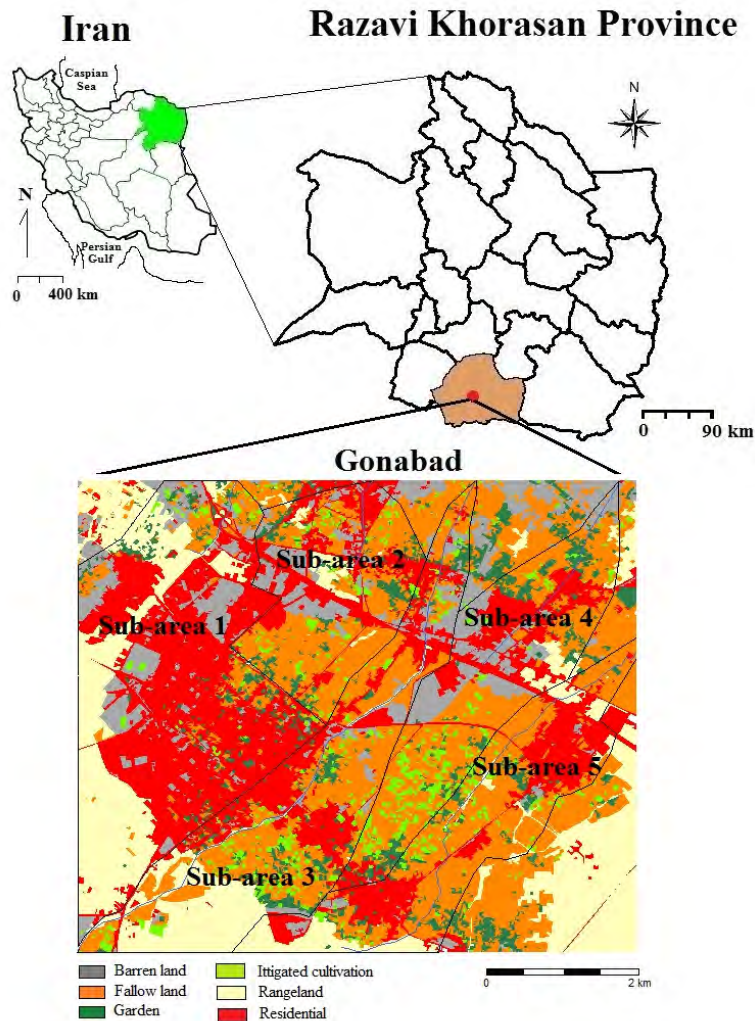


Fig. 1: Geographic location of Gonabad city and their sub-areas in the study (Source: 1:25000 topographic map, soil map, land use map, and field surveys of Gonabad city)

cover description and hydrologic soil group of each land use category in the land use details window. To calculate the time of concentration, enter the data of the length, slope, surface type, Manning's roughness coefficient, flow area, and wetted perimeter via the time of concentration details window. For each reach must be determined data of receiving reach, length, Manning's roughness coefficient, slope, bottom width, average side slope, and structure name. The required data was gathered and calculated based on the aerial photos, 1:25000 topographic map, soil map, land use map, and field surveys of Gonabad

city. Table 1 and 2 shows the data of sub-areas and reaches for the study area. Storm data in the TR-55 are 24-hour rainfall amounts in each return period and associated rainfall distributions. The amount of the 24-hour rainfall amounts in the return period and associated rainfall distributions were calculated based on the rainfall data of the Gonabad synoptic weather station. Table 3 shows the 24-hour rainfall amounts in the return period and rainfall distribution for the study area. After inputting the required data, the model was executed and the values of peak discharge, the total volume of surface runoff, and

Table 1: Land use of sub-areas for the study

Sub-basin	Total area (hr)	Residential (hr)	Rangeland (hr)	Agricultural (hr)	Abandoned fallow (hr)	Barren land (hr)	Garden (hr)
Sub-area 1	1138.9	549.4	300.7	15.9	75.1	149.8	48.0
Sub-area 2	490.8	127.2	22.5	23.6	216.4	65.5	35.6
Sub-area 3	799.9	182.2	155.5	50.8	301.6	60.9	48.9
Sub-area 4	601.6	127.8	22.5	53.5	252.8	91.9	53.1
Sub-area 5	587.9	163.8	79.9	23.4	273.7	15.9	31.2

Table 2: Data of sub-areas and reaches for the study area inputted into WinTR-55

Sub-basin	Length of the sheet flow (m)	The slope of the sheet flow (%)	Length of the shallow channel (m)	The slope of the shallow channel (%)	Reach	Length of main river (m)	Slope of main river (%)
Sub-area 1	705	1.8	3897	1.25	1	1275.9	0.8
Sub-area 2	309	1.9	2077	0.7	2	1177.1	0.7
Sub-area 3	878	1.5	1214	0.8	3	8674.2	0.83
Sub-area 4	652	1	1022	0.9	4	2975.7	0.64
Sub-area 5	250	0.8	2488	0.9	5	6150.2	0.84

Table 3: 24-hour rainfall amounts in return period and rainfall distribution

Return period (year)	24-hour rainfall amounts (mm)	Rainfall distribution (SCS)
2	19	II
5	27.4	II
10	33.1	II
25	40.5	II
50	46.1	II
100	51.8	II

output hydrograph were extracted in return periods of 2, 5, 10, 25, 50, and 100 years. The calibration and validation of the model were previously done by the SCS-CN in the Kakhk experimental watershed (Eshghizadeh *et al.*, 2018). Also, to evaluate the accuracy of the model, the obtained results were compared with the hydrograph of the extracted Geomorphological Instantaneous Unit Hydrograph (GIUH).

Urban Development Scenarios

The most important changes that may occur in the current land use in the study area were defined in the form of scenarios in Table 4. Each scenario was defined in the WinTR-55 according to the changes in the area of land use. Then, the model calculated the peak flow, total flow volume, and hydrographs based on these changes.

RESULTS AND DISCUSSION

The results showed the WinTR-55 model can be

used to evaluate the effect of land use changes on runoff in the urban watershed. Based on the results, the maximum peak discharge and flow volume occurred in sub-area 1 (Fig. 2). Sub-area 1 in all studied return periods has the most peak flow discharge. This sub-area has the largest area, residential area, rangeland, and barren land compared to other sub-areas. This shows that the increase in the residential areas can increase the floods in urban areas.

The scenarios were defined for urban development in Gonabad city which were related to the reduction of water resources and population growth and the need to develop urban green spaces. Reduction of water resources and population growth causes agricultural and other natural lands to convert to residential lands. Based on the results, this conversion causes an increase in the peak discharge and runoff volume. Because surfaces with lower permeability increase. Developing urban green spaces can increase the infiltration areas. Fig. 3 shows the change of the peak flow discharge in the

Table 4: Urban development scenarios for the study area

Scenarios	Description
Scenario 1	Conversion of urban barren lands to residential lands
Scenario 2	Conversion of abandoned fallow and agricultural lands within the urban area to residential
Scenario 3	Conversion of irrigated agricultural land within the urban area to residential
Scenario 4	Conversion of garden lands within the urban area to residential
Scenario 5	Converting 10% of current rangeland in the urban area to residential
Scenario 6	Converting 25% of current rangeland in the urban area to residential
Scenario 7	Development of green spaces and urban gardens to the amount of 10% of the current situation
Scenario 8	Development of green spaces and urban gardens to the amount of 25% of the current situation
Scenario 9	Development of green spaces and urban gardens to the amount of 50% of the current situation

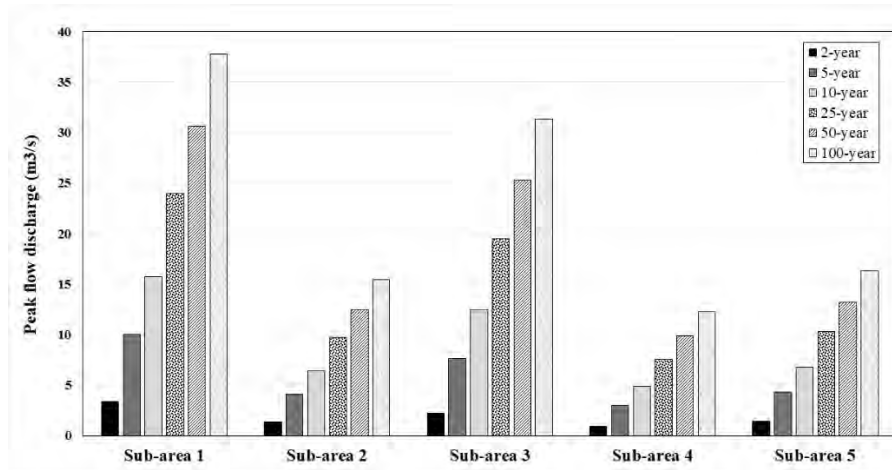


Fig. 2: Peak flow discharge in the studied return period and sub-areas

studied return period and sub-areas in response to land use changes in defined scenarios. Also, tables 5 and 6 show the changes in the peak flow discharge and total flow volume in the studied return period and sub-areas in defined scenarios. In sub-area 1, which has the most residential areas, only scenarios 1, 4, and 6 had an increase in flow characteristics for the studied return periods. Most of their increases were at the 2-year return period. The peak flow discharge was increased by 26.3% and the total flow volume by 17.7% compared to the current situation. Also, scenario 9 showed the most decrease at the 2-year return period to 22.4% in peak discharge and 15.6% in total flow volume. The other scenarios did not show any effect on the flow rates (Tables 5 and 6). In sub-area 2, the largest area of land use was abandoned fallow lands with 44.1 percent. In this sub-area, the highest increase in peak flow discharge and the total flow volume was in scenario 2 for the 2-year return period with 92 and 60.7%, respectively.

