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



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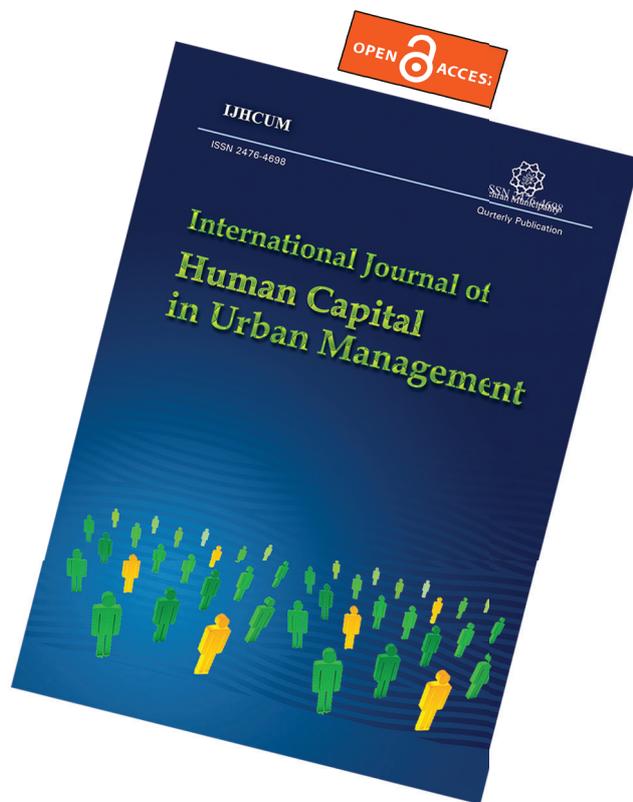
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ORIGINAL RESEARCH PAPER

Hydrogen wear of metal friction elements of vehicle brakes for urban infrastructure facilities

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ABSTRACT

BACKGROUND AND OBJECTIVES: In urban conditions, traffic flows are equipped with various types of braking devices operating in an aperiodic cyclic braking mode with a high surface-volume temperature of their friction pairs. Theoretical and experimental studies of hydrogen wear of movable and stationary joints at variable electrical surface-volume temperatures and equivalent stresses caused by pulsed specific loads, contributing to the emergence of gradients, made it possible to establish the following: positive and negative values of the heat of transfer correspond to forces directed, towards more cold or warmer parts of the product. Hydrogen moves in the metal friction element to its more heated section. Due to the mutual mass transfer of materials of friction pairs, the sign of their polarity changes, and negatively charged external hydrogen enhances the negative electronic field of the metal friction element, and as a result, leads to intensive wear of pairs of friction elements of the brakes. The purpose of the article is to assess the electron-ion interaction during hydrogen wear on the working surfaces of metal friction elements of friction pairs of brake devices.

METHODS: The data was obtained on a model disc, drum, and band-shoe brake and processed using a computer program package. As a result, graphical dependences of the main parameters of the brakes on the duration of hydrogenation were obtained.

FINDINGS: The research results have shown that the described main stages of hydrogen wear and destruction of a metal friction element during electrothermal-mechanical friction, as well as the influence of dislocation and double electrical layers in brake friction pairs, will be able to justify the choice of ways and methods to suppress hydrogenation and prevent the destruction of surfaces and, as a result, reduce hydrogen wear by 15% and improve the performance parameters of brake pairs by 10%.

CONCLUSION: This study examined the factors affecting the wear of metal brake friction elements of urban infrastructure vehicles. Empirical results have shown that positive and negative heat transfer values correspond to forces directed, towards colder or warmer parts of the product. These results can provide important information to factory designers for more efficient development of friction pairs of friction units, and researchers for further research and improvement of brake performance.

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INTRODUCTION

One of the intense types of hydrogen wear of the rubbing surfaces of parts is accompanied by the destruction of the harder surface layer of a steel or cast-iron part and the transfer of wear products to a softer mating surface. The main factor influencing the hydrogen wear of metal friction elements of brakes of urban infrastructure vehicles is the dynamic coefficient of mutual overlap of their friction pairs. In drum and shoe brakes it reaches 0.7 - 0.75, and in disc and shoe brakes it is 0.15 - 0.25. Disc-pad brakes are made with one solid disc or two self-ventilated discs, between which cooling elements are located. The friction pairs of the braking devices were FK-24 materials – steel 35KHNL. Most friction pairs of brake devices operate in a hydrogen-containing environment, which, when contacted with their heated surfaces, contributes to the formation of hydrogen (Babenko, 2019; 2020). The interaction of released hydrogen with the surface layer of brake discs, drums, and pulleys causes embrittlement of their materials and, as a result, intense wear (Hrabovskyi et al., 2020). The mechanism of hydrogen wear by destruction during dislocation and double electrical layers in brake friction pairs is not clear enough, which makes it difficult to make a reasonable choice of ways and methods to suppress hydrogenation and prevent the destruction of surfaces. An analysis and synthesis of thermoelectric processes characterizing the electro-thermomechanical friction interactions of friction pairs of braking devices is given (Gontareva et al., 2020). The top layer of the polymer lining is isolated at temperatures higher than permissible for its material when the cracking process begins (Dzhanakhmedov et al., 2020). Thermokinetic models of the interaction of a metal friction element during its operation in various media are considered. The influence of surface and volume temperatures, specific loads, the coefficient of mutual overlap of friction pairs, the relationship between the number of reagents, the presence of inert gases, and the type of reactions on the rate of chemical reactions during the cracking process in the upper layer of polymer linings of friction units of brake devices has been established. It is shown that when assessing the equilibrium of a chemical reaction, it is necessary to take into account the change in the Gibbs energy (Ramkumar et al., 2024). It was noted that there is an intense release of hydrogen during electrothermomechanical friction

as a result of tribodestruction of water-containing polymer linings in brake friction pairs, creating a source of continuous supply of hydrogen into the surface layer of steel or cast-iron metal friction elements (Dzhanakhmedov et al., 2020). It has been established that under severe conditions of frictional interaction of the friction pairs of the band-shoe brake of a drill drawworks, the maximum surface-volume temperature is formed at a certain depth of the pulley rim (Kindrachuk et al., 2017, Kindrachuk et al., 2023). This creates conditions under which hydrogen, if it is adsorbed on the surface of the part, under the influence of a temperature gradient, diffuses deep into the surface, concentrates there, and increases wear (Liu et al., 2004, Zhang et al., 2019). The energy conditions for the occurrence of hydrogenation of the surface layer of metal friction elements were not taken into account (Duryagina, 2009). The influence of hydrogen on various properties of metals and alloys and the occurrence of specific defects in them is illustrated. Information about hydrogen brittleness and the influence of hydrogen on mechanical characteristics in the hydrogen-metal pair in groups of D. Mendeleev's periodic table has been expanded (Dzhanakhmedov et al., 2021). The work is devoted to the wear of sub-roughness of friction surfaces in a hydrogen-containing environment. In the latter, hydrogen pumped into the subsurface layer of a metal body interacts with its crystal lattice (Dzhanakhmedov et al., 2021). It is noted that the driving forces in hydrogen wear processes are temperature, pressure, deformation, structure, and crystal lattice defects (Kindrachuk et al., 2021, Kindrachuk et al., 2019, Kindrachuk et al., 2018). Physical and mechanical processes on the friction surface of hydrogen wear of machine parts and equipment were studied. The reasons for the release of hydrogen, hydrogenation of rubbing surfaces, and their destruction have been established (Volchenko et al., 2021). A complex picture of the behavior of hydrogen in surface layers during friction under the influence of various factors is shown, and the influence of "biographical" hydrogen on the wear of parts is determined. The reasons for the transfer of a harder material to a soft material during friction are outlined: steel to bronze, cast iron to plastic. Practical recommendations are given for suppressing hydrogen wear and increasing the durability and reliability of friction units of machines and equipment (Volchenko et al., 2020). At the same

time, the following was not considered: the effect of external hydrogen on the surface layer of the metal friction element and its entry into the subsurface layer by injection; the phenomenon of adhesion and the types of contacts of friction pairs during their frictional interaction were not taken into account, as well as the combination of adsorption - diffusion phenomena observed in the surface and subsurface layers of friction pairs (Fidrovskaya *et al.*, 2021, Kamarposhti *et al.*, 2024). And the most important thing is that there was no approach to external and internal hydrogen and their role in tribological reactions. It was established that under severe friction conditions, the maximum temperature is formed at a certain depth from the friction surfaces (Kindrachuk *et al.*, 2019, Fidrovskaya *et al.*, 2021). This creates conditions under which hydrogen if it is adsorbed on the surface of the part, under the influence of a temperature gradient, diffuses deep into the surface, concentrates there, causes embrittlement of the surface layers and increases wear. It was not specified what happens in the subsurface layer of the metal element with the structures of its crystal lattices (Volchenko *et al.*, 2019). It was noted that dislocations, vacancies, and grain boundaries have different binding energies and the binding energy of hydrogen affects the type of defect into which hydrogen is directed. At concentrations of 100 ppm and above, hydrogen begins to affect the electrical, chemical, and magnetic properties of materials (Buketov *et al.*, 2023). The purpose of the work is to evaluate the electron-ion interaction during hydrogen wear of the working surfaces of metal friction elements of friction pairs of brake devices. The latest research was carried out at a bench in laboratory conditions in Ivano-Frankivsk city, Ukraine in 2022. The scientific hypothesis is to establish a relationship between the operational parameters of brake friction pairs and the variable state of materials in their surface and subsurface layers.

MATERIALS AND METHODS

The essence of hydrogen wear of metal friction elements of brake devices

Hydrogen wear occurs as a result of cooperative (synergistic) interaction of surface phenomena and effects, exo-emission. Adsorption and tribodestruction of the surface layers of polymer pads, lead to the release of hydrogen. Together

with nonequilibrium processes occurring during the deformation of the surface layer of the metal, alternating electrical and thermal gradients are created in magnetic and equivalent voltage fields. This leads to the diffusion of hydrogen into the metal, its concentration in the subsurface layer, and accelerated wear or destruction of this layer. On the surface, during friction, isoelectronic emission occurs, supplying electrons that can solvate on water molecules and decompose them into oxygen and hydrogen. Hydrogen may be released as a result of secondary reactions of tribodestruction of hydrocarbons (for example, polymer pads). Inside the surface layer, a pumping system (in the form of micro bellows) of hydrogen takes place to a super-equilibrium concentration under the influence of the mentioned gradients that arise during deformation. The massive formation of defects in the deformed layer also increases the concentration of hydrogen, its destruction of the metal (fretting). The stages of hydrogen wear are given in Table 1.

Depending on the nature of the external influence, one or another relationship arises between the two forms of the state of hydrogen:

- in the first case of corrosion (fretting corrosion), a gradual, irreversible transition of hydrogen dissolved in an equilibrium concentration into a segregated (molecular) form occurs;

- in the second case, when a mechanical effect occurs on the structure, hydrogen, under the influence of a gradient of equivalent stresses, is concentrated in the zone of its maximum values, where it transforms into a molecular form and causes destruction;

- in the third case, when there is friction and gradients of surface-volume temperatures, equivalent stresses, electric and magnetic fields appear on the surface, a super-equilibrium concentration of hydrogen is formed in the surface layer, released (during friction) from the adsorbed water of the plastic. The transition from a super-equilibrium concentration in a dissolved state under deformation conditions to a molecular form can occur almost instantly due to the dynamics of defect formation (Dzhanakhmedov *et al.*, 2014).

The hydrogen atom is magnetic, and the proton is electrically charged, which determines the connection between electrical phenomena during friction and the accumulation and migration of hydrogen under the influence of electric and magnetic fields.

Hydrogen wear of brake elements

Table 1: Stages of hydrogen wear in brake friction pairs

Stages	Processes in the contact zone during hydrogen wear	Reasons causing the process
1	Intensive release of hydrogen in the friction zone from moisture and non-metallic material of the rubbing pair.	Friction caused a tribochemical reaction
2	Desorption of moisture from the surface of a metal part.	Friction increases the surface temperature
3	Adsorption of hydrogen by the surface of a metal friction element.	Friction created the conditions for adsorption
4	Formation of double electrical layers in friction pairs.	To create an electric current gradient
5	Diffusion of hydrogen into the surface layers of metal elements of a rubbing pair, the speed of which is determined by temperature and stress gradients.	The friction created gradients of surface-volume temperature and equivalent stresses
6	Hydrogen concentration at a certain depth from the friction surface in the maximum temperature zone.	The friction created a temperature gradient below the surface
7	a) Low-temperature brittle destruction of the surface layer of metal elements of rubbing pairs, saturated with hydrogen, as a result of the formation of a large number of cracks with different energy levels in the contact zone. b) High-temperature vicious destruction of the rubbing metal in the form of spreading onto the counter body as a result of liquefaction of the surface layer.	Mobilization of hydrogen from friction Supersaturation of steel with hydrogen at heating temperature fluctuations of the order of 800...1000°C

Table 2: The chemical composition of materials steel 35HNL

Chemical element	Percentage content, %
Silicon (Si)	0,20 - 0,42
Copper (Cu), not more	0,30
Manganese (Mn)	0,40 - 0,90
Nickel (Ni)	0,70 - 0,90
Phosphorus (P), not more	0,047
Chrome (Cr)	0,50 - 0,80
Sulfur (S), not more	0,04

Transfer processes are caused by forces acting on the implanted hydrogen atoms. The force of electrical transfer occurs in the presence of electric current and is phenomenologically determined by the effective charge Z' , which is determined by Eq. 1 (Kindrachuk *et al.*, 2023):

$$F = -e Z' \text{grad} \phi, \quad (1)$$

where e - elementary, positive charge; $\text{grad} \phi$ - applied electric field causing electric current.

The value $e Z'$ characterizes the electric charge, which, in the presence of an external field, would be subject to the same forces as a hydrogen atom embedded in the metal. According to this definition, a positive or negative effective charge indicates that the effective force, which is determined by Eq. 2, is directed toward the cathode or anode. Analogue of electric transport. the heat transfer force occurs

in the presence of a surface-volume temperature gradient - degrees T; it is determined by the transfer heat Q' (Volchenko *et al.*, 2023):

$$F = Q' \text{grad} T / T. \quad (2)$$

Positive and negative values of heat transfer correspond to forces directed, towards colder or warmer parts of the product. Hydrogen moves in the metal friction element to its more heated section. The chemical composition of the material steel 35 KhNL is given in Table 2.

This is the basis for the process of dehydration of products, for example, chrome-plated aircraft power bolts. They are heated in a thermal oven to temperatures of 200°C, and sometimes to higher temperatures - 350...400°C and held for 20 minutes. In the case of simultaneous action of the electric field of the surface-volume temperature gradient on

Table 3: Chemical composition of lining materials

Friction pad	Content of elements, %								
	C _{free}	S	Al	Cu	Fe	Si	Zn	Pb	Ni
G	16,40	3,70	3,33	7,66	3,69	0,64	2,78	3,10	0,260
B	24,20	2,95	3,95	3,34	14,90	1,08	2,23	0,08	0,020
C	18,10	-	0,84	11,80	27,40	-	3,28	0,13	-
A	22,70	-	1,97	5,84	14,30	1,12	3,67	0,16	0,023
H	19,60	-	0,24	5,13	19,50	0,34	1,10	0,01	0,004
D	19,10	-	0,13	11,77	35,20	0,29	3,52	0,05	0,008
J	22,30	-	0,31	0,23	30,90	0,21	0,07	2,08	0,001
K	-	-	0,50	9,50	32,70	0,28	2,68	2,40	-
L	-	-	0,36	10,50	34,00	0,29	2,97	2,66	-
E	19,4	19,4	0,67	8,23	19,4	0,11	2,41	0,09	0,01
F	19,0	19,0	0,82	9,85	19,6	0,24	3,56	0,16	0,05

Friction pad	Content of elements, %								
	Ti	Sb	Ba	Ca	K	Mn	Mg	Na	Sr
G	-	-	-	-	-	-	-	-	-
B	-	-	-	-	-	-	-	-	-
C	0,140	-	-	-	-	-	-	-	-
A	0,140	-	-	-	-	-	-	-	-
H	0,060	-	-	-	-	-	-	-	-
D	0,020	-	-	-	-	-	-	-	-
J	0,060	-	-	-	-	-	-	-	-
K	0,040	4,50	0,84	-	-	-	-	-	-
L	0,040	4,90	0,58	-	-	-	-	-	-
E	0,002	-	2,88	2,88	0,04	0,13	0,10	0,05	0,02
F	0,080	-	2,87	0,36	0,21	0,17	0,30	0,05	0,03

hydrogen atoms, a linear superposition of forces takes place. It follows that electrical, thermal, magnetic, and vibration phenomena during friction affect the wear of the surface layer as forces that control the movement and concentration of hydrogen. The opposite direction of electrical transfer and heat transfer will reduce wear, while the joint action in one direction will increase it on the hydrodonor and hydroacceptor subsystems. Hydrodonor consists of providing exoelectrons to water or hydrocarbon molecules adsorbed on the surface which, when decomposing, release hydrogen. The hydro acceptor subsystem consists of the absorption of released hydrogen by the surface layer as a result of the emergence in this layer of an internal source of heat and electrical potential during its deformation (Kindrachuk *et al.*, 2023). The chemical composition of lining materials is given in Table 3.