Also, scenarios 1, 3, and 4 had an increase in peak flow discharge and the total flow volume to 25.5 and 17.6%, respectively. Also, scenario 9 showed the most decrease at the 2-year return period to 22.6% in peak discharge and 15.9% in total flow volume. The other scenarios did not show any effect on the flow rates (Tables 5 and 6). In sub-area 3, scenarios 1, 2, 3, 4, and 6 had an increase in peak discharge and total flow volume. Among these scenarios, scenario 2 showed the most change with an increase to 108% in peak discharge and 64.3% in total flow volume for the 2-year return period. Also, scenario 9 showed the most decrease at the 2-year return period to 25.3% in peak discharge and 16.5% in total flow volume. The other scenarios did not show any effect on the flow rates (Tables 5 and 6). In sub-area 4, scenarios 1, 2, 3, and 4 showed an increase in peak discharge and total flow volume. Among these scenarios, scenario 2 had the most change with an increase to 96.8% in peak discharge and 64.7% in total flow volume for

Table 5: Changes in the peak flow discharge in the studied return period and sub-areas compared to the current situation in percent

Sub-basin	Return period (year)	Scenarios								
		1	2	3	4	5	6	7	8	9
Sub-area 1	2	26.3	0	0	26.3	0	26.3	0	0	-22.4
	5	15.1	0	0	15.1	0	15.1	0	0	-14.2
	10	12.1	0	0	12.1	0	12.1	0	0	-11.1
	25	9.6	0	0	9.6	0	9.6	0	0	-8.6
	50	8.1	0	0	8.1	0	8.1	0	0	-7.5
	100	6.9	0	0	6.9	0	6.9	0	0	-6.9
Sub-area 2	2	25.5	92	25.5	25.4	0	0	0	0	-22.6
	5	15.4	49.2	15.4	15.4	0	0	0	0	-14.1
	10	12.4	39.1	12.4	12.4	0	0	0	0	-10.9
	25	9.6	29.8	9.6	9.6	0	0	0	0	-8.6
	50	8.1	24.8	8.1	8.1	0	0	0	0	-7.8
	100	6.9	21.5	6.9	6.9	0	0	0	0	-7
Sub-area 3	2	30.2	108	66.2	30.2	0	30.2	0	0	-25.3
	5	16.4	54	34.3	16.4	0	16.4	0	0	-14.7
	10	12.4	40.5	25.9	12.4	0	12.4	0	0	-11.8
	25	9.7	30.5	19.7	9.7	0	9.7	0	0	-9.2
	50	8.2	26	16.9	8.2	0	8.2	0	0	-8
	100	7.4	22.3	14.8	7.4	0	7.4	0	0	-6.9
Sub-area 4	2	27.6	96.8	59.6	59.6	0	0	0	0	-21.3
	5	15.9	53.6	34.1	34.1	0	0	0	0	-14.6
	10	12.7	41.3	26.3	26.3	0	0	0	0	-11.3
	25	9.9	31.6	20.8	20.8	0	0	0	0	-9.3
	50	8.4	26.9	17.6	17.6	0	0	0	0	-8.4
	100	7.4	22.8	14.7	14.7	0	0	0	0	-7.2
Sub-area 5	2	0	93	25.9	25.9	0	0	0	0	-21.7
	5	0	49.9	14.8	14.8	0	0	0	0	-14.4
	10	0	39	12	12	0	0	0	0	-11.4
	25	0	28.8	9	9	0	0	0	0	-9.6
	50	0	24.5	8.1	8.1	0	0	0	0	-7.4
	100	0	21.1	6.1	6.1	0	0	0	0	-7.3

the 2-year return period. Also, scenario 9 showed the most decrease at the 2-year return period to 21.3% in peak discharge and 16.9% in total flow volume (Tables 5 and 6). In sub-area 5, scenarios 2, 3, and 4 showed an increase in peak discharge and total flow volume. The most change was by scenario 2 with an increase to 99% in peak discharge and 62.2% in total flow volume for the 2-year return period. Also, only scenario 9 showed the most decrease at the 2-year return period to 21.7% in peak discharge and 15.8% in total flow volume (Tables 5 and 6).

The results showed that the TR-55 model is capable of comparing sub-areas for potential flooding by estimating flow rates in each sub-area in an urban watershed. Many studies have confirmed the ability of this model to estimate runoff in urban and agricultural watersheds (Blair *et al.*, 2014). Alkan (2022) and Corbin *et al.* (2021) confirmed that the WinTR-55 model is suitable and comfortable for

predicate floods in watersheds. By combining the SCS-CN model and the physical characteristics of the land surface, the Tr-55 model has a good ability to estimate the peak discharge and flow volume, especially in urban watersheds. Its most important feature can be simple and accessible data. Alkan (2022), compared to other hydrologic models, the WinTR-55 model requires fewer input data to determine the surface flow changes in urban areas. Based on the results, the greatest increase in runoff production was related to the conversion of abandoned fallow and agricultural lands to residential. The sub-area 3 had the most increase in peak discharge and runoff due to the change of land uses to residential. The area of abandoned fallow lands in sub-area 3 was more than other sub-areas. the conversion of them to residential had the most increasing effect on peak discharge and runoff. Can be said, that conversions increase the area of impermeable surfaces. This effect was well

Table 6: Changes in the total flow volume in the studied return period and sub-areas compared to the current situation in percent

Sub-basin	Return period (year)	Scenarios								
		1	2	3	4	5	6	7	8	9
Sub-area 1	2	17.7	0	0	17.7	0	17.7	0	0	-15.6
	5	11.7	0	0	11.7	0	11.7	0	0	-10.7
	10	9.7	0	0	9.7	0	9.7	0	0	-8.7
	25	8	0	0	8	0	8	0	0	-7.5
	50	7.1	0	0	7.1	0	7.1	0	0	-6.7
	100	6.4	0	0	6.4	0	6.4	0	0	-6.1
Sub-area 2	2	17.6	60.7	17.6	17.6	0	0	0	0	-15.9
	5	11.6	38.6	11.6	11.6	0	0	0	0	-10.7
	10	9.7	31.6	9.7	9.7	0	0	0	0	-8.9
	25	8	25.7	8	8	0	0	0	0	-7.5
	50	7.2	22.6	7.2	7.2	0	0	0	0	-6.7
	100	6.4	20.2	6.4	6.4	0	0	0	0	-6
Sub-area 3	2	18.7	64.3	40.1	18.7	0	18.7	0	0	-16.5
	5	12	39.5	25.1	12	0	12	0	0	-11
	10	9.9	32.2	20.6	9.9	0	9.9	0	0	-9.2
	25	8.1	26.1	16.8	8.1	0	8.1	0	0	-7.7
	50	7.2	22.9	14.8	7.2	0	7.2	0	0	-6.8
	100	6.5	20.4	13.3	6.5	0	6.5	0	0	-6.2
Sub-area 4	2	18.8	64.7	40.2	40.2	0	0	0	0	-16.9
	5	12.1	53.3	25.4	25.4	0	0	0	0	-11.2
	10	9.9	32.2	20.6	20.6	0	0	0	0	-9.4
	25	8.1	26.1	16.9	16.9	0	0	0	0	-7.9
	50	7.2	23	14.9	14.9	0	0	0	0	-7.1
	100	6.5	20.5	13.3	13.3	0	0	0	0	-6.4
Sub-area 5	2	0	62.3	18.4	18.4	0	0	0	0	15.8
	5	0	38.8	11.8	11.8	0	0	0	0	10.6
	10	0	31.7	9.7	9.7	0	0	0	0	8.9
	25	0	25.7	8	8	0	0	0	0	7.5
	50	0	22.6	7.1	7.1	0	0	0	0	6.6
	100	0	20.1	6	6	0	0	0	0	6