To heat and electricity, equivalent stresses arise in this zone, and an increase in the number of defects that can serve as microbellows for hydrogen occurs, which causes irreversibility and creates a super-non-equilibrium concentration. Depending on some reasons, for example, on the nature of loading, tribodestruction, and adsorption of certain or other substances, the design of the friction unit, and the degree of hydrogenation can vary significantly. Following this degree, there will be a transition from delayed destruction of the surface layer to brittle instantaneous destruction. The area of manifestation of hydrogen wear is extensive. Almost all rubbing surfaces of steel and cast-iron parts contain an increased amount of hydrogen and have increased wear. The presence of water vapor in the air creates favorable conditions for hydrogen wear, not to mention decomposition in the contact zone of the

friction material of the lining.

Dislocations and double electrical layers in friction pairs of braking devices

In real ionic crystals, potential charge carriers can be any irregularities, such as edges, steps on the surface, or intersections of dislocations. Charged dislocations are considered a significant reason for the appearance of charges during plastic deformation even without any contact with tribological interfaces during electrothermomechanical friction. During plastic deformation with increasing dislocation density, some dislocations are squeezed out of the slip plane. Dislocations of opposite signs annihilate (destroy) when they meet. The dislocation density decreases. At the same time, microcracks form, which destroy the crystal, which determines the amount of plastic deformation. During the operation of the part, periodic repeated processes of formation and destruction of this layer occur. Edge dislocations in metals with a lattice type formed during plastic deformation have a Burgers vector $a_0/2$ (Volchenko et al., 2023; Kindrachuk et al., 2023). Sliding occurs along the plane (Fig. 1 (a,b)). Fig. 1(a) shows a dislocation line in the crystal that limits the plane. Hydrogen ions of different signs alternate on an ideal dislocation line so that no excess charge exists. If there are kinks on the dislocation line, like this shown in Fig. 1(b),

then excess charges appear, positive or negative. If the dislocation as a whole must be charged, then there must be kinks on the dislocation line with ions predominantly of one sign. This is the case when the energies of the formation of cationic and anionic dislocations are different. Dislocations collect vacancies on their way through the crystal and carry them to the surface. The nature and concentration of impurities in the crystal, as well as their local distribution, are very important for the formation of charged regions. The formation of positively and negatively charged regions on the surface of a crack can be associated with an irregular distribution of impurities in the crystal due to the conditions of its growth.

One should take into account the possibility of local accumulation of charges due to their mechanical separation and the formation of an electrical double layer with an electrothermodynamic potential. The presence of anion and cation vacancies migrating from the surface into the crystal leads to the formation of a dipole layer near the surface and near screw dislocations due to differences in the formation energy and exchange energy. As for the magnetic field lines near the circular current (Fig. 2(a)) and the magnetic dipole (Fig. 2(b)), the fields are the same at large distances. In Fig. 3 shows the power of thermal saturation of the metal surface layer with hydrogen at

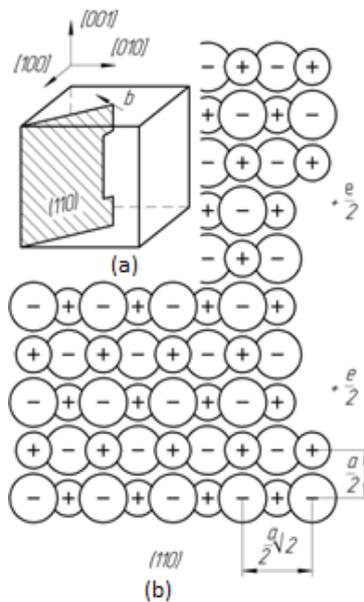


Fig. 1(a,b): Geometry of a charged edge dislocation: lattice constant (a); elementary charge (b)

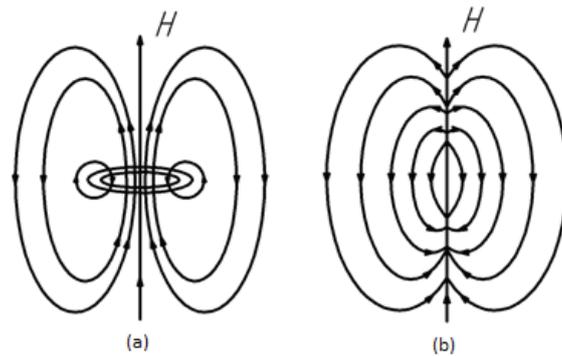


Fig. 2(a,b): Magnetic field lines near a circular current (a) and a magnetic dipole (b)

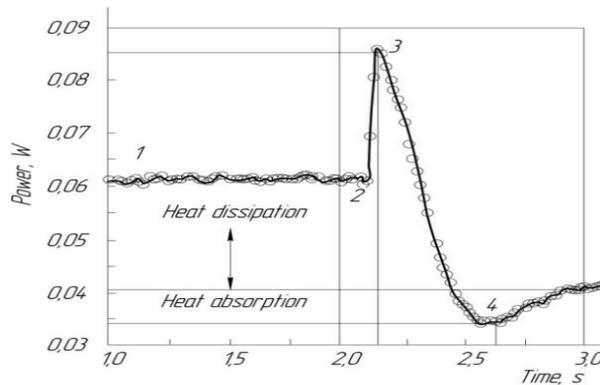


Fig. 3: Regularity of thermal saturation of the surface metal layer with hydrogen at $p = 1,2$ MPa

$p = 1,2$ MPa versus time.

Straight line 1-2 for a time of 2.1 s characterizes the power equilibrium of the surface layer at $P = 0,061$ W. The micro-explosion lasts 0.05 s with a power of 0.086 W. After which, throughout 0,5 s, the power dropped to 0,034 W. It should be emphasized that explosive processes can cover part of the film or be repeated if, after the first explosion, the formation of the film continues, which makes it difficult to carry out spontaneous explosive processes. The processes of formation and changes in the structure of condensates at high surface-volume temperatures, as well as the size of the particles involved in the process, are of decisive importance for specific chemical mechanisms forming films. Processes can be initiated by cracks after reaching the ultimate strength. In high-temperature reactions, physical and chemical processes are closely intertwined. It has been established that adsorption layers are

responsible for the formation of uncompensated charges, due to which polar molecules or charged particles accumulate on the surface, compensating the internal charges. The movement of charges may be due to differences in contact potentials that arise inside the oxide films and lead to high field strengths due to the small distances.

Mechanical separation is achieved by lifting adhesive films from metal surfaces

There is usually an excess positive charge on the fresh surface of a crack. In the temperature range of 110 – 425 K, the maximum charge density does not depend on the temperature of the crystal. The size of uniformly charged regions reaches several millimeters. There is no correlation between the accumulation of charges on the mirror-like surfaces of the crack. Based on the above, a structural diagram of double electrical layers has been drawn up, creating

Hydrogen wear of brake elements

an electrothermodynamic potential in the surface and near-surface layers with ionized hydrogen in friction pairs of a belt (a) and drum (b) shoe brake (Table 4). During hydrogen wear by dispersion, no scuffing, tearing, or noticeable transfer of material from one friction surface to another is observed on the friction surfaces. The friction surfaces may have shine and very small scratches, marks that are not visible to the naked eye and are directed in the direction of sliding. Atomic hydrogen, depending on its amount in the surface layer, enhances the dispersion of the metal. It has been established that with slight hydrogenation, the wear resistance of steel 45 samples increases slightly, and with further

hydrogenation, it decreases. This is explained by the fact that with slight hydrogenation the hardness of steel increases slightly.

Fig. 4 shows the dependence of the change in the relative microhardness of steel 45 on the duration of hydrogenation. As can be seen from the figure, the microhardness increases during the first two hours of hydrogenation, and then decreases and becomes less than the initial one at the sixth stage of testing. This indicates that when the steel surface is saturated with hydrogen, the layer loosens and, as a consequence, its wear resistance decreases. Fig. 5 shows the dependence of the amount of absorbed hydrogen and the wear rate on the duration of hydrogenation.

Table 4: Structural diagram of double electrical layers with ionized hydrogen in friction pairs of a belt (a) and drum (b) - shoe brake

Name of working elements of friction pairs and their charge	Hydrogen ionization			
	H ⁻	H ⁺	H [±]	
The working surface of the pad	+	-	+	+ -
The outer working surface of the metal layer	-	-	+	+ -
The inner working surface of the metal layer	-	-	+	+ -
The outer surface of the subsurface metal layer	-	-	+	+ -
The inner surface of the subsurface metal layer	-	-	+	+ -
The remaining volume of the body of the metal friction element with hydrogen	-	-	+	+ -

(a)

Name of working elements of friction pairs and their charge	Hydrogen ionization			
	H ⁻	H ⁺	H [±]	
The remaining volume of the body of the metal friction element with hydrogen	-	-	+	+ -
The outer surface of the subsurface metal layer	-	-	+	+ -
The inner surface of the subsurface metal layer	-	-	+	+ -
The outer working surface of the metal layer	-	-	+	+ -
The inner working surface of the metal layer	-	-	+	+ -
The working surface of the pad	+	-	+	+ -

(b)

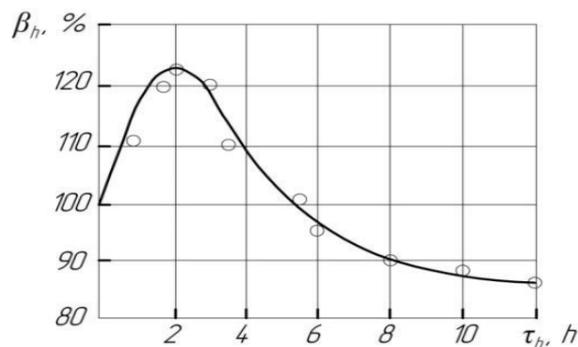


Fig. 4: Dependence of the relative microhardness of steel 45 on the duration of hydrogenation

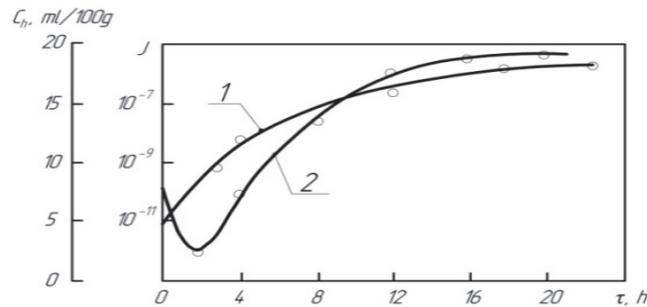


Fig.5: Dependence of the amount of absorbed hydrogen C_h (1) and wear rate J (2) on the duration of hydrogenation

Hydrogen wear by destruction is distinguished by the fact that the surface layer of metal (cast iron or steel) up to 1 - 2 microns thick under certain conditions is destroyed instantly. This happens when a sufficiently large amount of hydrogen accumulates in the surface layer. The accumulation of hydrogen is facilitated by the thermal destruction of the surface layer of the lining during friction since hydrogen can occupy a large number of adsorption centers on the surface. During friction, the concentration of hydrogen in steel continuously increases. Hydrogen penetrates the emerging microcracks of the cavity, intercrystalline boundaries, and other places. Under friction conditions, periodic plastic deformation of the surface layer occurs, and the volume of defective areas changes. Hydrogen entering the microcavities is hemolyzed and, unable to escape back when the volume decreases, tends to expand the microcavity, creating large specific loads.

CONCLUSION

This study examined the factors affecting the wear of metal brake friction elements of urban infrastructure vehicles. As a result of theoretical and experimental studies of hydrogen wear of movable and stationary joints, which were carried out at variable electrical surface-volume temperatures and equivalent voltages and were caused by pulsed specific loads that contribute to the emergence of gradients, it was possible to establish the following. Empirical results have shown that positive and negative heat transfer values correspond to forces directed, towards colder or warmer parts of the product. This occurs because hydrogen moves in the metal friction element to its more heated section.

Also, due to the mutual mass transfer of materials in the friction pairs of brake devices, the sign of their polarity changes, and negatively charged external hydrogen enhances the negative electronic field of the metal friction element. Research has established that the hydrogen atom is magnetic, and the proton is electrically charged, and this determines the connection between electrical phenomena during friction and the accumulation and migration of hydrogen under the influence of magnetic and electric fields. Heat transfer processes are caused by forces acting on the embedded hydrogen atoms. The force of electrical transfer occurs in the presence of electric current and is phenomenologically determined by the effective charge, which is confirmed by empirical dependencies. Due to the lack of knowledge of the phenomena and effects, as well as the complexity of the processes during hydrogen wear of the working surfaces of the metal friction elements of brakes, the structure of their metal under the influence of hydrogen turns into a dynamically changing system, passing into a state of chaos (catastrophically intense wear and emergency destruction). Because of the above, it has been established that during electrothermomechanical friction, the working surface of the metal friction element is exposed to hydrogen, which, under the influence of a gradient of equivalent stresses, is concentrated in the zone of their maximum values, where it transforms into a molecular form and causes destruction, which negatively affects the operation of friction pairs of brake devices and as a result, on the operation of the vehicle as a whole. With further study of hydrogen wear, it is necessary to develop a set of methods to combat such a negative phenomenon.

AUTHOR CONTRIBUTION

N. Fidrovskaya reviewed the literature and prepared the experiment. S. Dotsenko reviewed the literature, set up the experiment, and analyzed and interpreted the data. S. Nikipchuk and V. Nesterenko based on experimental data, using a computer program package, built the graphical dependencies presented in the article. M. Ostashuk and P. Yefimenko helped in the literature review and preparation of 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

$\alpha_v/2$	Burgers vector
β_H	Relative microhardness
C_H	Amount of absorbed hydrogen
J	Duration of hydrogenation
e	Elementary, positive charge
grad T	Temperature gradient
grad ϕ	Applied electric field causing electric current
P	Power
ρ	Specific loads
Q'	The heat of transfer
τ	Time
Z'	Effective charge

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ORIGINAL RESEARCH PAPER

The influence of managerial coaching on employee expertise: Promoting work motivation as a mediator

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ABSTRACT

BACKGROUND AND OBJECTIVES: The current organizational environment, extreme competition, and rapid change in the working environment have increased the motivation of researchers to identify important variables that can help organizations to be competitive to overcome these challenges. Therefore, this article examines how immediate superiors use different managerial coaching, namely guidance coaching and facilitation coaching, to regulate the practice and behavior of employees. In addition, this study examines workplace motivation medium as the mediator of the relationship between managerial coaching and employees' expertise.

METHODS: The cross-sectional research design was employed to collect data from 500 employees across various policy-making agencies in Malaysia. The sample size was determined using the Raosoft formula, and 473 employees were selected using this technique. SmartPLS software was used to evaluate the measurement and structural models. This software is capable of analyzing complex study models.

FINDINGS: The results of mediating structural equation modeling show two findings. First, guidance indirectly relates to employees' expertise, mediated by workplace motivation ($\beta=0.169$; $t=4.683$; $p=0.000$). Second, facilitation coaching is indirectly associated with employees' expertise, mediated by workplace motivation ($\beta=0.167$; $t=3.926$; $p=0.000$). These findings report that a leader's ability to demonstrate managerial coaching (e.g., guidance and facilitation coaching) can enhance an employee's expertise. Consequently, this positive situation can increase employees' expertise, including practicing good attitudes, adapting to tasks, and understanding the organization's objectives and tasks, within the studied organization.

CONCLUSION: The findings have recognized that facilitating coaching is a crucial managerial problem that organization must solve. Therefore, for practical contribution, organizations should establish an effective selection system based on coaching instruments to recruit leaders who already have coaching ability externally and promote potential employees as coaches internally. Other than that, organizations can provide or support formal training and education programs to help leaders become effective coaches in the future.