seen in sub-area 1 due to the large area of residential. Urban development has created certain changes to the hydrology of the urban watershed due to large areas of impervious surface cover (Fang *et al.*, 2020). The change rate of imperious surfaces and vegetated land cover affected the peak discharge and runoff volume in an urban watershed (Elaji and Ji, 2020). The increase of residential areas in urban watersheds has reduced rainfall losses (soil infiltration, surface storage) that increase surface runoff. This process can lead to a higher peak flow discharge and higher flow volume in a shorter time base (O'Driscoll *et al.*, 2010). With the change in land use the soil moisture can be increased or decreased. Rogger *et al.* (2017) emphasized that the change in land use has a very strong effect on floods. Also, Umukiza *et al.* (2021) have confirmed that the peak discharge and flow volume are affected by the land use and land cover

scenarios. These scenarios have a direct impact on the CN of sub-areas. The results of Apollonio *et al.* (2016) showed that a decrease in the area of the rangelands, forests, and bare lands can have a direct effect on the increase in floods. Also, Gholamian and Ildoromi (2020) showed that the conversion of agricultural lands to residential is the main reason for to increase in runoff in an urban watershed. Based on the results, the most effective increase or decrease of land cover change in peak flow discharge and total flow volume was at the 2-year return period. The results of Gholamian and Ildoromi (2020) showed that the most change in runoff rate had been at the 2-year return period. This result showed that the reaction of nature to their manipulations by humans shows itself quickly. The results of Corbin *et al.* (2021) showed that predicted peak flow rates by WinTR-55 are accurate in lower return periods, it is a capable

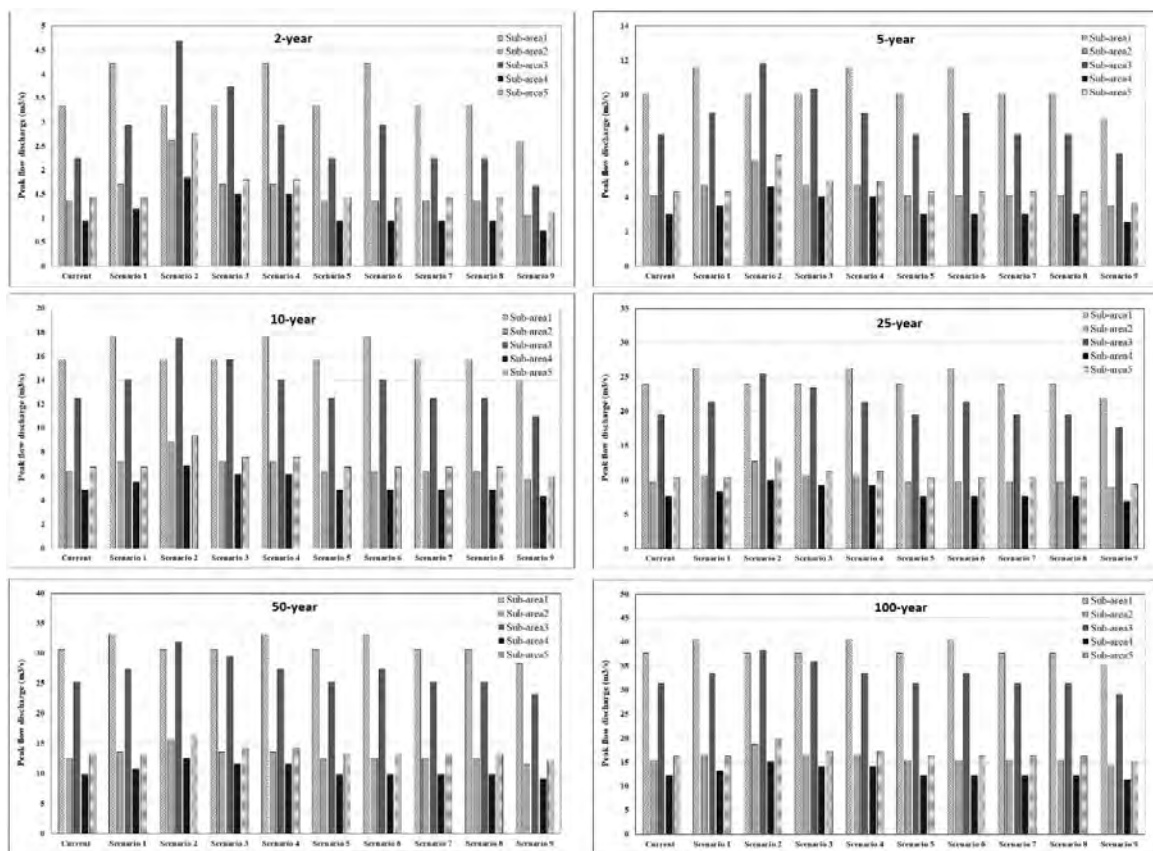


Fig. 3: Change of the peak flow discharge in the studied return period and sub-areas

model to assess the effect of land use change on floods in urban watersheds.

The results showed that the decreased effect of the development of green spaces and urban gardens on peak flow discharge and total flow volume was seen only if their development was more than 50%. [Siriwardena et al. \(2006\)](#) have confirmed that uniform changes in land use, especially vegetation, are closely related to the hydrological response of the watershed in floods. A decrease in surface storage areas of precipitation by urbanization can lead to an increase in floods ([Berkessa et al., 2023](#)). Vegetation and natural ground cover by interception and increasing infiltration reduce the surface flow ([Day and Bremer, 2013](#)). The role of land vegetation cover in reducing peak discharge is more important than the type of vegetation ([Henning, 2009](#)). The results showed that the effect of increasing the peak discharge and the total flow volume due to the changes of land use to

residential is more than the effect of a 50% increase in green spaces and urban gardens. The average maximum decrease in peak discharge and total flow volume was 22.7% and 16.1%, respectively. While the average maximum increase in peak discharge and total flow volume was 84.4% and 53.9%, respectively. Land management and preventing the conversion of permeable land uses such as agricultural, gardening, fallow lands, and rangeland will be much simpler and less costly. Because with the application of 50% development in green spaces and urban gardens, the effect of its reduction, despite the high costs of its construction, will be less than the ratio of the increase in peak discharge and the total volume of the surface runoff due to the development of residential areas. The results showed that in Gonabad city, converting barren and fallow lands to residential have the most effect on runoff generation. Also, to reduce runoff, the minimum increase of green spaces should be

50%. These are the important novelty of this research that can be beneficial for future urban developments of Gonabad city and its flood management activities.

CONCLUSION

The results showed that WinTr-55 is a capable model for estimating runoff in an arid urban watershed. Based on the results, converting barren and abandoned fallow lands to residential areas has the most effect on runoff generation and flood discharge in Gonabad city. Also, the minimum increase in green spaces should be 50% to reduce the peak discharge and volume of runoff. The TR-55 model showed that the urban development of Gonabad city increases surface runoff in all sub-areas. The greatest increase in discharge has occurred for urban development scenarios in sub-area 3. The conversion of abandoned fallow and agricultural lands to residential (scenario 2) had the greatest effect on increasing the peak discharge and volume of runoff. The effect of increasing green spaces and urban gardens on the reduction of peak discharge and volume of runoff was also evident in all sub-areas. The results showed the minimum amount of development should be more than 50% of the existing area of green spaces and urban gardens in each of the sub-areas. Also, the WinTR-55 model can be used to estimate the changes in land use on discharge in urban development. Based on the results, WinTR-55 is a simple and available model that can be used to examine various scenarios of urban development on the changes of surface runoff. The limitations or uncertainties of this study can be divided into two groups. The first group is related to the conditions of the study area which includes factors such as large area, low slope and not clear boundaries of sub-areas, low density of residential areas, and high interference of different land use within the urban area. The second group is related to the bases of the TR-55 model. The runoff calculation part of this model is based on the SCS-CN model. All the limitations and uncertainties of this model will also exist for the TR-55 model. These limitations include the tabulated curve numbers are questionable spatially in urban areas with low density of residential areas. Also, Bias from inconsistencies in the derivation and the inability to define the quality of the tabulated curve numbers. Cannot be used if weighted CN < 40. Not applicable for snow melt. Variation in rainfall duration and intensity

during storms is not considered. Infiltration rate and capacity, and thus the explicit subsurface storage of moisture is not considered. Long-term evaporation and transpiration losses are not considered. It is suggested to use physically-based models instead of experimental models in arid urban watersheds. Also, user changes can be dynamically defined using remote sensing data for models. The results of this study contribute to the existing body of knowledge in the fields of hydrology, urban planning, and flood risk management. Because showed that in an arid urban watershed, the conversion of abandoned and fallow agricultural lands into residential areas has a great impact on the increase in flow rate. Urban land use management to prevent urban floods requires the expansion of permeable surfaces, especially green spaces, and urban gardens.