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INTRODUCTION

The result of dynamic changes and the rapid use of digital technology in the environment inspires the leadership to change the role of human resource management gradually, that is from financial performance to improving the quality of internal human resources (Kuan and Abu Bakar, 2023; Ismail et al., 2023). This transformation has prompted human resource managers to work closely with managers, leaders, immediate supervisors, and stakeholders in planning, controlling, and monitoring adverse effects and undesirable aspects of the work environment (Enhart et al., 2020; Faisal, 2023; Kramar, 2022). The behavioral approach of leadership coaching will usually focus on immediate leaders, in studying the content of management activities and dimensions to classify categories and taxonomies in management coaching. Several studies have identified categories and taxonomies that are often referred to such as guidance of subordinates (Kraut et al., 1989; Echeverri (2020), training (Borman and Brush, 1993; McLennan, 1967), training-coaching (Yukl, 1981), provide growth and development (Morse and Wagner, 1978) and mentoring and development (Quinn, 1988; Yukl, 1981) which are valued as important components that activate the managerial role or as a subset of the leader role (Mintzberg, 1973, 1990, 1994). This taxonomy is often used interchangeably when many researchers suggest that there are differences between them (Burdett, 1998; Evered and Selman, 1989; Hargrove, 1995). For example, coaching is associated with the process of improving problematic work performance (Fournies, 1987), and the process of empowering employees to exceed previous performance levels (Burdett, 1998; Evered and Selman, 1989; Hargrove, 1995). On the other hand, mentoring usually describes a long-term process that is developmental, career-focused, and encompasses all life structures (Mink et al., 1993; Abdelwahed et al., 2023). Although these terms are different, all these meanings are interrelated with each other, especially in evaluating leadership styles in learning-based organizations. Managerial coaching can be applied to various leadership behavior characteristics such as transformational leadership (Odeh et al., 2023), transactional leadership (Abdelwahed et al., 2023), laissez-faire leadership (Khan et al., 2023), and servant leadership (Wong et al., 2023). These types of coaching leadership behaviors have practiced various styles

of guidance and facilitation to help employees find good opportunities in handling organizational tasks, learn new and updated competencies, change work behavior in a positive direction, and improve skills in handling challenging environments (Imran et al., 2023; Liu and Xi, et. al., 2023; Nyathi and Kekwaletswe, 2023). Overall, coaching is important in organizations based on organization, where immediate superiors practice it towards subordinates to improve the learning, skills, and performance of employees over time. It aids colleagues in fostering team spirit, such as closeness, harmony, and mutual respect potential, while also contributing to the achievement of organizational goals (Rosha & Lace 2016; Bachkirova, 2024). Many scholars have identified several gaps in research on managerial coaching. First, previous studies have focused on the leadership qualities of coaching style, including its goals, types, and values in commercial and non-commercial organizations (Yafi et al., 2021; Kim et al., 2023). Second, the direct effect model was used to study the relationship between managerial coaching and workplace motivation (Wang et al., 2022), employees' expertise (Niu et al., 2022), and the relationship between workplace motivation and employees' expertise (Nyfoudi et al., 2023). However, these models only describe the effect of the cause variable on the criterion variable in model development. Third, the direct effect model only uses simple behavioral statistical analysis, which cannot measure the mediating effect of workplace motivation in the structural model (Nyfoudi et al., 2023). Therefore, research paradigms only provide general recommendations, which may not be sufficient for practitioners to understand how employees perceive their ability to handle their work. This information is important for leadership planning and development programs to achieve their organizational strategies and goals in a rapidly changing global environment (Yafi et al., 2021; Niu et al., 2022). Due to limitations in empirical studies, researchers now focus on the relationship between managerial coaching, workplace motivation, and employees' expertise to fill the gaps in the literature, especially in Malaysia. The novelty of this study lies in its focus on the specific context of coaching within policy-making organizations in Malaysia. While coaching is a well-established practice in many organizational contexts, its application within policy-making environments presents unique challenges and opportunities. This study provides insights into

how coaching can be effectively implemented in such settings, offering guidance and best practices that can be extrapolated to other organizations facing similar circumstances. It serves as a practical resource for organizations seeking to leverage coaching as a strategic tool for enhancing learning, skills development, team dynamics, and organizational performance.

Literature review

The organizational discussion related to managerial coaching dates to the 1980s. Ellinger *et al.* (1999) highlighted the impact of guidance during working hours, leading to positive changes in employee behavior. This approach is developed based on classical management theories where the role of the organization is activated to be a factor that greatly influences the attitude and behavior of employees. In a management philosophical context, managerial coaching refers to the ability given by leaders to employees in providing skilled and professional assistance to help employees improve their ability to manage and perform various tasks at work (Khan *et al.*, 2020; Ellinger *et al.*, 1999). This form of leadership is often associated with changes in social structures where organizational members actively interact in addressing the challenges and complexities present in the organizational environment, monitoring the organizational environment, identifying strategies and goals, providing direction and resources, monitoring performance, and providing feedback and make monitoring (Morgeson *et al.*, 2010; Kim *et al.*, 2023). The concept of managerial coaching in two main aspects, namely (a) guidance coaching and (b) facilitate coaching (Ellinger *et al.*, 1999; Ismail *et al.*, 2023). According to the coaching perspective, guidance coaching is usually defined as a coaching style that focuses on demonstrating good moral standards in personal conduct and communication, possessing integrity, honesty, credibility, consideration (Ren and Chadee, 2017; Hwang *et al.*, 2023), delivering complete information, offering the opportunity to learn new skills, explaining vision (Westbrook and Peterson, 2022), cultural practices in the professional learning communities (Hui *et al.*, 2021; Zhang *et al.*, 2023). In general, coaching is considered a hands-on process to help individuals recognize opportunities to improve or develop certain aspects of a task through coaching that is realized when the immediate superior supports his employees (e.g., for example, in achieving

goals). In a work context, it has been suggested that mentoring is positively associated with work-related performance (e.g., Grant and Cavanagh, 2004; Hanna, 2004; Kim *et al.*, 2023); in addition to being a way to recognize opportunities to improve working skills (Baek-Kyoo, 2005; Popper and Lipshitz, 1992); and is seen, in service, as a measure to achieve employee efficiency in performing tasks (Berry, 1999; Zeithaml *et al.*, 1990). Accordingly, the role of management coaching practices has been emphasized in terms of influencing employee behaviors and responses in ways that improve service quality (e.g., Sellgren *et al.*, 2007; Slåtten *et al.*, 2011). Meanwhile, facilitated coaching is often associated with the leader's ability to provide support internally and externally, give positive feedback, recognize employee achievements, provide adequate resources, and remove obstacles to goal achievement (Ellinger *et al.*, 1999; Ismail *et al.*, 2023). These two skills are interrelated and contribute to effective coaching in fulfilling organizational roles and understanding task performance in the workplace. Therefore, recent studies on managerial coaching emphasize that guidance coaching and (b) facilitating coaching are equally important and complement each other in achieving positive results, especially in the context of employees' expertise (Collie, 2023). Furthermore, studies on managerial coaching highlight that workplace motivation is an important outcome that exists within the nature and relationship between managerial coaching and employees' expertise, and it can act as an effective mediating variable in that relationship (Hui *et al.*, 2021; Wang *et al.*, 2022; Nyfoudi *et al.*, 2023). Employees in an organization are the biggest asset in a dynamic and competitive environment. If an organization wants to be efficient and effective to maintain success for a longer period, the organization needs to have human resources that are committed motivated, and ready to learn (Hwang *et al.*, 2023). The last three decades have witnessed an avalanche of studies that emphasize the point that motivation in place is essential for organizational success. Thus, motivating employees adequately is a challenge as it has what it takes to define employee satisfaction in the workplace (Hwang *et al.*, 2023). Workplace motivation is often associated with an individual's belief in their capacity and high motivation to achieve desired goals (Law and Choi-Ping Lau, 2020; Hwang *et al.*, 2023). Those who have high motivation at work usually show a strong desire to manage

and perform tasks (Hwang *et al.*, 2023). Conversely, those with low motivation at work often show poor motivation in managing and performing organizational tasks. An individual's behavioral response results from the overall action within themselves or their ability to perform a task (Gist and Mitchell, 1992, Bandura, 1986). Meanwhile, high motivation will usually lead to individuals acting more effectively and appropriately, further helping to improve employee performance in their tasks. For example, previous studies on managerial coaching have shown that employees with good workplace motivation tend to have clear goals, allocate greater effort, work diligently, persevere in the face of task challenges, strive to complete difficult tasks, strive to acquire new competencies, and are willing to assume important responsibilities in organization (Yafi *et al.*, 2021; Kim *et al.*, 2023). On the other hand, employees who have weak workplace motivation do not have clear goals and are less inclined to take proactive actions to become successful employees (Herzberg *et al.*, 1959). Furthermore, there are recent studies on coaching styles highlighting that workplace motivation is an important result that exists in the nature and relationship between managerial coaching and employees' expertise, and it can act as an effective mediating variable in the relationship. Employees' expertise often involves practicing good attitudes, adapting to tasks, understanding the organization's objectives and tasks, being engaged to perform their duties efficiently and effectively, being able to work with others, accepting new ideas, showing respect for colleagues, and being responsible. The current and future ability of employees to remain in the workforce is determined by a healthy organizational culture that supports and values employees (Yafi *et al.*, 2021). These elements are very important, to improve skills and knowledge in their respective fields of work, provide meaningful experiences, increase employee awareness and motivation, and are very valuable in encouraging effective behavior to achieve organizational goals (Ellinger *et al.*, 2003). Furthermore, recent research on coaching styles shows that employees' expertise is an important result that deserves due attention in managerial coaching (Yafi *et al.*, 2021; Kim *et al.*, 2023).

Theoretical background and hypotheses development
Managerial coaching and employee expertise

The relationship between managerial coaching and employees' expertise is consistent with the Leader-Member Exchange Theory by Graen and Uhl-

Bien (1995). This theory suggests that a leader will develop an exchange relationship over time with each subordinate (Dienesch and Liden, 1986; Graen and Uhl-Bien, 1995). The Social Exchange Theory explains how exchange relationships develop gradually as a leader interacts with each subordinate. In a high-exchange relationship, there is high trust and respect. Leaders provide desired outcomes for subordinates (e.g., support, motivation, goals, interesting tasks, additional responsibilities, more rewards), and in return, subordinates are expected to be committed to the work and loyal to the leader. On the other hand, in low-quality exchange relationships, subordinates are only expected to perform the formal requirements of their jobs, and the leader does not provide additional benefits. Next, Self-Determination Theory (Ryan and Deci, 2017) is focused on human development, and a core aspect of the theory is its depiction of qualitatively different types of motivation that fall along a continuum of self-determination (such as extrinsic motivators and positive feedback). Applying these theories in organizations is often referred to as transformational leadership present within individuals. Empirical studies have found a positive correlation between the quality of managerial coaching and employees' expertise. For example, a two-wave longitudinal field study of 114 Hong Kong employees (Hui *et al.*, 2020), a systematic literature search to identify primary studies ($k = 20$, $n = 957$) (Wang *et al.*, 2022), 230 Zambian subordinates and their immediate expatriate supervisors working in the Chinese company in Zambia (Niu *et al.*, 2022) and 579 survey questionnaires from Malaysian public sector employees (Ismail *et al.*, 2023). According to these studies, managerial coaching practiced in an organization (e.g., guidance coaching and facilitate coaching) is one of the most important factors in improving employees' expertise (e.g., employees' expertise). Overall, this study examined the conduct of immediate superiors in guiding employees in an organization. Immediate superiors must be honest and use a continual coaching method to develop employees' task-performance skills. In this regard, the most recent empirical research shows that an immediate superior is judged to have used a continuous guidance strategy throughout working hours if he successfully affects the attitude and behavior of the individual being directed. Therefore, based on the theory supporting exchange relationships develop gradually and empirical study findings, the following hypotheses are formulated:

H1a: Guidance coaching is positively associated with employees' expertise.

H1b: Facilitating coaching is positively associated with employees' expertise.

Managerial coaching and workplace motivation

The relationship between managerial coaching and workplace motivation is consistent with the Path-Goal Theory by House (1971). This theory is frequently associated with the influence of macro theory based on leadership styles and leaders. This theory assists leaders in determining the best leadership style for the situation and the people they lead. It is founded on four leadership styles: supportive, directive, participative, and goal-oriented. According to this theory, managers can influence their team's performance by adopting a leadership style that is tailored to their team's specific needs. Employee motivation, according to the path-goal theory, is dependent on leadership support and the leader's ability to effectively balance team challenges. This theory's application in organizations is commonly referred to as coaching present within individuals. Empirical studies show that there is a positive correlation between managerial coaching and workplace motivation. Many previous studies have used different sample sizes to evaluate the effects of this relationship such as the perception of a two-wave longitudinal field study of 114 Hong Kong employees (Hui et al., 2020), 584 paper questionnaires were distributed to nearly 50 companies in Chengdu, China (Wang et al., 2022) and 242 fully completed and matched responses (60 managers and 182 team members) (Nyfoudi et al., 2023). According to these studies, managerial coaching practiced in an organization (e.g., guidance coaching and facilitate coaching) is one of the most important factors in enhancing workplace motivation. Overall, studies on managerial coaching and workplace motivation have received little attention. According to the findings of earlier studies, the majority of previous studies have less to explain the role and critical factors involved in managerial coaching in public organizations. Thus, the following hypotheses are proposed in this study:

H2a: Guidance coaching is positively associated with workplace motivation.

H2b: Facilitating coaching is positively associated with workplace motivation.

Managerial coaching, workplace motivation, and employees' expertise

The mediating effect of workplace motivation in the relationship between managerial coaching and employees' expertise is consistent with the essence of Social Cognitive Theory by Bandura (1986). The main idea of this theory discusses individual behavior that is influenced by learning produced through research on other individuals or individuals who are considered models. This social learning involves the influence relationship of three elements namely the environment (closest leaders, other individuals, and peers), cognitive (language, imagination & logic), and behavior (cheerful, angry, caring, firm, patient & other positive behavior). Usually, this learning process involves four main processes. First, observation of certain behaviors or work movements that you want to emulate. Second is retention, which is recalling observed behavior, and the results of observation are stored in memory. Third, reproduction, i.e. doing it again based on something observed before. This behavior can also be used as practice and implementation in the future. Fourth, reinforcement and motivation which is the reward obtained to strengthen the new behavior practiced (Bandura, 1986). The application of this theory in organizations is often referred to as workplace motivation within individuals. Some further studies have used an indirect effect model to evaluate the influence of commitment-based practice on the relationship between managerial coaching and employees' expertise. For example, 579 survey questionnaires from Malaysian public sector employees (Ismail et al., 2023) and 242 fully completed and matched responses (60 managers and 182 team members) (Nyfoudi et al., 2023) and 20 companies across multiple industries in South Korea, and a total of 386 leader-follower dyads' (Kim et al., 2023). These surveys discovered that the ability of leaders to implement managerial coaching practiced in an organization (e.g., guidance coaching and facilitate coaching) strongly stimulates commitment-based practice. Consequently, this sense of empowerment was found to lead to enhanced employees' expertise (e.g., employees' expertise). Most previous studies focused on discussing the relationship between managerial coaching and employee self-efficacy and organizational commitment (Nyfoudi et al., 2023;

Kim et al., 2023). Although this concept is relevant and represents an important aspect of employee behavior to be studied in organizations, there was a lack of exposure to organizational learning in the context of policy-making agencies before this study. Consequently, drawing upon the principles of Social Learning Theory and insights from empirical research, the hypothesis is formulated as follows:

H3a: Workplace motivation acts as a mediating variable between guidance coaching and employees' expertise

H3b: Workplace motivation acts as a mediating variable between facilitating coaching and employees' expertise.

Research model

The theoretical and empirical evidence had been used to formulate a study model, as exhibited in Fig 1.

From the above framework, the study aims to investigate the relationship between managerial coaching, workplace motivation, and employees' expertise. The current study has been carried out in Malaysia in 2020.