AUTHOR CONTRIBUTIONS

M. Eshghizadeh performed the literature review, compiled the data, and experimental design, analyzed and interpreted the data, and prepared the manuscript text, and manuscript edition. compiled the data and manuscript preparation.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. 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.

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ABBREVIATIONS

CN	Curve number
GIUH	Geomorphological Instantaneous Unit Hydrograph
hr	hour
SCS	Soil Conservation Service
TR-55	Technical Release 55

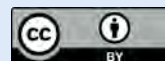
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CASE STUDY

Designing star employee retention model

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ABSTRACT

BACKGROUND AND OBJECTIVES: Star Employees are high performers who have little chance of staying with an organization unless they can get more value than what they have created. Identifying and keeping star employees is the concern of many organizations today. This research seeks to identify the factors that Retention organizational stars.

METHODS: This research was conducted using a mixed method. First, using the qualitative method of content analysis, the dimensions of the star employee model and their retention techniques were identified, and then confirmed by the structural equation modeling method of the star employee model, and finally, after identifying the star employees, the retention techniques was extracted using the fuzzy Delphi technique. The statistical population of this study consists of Petroleum engineering and development company managers and their subordinate Star employees. To collect data, the purposeful sampling method was used with 8 selected experts through a questionnaire in person.

FINDINGS: Research findings showed that the Star employees are people with six characteristics: performance ($\beta=0.865$, $p<0.01$), visibility ($\beta=0.737$, $p<0.01$), social capital ($\beta=0.537$, $p<0.01$), status ($\beta=0.891$, $p<0.01$), creativity ($\beta=0.905$, $p<0.01$) and rareness and inimitability ($\beta=0.913$, $p<0.01$). Also, 16 indicators were identified as the retention factors of Star employees by fuzzy Delphi method. These factors were classified in the form of two dimensions "focus on the individual/organization" and "short-term/long-term time".

CONCLUSION: Based on the research results, in order to retention star employees, organizations should use different techniques: job design in such a way that there is freedom of action, work independence and flexibility, creating a flexible and creative work environment, creating a flexible and agile organizational structure and to benefit from a learning organization with a suitable social position, so that they can benefit from their capabilities and capacities in realizing organizational goals.

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INTRODUCTION

The success and credibility of a company depends on the quality of its human capital, as a result, many organizations make a special investment in retaining their Star Employees (SE), who have high visibility in the foreign labor market (Kehoe and Tzabbar, 2015). SE are people who are widely and consistently recognized as people with desirable and rare characteristics who have exceptional outcomes (Asgari et al., 2021). In terms of loyalty, SE have little loyalty to the organization and more loyalty to the profession. From a performance perspective, they are much more valuable than their low-performing colleagues. As a result, such employees request higher rates from the point of view of economic value during employment negotiations (Morris et al., 2020). Morris and Oldroyd (2017) showed that stars had a higher workload compared to other employees. A higher workload often leads to burnout and increases the likelihood that stars will leave the organization in search of a more attractive dance partner. In fact, researchers have pointed out this deficiency in the literature and called for a more dynamic model for how to manage SE (Morris et al., 2020). SE are creative and innovative people (Li et al., 2020) and in the last decades, large organizations have paid more attention to the topics such as creativity and innovation in organizational level because of changes and evolutions in the increasing competition field and unreliable environmental conditions. (Tajpour et al., 2018). The overall value of the company is realized by a small fraction of elite employees. For example, 80% of company sales are often attributed to 20% of employees. In the field of professional service industries, they carry out a major part of the business and form the main knowledge asset of the organization (Kang et al., 2018). These employees have a wider employment opportunity than their peers (Kang et al., 2018). Also, social science thinkers have understood this situation for a long time that having a suitable position and social prestige can help individuals and organizations to attract resources and development opportunities (Kim and King, 2014). According to the report of McKinsey Consulting Center, the demand of companies to attract human capital has increased to the level of SE (Asgari et al., 2021). What has terrified today's organizations is the inability to attract and retain stars. They are essential in order to achieve the successful performance of

companies. Especially in high-tech industries, stars have a significant impact on innovation. Bell Labs, for example, is the largest and most productive private sector that has brought together technical stars and has 9 Nobel Prize winners, leading global competition. They have developed transistors, lasers, Unix, C Plus Plus, radio astronomy and photovoltaic cells (Asgari et al., 2021). From the perspective of Agrawal et al. (2017), the presence of SE in the organization leads to the improvement of the quality of recruitment and increase in productivity. Zucker and Darby's (2009) research showed that stars scientists have a significant impact on the early stages of new ventures. Looking at technology commercialization from the 1980s to the 1990s, Zucker and Darby (2009) also showed that stars scientists have a direct effect on a number of important investment characteristics, such as: company location, timing of initial public offering, dollar amount raised in initial public offering, and product development (Fuller and Rothaermel, 2012). Maintaining valuable employees is a vital task for organizations so that they can introduce themselves to their audiences as competent and efficient organizations (Bustos, 2022). Stars have a high chance of being hunted due to their high performance and ability to be seen by competitors. For this purpose, companies take various measures to maintain stars (Tzabbar and Baburaj, 2020). The separation of a star from the organization is not only dangerous for the organization's performance, but it can also indicate the star's entry into a rival organization (Aguinis and Oboyle, 2014). The main assumption about Employee Retention (ER) is that the ability to attract and retain employees is necessary to obtain a Competitive Advantage (CA) for organizations. Organizations are disinclined to terminate their employees due to the expenses associated with recruiting and training new staff. Additionally, they acknowledge that the depletion of knowledge and human capital has an adverse impact on productivity. While the costs of leaving the service are high, this cost is often hidden from the managers and they give priority to other technical and managerial issues instead of leaving the service of employees (Parmenter and Barnes, 2021). One of the primary concerns of managers in the past century has been the issue of employee turnover. Rubenstein et al. (2017) found that the cost of replacing employees who leave an organization is more than 200% of annual salaries for recruiting,

hiring, and training employees. In addition, the departure of employees can lead to the alienation of customers (by disrupting the provision of services), reduce performance (the departure of talents from the organization and the entry of technical knowledge to competitors), hinder the diversity of the workforce (the departure of women from the organization) and employees remaining weakened (by increasing the workload of people who left the organization). Finally, employee turnover can inspire others to quit (Lee *et al.*, 2018). The departure of a SE from the organization affects not only the productivity but also the reputation of the organization (Call *et al.*, 2015). According to the above, the importance and necessity of research can be mentioned in the form of the following points: (Fig. 1):

What is raised as a problem in this research is the existence of different definitions and attitudes towards the SE and how to retain a SE who is an expert in his field of expertise and a brand in the relevant industry in the organization. Theoretical and experimental studies show that there is a theoretical vacuum in the field of SE and their retention in organizations, and this research answers the following two questions:

- What are the characteristics of a SE?
- What is the SE retention model?

This research, with a mixed method (qualitative-quantitative), seeks to extract the meaning and concept of SE from the theoretical foundations and viewpoints of organizational experts, and then seeks to design a star retention model from the perspective

of SE.

In this article, at the beginning, the theoretical foundations of the concept of SE and ER techniques have been investigated. In the next step, after the research methodology, based on the data collected from research experts, the definition of the characteristics of SE will be analyzed and examined and their retention model is discussed and finally, the calculated models are presented in the conclusion section.

The concept of SE

Scholarly work on star actors has its roots in the era of the big manufacturing giants after World War II (Whyte, 1956). Whyte main finding was that in static industries, average employees are preferred, while stars are desirable in dynamic environments (MacKinnon, 1966). From that initial study, researchers began to identify other characteristics of stars, such as creativity and credibility. Over the following decades, a narrative emerged that conceptualized stars as rare contributors to the company's success. The productivity of its stars is so exceptional that their output cannot be replaced by other employees. Hunter *et al.* (1990) showed the importance of stars in high-complexity jobs and stated that their productivity is twice that of average workers (Asgari *et al.*, 2021). The star has been defined in different ways in the theoretical literature. Many studies have focused on productivity, as the social aspect that has been identified from stars, other studies tend



Fig. 1: Importance and necessity of research

Tab1: Dimensions of SE

Row	Dimension	Reference
1	Productivity	Hunter <i>et al.</i> (1990)
2	Celebrity status	Hoegele <i>et al.</i> (2014)
3	Performance and external position	Terry (2017)
4	Status and performance	Kehoe <i>et al.</i> (2018)
5	Performance	Chen and Garg (2018)
6	potential, performance and Expertise	Woolley (2019)
7	knowledge, performance and visibility	Tzabbar and Baburaj (2020)
8	Creativity	Li <i>et al.</i> (2020)
9	Performance, Visible, Social capital	Call <i>et al.</i> (2020)
10	Unique, exceptional knowledge, extraordinary performers, visible, social capital	Call <i>et al.</i> (2020)
11	Desirable, rare and exceptional outcomes	Asgari <i>et al.</i> (2021)
12	Performance, visible	Taylor and Bendickson (2021)

to present stars as individuals who possess specific characteristics. Call and his colleagues examined stars from the perspective of three disciplines - economics, sociology and management - and presented a coherent definition, stars are employees with a high and long-term level of: 1. performance 2. Visible 3. Social capital is identified. Terry (2017) emphasized that the difference in performance and external position. SE are referred to as a type of unique human capital that not only have exceptional knowledge, but also influence the performance of the organization. Stars are conceptualized as extraordinary performers, their performance is visible inside and outside the organization, and they also have high social capital. These features make stars stand out from others (Call *et al.*, 2020). The most fundamental consequence of star employees SE is performance. Producing a high level of individual performance is essential in defining stars, and their individual level performance is well visible (Taylor and Bendickson, 2021). SE bring technical resources, with company and industry knowledge, with a high level of performance and visibility in the foreign labor market. For example, the best software developer in Apple is several times more productive than his competitors (Tzabbar and Baburaj, 2020). Li *et al.* (2020) consider creative stars to be those who have shown high creativity compared to colleagues and also have a reputation for Creativity. Creative stars have skills that make them particularly adept at executing and directing creative combination (Liu, Mihm, and Sosa, 2018). Chen and Garg (2018) consider stars as people who have a high individual contribution to their organization and follow the 80-20 rule. Superstars are defined as individuals who

dominate their field through exceptional talent or tremendous popularity. CEOs and other managers can Achieve Celebrity status and their image can act as a “mirror reflecting the reality of corporate actions” (Hoegele *et al.* 2014). This point is important in identifying and defining organizational stars, that star is a continuous category and based on the situation, one person can be more star than another person, or in other words, in comparison, from a higher position than other stars. to have (Aversa and Marino, 2017). According to Woolley (2019), the difference between SE and other employees is their high potential, extraordinary performance and expertise. Based on the above definitions, stars are defined as: “rare and unique human capital that is associated with the characteristics of extraordinary performance, high social capital, visibility, special status and creativity”. The theoretical structures of SE are shown in Table1:

SE theories

Incomplete Contract Theory This theory is intended to explain the management of exchanges that are created with certain investments in such a way that the future consequences cannot be clearly determined at the time of the contract. In HR, if an employee produces knowledge that creates value for the company and is also visible and valued by competitors, that employee is likely to receive alternative job offers. Rather than losing an employee to a competitor, the organization may renegotiate the employee’s salary rather than letting the employee leave the organization. This is the renegotiation of the dance between the SE and the organization. This action increases the potential of economic value creation. By creating the opportunity

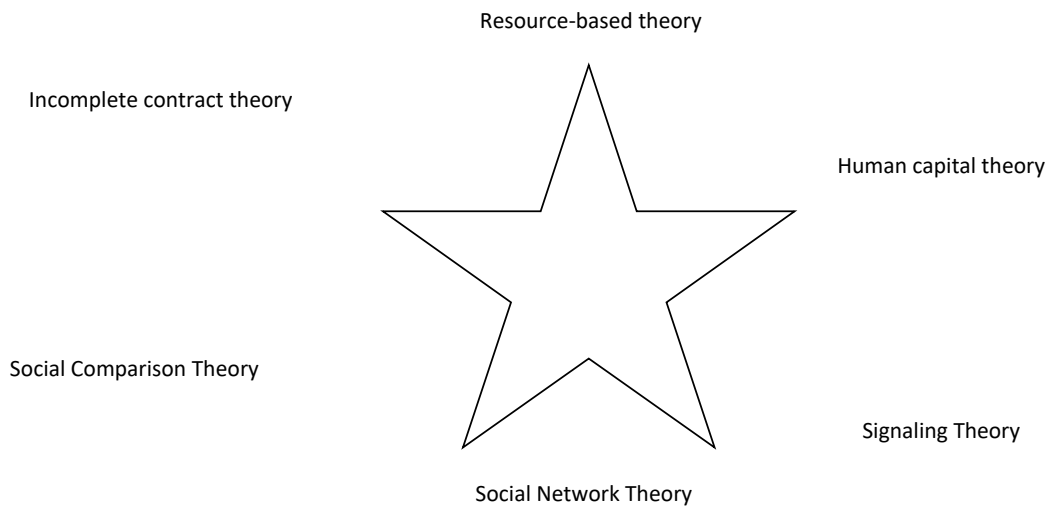


Fig. 2: SE theories

for stars to gain more value and keeping them in the company, the company can gain more value than competitors (Morris *et al.*, 2020). Resource-based theory Firms that possess resources that competitors cannot easily copy or replace such as human capital will outperform firms that lack such valuable resources. Knowledge, skills, abilities and other characteristics that make up the human capital of a company are the most valuable and inimitable resources that an organization can have to achieve a competitive advantage. Human capital theory states that an organization's human resources are a key source of CA because superior talent can contribute transparently to organizational performance. Human capital becomes a more strategic resource while doing work and progressing in a job. People with higher levels of human capital are highly desirable to organizations and are usually difficult to find, recruit, and retain. Individually, a higher level of human capital is associated with higher performance, career advancement, career success, and better compensation. What makes human capital different from other assets is that people cannot be separated from their knowledge, skills and abilities. Researchers consider human capital as a resource at the unit level, which is a set of knowledge, skills and abilities of people within the unit (Terry, 2017). Signaling theory is useful for describing behavior when two parties (individuals or organizations) have access to different information.

This theory has a prominent position in various management texts, including strategic management, entrepreneurship and HRM. From the point of view of Connelly *et al.* (2011), the key constructs of signaling theory include: honesty of the signaler (authenticity and authenticity), reliability (credibility) of the signal, cost of the signal, visibility (intensity, strength, clarity and visibility), appropriateness (value and quality), frequency (timing), consistency, receiver, receiver attention, receiver interpretation (calibration), feedback/environmental cross-signals (feedback), and distortion (Connelly *et al.*, 2011). Theory of social networks, the social capital of stars, enables them to have good access to advanced knowledge, thereby identifying new opportunities and discarding obsolete institutions. The importance of social mechanisms in the production of new knowledge indicates efforts to change the scientific focus from the unique productive capacities of stars to their networking ability. Social capital affects the company's results (Asgari *et al.*, 2021). Social comparison theory was first presented by Festinger (1954), which suggested that people have an innate desire to evaluate themselves and often do this in comparison with others. In this way, the analysis of people themselves in relation to others is done. In this way, people evaluate their skills and progress and compare their performance with other colleagues (Fig. 2).

ER

The traditional thinking was that employees stay in the organization because they are satisfied with their jobs, committed and feel supported by their founder. However, Mitchell and Lee challenged this conventional thinking and pointed out that there are various reasons why employees stay in an organization. Instead of a linear relationship between job satisfaction, organizational support, commitment and retention, they see the life of employees as a network with several internal and external continuums of the organization, which are different in terms of number, strength and connection. The strength of these strands may increase one's longevity and reduce the tendency to disorder. They call this job embeddedness, which consists of three factors: ties, compatibility, and sacrifice (sacrifice). Links can be inside or outside work, formal or informal social, psychological and financial connections. Suitability expresses the perceived compatibility of the employee or his comfort with the values and customs of the institution (internal) and society (external). Sacrifice is defined as what the employee has to lose (financial or non-financial) if he decides to leave the job. Various job-related parameters include (Mitchell *et al.*, 2001): friendships, volunteer activities, seniority benefits, childcare/schooling, career development, family support, tuition payments, affection, childcare facilities, religious associations, retirement benefits, home ownership and other job-related parameters.

Retention strategies

Scott *et al.* (2020) identified retention strategies under the heading of 5Cs that not only improve retention but also combat burnout and disengagement. These five strategies include: socializing and communicating, communication and cooperation, creating learning opportunities, skill (job independence) and celebration.

Retention typology

From the point of view of Reiche (2008), the typology of human resource methods to Retention employees can be distinguished in two axes: first, the time frame in which they can be applied and second, the nature of the work relationship that they exist and can be directed to the control of leaving the service should be more appropriate (Fig. 3).