MATERIALS AND METHODS

Research design

A cross-sectional study design was employed in this research. This selection allows researchers to consolidate important information from leadership literature studies, pilot studies, and questionnaires that allow researchers to collect data more accurately, reduce bias, and improve the quality and value of data (Cresswell, 2012; Sekaran and Bougie, 2019). This study was carried out at a policy-making agency in Malaysia. To maintain the organization's confidentiality policy, the

actual name of the institution has been withheld. In the data collection procedure of the study, in the first stage, the researcher prepares a draft questionnaire that is developed based on the study of leadership literature and has been adapted. Wright (1996) suggests that the translation process is most effectively employed to ensure accurate utilization of the principle in the questionnaire. This involves comparing the original version with the translated version from English to Malay. To ensure the questionnaire aligns with the context of the research organization, the researcher engaged a professional translation service to translate the questionnaire. This approach enhances the quality of the research instrument while preserving the original content (Brislin, 1970; Lomand, 2016).

Instrument

The questionnaire form of this study contains three parts: First, managerial coaching is assessed based on twelve items adapted from literature studies related to coaching literature (Park et al., 2008; McLean et al., 2005). Managerial coaching is evaluated based on two measurements, namely facilitate coaching with seven items and facilitate coaching with five items. Second, workplace motivation is assessed based on five items adapted from a literature review related to organizational learning (Parker, 1998). Third, employees' expertise is assessed based on five items adapted from a literature review related to employees' expertise (William and Anderson, 1991). All the items have been evaluated according to a 7-choice answer scale, starting from "strongly disagree/very dissatisfied" (1) to "strongly agree/very satisfied" (7). This measurement scale was chosen in this study because it can increase the optimal reliability

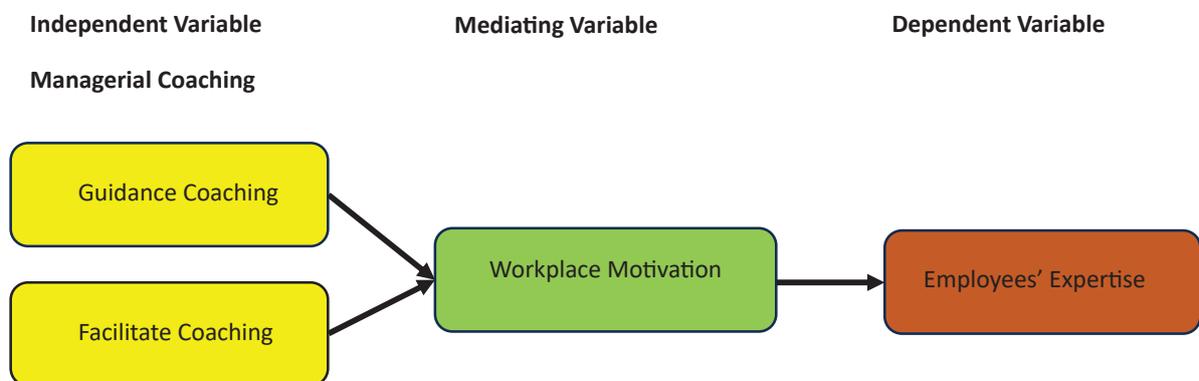


Fig. 1: Research model

in evaluating the respondent's reaction (Lewis and Smith, 1993) resulting in a neutral and better response (Cox, 1980). The demographic characteristics of the respondents were used as control variables because this study only focused on employee attitudes.

Sampling and data collection

The study involved employees from different policy-making agencies in Malaysia. In the data collection process, a total of 500 questionnaires were distributed among employees using purposive sampling techniques. Among the criteria for the respondents involved are individuals who have been supervised by their immediate supervisor for a minimum period of six months. These mentored employees will reflect on how their immediate superior guides them in their daily tasks. The procedure carried out involves first, identification of criteria. The researcher identified specific criteria for selecting respondents, such as individuals who had been supervised by their immediate superior for at least six months. Second, is the selection process. Using the established criteria, the researcher purposefully selected respondents who met the eligibility requirements. This selection was based on the researcher's judgment and knowledge of the population being studied. Third, verification. The researcher ensured that the chosen respondents fit the criteria by confirming their supervisory relationships and tenure under their immediate supervisors. This process is assisted by the Administrative Officer and Administrative Assistant of the Division. This sampling technique was chosen because the organization's management could not provide a complete list of employees for confidential reasons and wanted to protect the organization's reputation and corporate image. As a result, the researcher is unable to use a random method to select study participants in this situation. Only 473 (94.6%) of the total number of questionnaires distributed were completely completed and returned to the researcher. This questionnaire was completed voluntarily and without coercion by all the respondents. Most participants were 34 to 39 years old (37.8%), Malay (93.9%), married (72.1%), permanent services (91.1%), and length of services from six to ten years (29.4%). Data analysis was conducted using SPSS and SmartPLS software. In SPSS analysis, the data screening process involved removing missing values, straight-lining answers, extreme values, and non-normally distributed (Hair *et al.*, 2017). Meanwhile,

the SmartPLS software is used to build measurement models, structural models, and hypothesis testing. Additionally, the sample size was determined using the Raosoft formula. The rule indicates a minimum sample size of 218 respondents, indicating that the sample size in this study was sufficient.

RESULTS AND FINDING

Table 1 shows that the outer loadings for all the study constructs are greater than 0.708 (Henseler *et al.*, 2009) and the AVE values are greater than 0.5 (Hair *et al.*, 2017), indicating that the results meet the convergent validity criteria. Furthermore, the composite reliability values for all study constructs are greater than 0.8 (Hair *et al.*, 2017), indicating a high level of internal consistency.

The Heterotrait-Monotrait (HTMT) ratio of correlations was used to evaluate all the study constructs, as shown in Table 2. This analysis reveals that all study constructs have values less than 0.85 (Hair *et al.*, 2017), indicating that they met the discriminant validity criterion.

Table 3 presents the means for the study constructs, ranging from 5.654 to 5.917. These values suggest that participants' perceptions of facilitate coaching, guidance coaching, workplace motivation, employees' expertise, and workplace motivation range from a high level (4) to the highest level (7). Furthermore, the Variance Inflation Factor (VIF) values for the associations between the study constructs are all below 5.0. This indicates that the data is not significantly influenced by collinearity issues (Hair *et al.*, 2017).

Table 4 reported the results of the structural model. The results of effect size (f^2) indicate that the relationship between facilitate coaching and employees' expertise is 0.049 (small effect size), facilitate coaching and workplace motivation is 0.586 (substantial effect size), guidance coaching and employees' expertise is 0.150 (medium effect size), guidance coaching and workplace motivation is 0.054 (small effect size), workplace motivation and employees' expertise is 0.010 (small effect size). A large coefficient of determination (R^2) for workplace motivation is 0.613 and employees' expertise is 0.475. Blindfolding was conducted to generate predictive relevance (Q^2) values. The Q^2 value is 0.475 demonstrated acceptable predictive relevance.

To estimate the statistical significance of the

Managerial coaching, employees' expertise and workplace motivation

Table 1: Convergent validity analysis

Constructs	Outer Loading	Composite Reliability	Average Variance Extracted (AVE)	Cronbach Alpha
Guidance Coaching		0.944	0.709	0.931
A1:	0.888			
A2:	0.889			
A3:	0.917			
A4:	0.902			
A5:	0.907			
A6:	0.927			
A7:	0.890			
Facilitate Coaching		0.930	0.726	0.905
B1:	0.878			
B2:	0.835			
B3:	0.879			
B4:	0.872			
B5:	0.770			
Workplace Motivation		0.937	0.711	0.919
C1:	0.796			
C2:	0.888			
C3:	0.918			
C4:	0.908			
C5:	0.902			
Employees' Expertise				
D1	0.827			
D2	0.877			
D3	0.864			
D4	0.868			
D5	0.867			

Table 2: Results of discriminant validity and HTMT confidence interval values

Constructs	Employees' Expertise	Facilitate Coaching	Guidance Coaching
Employees' Expertise			
Facilitate Coaching	0.680		
Guidance Coaching	0.680	0.717	
Workplace Motivation	0.612	0.838	0.656

Table 3: Results of VIF and descriptive constructs analysis

Construct	VIF Values		Mean	Std. Deviation
	Employees' Expertise	Workplace Motivation		
Facilitate Coaching	2.873	1.811	5.704	0.832
Guidance Coaching	1.910	1.811	5.654	0.835
Workplace Motivation	2.593		5.785	0.786
Employees' Expertise			5.917	0.666

Table 4: R², f², and Q² of endogenous constructs.

Constructs	f ²		R ²	Q ²
	Employees' Expertise	Workplace Motivation		
Employees' Expertise			0.475	
Facilitate Coaching	0.049	0.586		
Guidance Coaching	0.150	0.054		0.475
Workplace Motivation	0.010		0.613	

Table 5: The results of the hypothesis testing of the research model (direct effect)

Relationship	Beta	T statistics (O/STDEV)	P values
H1a: Facilitate Coaching -> Employees' Expertise	0.271	4.148	0.000
H1b: Facilitate Coaching -> Workplace Motivation	0.640	13.258	0.000
H2a: Guidance Coaching -> Employees' Expertise	0.387	6.377	0.000
H2b: Guidance Coaching -> Workplace Motivation	0.195	3.906	0.000

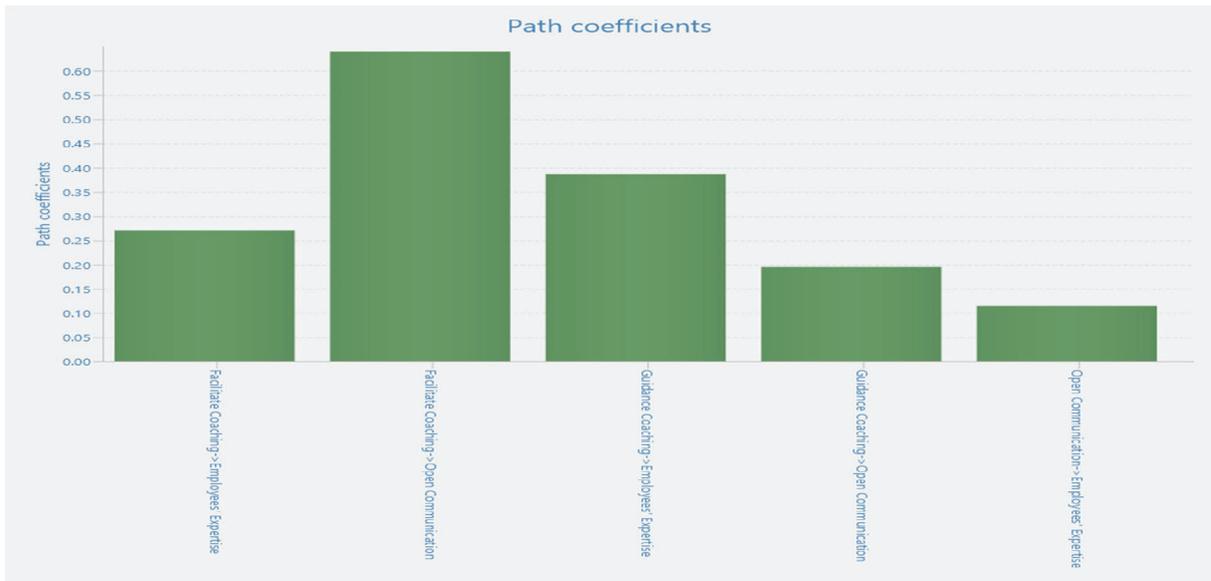


Fig. 2: Path coefficients for direct hypothesis

parameter, the bootstrapping technique (5,000 subsamples, one-tailed significance) was used. The results of the direct effect hypothesis are presented in Table 5. The findings of the analysis revealed four significant findings. First, facilitating coaching is associated with increased employee expertise (H1a, =0.271; $t=4.148$; $p=0.000$). Second facilitating coaching positively and significantly workplace motivation (H1b, =0.640; $t=13.258$; $p=0.000$). Third, guidance coaching affects employees' expertise positively and significantly (H2a, =0.387; $t=6.377$; $p=0.000$). Fourth, guidance coaching is positive and significant with workplace motivation (H2b, =0.195; $t=3.906$; $p=0.000$). Therefore, H1a, H1b, H2a and H2b were supported. Next, Fig. 2 shows the path coefficients for the direct hypothesis.

Table 6 presents the findings of the indirect effect hypothesis. The results of the analysis revealed two important findings. First, guidance coaching and workplace motivation are positive and significant with employees' expertise (H3a, $\beta=0.169$; $t=4.683$;

$p=0.000$). Second, facilitating coaching and workplace motivation are positive and significant with employees' expertise (H3b, $\beta=0.167$; $t=3.926$; $p=0.000$). Therefore, H3a and H3b were supported. Fig. 3 shows the path coefficients for path coefficients for H3a, and Fig. 4 shows the path coefficients for path coefficients for H3b.

Table 7 shows the Important-Performance Matrix Analysis (IPMA) analysis. The IPMA test results show that workplace motivation is higher, with a score of 76.267 and a total effect of 0.114. On the other hand, facilitate coaching was the lowest, with a score of 73.597 and a total effect of 0.344. These findings suggest that practitioners should pay more attention to facilitating coaching aspects to promote managerial coaching.

This study confirms that workplace motivation can function as a significant mediating variable in the relationship between managerial coaching (e.g., guidance coaching and facilitate coaching) and employees' expertise. In the context of the study, most

Table 6: The results of the hypothesis testing of the research model (indirect effect)

Relationship	Beta	T statistics (O/STDEV)	P values
H3a: Guidance Coaching -> Workplace Motivation -> Employees' Expertise	0.169	4.683	0.000
H3b: Facilitate Coaching -> Workplace Motivation -> Employees' Expertise	0.167	3.926	0.000

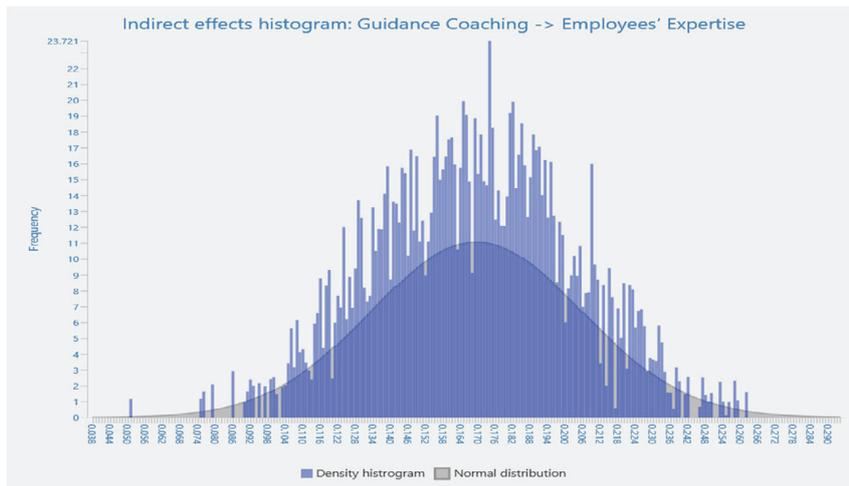


Fig. 3: Path coefficients for H3a

respondents felt that the level of managerial coaching, workplace motivation, and employee expertise was very high. This situation shows that the leader’s ability to be actively involved in facilitating coaching (such as communication, honesty, credibility, consideration, and giving opportunities) and facilitate coaching (such as providing support internally and externally, giving positive feedback, and recognizing employee achievements) can enhance workplace motivation (such as individual’s belief in their capacity and high motivation to achieve desired goals). Next, this positive situation can be able to increase employees’ expertise (such as practicing good attitudes, adapting to tasks, and understanding the organization’s objectives and tasks). This study has been supported by previous studies based on leadership in organizations by *Ismail et al. (2023)*, and *Nyfoudi et al. (2023)*. The findings of the study present three important implications: implications for theory, implications for methodological methods, and implications for practice. In terms of theoretical implications, this study acknowledges three significant findings: First, managerial coaching (e.g., guidance coaching and facilitate coaching) has been an essential antecedent

of employees’ expertise. This finding parallels the main idea of the Leader-Member Exchange Theory by *Graen and Uhl-Bien (1995)*. This theory suggests that a leader will develop an exchange relationship over time with each subordinate (*Dienesch and Liden, 1986; Graen and Uhl-Bien, 1995*). This idea has been supported by past managerial coaching studies, which reveal that managerial coaching practiced in an organization (e.g., guidance coaching and facilitate coaching) is one of the most important factors in improving employees’ expertise (e.g., employees’ expertise) (*Hui et al., 2020; Wang et al., 2022; Niu, et al., 2022; Ismail et al., 2023*). Second, managerial coaching (e.g., guidance coaching and facilitating coaching) has been an essential antecedent of workplace motivation. This finding aligns with the notion of Path-Goal Theory by *House (1971)*. This theory is frequently associated with the influence of macro theory based on leadership in determining the best leadership style for the situation and the people they lead. This notion has been supported by previous managerial coaching studies, which disclose that managerial coaching practiced in an organization (e.g., guidance coaching and facilitate coaching) can be able to enhance workplace motivation (*Hui et al.,*