Morris *et al.* (2020) have proposed the term

dancing with the stars, which means that the cooperation of the organization and the stars is like dancing. There are times when the organization must lead the dance. The organization tries to prevent SE from finding another dance partner by paying them money, and it should also try to benefit from their work value, and both dance partners should benefit from this dancing. In order to better understand the dance between SE and the organization, Morris *et al.*, (2020) state that the process of who receives value and when should be understood. Doing so requires a dance of exchange value between the organization and its employees to achieve stardom. According to researchers, this dance begins when the general and special human capital of the company is developed and value creation for the organization occurs, but in this situation, the ability and marketability of employees also increases. The challenge the organization faces is how to balance and negotiate value capture, because the skills acquired by employees are more valuable to the organization and visible to external competitors (Morris *et al.*, 2020). Boxall (2013) addressed the necessity of Aligning individual interests of employees with organizational interests and presented the dynamic fit model. Collings (2017) pointed out that organizations should see their employees as stakeholders, where the organization not only strives to find employees who align with their vision, but also align their vision with their rapidly changing skills and preferences. Sparrow and Makram (2015) introduced the development of dynamic capabilities and global knowledge to develop a value-based framework for retaining top talent. Bustos (2022) maintaining valuable employees is one of the hard tasks of HRM, and having a positive reputation of the organization is an important factor for these employees to decide to stay or leave the organization. Employees are generally attracted to positions that involve promotion and higher pay. This is true of SE, where stardom requires higher pay, prestige, and status. For example, Campbell and colleagues found that when high performers leave an organization, they are likely to move to positions that provide more value than they create. Because of reputation, organizations with higher status can provide stars with more resources, better colleagues, higher pay, and better prestige and status, and may help them gain access to new, higher-value customers. Therefore, a star is likely to move from a company to get more points. Campbell

	Responsive Practice in relational employment contract	Preventive Practice in relational employment contract
Relational	Job enrichment	Review of candidates' personal attributes/interests
	Job autonomy	Training with general content
	Teamwork	Mentoring programs
	Employee participation/empowerment	Nurturing of a strong corporate culture that stresses interpersonal relationships
	Joint performance evaluations	Distributive and procedural justice
	Firm specificity of training	Seniority-based pay
	Promotions	Career planning and internal labor markets
Employment contract		Attractive working conditions
	Responsive practices in transactional employment contracts	Preventive practices in transactional employment contracts
	Pay / benefits contingent on task and contextual performance	Assessment of candidates' job mobility
	Allocation of office space	Tailoring of jobs to employee skills
	Reduction of role ambiguity/conflict	Realistic job previews
		Timely performance feedback
		Flexible and organic work structures
Transactional		
	Responsive	Preventive

Fig. 3: Typology of ER (Reiche, 2008)

et al. (2012) showed that high performers who leave the organization go to smaller organizations. While the stars are pointing to companies with a higher position than before so that they can capture more value from what they have created, companies with a lower position may be able to have more credibility locally and domestically. They may also allow stars to maximize their bargaining power and tend to give stars a larger share of profits than high-profile companies with multiple stars. They can also give a higher share of decision-making authority to the stars

and increase their status and influence. Bargaining power stemming from star position is therefore likely to be enhanced for stars moving from one firm to another with lower temporality. This argument also expresses the findings of Mohammad and Nathan (2008), who found that stars who go to companies with a lower position will have higher wages, less workload, and more status. Knight (2017) states that in order to manage SE, attention should be paid to various factors, which include: Thinking about their development, giving them work autonomy, not giving

Table 2: Different Techniques of ER

Row	Technique	Reference
1	Friendships, volunteer activities, seniority benefits, childcare/schooling, career development, family support, tuition payments, affection, childcare facilities, religious associations, retirement benefits, home ownership	Mitchell <i>et al.</i> (2001).
2	higher wages, less workload, and more status Job enrichment Job autonomy Teamwork	Mohammad and Nathan (2008)
3	Employee participation/empowerment Joint performance evaluations Firm specificity of training Promotions Pay / benefits contingent on task and contextual performance	Reiche (2008)
4	Allocation of office space Reduction of role ambiguity/conflict Assessment of candidates' job mobility Tailoring of jobs to employee skills	Reiche (2008)
5	Realistic job previews Timely performance feedback Flexible and organic work structures Review of candidates' personal attributes/interests Training with general content Mentoring programs	Reiche (2008)
6	Nurturing of a strong corporate culture that stresses interpersonal relationships Distributive and procedural justice Seniority-based pay Career planning and internal Labor markets Attractive working conditions	Reiche (2008)
7	Better colleagues, higher pay, and better prestige, share of decision-making authority and status	Campbell <i>et al.</i> (2012)
8	Aligning individual interests of employees with organizational interests	Boxall (2013)
9	employees as stakeholders	Collings (2017)
10	Development, work autonomy, enough feedback, fair division of work, paying attention, work networks,	Knight (2017)
11	Development of dynamic capabilities and global knowledge	Morris <i>et al.</i> (2020)
12	Reputation of the organization	Bustos (2022)

too much positive feedback (giving enough feedback), managing the workload of the stars (ensuring a fair division of work), paying attention to the level of group dynamics (stars can be stressful), encouraging stars to create relationships with colleagues (encouraging work networks), don't be selfish (Table 2).

MATERIAL AND METHOD

This study was conducted from a quantitative-qualitative approach to investigate the characteristics of SE and ER techniques in Iran in 2023. In the first

step, the theoretical structures of SE were extracted by conducting a survey on theoretical bases and with a qualitative-content analysis approach. In the second step, the model of SE was validated with the method of structural equation modeling based on the opinions of experts. The participants in this section were 30 senior and middle managers of the Petroleum engineering and development company, which can be seen in Table. 3. In this section, the statistical population was selected by the whole number method. In the third step, organizational

Table 3: Research participants

Research participants		
Organizational position	Senior Managers	10
	chiefs of staff	8
	Project managers	12
Sex	Male	23
	Female	7
Education	Bachelor's degree	13
	Master's degree	12
	PhD	5
work experience	Less than 10 years	2
	Between 10 and 15 years	8
	Between 15 and 20 years	8
	More than 20 years	12

stars were identified based on the opinion of the managers of the Petroleum engineering and development company and based on the SE model. In this step, all employees of the company (183 people) were evaluated from the point of view of the star model, and 8 people were selected as stars with an average score above 90 out of 100. In the fourth step, various ER techniques were extracted from the theoretical bases and confirmed by the fuzzy Delphi method. The participants of this section were 8 SE of the company. The procedure for conducting the research is as described in Fig. 4:

To collect the data, the purposeful sampling method was used with 8 stars through a questionnaire in person, and the validity of the questionnaire was estimated to be 0.69 using the relative content validity method, using the expert opinions, which shows the approval. The questionnaire has validity. Also, the correlation of the answers based on the test-post-test method was achieved at the rate of 0.78, which has brought the reliability of the questionnaire.

RESULTS AND DISCUSSION

In this section, the validation of the developed model of SE has been discussed first. For this purpose, Structural SEM has been used. Fig. 5 shows the output of SmartPLS3 software in standard mode.

The factor loadings of all Constructs and items are larger than 0.5 and significant on their corresponding factors (Tables 4 and 5). As shown in Table 4, Cronbach's alpha and composite reliability of all constructs are larger than 0.7, suggesting that the measurement model has acceptable reliability. Meanwhile, Average Variance Extracted

(AVE) of each construct exceeds the threshold of 0.5, demonstrating acceptable convergent validity. Further, the square root of AVE of each variable is larger than the correlations between the variable and other variables, supporting acceptable discriminant validity by Fornell and Larcker (1981). Finally, the Goodness of Fit Index (GOF) has been calculated as 0.482, which is greater than the criterion value of 0.3 and indicates the appropriate fit of the model.

In the following, using the indicators of the developed model, a checklist was prepared and 8 SE were identified by surveying the statistical population of the first part, i.e. top and middle managers of the oil company. These 8 people formed the statistical community of the second part to present the star Retention model.

Fuzzy Delphi method

Step 1. Collect the fuzzify expert opinions

This process involves converting all linguistic variables into triangular fuzzy numbers. The triangular fuzzy number is represented by a triplet (L, M, U), where "L" represents smallest likely value, "M" the average, and "U" the largest value. Then, the triangular fuzzy number is used to generate a fuzzy scale, which uses a Likert scale to convert the linguistic variables into fuzzy numbers. The number of levels for the fuzzy scale is odd. In this research, all the data have been converted into the form of triangular fuzzy numbers based on a five-point fuzzy scale, as stated in Table 6.

Table 7 shows the opinions collected from SE in the form of a Likert scale.