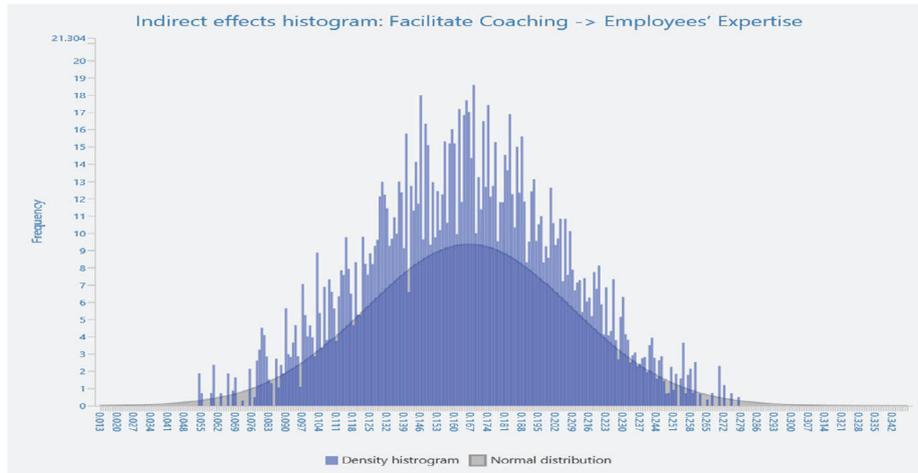


Fig. 4: Path coefficients for H3b

Table 7: IPMA analysis

Construct	Employees' Expertise	
	Importance (Total Effect)	Performance (Total Index)
Facilitate Coaching	0.344	73.597
Guidance Coaching	0.409	74.307
Workplace Motivation	0.114	76.267

2020; Wang *et al.*, 2022; Nyfoudi *et al.*, 2023). Third, workplace motivation has mediated the relationship between managerial coaching and employees' expertise. This finding is in line with the notion of Social Cognitive Theory by Bandura (1986) and Self-Determination Theory (Ryan and Deci, 2017). The main idea of this theory discusses individual behavior that is influenced by learning produced through research on other individuals or individuals who are considered models and focused on human development along a continuum of self-determination (such as extrinsic motivators and positive feedback). This finding is consistent with the managerial coaching research articles, which reveal that the effect of managerial coaching has been mediated by workplace motivation (Ismail *et al.*, 2023; Nyfoudi *et al.*, 2023). Regarding the robustness of the research methodology, the collected survey questionnaire data have met the standards of validity and reliability analyses. This condition may drive the production of accurate and reliable study results. Thus, concerning practical contributions, the IPMA results have recognized that facilitating coaching is a crucial managerial problem that needs

to be solved in organizations. To meet this purpose, practitioners should focus on the following aspects: First, organizations should establish an effective selection system based on coaching instruments to recruit leaders who already have coaching ability externally and promote potential employees as coaches internally. Second, organizations can provide or support formal training and education programs to help leaders become effective coaches. For example, organizations can use external professional coaching institutes to help managers become certified coaches. Leaders should provide the right leadership style and strategy to develop management skills to improve their organization's efficiency. Third, the organization should facilitate the construction of organizational culture, motivating leaders to have various types of construction behavior. For example, organizations can support managerial coaching-related behaviors such as mentoring, facilitating, and inspiring mentoring activities that further enhance employees' sense of belonging to the organization and psychological safety so that employees can continue their creative work. Fourth, various techniques (such as observational and

experiential learning, blended learning, and active learning through both face-to-face and online modes) should be used to effectively inspire, facilitate, guide, and exemplify the concept of interaction.

CONCLUSION

Employees are in dire need of suitable environmental guidance conditions to enhance motivation at work. It also concludes that workplace motivation can serve as an effective mediating variable in the relationship between managerial coaching and employees' expertise. These findings are also consistently supported by several articles grounded in organizational managerial coaching most of which have been examined in Western and Asian countries. In conclusion, this study reports that a leader's ability to demonstrate managerial coaching (e.g., guidance coaching and facilitate coaching) can enhance employees' expertise. As a result, this positive situation can be able to increase employees' expertise (such as practicing good attitudes, adapting to tasks, and understanding the organization's objectives and tasks) within the studied organization. The results of factor validation analysis indicate that the measurement scale used in this study meets high standards of validity and reliability. The study conclusion should consider certain constraints. First, participants' characteristics are excluded from the structural managerial coaching model testing. Second, cross-sectional data only explains general participants' attitudes about the association between latent variables. Third, this study only assesses the correlation between latent variables. Fourth, this study is conducted in agencies policy-making agencies in Malaysia. Fifth, data gathered by a purposive sampling plan cannot monitor participants' answers and represent the studied population. Hence, this study presents several suggestions for forthcoming studies. For example, some participants' features, especially age, types of services, education, and length of services should be included in future studies because it may highlight differences and similarities in their attitudes toward the study issues. Secondly, a longitudinal method may be considered in future studies if we plan to compare subsamples in different timeframes. Thirdly, three specific features of managerial coaching such as goal setting, action planning, building self-awareness, emotional intelligence, providing feedback, and accountability can be examined further due to their important determinants of employee outcomes. Fourthly, elements of employees' expertise such

as innovative behaviors, organizational citizenship behavior, engagement, and turnover intention, should be evaluated in future studies as they are emphasized in diverse organizational contexts. Finally, three essential dimensions of workplace motivation such as extrinsic factors, intrinsic factors, psychological empowerment, constructive voice behaviors, and communication (formal and informal). The above suggestions should be appropriately considered to strengthen future studies.

AUTHOR CONTRIBUTIONS

N.I. Mohamad performed the literature review, methodology, analyzed and interpreted the data, prepared the manuscript text, and manuscript edition. S. Sanusi performed the literature review, compiled the data, and manuscript preparation. A.S. Othman performed review and editing.

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

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ABBREVIATION

HTMT	Heterotrait-Monotrait
IPMA	Important-Performance Matrix Analysis
AVE	Average Variance Extracted
VIF	Variance Inflation Factor Values
Q ²	Predictive Relevance
R ²	Coefficient of Determination
F ²	Effect Size

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ORIGINAL RESEARCH PAPER

Strengthening human resource management system with digital practices, transformation, and task interdependence

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ABSTRACT

BACKGROUND AND OBJECTIVES: Given the new cost pressures, hybrid work models, and evolving needs of employees and customers, organizations are increasingly realizing the importance of digital workforce management practices and digital transformation in achieving success. This is especially critical for government organizations, including local governments, as digitalization plays a crucial role in streamlining human resource activities, reducing costs, improving data management, and strengthening human resource management systems. As local governments strive to become more agile and adapt to changing needs and expectations, digitalization enables them to respond quickly and foster innovation. Therefore, the objective of this study is to examine the impact of digital human resource management practices and digital transformation on the strength of the human resource management system, with a specific focus on the mediating role of digital task interdependence within the Tehran municipality.

METHODS: technique. The collected data was then subjected to statistical analysis. University professors and local government experts confirmed the content validity of the survey instrument. To evaluate the reliability and validity of the questionnaire, this study utilized average variance extracted, Cronbach's alpha, and composite reliability, all of which produced satisfactory outcomes. The data analysis was carried out using Analysis of Moment Structures, and SPSS26 software.

FINDINGS: The study emphasizes the importance of implementing digital human resources management practices and digital transformation to strengthen the human resource management system in Tehran municipality. This enables human resource processes to be faster, smarter, and more efficient. Additionally, the successful integration of both old and new human resource systems, along with the effective implementation of digitalization in Tehran municipality, relies on coordination and collaboration among employees through digital platforms.

CONCLUSION: The present study demonstrates that the implementation of digital human resource management practices and the process of digital transformation can effectively enhance human resource management systems and align the activities of human resources with strategic objectives. By embracing digital transformation and adopting digital human resource management practices, organizations can elevate the significance of human resource management and effectively communicate their intentions to employees. Furthermore, the analysis reveals that digital task interdependence fosters collaboration and coordination among geographically dispersed employees, reducing communication costs and improving access to diverse knowledge sources. Consequently, this enhances the efficiency of municipal operations

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INTRODUCTION

Human Resources Management (HRM) plays a critical role in the success of any organization. It encompasses a wide range of practices and strategies aimed at maximizing the potential of a company's workforce (Udekwe et al., 2021). In today's age of digital transformation, the impact of HRM practices combined with digital information has proven to be a significant strength in managing human resources effectively (Samuel and Moagi, 2022). For instance, with the implementation of digital HR systems, employee data can be stored and managed electronically. This eliminates the need for physical files, making information easily accessible and reducing the risk of data loss. Furthermore, digital HR systems can automate routine tasks like payroll processing, leave management, and performance appraisals, freeing up HR professionals to focus on strategic initiatives (Nadim Khan, 2022). With the rise of digital communication channels such as email, instant messaging, and video conferencing, employees can connect and share information regardless of their geographical locations. This has eradicated communication barriers, allowing companies to tap into a global talent pool and embrace remote work arrangements (Samuel and Moagi, 2022). Another significant impact of digital HRM practices is the ability to leverage data analytics for decision-making. With digital HR systems capturing vast amounts of employee data, organizations can gain valuable insights into their workforce (Blau and Shamir-Inbal, 2017). HR professionals can analyze this data to identify trends, predict employee behavior, and make informed decisions about talent acquisition, performance management, and employee engagement initiatives. Furthermore, the integration of Artificial Intelligence (AI) and machine learning algorithms in HRM has the potential to transform the field further. AI-powered HR chatbots can handle employee queries and provide real-time assistance, minimizing the need for human intervention (Shamout et al., 2022). Recent findings from Accenture indicate a significant technological transformation taking place globally, characterized by the evolution of AI and other disruptive technologies into being "Human by Design"—increasingly resembling human behavior and becoming more user-friendly and intuitive. This shift is expected to bring about a new phase of

unparalleled productivity and innovation. The study also proposes that with the advancement of human-centric technologies, which possess enhanced capabilities and are simpler to engage with, there will be a seamless integration of these technologies into every facet of our lives. Consequently, we are progressing toward a future where technology will be omnipresent yet inconspicuous (Basole and Major, 2024). These findings, along with other related survey results, prompted researchers to direct their attention toward digital HRM practices. Scholars argue that digital HRM serves as an organizational capability that yields positive outcomes by utilizing traditional statistics, sentiment analysis, and algorithms, all of which are based on accumulated data (Minbaeva, 2018). The implementation of digital HRM has been proven to enhance the quality of decision-making (Gal et al., 2020; Van Esch et al., 2020), enable organizations to adapt swiftly in a dynamic environment to attain a competitive edge (Wolfe et al., 2006), foster greater involvement of the HRM department in strategic matters (Lawler et al., 2004; Levenson, 2018), enhance employee performance and experience (Schiemann et al., 2018), and ultimately contribute to the overall financial performance of the organization (Malik et al., 2022). The digitalization of HR processes has streamlined operations, enhanced communication, and provided valuable insights for decision-making. As organizations continue to embrace digital transformation, the importance of leveraging digital tools and platforms in HRM practices will only grow, ensuring a more efficient and productive workforce (Ruel et al., 2019). As a result, digital transformation has brought significant changes in the field of HRM. With the advent of Digital Human Resource Management (DHRM) practices and digital transformation, there has been a profound impact on the strength of the HRM system (Belakang et al., 2019). Numerous research studies have revealed that digital HRM and digital transformation are positively correlated with the strength of the HRM system (Ranjan et al., 2008; Madhavi Lakshmi and Siva Pratap, 2016; Berry and Linoff, 2000; Zhou et al., 2021; Prikshat et al., 2023). The literature encompasses various conceptualizations regarding how individuals perceive the strength of the HRM system. In their seminal paper, Bowen and Ostroff (2004) focus on the design and administration of human resource management systems to enhance

effectiveness. e-HRM functions as a means of communication between a company and its employees (Hutchinson, 2014). Consequently, it can potentially enhance the effectiveness of HR policies in various ways. Firstly, it empowers employees to independently access and familiarize themselves with the HRM system's policies through web-based platforms. Secondly, it ensures that consistent messages regarding desired behaviors, which are tied to employee outcomes, are conveyed to all employees (Bowen and Ostroff, 2004). Additionally, it provides insights into the internal coherence of HR practices. For instance, the e-HRM system can furnish employees with comprehensive information regarding the allocation of rewards and how they are connected to performance evaluations. Lastly, as e-HRM is utilized by all employees, it facilitates the dissemination of consistent messages, fostering a shared understanding and agreement among employees regarding the fairness of the HRM system (Obeidat, 2016). The influence of digital transformation and DHRM practices on the strength of HRM systems may be more effectively elucidated by examining digital task interdependence, which denotes the interconnectivity of tasks within the organization enabled by digital technologies (Chen *et al.*, 2021; Shamout *et al.*, 2022). Digital Task Interdependence (DTI) refers to the extent to which different tasks within an organization are interconnected and rely on digital technology for seamless execution. Moreover, DTI combined with HRM practices, has also facilitated seamless communication and collaboration within organizations (Aibinu and Papadonikolaki, 2020). With the advent of digital tools and platforms, tasks that were once carried out independently can now be coordinated effortlessly, leading to improved efficiency and productivity (Honorina Samson and Vinita Agrawal, 2020). The integration of digital information in HRM practices has revolutionized the way organizations manage their workforce. Traditional HRM practices relied heavily on manual processes, such as filing cabinets and paperwork, consuming valuable time and resources (Nayak *et al.*, 2022). The digitalization of Human Resource (HR) processes has not only eliminated these manual tasks but has also enhanced the efficiency of HRM practices (Yu *et al.*, 2023). The impact of HRM practices combined with digital information, particularly in the context of

digital task interdependence, has strengthened the management of human resources (Honorina Samson and Vinita Agrawal, 2020). Despite the considerable scholarly interest in digital transformation extending beyond information systems, there remains a lack of clarity regarding the ability of traditional organizations to undergo digital transformation independently. Understanding this phenomenon is crucial, as traditional organizations face the risk of failing to successfully achieve digital transformation due to their limited comprehension of digitalization. Moreover, to thrive in a digitally disrupted environment, organizations must persistently innovate and adapt their work practices, particularly in the realm of HR processes (Siachou *et al.*, 2020; Bansal *et al.*, 2023), fortunately, Local governments have the potential to combine government, private, and citizen data to offer new digitally enhanced public services. However, progress in realizing these benefits has come to a standstill in many cases. This is primarily due to a lack of managerial expertise required to oversee the implementation and operation of integrated enterprise systems aimed at enhancing public service delivery processes, a key component of the digital transformation journey (Pittaway and Montazemi, 2020). Despite the initiation of ambitious projects such as digital and smart city initiatives by local governments, there exists a knowledge gap regarding the influence of these projects on HRM systems within traditional organizations, particularly in Municipalities that are embarking on such endeavors. Traditional organizations often lack a comprehensive comprehension of the complexities associated with digital transformation, particularly about HRM systems. The extent to which these projects positively or negatively affect HRM systems remains uncertain in the absence of managerial expertise. Furthermore, there is a limited understanding of how digital task interdependence within these projects contributes to the strength of HRM systems in such organizations. Gaining insight into these dynamics is crucial for the effective implementation of digital transformation and digital HRM practices in municipal settings like Tehran. The success of digital initiatives heavily relies on managers' ability to comprehend these intricacies, recognize their interplay, and effectively integrate these practices while managing task interdependence. To achieve these results this study was conducted in

Tehran Municipality in 2023.