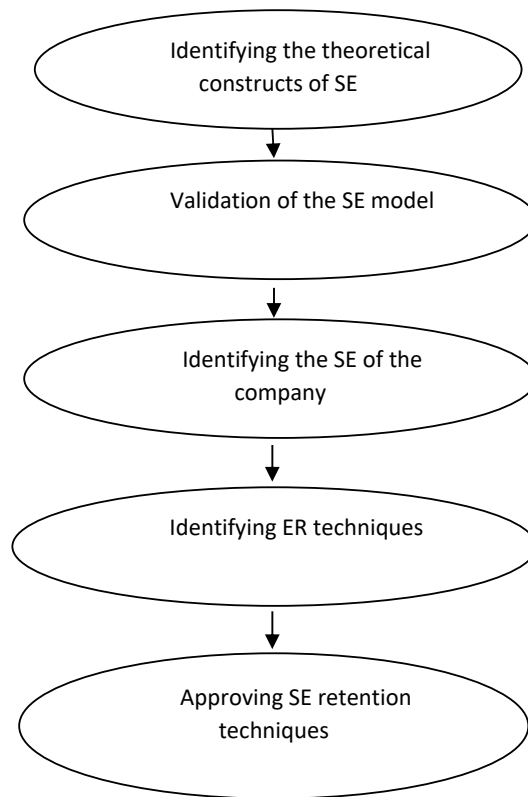


Fig. 4: Search Procedures

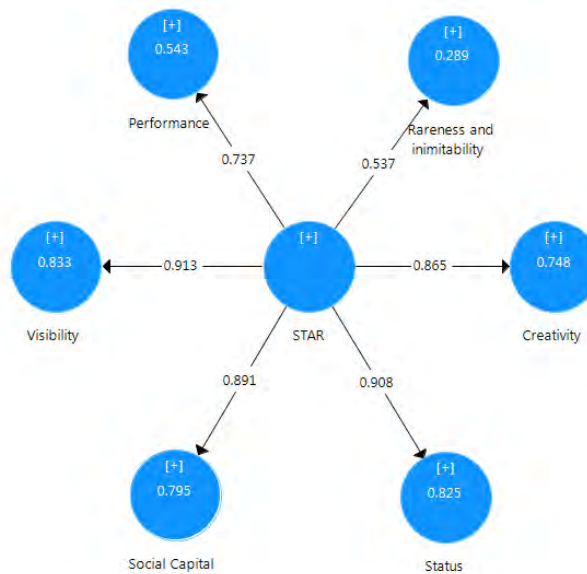


Fig. 5: Model of stars in standard mode

Table 3: Item descriptive statistics

Constructs	Items	loadings	T
Performance	The capacity to develop the team	0.751**	5.199
	Self-directed capacity	0.887**	20.656
	Appropriate scientific capacity and skills	0.951**	48.369
	Successful in achieving the goals of the organization	0.819**	11.839
	The capacity to lead and influence	0.869**	26.487
Visibility	Awarding others about the good job he/she has done in the organization	0.600**	3.252
	Familiar of other employees with one's achievements	0.904**	25.286
	Visibility of person's performance to other organizations	0.915**	37.432
Social Capital	Having a strong professional network	0.970**	103.985
	Talking to the right person when something goes wrong	0.938**	32.409
	Does this person make all the right and proper connections to get the job done	0.939**	32.508
Status	Having a social and respectable position	0.894**	25.119
	having a special position in the organization and work team	0.940**	46.964
	Having a special place and position in his industry and profession	0.921**	24.870
Creativity	Having new and interesting ideas in the organization	0.906**	20.127
	Having breakthrough ideas to solve the organization's problems	0.933**	36.949
	Having ideas that create a competitive advantage	0.923**	30.931
Rareness and inimitability	Having capacities and capabilities that are not easily accessible in the labor market	0.968**	9.343
	Having professional capacities that cannot be imitated easily	0.967**	8.094

Note: *** p < 0.001

Table 4: Reliability and Validity

Constructs	Loadings	AVE	Cronbach's alpha	Composite reliability
Performance	0.865***	0.736	0.909	0.933
Visibility	0.737***	0.671	0.742	0.856
Social Capital	0.537***	0.881	0.955	0.967
Status	0.891***	0.865	0.922	0.951
Creativity	0.908***	0.661	0.723	0.849
Rareness and inimitability	0.913***	0.503	0.711	0.784

Note: *** p < 0.001

Table 5: Fornell-Larcker Criterion for discriminant validity

Constructs	1	2	3	4	5	6
1.Performance	0.858					
2.Visibility	0.550	0.819				
3.Social Capital	0.418	0.809	0.949			
4.Status	0.460	0.833	0.916	0.919		
5.Creativity	0.541	0.734	0.731	0.822	0.921	
6.Rareness and inimitability	0.713	0.400	0.282	0.278	0.280	0.968

Note: Values on the diagonal are square root of AVE

Step 2. Fuzzy aggregation of opinions

In the second step, experts' opinions should be aggregated according to linguistic variables that have been converted into fuzzy numbers. Several

methods have been proposed for fuzzy aggregation of expert opinions. If the opinions of each of the experts are displayed as triangular fuzzy numbers (l, m, u), the simplest way to calculate the fuzzy

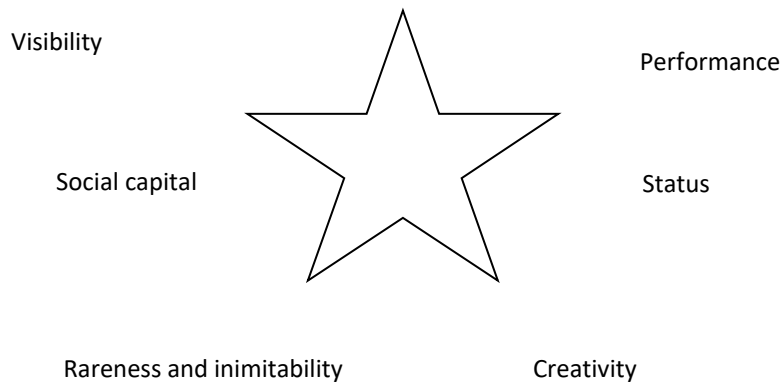


Fig. 6: Organizational star model

Table 6: Seven point of fuzzy scale (Habibi et al., 2015)

Scale	Level of Consensus	Fuzzy Scale
1	Strongly Disagree (SD)	(0.0,0.0,0.25)
2	Disagree(D)	(0.0,0.25,0.5)
3	Moderately Agree (MA)	(0.25,0.5,0.75)
4	Agree(A)	(0.5,0.75,1)
5	Strongly Agree (SA)	(0.75,1,1)

average of the experts' opinions is as Eq. 1:

$$F_{AVE} = \frac{\sum l}{n}, \frac{\sum m}{n}, \frac{\sum u}{n} \quad (1)$$

The data analysis is based on calculations on triangular fuzzy numbers, with the aim of comparing with the threshold value (d). To get expert agreement, the condition that must be met is that d is greater than or equal to 0.7, otherwise, the second round must be implemented (Habibia et al., 2015). However, in this study, the second round was not conducted due to unsatisfactory evaluation results. The data obtained on a Likert scale were calculated using Microsoft Excel and presented in Table 8.

As stated, organizational Star Retention Model can be present in Fig. 7:

CONCLUSION

SE are individual who have a significant contribution to the performance and success of the organization and are easily identified and hunted by competing organizations. Today, one of the main concerns of human resources managers is identifying

and Retentions SE in the organization. The purpose of this research is to identify the characteristics of SE and design a model for their retention in the organization. This research, with a mixed method, first with a qualitative method, sought to identify the characteristics of SE, and then with a quantitative method, it was used to identify the techniques that Retention SE in the organization. The results showed that Star employees have six characteristics: performance, visibility, Status, Social capital, creativity and Rareness and inimitability. Also, the results showed that the techniques of Retention SE can be classified according to two-time dimensions (short-long time) and focus (Individual-organization). In the short-term time dimension and focusing on Individual, organizational stars are considered on the parameters of reaching a better organizational position, paying attention to individual interests, receiving feedback about the way of functioning and granting work independence to do the work. In the long-term time dimension and focusing on Individual, organizational stars are considered on the parameters of organizational promotion, existence of career development, creation of learning