Literature review

Digital HRM practices, digital transformation, and HRM system strength

Thanks to the pervasive use of computers and digital technologies, some of the most common and talked-about concepts are “digitalization,” “digital transformation,” “digital disruption,” and “digitization.” This is true about human resource management as well; it has transformed traditional HRM into DHRM. And now terms like digitalization, digital transformation, and digital disruption are progressively used in HRM (Pantelidis, 2019; Thite, 2019; Dixit, 2017; Parry and Strohmeier, 2014; Spitzer, 2014; Bondarouk and Ruël, 2009; Ruël and Bondarouk, 2014), and though digital HRM has been going on for more than 50 years and has been meeting its performance expectations, the performance, and its continuation is taken for granted (Theres and Strohmeier, 2023). The adoption of new technologies and the growing trend of corporations introducing e-HRM processes carry with them several benefits and drawbacks that are anticipated by the company, particularly by the HR department and its staff (Ismail *et al.*, 2017; Nikolaou, 2021). The recruitment, selection, and appraisal of employees are some of the most crucial HRM procedures, and these are all immediately impacted by technology, either favorably or unfavorably (Thompson *et al.*, 2008; Nikolaou, 2021). DHRM is a great contributor to the effectiveness of HRM strategy and practices in various organizations (Ruël *et al.*, 2004; Bondarouk and Ruël, 2009; Theres and Strohmeier, 2023). Research findings show that it has a significant positive impact on organization performance and digital innovation (Yusuf *et al.*, 2023), Helps in improving HR’s administrative efficiency, but barely adds anything to assist the advancement of employee competencies, and this is due to the slight disinclination of HR professionals for adopting new technologies (Ruël *et al.*, 2004; Mazurchenko and Maršíková, 2019), and its contribution in helping organizations to gain competitive advantage is based on a change in working style and HR’s competencies (Mazurchenko and Maršíková, 2019). Although it is widely believed that e-HRM deployment will increase organizational productivity, there isn’t much empirical support for this claim. Therefore, further study is needed to

understand better how e-HRM affects organizational productivity and provide measures to evaluate that impact (Poisat and Mey, 2017). Though the constant development of HR digitalization and the pursuit of new avenues for HR excellence and sustainable business performance as necessary conditions for its success is still improving (Sharma *et al.*, 2022), researchers have identified five factors (i.e. internal customer digital needs, industry digital innovation, competitor challenges, digital innovation governance, and digital era needs) that drive the transformation of digital human resource management (Zhang and Chen, 2023). According to Bilgeri *et al.* (2017) and Heilig *et al.* (2017), digital transformation is defined as a significant organizational transition that is enabled, established, or maintained by digital technologies that change how company activities are conducted. It will eventually use digital initiatives to accomplish significant business management reforms, which will have a major impact on an organization or an industry as a whole. Digital transformation alters the whole organization, particularly job duties and business processes (Amit and Zott, 2001). The significance of digital transformation and how it may support companies in maintaining their competitiveness in the market have been brought to light by the growing digitalization of economies. Disruptive innovations, in addition to the business level, have an impact on the environment, society, and institutions (Kraus *et al.*, 2021). Numerous studies have discovered and indicated that digital HRM and digital transformation have a positive association with HRM system strength (Ranjan *et al.*, 2008; Madhavi Lakshmi and Siva Pratap, 2016; Berry and Linoff, 2000; Zhou *et al.*, 2021; Prikshtat *et al.*, 2023). The literature contains a variety of conceptualizations on how people perceive the strength of the HRM system. First, Bowen and Ostroff (2004), In their landmark paper focus on the question of How human resource management systems should be designed and administered in a way that would be effective. They offered a distinction between the HRM process and content. While the process refers to the procedures and structural support that the HR department uses, the content refers to the specific HR practice or collection of practices used to accomplish particular goals. They contend that by taking into consideration the robustness of the HRM system, the relationship between HRM and performance can be better understood. Due to its

duty for the creation and execution of HR policy, the HR department plays a crucial role in this regard (Gues *et al.*, 2013). High degrees of distinctiveness, consistency, and consensus in the messages the HR department communicates are characteristics of a strong system (Bowen and Ostroff, 2004; Hewett *et al.*, 2018; Delmotte *et al.*, 2012), and a strong HRM system is well associated to the psychological concept of strong situation (Cooper and Withey, 2009). The second way that the strength of the HRM system is conceptualized is as an employee's view of the collection of practices that have been put in place. A large number of procedures suggests that the HR division is communicating with an employee about their performance more frequently. This is guided by the theory of motivation which teaches that investing in some forms of HRM practice, which help to achieve intrinsic company values and consequently influence workers' views about their job and the firm is one way by which firms can deliver greater results (White and Bryson, 2013). Third, the quality of HR content, e.g. specific human resource practices, must be taken into account as a criterion for determining the strength of an HR system. A good rating on a particular practice must be accompanied by a strong system, as ratings provide a suggestion of the common view that enhanced systems have been put in place between employees (Stumpf *et al.*, 2010; Veld *et al.*, 2010). Researchers have shown that HRM system strength has a strong positive association with affective commitment (Sanders *et al.*, 2008), and plays a crucial role in shaping the behaviors of employees in the workplace (Dust *et al.*, 2013; Bowen and Ostroff, 2004). While existing studies have shed light on the potential impact of digital HRM practices and digital transformation on HRM system strength (Ranjan *et al.*, 2008; Madhavi Lakshmi and Siva Pratap, 2016; Berry and Linoff, 2000; Zhou *et al.*, 2021; Prikshat *et al.*, 2023), however, these studies primarily concentrated on local context, thus, fail to address cultural nuances, hence, there remains a shortage of cultural nuances of the acceptance of digital transformation and digital HRM practices in the Iranian context particularly in governmental organization and their impact on HRM system strength. Therefore, against this background, the two initial hypotheses are postulated.

H1: digital HRM practices have a significant positive impact on HRM system strength

H2: digital transformation has a significant positive impact on HRM system strength

Digital HRM practices, digital transformation, and digital task interdependence

Increased interactions among coworkers and external stakeholders have led to a greater interdependence in work arrangements. This has resulted in individuals actively participating in the co-designing of work processes to adapt to environmental changes (Kinnie and Swart, 2020). In response to this shift, organizations have begun to explore various work designs, encompassing the structure and organization of work tasks, activities, relationships, and responsibilities (Parker, 2014). This experimentation is not limited to start-ups and technology companies like Spotify and Zappos but extends to other industries and throughout the lifespan of organizations (Laloux, 2014; Lee and Edmondson, 2017). Despite the extensive discussions and debates among scholars and the general public regarding this matter, organizations are inadequately prepared to confront the profound transformations brought about by the emerging work landscape. With the growing trend of breaking down work into individual tasks and projects that can be performed by both machines and contingent workers, organizations are confronted with the challenge of reevaluating their approaches to coordinating and managing work processes (Boudreau and Donner, 2021). It has been argued in current discussions that organizations that fail to recognize the importance of digitalization in shaping the nature of work may become irrelevant in the long run (Li *et al.*, 2020). Salvi *et al.* (2021) emphasize that digitalization has become a widespread global phenomenon that continues to drive changes in job requirements. Notably, the use of AI and augmented reality systems enables organizations to digitally enhance various complex tasks, and core digital tasks that are managed by different interdependent teams can be more efficiently and effectively accomplished (Masood and Egger, 2020). Digitalization not only challenges the way jobs are performed but also enables teams to work interdependently through digital platforms, thereby expediting organizational objectives. Embracing digital leadership strategies is recommended for businesses seeking success in the digital era (Stoldt *et al.*, 2018; Arabiun *et al.*, 2024; Tajpour and Razavi, 2023). HRM practices necessitate

thorough consideration to guarantee their continuous alignment, adjustment, and integration with ever-changing technology, commonly referred to as “smart” HRM (Bondarouk and Brewster, 2016, Strohmeier, 2018). Although traditional HRM approaches retain their viability, however, companies must recognize that the swift evolution of technology is revolutionizing HRM practices. Therefore, its adoption is recommended to retain competitive advantage and cater to the evolving needs of the modern marketplace (Halid et al., 2022), especially from the point of view of teams, in modern organizations, the use of distributed teams made possible by the use of digital technology, and the challenges posed by technology-enabled distributed teams due to digital task interdependence and those of co-located teams are considered to be different (Wong et al., 2019). While the impact of technology on a team’s interdependent tasks is studied, the empirical evidence of the impact of individual digital HRM practices as well as digital transformation on digital task interdependence is scarce. Therefore, it is intended to extend the literature on these concepts and empirically study the impact of digital transformation and digital HRM practices on digital task interdependence, hence, against this ground the formulated hypotheses are:

H3: digital HRM practices have a significant positive impact on digital task interdependence

H4: digital transformation has a significant positive impact on digital task interdependence

Digital task interdependence as a mediator

Task interdependence is a way that people on a team work together. It is all about how much they need to coordinate and share things to get the work done and reach their goals (Liden et al., 2006; Vegt and Vliert, 2005). From a group’s point of view, when tasks are more interdependent, team members need to work together and help each other more to finish the tasks. On the other hand, if the tasks do not depend on each other much, then there is less need for collaboration and it shows that team members can work on their own (Hu and Liden, 2015), in multi-stage programs, the success of the programs and project is dependent upon the association of the team members (Shen et al., 2022), therefore, to enhance linkage and improve organizations’ efficiency and effectiveness,

especially in distributed teams companies are becoming more reliant on technology (Colbert et al., 2016), still, with the increasing use of digital labor and computer-mediated technology, organizations have not yet fully understood how to effectively leverage the benefits of technology and determine the impacts of digitalization on organization’s outcome (Colbert et al., 2016; Alsufyani and Gill, 2022). To leverage the benefits of digitalization and avoid failure BCG recommended inculcating digital transformation in the culture of the organization. Arguing digital transformation without digital culture is doomed to fail (Halid et al., 2022). Consistent with the surge of advancement in digitalization in the companies, digital task interdependence is gaining relevancy as it holds the level to which distinct teams digitally communicate and accomplish their parts as per the shared contribution of data from all teams involved in specified projects (Salvi et al., 2021; Sarc et al., 2019). As a leading digital strategy, digital task interdependence shows new avenues by which diverse teams irrespective of their geographical locations can evaluate, exchange, utilize, and execute defined initiatives digitally to attain specified goals and objectives of the organization (Stoldt et al., 2018), researchers argue that by promoting digital task interdependence across digital platforms this possibly boosts performance, increases speed and lessens the complexity of challenging tasks (Antikainen et al., 2018; Stoldt et al., 2018). The process of digitalization, while advantageous for the overall organizational outcome, may inadvertently impact employee retention rate when they are threatened and become aware that they are in danger of losing their job and therefore start to look for a new job outside their current organization (Salvi et al., 2020), therefore, there is a long way to go to strengthen the relationship between tasks interdependence and turnover intention in the fields of digitization and human resource management, even with the abundance of studies that are available so far (Mahlasela and Chinyamurindi, 2020; Ngo-Henha, 2017; Ogbeibu et al., 2021; Ogbeibu et al., 2022). Against this background, the impact of digitalization can go both ways, as such, digital task interdependence is highly likely to influence HRM system strength, and the study expects that influence to be positive on HRM system strength. Therefore, the suggested hypotheses are:

Table 1: Demographics of respondents

Variables		Percentage
Gender	Man	71/4
	Woman	28/6
Age	Bellow 30 years	35/2
	30 to 40 years	47/3
	41 to 50 years	13/1
	Above 50	4/4
Level of education	Associate degree and below	15/1
	Bachelor	30/4
	Masters and above	50/5
Position	Senior manager	19/1
	Middle manager	51
	Lower-level manager	29/9

H5: digital task interdependence has a significant positive impact on HRM system strength

H6: digital task interdependence mediates the impact of digital HRM practices and digital transformation on HRM system strength.

MATERIAL AND METHOD

This research is classified as applied research based on its purpose. In terms of data collection criteria, it falls under the survey group category. Furthermore, due to the nature of the data, it can be categorized as quantitative research. The research was centered around employees of Tehran municipality as the main focus. The statistical population included the employees of Tehran city municipalities. The selection criteria for municipal organizations in Tehran province were based on the advantages of digital transformation and electronic services, as well as the researchers' accessibility to these organizations. Questionnaires were then distributed among units and individuals knowledgeable about the research topic. To determine the sample size, the researcher utilized SPSS Sample Power, a software that considers research hypotheses and important statistical assumptions related to sampling. The study had impact-based hypotheses. The software examined various scenarios, including 2 independent variables, 1 dependent variable, 1 mediating variable, and 5 basic assumptions. These assumptions included a maximum probability of 5% for the first type of error (Alpha value), a maximum probability of 20% for

the second type of error (Beta value), a test power of 80%, a confidence level of 95%, and a sample size large enough to accurately identify at least 4% of the coefficient of determination (R²) in the statistical population. Based on these considerations, the initial sample size for the research was determined to be 266 individuals. In this study, a total of 300 questionnaires were distributed among the statistical population. The aim was to ensure that the final sample size would be proportional to the sample size calculated by the SPSS SAMPLE POWER software, which recommended a sample size of 266 individuals. Out of the 280 individuals who cooperated in the study, 14 questionnaires were deemed unsuitable for statistical analysis and were therefore excluded. The remaining 266 questionnaires, as suggested by SPSS SAMPLE POWER, were analyzed. It is worth noting that no unanswered data was observed in any of the final 266 questionnaires of the study. Four standard questionnaires with a 5-point Likert scale were utilized as the primary instrument for data collection. The scale ranged from "1" representing "strongly disagree" to "5" representing "strongly agree". The questionnaires for digital human resource management practices were sourced from [Patel et al., \(2013\)](#), while the digital task interdependence questions were obtained from [Ogbeibu et al., \(2021\)](#). The digital transformation questions were based on [Verhoef et al., \(2021\)](#), and the human resource management system strength questions were adopted from [Hauff et al., \(2017\)](#). The collected data was analyzed using SPSS26 and AMOS.

The demographic information of the respondents revealed that 82.5 percent of the employees were below the age of 40 years, and over 50 percent held a master's degree as indicated in Table 1. The results of the sampling method are presented in Figs. 1 and 2. To assess the relationship between variables and draw conclusions from a sample to a larger population, various models such as simple regression, mediator, and path models were utilized to test research hypotheses and the conceptual framework. Ethical considerations were also integrated into the study through several measures, including ensuring

participant confidentiality, using trustworthy sources, and emphasizing voluntary participation.

Conceptual framework

The current study and its theoretical framework have been developed using scientific references and prior research with a fresh structure. As a result, no research has been carried out in Iran on digital transformation, digital HRM practices, and the strength of the HRM system with the mediating role of digital task interdependence based on the studies conducted thus far. Hence, the research's theoretical

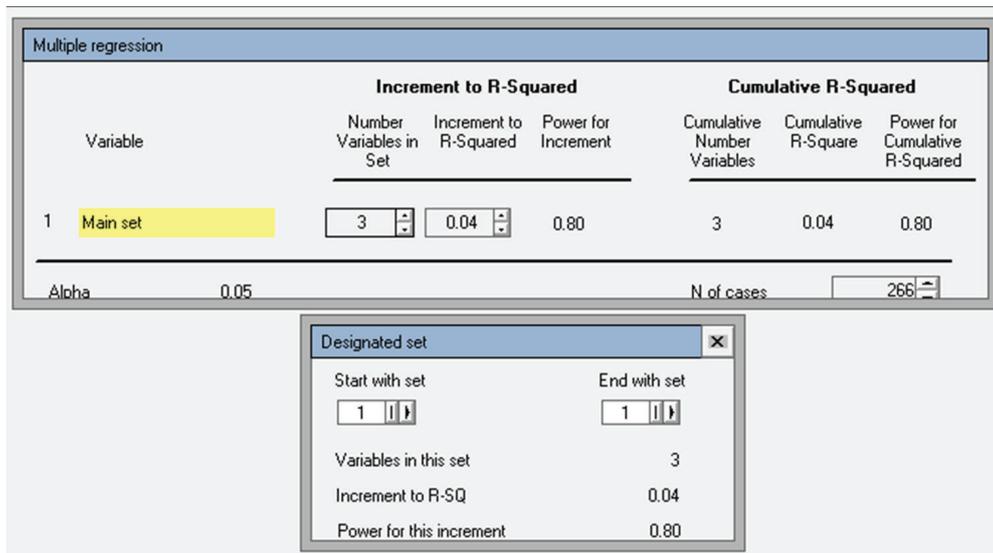


Fig. 1: SPSS sample power sample size estimation output

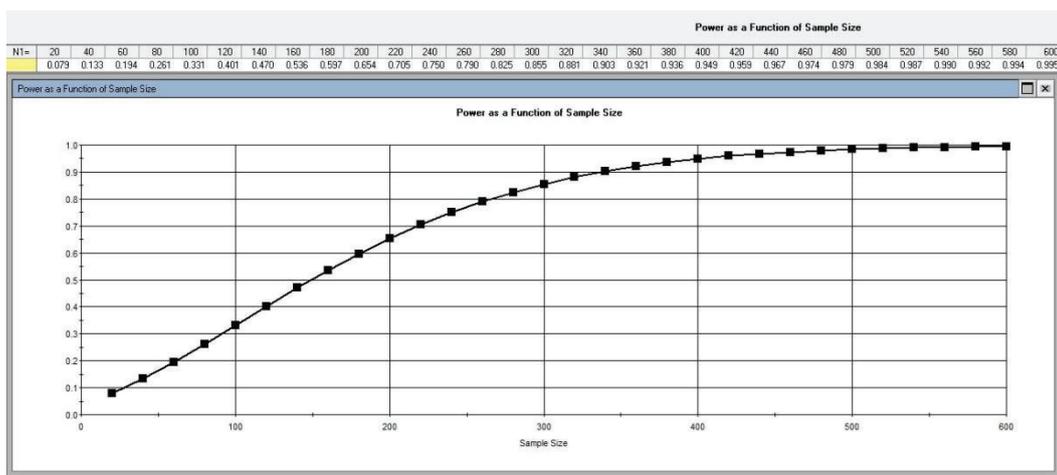


Fig. 2: Estimated sample size

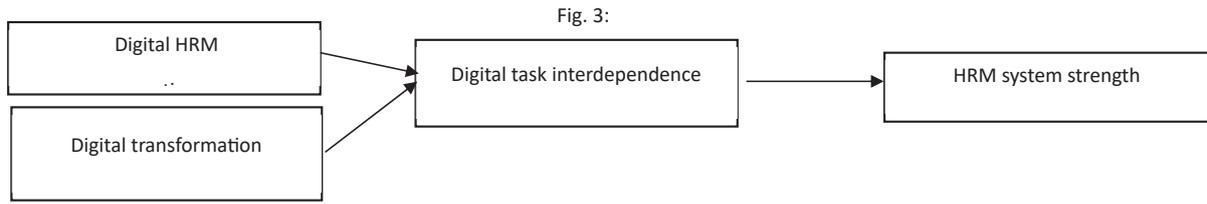


Fig. 3: Conceptual framework

Table 2: Mean and Standard deviation

Variables	mean	Standard dev.
digital human resource management practices	3/98	0/65
digital transformation	3/44	0/78
digital task interdependence	3/60	0/84
human resource management system strength	3/71	0/80

Table 3: Kolmogorov-Smirnov test of normality

Variables	Sig. level	Test Result
digital human resource management practices	0/30	Normal distribution of data
digital transformation	0/18	Normal distribution of data
digital task interdependence	0/12	Normal distribution of data
human resource management system strength	0/16	Normal distribution of data

Table 4: Standardised output of regression weights

Measures	Standardized values	Critical points	Significance level
The impact of digital human resource management practices on human resource management system strength	0/23	5/73	0/0001
The impact of digital human resource management practices on digital task interdependence	0/29	5/37	0/0001
The impact of digital transformation on human resource management system strength	0/16	3/04	0/002
The impact of digital transformation on digital task interdependence	0/33	6/54	0/0001
The impact of digital task interdependence on the strength of the human resource management system	0/12	2/67	0/007

framework has been chosen in line with the existing literature (Fig. 3).

RESULTS AND DISCUSSION

The acquisition criteria of changes in digital human resources management practices, digital transformation, digital tasks interdependence, and human resource management system strength from the average and standard deviation of the population

reported as (3) the highest, which indicates the optimal level.

As per the above test and the significance levels of all variables which are reported to be greater than 0.05, it can be concluded that all variables follow the normal distribution, and parametric tests should be used in this research. To infer the normal distribution of the variables, the Sig. level test was used, which for the variables digital human resource management

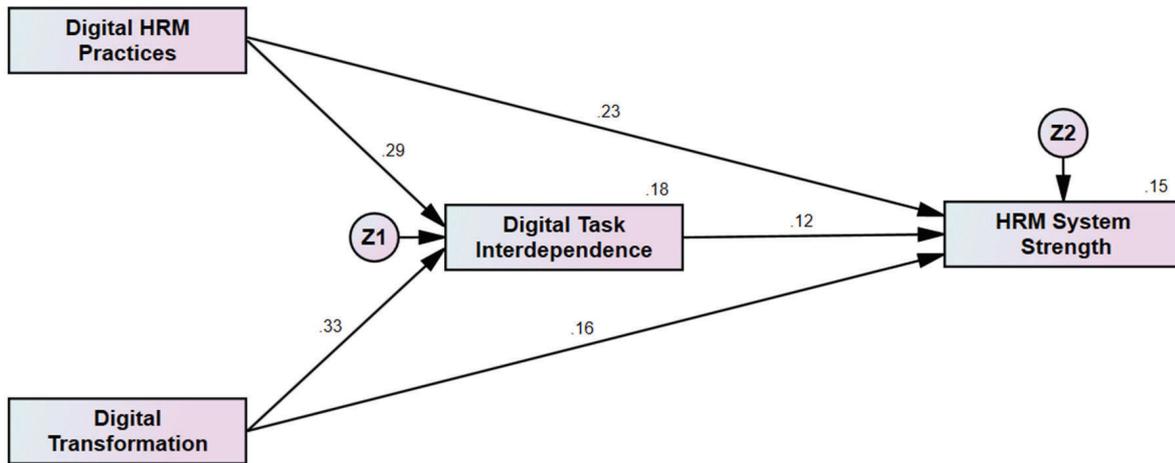


Fig. 4: Research model software output

Table 5: Indirect analysis significance level

Measures	Indirect impact	total effect
The impact of digital human resource management practices on human resource management system strength through the mediating role of digital task interdependence	0/006	0.001
The impact of digital transformation on human resource management system strength through the mediating effect of digital task interdependence	0/003	0.001

practices, 0/30; digital transformation, 0/18; digital task interdependence, 0/12 and for human resource management system strength, 0/16 reported.

Test of hypotheses

Investigating the effect of mediation using a regression model with a hidden variable

“In the effect of digital human resource management practices and digital transformation on the power of the human resource management system, the interdependence of digital tasks has a mediating role”

According to the above model and the output of the regression weights and the values of the significance levels of direct and indirect effects, it can be concluded that the direct effect of digital human resources management practices on the strength of the human resources management system is equal to 0.23 and its significance level is equal to 0.0001. This value is smaller than the error level of 0.05 with confidence of 0.05 and is reported to be significant. Also, the significance level of its indirect effect considering the mediating role of the interdependence variable of digital tasks is reported

to be 0.006 and significant) according to Table 5(. The direct effect of digital transformation on the strength of the human resource management system is equal to 0.16 and its significance level is equal to 0.002, which is smaller than the error level of 0.05 with a confidence of 0.95 and has been reported to be significant. Its indirect effect, taking into account the mediating role of digital task interdependence, is reported to be 0.003 and significant) according to Table 5). In the mediation model, if both the direct and indirect effects are statistically significant, it can be concluded that the mediation is partial. According to the above model and the output of the regression weights and the values of the significance levels of direct and indirect effects, it can be concluded that the indirect effect of digital human resources management practices and digital transformation on the strength of the human resources management system is significant. According to the bootstrap or self-management test that has been used for this model, and also according to the principles governing the discussion of mediation in structural equation modeling in general, it can be concluded that in this model, as both direct and indirect effects of digital

Table 6: Coefficient of determination (R2)

Indicators	R2	Sig. lev.
The impact of digital human resource management practices and digital transformation on human resource management system strength with the mediation of digital task interdependence	0/21	0/02

Table 7: Results of confirmatory factor analysis

Measures	CMIN	CMIN/DF	RMSEA	CFI	TLI	PCFI
Critical value	975.3	1<5	<0/05	>0/90	>0/90	>0/5
Reported value	DF	98/3	04/0	0/92	0/93	0/53
Adjusted value	245	**	**	**	**	**
Measures	PNFI	GFI	AGFI	NFI	NNFI	IFI
Critical value	0/05<	>0/90	>0/90	>0/90	>0/90	0<1
Reported value	0/51	0/93	0/92	0/94	0/91	0/68
Adjusted value	**	**	**	**	**	**
Model fitness	Model is fit					

human resource management practices and digital transformation have been reported to be significant on the strength of human resources management system, it can be concluded that there is mediation and the variable of digital task interdependence in the effect of digital human resources management practices and digital transformation on the strength of human resources management system has a partial mediating role, so The above hypothesis is confirmed.

The results of the confirmatory factor analysis are as follows:

The reliability and validity of the constructs are demonstrated in Table 8. According to Table 8, the AVE values exceed 0.5, thus confirming convergent validity. Additionally, the reliability of the constructs is deemed acceptable based on the composite reliability and Cronbach’s alpha, both of which are above 0.7. This research was conducted to address 6 hypotheses. The first hypothesis examined the degree of influence of the independent variable (digital human resource management practices) on the dependent variable, with a reported value of 5.73. This indicates a suitable level of intensity, and the coefficient of determination (R2) is 0.23, signifying that 23% of the variance in the dependent variable can be explained by the independent variables. Consequently, digital human resource management practices have an impact on the strength of the human resource management system. In general, the results of this hypothesis suggest that the strength of the human resource management system can be predicted based on digital human

resource management practices. These findings align with the studies conducted by Kellogg *et al.* (2020), Bondaruk *et al.* (2017), Levenson (2018), and Garcia-Arroyo and Osca (2021). Moving on to the second hypothesis, the impact of digital transformation on the strength of the HRM system is confirmed. Therefore, digital transformation can enhance the strength of the human resource management system, thus validating this hypothesis. This result is consistent with the studies conducted by Strohmeier (2020), Garcia-Arroyo and Osca (2021), and Cheng and Hackett (2021). The integration of digital technologies into HRM processes can lead to increased efficiency, improved communication, and enhanced employee engagement. This can result in faster and more efficient processes, reducing the time and resources required for HR tasks. For example, digital recruitment platforms can help municipalities quickly identify and attract suitable candidates, while online training programs can provide employees with the skills they need to perform their jobs effectively. Digital transformation, on the other hand, involves the broader adoption of digital technologies across an organization, including HRM systems. This can lead to a more integrated and data-driven approach to HRM, allowing municipalities to make more informed decisions about their workforce. For example, data analytics can be used to identify trends in employee performance, which can inform decisions about training and development. The use of digital technologies in HRM can also improve communication between HR and employees. For example, digital platforms can facilitate more regular and effective communication between managers and

Table 8: Reliability and validity analysis

Variables	Dimensions	Cronbach's alpha	Convergent validity	Composite reliability
Digital human resource management practices	Employees' selection	0/74	0/60	0/79
	Comprehensive education			
	Performance appraisal			
	Fair reward system			
	Flexibility of human resources			
Digital transformation	Organizational ambivalence	0/78	0/65	0/83
	Stages of digital transformation			
	Digital resources			
	Organizational Structure			
	Digital growth strategy			
Criteria and objectives				
human resource management system strength	-	0/77	0/68	0/85
digital task interdependence	-	0/73	0/60	0/80

their teams, leading to increased engagement and job satisfaction. Furthermore, digital tools can help to reduce the administrative burden on HR staff, allowing them to focus on more strategic tasks. In conclusion, digital HRM practices and digital transformation can have a significant positive impact on HRM system strength in municipalities. The confirmation of the third and fourth hypotheses, which examine the influence of digital HRM practices on digital task interdependence and the impact of digital transformation on the interdependence of digital tasks, aligns with the findings of previous studies conducted by Bondarouk *et al.* (2017), Levenson (2018), Esch *et al.* (2019), and Shin and Konrad (2017). The impact of digital HRM practices on digital task interdependence and the effect of digital transformation on the interdependence of digital tasks have been studied in the realm of Human Resource Management (HRM) and organizational dynamics. Results have shown that digital HRM practices, such as the use of technologies like Chatbots, QR codes for job applications, mobile HR applications, data-driven analysis through dashboards, and the integration of artificial intelligence in recruitment processes, play a significant role in transforming how tasks are interconnected in a digital environment. as a result Digital HRM practices have significantly impacted the interdependence of digital tasks in municipalities. The use of digital tools and platforms has enabled employees to work more collaboratively and efficiently, even in the context of task interdependence. Moreover,

the broader scope of digital transformation within organizations, driven by the rapid evolution of technology, has reshaped the landscape of human capital management. The adoption of digital technologies has led to changes in how organizations function, communicate, and compete, ultimately impacting the interdependence of tasks within digital frameworks. Strategies focusing on enhancing employees' digital competencies, cultural shifts, leadership changes, talent management, effective communication, and risk management have been identified as crucial elements in leveraging DHRM practices to optimize task interdependence and achieve competitive advantage in the digital era. as a result The digital transformation has also influenced the nature of tasks within municipalities. For instance, the use of digital tools and platforms has allowed for more efficient and effective communication among team members, which can lead to better task coordination and completion. Moreover, DHRM practices have been found to improve creativity and innovation by bolstering creativity willingness through digital task interdependence. This can be particularly beneficial for municipalities, where creativity and innovation are essential for addressing complex challenges and improving public services. However, digital transformation also presents challenges for HRM practices. For example, the use of digital tools and platforms can lead to changes like HRM tasks, which may require new skills and competencies from HR professionals. The positive and significant direct

impact of digital task interdependence on the strength of the human resource management system (H5) has been reported. Similar findings have been observed in the studies conducted by [Shin and Conrad \(2017\)](#), [Ahmed et al. \(2021\)](#), and [Min et al. \(2022\)](#). This is because digital task interdependence fosters collaboration, communication, and knowledge sharing among employees, which in turn enhances the overall effectiveness of the human resource management system. Digital task interdependence refers to the interconnectedness of tasks within an organization that is facilitated by digital technologies. This interconnectedness can lead to increased collaboration and communication among employees, as they can work together more effectively and efficiently. For example, digital task interdependence can enable employees to work on the same project simultaneously, even if they are located in different physical locations. This can lead to improved decision-making, increased innovation, and a more agile workforce. In the context of municipalities, digital task interdependence can have a significant impact on the delivery of public services. For example, digital task interdependence can enable employees in different departments to work together more effectively to provide integrated services to citizens. This can lead to improved customer satisfaction, increased efficiency, and better outcomes for the community as a whole. In conclusion, By fostering collaboration, communication, and knowledge sharing among employees, digital task interdependence can enhance the overall effectiveness of the human resource management system and contribute to the delivery of high-quality public services. Furthermore, the significant indirect impact of digital human resource management practices and digital transformation on the strength of the human resource management system (H6) has been established. The significance levels, which are lower than the standard level of 0.05, confirm that a portion of the impact of digital HRM practices and digital transformation on HRM system strength is mediated by digital task interdependence (DTI). Therefore, DTI plays a role as a mediator in the relationship between digital HRM practices, digital transformation, and the strength of the human resource management system. These findings are consistent with the studies conducted by [Naqvi et al. \(2021\)](#), [Strohmeier \(2020\)](#), [Levenson \(2018\)](#), and [Esch et al. \(2019\)](#). The digitalization of HRM practices and the implementation

of digital transformation strategies can significantly influence the strength of HRM systems in municipalities. However, the impact of digital HRM practices and digital transformation on HRM system strength is not solely determined by these factors. The role of digital task interdependence is also crucial. Digital task interdependence refers to how tasks and processes are interconnected in a digital environment. By understanding the interconnections between tasks and processes in a digital environment, organizations can more effectively implement digital HRM practices and ensure that their HRM systems are strong and adaptable in the face of changing circumstances.