Table 7: Gathering experts' opinions with five-point Likert scale

Index	Star1	Star2	Star3	Star4	Star5	Star6	Star7	Star8
C1	D	A	A	A	D	A	SA	A
C2	D	SA	SA	MA	MA	A	A	A
C3	MA	A	SA	SA	MA	MA	D	MA
C4	MA	A	SA	A	D	MA	D	MA
C5	MA	A	SA	A	MA	SA	D	A
C6	A	A	SA	SA	MA	MA	D	MA
C7	A	MA	MA	MA	MA	A	A	A
8	A	SA	A	SA	A	A	SA	A
9	5	SA	MA	SA	SA	D	D	D
10	A	A	MA	MA	MA	A	A	A
11	MA	A	A	A	A	SA	A	A
12	A	A	A	SA	A	A	A	A
13	MA	MA	A	A	SA	MA	MA	A
14	MA	MA	SA	A	A	MA	MA	MA
15	MA	MA	SA	MA	MA	A	A	A
16	SA	MA	SA	A	A	MA	A	A
17	SA	A	SA		A	SA	A	SA
18	A	A	SA	D	MA	A	A	MA
19	A	A	SA	D	MA	SA	A	MA
20	A	A	SA	D	MA	SA	SA	MA
21	MA	SA	A	SD	SA	A	SA	A
22	MA	SA	A	SA	SA	SA	SA	A
23	MA	MA	SA	A	A	MA	MA	MA
24	D	SA	A	SA	SA	SA	SA	MA
25	A	A	A	D	MA	MA	MA	SA
26	D	A	MA	A	SA	MA	MA	MA
27	MA	A	A	A	A	SA	MA	MA
28	MA	MA	A	MA	A	SA	A	MA
29	A	MA	SA	MA	SA	SA	A	MA
30	SA	SD	SA	SD	SA	A	A	SA
31	SA	D	SA	D	SA	SA	A	SA
32	A	D	SA	MA	SA	A	MA	A
33	A	MA	A	MA	MA	MA	MA	SA
34	A	A	A	D	MA	MA	MA	SA
35	A	SA	A	SD	MA	MA	MA	SA
36		A	SA	D	MA	MA	MA	SA
37	A	A	SA	MA	MA	MA	MA	A
38	MA	A	SA	A	MA	MA	MA	A
39	A	SA	A	A	MA	MA	MA	A
40	MA	SA	A	A	A	A	A	A
41	MA	MA	MA	MA	SA	SA	A	SA
42	MA	MA	MA	MA	SA	SA	A	A
43	A	MA	MA	A	A	MA	MA	A
44	A	D	SA	A	SA	SA	A	A
45	A	MA	SA	D	SA	SA	SA	A
46	A	A	MA	A	SA	SA	D	MA
47	A	SA	A	SD	MA	MA	MA	SA
48	SA	A	MA	MA	A	A	MA	A
49	SA	A	A	A	A	MA	MA	MA
50	MA	MA	A	A	A	MA	MA	MA
51	D	MA	A	A	SA	SA	SA	SA
52	SD	MA	SA	MA	SA	SA	A	A
53	D	A	A	SA	A	A	A	A
54	D	SA	MA	A	SA	SA	SA	A

Table 8: Defuzzification results of aggregated experts' values

Index	Opinion's mean			Crisp value	Result
	<i>I</i>	<i>M</i>	<i>U</i>		
C1	0.406	0.656	0.875	0.646	Rejected
C2	0.438	0.688	0.938	0.688	Rejected
C3	0.375	0.625	0.938	0.646	Rejected
C4	0.313	0.563	0.875	0.583	Rejected
C5	0.438	0.688	0.938	0.688	Rejected
C6	0.375	0.625	0.938	0.646	Rejected
C7	0.375	0.625	1.000	0.667	Rejected
8	0.594	0.844	1.000	0.813	Accepted
9	0.406	0.656	0.813	0.625	Rejected
10	0.406	0.656	1.000	0.687	Rejected
11	0.500	0.750	1.000	0.750	Accepted
12	0.531	0.781	1.000	0.771	Accepted
13	0.406	0.656	1.000	0.687	Rejected
14	0.375	0.625	1.000	0.667	Rejected
15	0.406	0.656	1.000	0.687	Rejected
16	0.500	0.750	1.000	0.750	Accepted
17	0.643	0.893	1.000	0.845	Accepted
18	0.406	0.656	0.875	0.646	Rejected
19	0.438	0.688	0.875	0.667	Rejected
20	0.469	0.719	0.875	0.688	Rejected
21	0.500	0.719	0.906	0.708	Accepted
22	0.625	0.875	1.000	0.833	Accepted
23	0.375	0.625	1.000	0.667	Rejected
24	0.563	0.813	0.938	0.771	Accepted
25	0.375	0.625	0.750	0.583	Rejected
26	0.344	0.594	0.938	0.625	Rejected
27	0.406	0.656	1.000	0.688	Rejected
28	0.438	0.688	1.000	0.708	Accepted
29	0.500	0.750	1.000	0.750	Accepted
30	0.500	0.688	0.813	0.667	Rejected
31	0.531	0.781	0.875	0.729	Accepted
32	0.438	0.688	0.938	0.688	Rejected
33	0.375	0.625	0.813	0.604	Rejected
34	0.375	0.625	0.750	0.583	Rejected
35	0.406	0.625	0.719	0.583	Rejected
36	0.375	0.625	0.750	0.583	Rejected
37	0.406	0.656	0.813	0.625	Rejected
38	0.406	0.656	0.813	0.625	Rejected
39	0.438	0.688	0.813	0.646	Rejected
40	0.500	0.750	1.000	0.750	Accepted
41	0.469	0.719	0.906	0.698	Rejected
42	0.438	0.688	0.906	0.677	Rejected
43	0.375	0.625	0.938	0.646	Rejected
44	0.469	0.719	0.875	0.688	Rejected
45	0.469	0.719	0.875	0.688	Rejected
46	0.406	0.656	0.906	0.656	Rejected
47	0.406	0.625	0.719	0.583	Rejected
48	0.438	0.688	1.000	0.708	Accepted
49	0.438	0.688	0.906	0.677	Rejected
50	0.344	0.594	0.906	0.615	Rejected
51	0.531	0.781	0.938	0.750	Accepted
52	0.469	0.688	0.906	0.688	Rejected
53	0.531	0.781	1.000	0.771	Accepted
54	0.594	0.844	1.000	0.813	Accepted

		Time Dimension	
		Long term	Short term
Focus Dimension	Individual	Promotion Career development Learning opportunities Empowerment	Better position Attention to individual interest's Timely performance feedback Job autonomy
	Organizational	Reduction of administrative bureaucracy Organizational reputation Social prestige Dynamic and flexible work structure	Space for creativity and innovation Merit and competency of leaders Satisfaction with goals and plans Meritocracy

Fig. 7: Organizational Star Retention Model

opportunities and empowerment. In the short-term dimension and focusing on the organization, the organizational stars have emphasized on the parameters of the atmosphere of creativity and innovation, worthiness and competence of leaders, satisfaction with organizational goals and plans, and meritocracy. In the long-term time dimension and focusing on the organization, organizational stars have emphasized on the parameters of administrative bureaucracy reduction, organizational reputation, social prestige and dynamic and flexible work structure. The investigations of this research show that an organization can be successful in retaining SE, if from a job perspective, the job is enriched and has desirable job characteristics, from the organizational perspective, it has a brand and a professional position, from the Environment perspective A dynamic and creative organization should be agile and flexible in perspective of organizational structure. The significance and usefulness of this study is the investigation of various theoretical foundations in the field of SE and the achievement of the characteristics of SE and the design of their retention model in the organization. Considering the importance and influence of these people in the organization, knowing the techniques of retention them in the organization is effective on organizational success and gaining competitive advantage.

Suggestion and limitations

- The organizational star's retention model has been carried out in the Petroleum industry, to understand it more deeply, it can be examined in other organizations and industries as well.
- This research has identified the organizational star's retention model, other subsystems of HRM can also be studied.
- The results of the research showed that the needs of Star employees SE are at the high levels of Maslow's needs, and in order to maintain and sustain them, these needs should be considered.
- The results of the research showed that the design of the jobs of the organizational stars should be in such a way that it is accompanied by the characteristics of matching with individual interests, providing continuous feedback, delegation of authority, career development and growth and promotion, and learning opportunities.
- The results of the research showed that a work structure suitable for organizational stars is a dynamic, flexible and agile structure so that employees have freedom of action and decision-making power.
- The results of the research showed that according to the characteristics of SE, the atmosphere of creativity, initiative, having appropriate goals and plans can be effective in realizing their optimal performance.

AUTHOR CONTRIBUTIONS

M. Alizadeh examined the theoretical foundations and methodology, S. Ramzanzadeh analyzed the research data, and modeling and conclusions were made in a combined manner.

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CONFLICT OF INTEREST

The authors of this article do not declare any conflict of interest with the publication of this article. Various ethical issues such as plagiarism, fabrication, data forgery, informed consent, duplication, submission and redundancy have been controlled.

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ABBREVIATIONS

AVE	average variance extracted
CA	Competitive Advantage
ER	Employee Retention

GOF	goodness of fit index
HRM	Human Resource Management
SE	Star Employee

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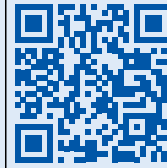


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