Discussion

Based on the research conducted by [Kellogg et al. \(2020\)](#), [Strohmeier \(2020\)](#), [Garcia-Arroyo and Osca \(2021\)](#), and [Cheng and Hackett \(2021\)](#), the objective and elements of digital human resources management, as indicated by the dimensions of the questionnaire employed, encompass employee selection. This involves utilizing digitalization methods in the selection and recruitment process to ensure the selection of competent employees with enhanced speed of action and a broader pool of candidates. Additionally, the utilization of digital tools for sourcing, screening, and selecting candidates, such as applicant tracking systems and recruitment platforms based on artificial intelligence, is also being considered. Furthermore, comprehensive training is a key aspect, which entails leveraging digital learning platforms and tools to provide continuous and personalized learning experiences to employees. This includes online courses, micro-training, and virtual training sessions, as well as the design of online and virtual training processes at all levels, thereby enhancing learning outcomes while saving time and resources. Concerning performance evaluation, the utilization of digital performance management systems is incorporated to provide continuous feedback, real-time performance tracking, and data-driven insights. This encompasses the use of performance analysis software and continuous performance evaluation methods. By aligning the collection of performance evaluation indicators with improvement efforts, conclusions can be reached more efficiently while minimizing human error. Additionally, incorporating personal opinions into the performance evaluation process can be facilitated through digital human resources

management systems within the realm of digital performance evaluation. To establish a fair reward system, the aforementioned provisions, which encompass comprehensive performance evaluation and measured indicators, are employed. Furthermore, the implementation of reward and benefits management systems, such as digital payroll systems and total reward platforms, ensures transparency and equity in the distribution of rewards. Concerning workforce flexibility, it encompasses the utilization of digital tools for managing the workforce to facilitate flexible work arrangements. These tools include technologies for remote work, digital communication platforms, and software for employee scheduling. It is worth mentioning that in today's ever-changing and turbulent organizational environment, flexibility plays a crucial role in all aspects of the organization. Similarly, the flexibility of the human resources department is considered the most vital resource for the organization when employing electronic human resources methods. This flexibility aims to enhance operational processes and provide greater freedom of action. Organizational ambidexterity also involves addressing the challenges and opportunities brought about by digital transformation. This is achieved through strategic alignment, change management, and fostering an innovative and adaptive culture. The role of human resource practices in implementing digital transformation is emphasized, as it helps to overcome bureaucratic processes and significantly reduce them through the use of digital human resource management. Furthermore, it is important to consider various dimensions related to digital transformation, such as the stages of digital transformation, digital resources, organizational structure, and digital growth strategy. Digital resources encompass a wide range of tools and resources that are crucial for supporting digital transformation. These resources include collaborative collections, communication tools, CRM systems, and next-generation intranet platforms. The success of digital transformation is also heavily influenced by the organizational structure. It is important to emphasize the significance of a strong organizational structure, effective leadership, and a healthy corporate culture in maximizing the impact of digital transformation. Additionally, insights on the appropriate organizational structure for digital transformation should be provided, along with a focus on creating a digital culture and addressing

organizational elements. In terms of digital growth strategy, it is essential to have a well-defined plan for planning, indexing, and forecasting. This involves identifying the digital areas that provide the most value, profiling online audiences, selecting deployment channels, and aligning the strategy with growth needs and goals. Furthermore, the criteria and goals of digital transformation may vary depending on the specific needs and objectives of each organization. These factors can include enhancing customer experience, improving operational efficiency, and gaining a competitive advantage. Moreover, digital human resource management practices and digital transformation are closely intertwined. Additionally, research has shown that different forms of task interdependence can impact the performance of distributed teams, particularly in digital and asynchronous work environments. Therefore, it is important to integrate digital HRM practices and effectively manage the interdependence of digital tasks. Therefore, The Municipality of Tehran can significantly benefit from implementing digital human resource management practices and undergoing digital transformation. These initiatives can have a significant impact on the strength of human resource management in the organization, particularly concerning the mediation of digital task interdependence. By adopting digital human resource management practices, the Municipality of Tehran can streamline its HR processes, enhance efficiency, and improve data management and analysis. Digital technologies such as HR management systems, applicant tracking systems, and performance management tools can automate manual tasks, reduce paperwork, and provide real-time access to important HR information. This automation and digitization of HR processes can lead to greater accuracy, quicker decision-making, and improved employee experience. Furthermore, digital transformation in human resource management can enable the Municipality of Tehran to leverage advanced analytics and automation to gain valuable insights from HR data. These insights can help in predicting workforce needs, identifying skill gaps, and developing targeted training programs. Digital tools can also facilitate effective communication and collaboration between HR departments and employees, leading to better employee engagement and satisfaction. In terms of mediation on digital task interdependence, digital HR practices can enable

better coordination and collaboration among employees and departments by providing a centralized platform for sharing information, assigning tasks, and tracking progress. This can be particularly beneficial for the Municipality of Tehran, which deals with a wide range of tasks and projects in various sectors such as transportation, infrastructure, and urban planning. By digitizing task management and fostering digital task interdependence, the Municipality can ensure better communication, smooth workflow, and effective resource allocation. Overall, the impact of digital human resource management practices and digital transformation on human resource management strength for the Municipality of Tehran is substantial. It can enhance efficiency, improve decision-making, and foster collaboration and coordination across departments. Digital transformation and digital human resources management practices have a significant impact on the productivity, efficiency, and effectiveness of organizations, including those in urban municipalities like Tehran. The implementation of digital technologies and systems can streamline processes, improve communication, and enhance decision-making, leading to increased productivity and efficiency. In the context of human resources management, digital transformation can facilitate the development and management of human capital, which is a strategic resource for any organization. Digital tools can be used to improve the productivity of human capital by providing training and development opportunities, enhancing communication and collaboration, and enabling more effective performance management. The use of digital technologies in urban management can also help to address challenges related to the provision of infrastructure and social services, as well as to promote sustainable development. For example, digital platforms can be used to improve the coordination of services among different offices and to better respond to the needs of citizens. However, the successful implementation of digital transformation in urban municipalities requires careful planning and management. Challenges such as system integration, data management, and organizational coordination must be addressed to ensure the effective deployment of digital services. Additionally, the role of human resources in the digital transformation process is crucial, as they are responsible for managing and implementing the new technologies and systems. In summary, digital transformation and digital human

resources management practices can have a positive impact on the productivity, efficiency, and effectiveness of urban municipalities like Tehran. However, careful planning and management are necessary to ensure the successful implementation of these technologies and to address the challenges associated with digital transformation in the urban context. The study on the feasibility of an e-learning management system for the staff of Tehran Municipality indicates that electronic learning courses can be an effective method for educating staff in specialized and general qualifications fields, which is required for urban management organizations. This suggests that digital human resources management practices can contribute to the overall productivity and effectiveness of the organization by empowering employees and improving their qualifications. Moreover, the use of digital city concepts has been proposed to enhance human resource performance management, with a focus on the digital city and the prioritization of factors in the Municipality of Tehran. This indicates that digital transformation strategies can play a crucial role in the overall performance of Tehran's urban municipalities. Therefore, the implementation of digital transformation strategies and digital human resources management practices has a positive impact on the productivity, efficiency, and effectiveness of Tehran's urban municipalities. The use of e-learning systems and the adoption of digital city concepts can further enhance the performance of these organizations. The mediation on digital task interdependence further strengthens the overall HR management capabilities, enabling the Municipality to effectively meet its goals and deliver efficient services to its residents. The municipality of Tehran has experienced a significant impact on its human resource management practices due to the implementation of digital technologies. This digital transformation has brought about substantial improvements in the efficiency and effectiveness of HR processes, consequently strengthening the overall human resource management function. One of the critical impacts of digital human resource management practices is the automation of routine HR tasks. This has allowed the HR department to streamline processes such as recruitment, onboarding, payroll management, and performance evaluation. With the integration of digital tools, the municipality can now process these tasks faster, reducing manual errors and enhancing the overall productivity of HR teams. Digital

transformation has also facilitated the collection and analysis of HR data, enabling evidence-based decision-making. The municipality of Tehran can now leverage digital analytics tools to gain insights into various HR metrics, such as employee engagement, turnover rates, and training effectiveness. This data-driven approach strengthens HR management by providing valuable insights for strategic workforce planning, talent development, and retention strategies. Additionally, digital task interdependence has been positively mediated by these practices. By implementing digital tools such as cloud-based collaboration platforms, project management software, and virtual communication tools, HR teams in Tehran's municipality can now collaborate and work on tasks remotely. This has increased flexibility and reduced dependency on physical presence, enabling employees to work together efficiently despite geographical barriers. Digitalizing HR processes has also facilitated communication and engagement between HR and employees. Through the implementation of digital platforms such as employee self-service portals, mobile HR apps, and social media groups, the municipality can now interact with employees on a real-time basis. This improved communication has strengthened the relationship between HR and employees, resulting in increasing employee satisfaction, motivation, and productivity. In conclusion, the impact of digital human resource management practices and digital transformation on the municipality of Tehran has been significant. Implementing digital tools and technologies has improved HR efficiency, decision-making, collaboration, and employee engagement. These improvements have ultimately strengthened the overall human resource management function, bringing positive outcomes for the municipality's workforce.

Implications

The study highlights the significance of digital human resources management practices and digital transformation in enhancing HRM system strength in Tehran municipality by enabling faster, smarter, and more efficient HR processes which ultimately results in greater performance and productivity. The implications of these findings are significant for both researchers and practitioners in the field of HR management. From a theoretical standpoint, it adds to the existing literature by highlighting the

transformative impact of digital technologies on HR systems. It emphasizes the need for organizations to embrace digital HR practices and undergo digital transformation to ensure a more effective HR management system. Additionally, the findings support the notion that digital task interdependence plays a crucial mediating role in strengthening the HR system, suggesting that fostering a collaborative digital work environment is essential. Practically, the findings of this study have several implications for the Tehran municipality. First and foremost, these organizations must invest in digital HR practices and develop capabilities to support their implementation. This involves integrating HR processes with digital tools, providing training and development opportunities for employees to adapt to digital technologies, and making HR information and services accessible through digital platforms. Additionally, Tehran municipality should prioritize digital transformation efforts to optimize its HR systems. This involves utilizing advanced HR technologies, such as AI-powered recruitment software, HR analytics tools, and mobile-based employee management applications. By implementing these technologies strategically, HR departments can streamline their processes, enhance data accuracy, and improve decision-making, all of which contribute to a stronger HR system. Furthermore, the findings emphasize the importance of promoting digital task interdependence among employees. Tehran municipality should encourage a collaborative work environment by utilizing digital collaboration tools, providing opportunities for cross-functional teams, and fostering a culture of knowledge sharing. This will not only strengthen the HR system but also enhance overall organizational performance. In conclusion, the impact of digital human resource management practices and digital transformation on the strength of the human resource management system is evident in Tehran municipality. The study highlights the significant role of digital HR practices, digital transformation, and digital task interdependence in enhancing the effectiveness and efficiency of the HR system. To leverage these benefits, Tehran municipality should invest in digital HR practices, prioritize digital transformation efforts, and foster a collaborative digital work environment.

Practical suggestion

Therefore, the practical procedures provided below for a successful digital transformation and

digital HRM practices implementation are worth considering.

1. Conduct a baseline assessment

Before implementing DHRM practices or embarking on a digital transformation, it is crucial to conduct a comprehensive assessment of the current HRM system. This will help identify existing strengths, weaknesses, and areas for improvement. Gathering feedback from employees and managers through surveys or interviews can provide valuable insights into the organization's needs.

2. Develop a roadmap for digital HRM implementation

Craft a detailed plan outlining the specific steps and timeline for implementing digital HRM practices and digital transformation initiatives. This roadmap should align with the organization's goals and address identified weaknesses. Prioritize the implementation of technologies that have the potential to enhance HRM system strength, such as talent acquisition and development, performance management, and employee engagement tools.

3. Emphasize change management and training

Introduce change management practices to help employees embrace digital transformation. Train HR personnel and other staff members on the effective utilization of digital HRM tools, ensuring they are well-versed in the software, platforms, and processes associated with the adopted technologies. Encourage ongoing learning and professional development to maximize the benefits of digital HRM practices.

4. Foster a culture of collaboration and teamwork

Digital task interdependence plays a significant role in leveraging the benefits of digital HRM practices. Encourage collaboration and teamwork among employees by implementing cross-functional teams, establishing transparent communication channels, and promoting knowledge-sharing. Emphasize the importance of digital task interdependence to ensure the efficient utilization of digital HRM tools. Because Digital task interdependence facilitated by technology promotes collaboration among HR teams and other departments, fostering a more cohesive and integrated work environment

Digital tools can enhance communication, feedback mechanisms, and employee development, leading to higher engagement and satisfaction levels among employees.

5. Monitor and measure the impact of digital HRM practices

Continuously monitor and evaluate the impact of digital HRM practices and digital transformation initiatives on HRM system strength. Utilize key performance indicators (KPIs) and feedback mechanisms to measure progress. Regularly collect and analyze data related to employee satisfaction, productivity, retention rates, and overall HR operational efficiency. Identify areas for improvement and make necessary adjustments to further enhance the HRM system.

6. Encourage employee feedback and participation

Engage employees by seeking their opinions and actively involving them in the decision-making process related to digital HRM practices and digital transformation. Create channels for employees to provide feedback, suggestions, and concerns regarding the implemented technologies, allowing for iterative improvements. Incorporate employee feedback into the continuous improvement cycle of the HRM system.

7. Data-driven decision-making

Digital transformation enables the collection and analysis of HR data, providing insights for strategic decision-making and improving overall HR performance.

8. Improve HR system strength

The adoption of digital HRM practices and digital transformation initiatives can strengthen the overall human resource management system within Tehran city municipalities. This can result in increased agility, responsiveness, and innovation in HR processes, ultimately contributing to organizational success and employee satisfaction. Also Implementing digital HRM practices can enhance the efficiency and effectiveness of HR processes within Tehran city municipalities. This can include the use of digital tools for recruitment, training, performance management, and employee engagement.

9. Using technological advances and technological capabilities at different levels of Tehran Municipality

welcome technological advances to improve human resource performance management with a focus on digital tools and systems. Also, this feature of Hel should be implemented at all levels and in all municipalities in an integrated manner as a digital network.

10. Developing a model

Designing a human resource performance management model appropriate to the requirements of a digital city, emphasizing the philosophy of digital human resource management. Also, under the design of this digital model, the design of salary payment and digital training models should be done.

11. Prioritizing factors

Identifying and prioritizing factors affecting the implementation of electronic human resources management and digital transformation, such as technological, organizational, behavioral, and environmental factors, focusing on the impact of technology.

12. Implementation of digital age approaches

Explain and implement HR performance management models with a Digital Age approach and ensure compatibility with the Digital City framework.

13. Leverage digital transformation

Embrace digital transformation to streamline HR processes, improve communication, and facilitate data-driven decision-making. Utilize technologies such as AI, data analytics, and automation to optimize HR functions.

14. Compliance with regulations

Ensure that all digital HRM practices comply with legal regulations and standards to maintain ethical and legal integrity in managing human resources.

15. Share success stories and best practices

Highlight success stories and best practices that showcase the positive impact of digital HRM practices on HRM system strength. Share these examples through internal communication channels, such as newsletters, intranets, or workshops. This will inspire employees, generate enthusiasm, and contribute to a

culture of innovation and continuous improvement. The impact of digital human resource management practices and digital transformation on human resource management system strength can be observed through the mediation of digital task interdependence, as evidenced in the case study of Tehran municipality. Digital human resource management practices, such as the use of digital technologies in recruitment, training, and performance appraisal, can enhance the efficiency and effectiveness of HR processes, leading to a stronger HR management system. The role of digital task interdependence in this context is significant. Digital task interdependence refers to the interconnectedness of tasks in a digital environment, which can lead to increased collaboration and coordination among employees. This can result in improved performance and productivity, as well as a more agile and responsive HR system. In the case study of Tehran municipality, the implementation of digital technologies in HR practices has led to a more efficient and effective HR system, as well as increased collaboration and coordination among employees. This has contributed to the overall strength of the HR management system and has facilitated the city's digital transformation.

CONCLUSION

One significant impact of DHRM practices and digital transformation on the strength of the HRM system is improved efficiency and effectiveness. Digital technologies enable the automation of various HR tasks such as recruitment, onboarding, performance management, and training. This automation saves time, reduces errors, and allows HR professionals to focus on strategic activities rather than administrative tasks. As a result, the HRM system becomes more potent in its ability to deliver HR services efficiently and effectively. Digital transformation also enhances the quality of HRM data and analytics. Digital tools enable the collection, storage, and analysis of vast HR-related data. This data can be used to gain insights into employee performance, engagement, and satisfaction. By leveraging data analytics, HR professionals can make data-driven decisions, identify trends, and predict future needs. The availability of accurate and timely data strengthens the HRM system's ability to provide evidence-based recommendations and support strategic decision-making. Furthermore, DHRM practices and digital transformation promote

collaboration and communication within the HR function and organization. Digital tools such as collaboration platforms, instant messaging, and video conferencing enable HR professionals to connect and collaborate with ease, irrespective of geographical boundaries. This facilitates knowledge sharing, cross-functional collaboration, and effective teamwork, strengthening the HRM system. Digital task interdependence plays a mediating role in the impact of DHRM practices and digital transformation on the strength of the HRM system. Digital task interdependence refers to the interconnectivity of HR tasks and processes facilitated by digital technologies. It enables seamless integration of various HR functions, promotes cross-functional collaboration, and enhances agility in responding to changing business needs. Reducing task interdependence, digital technologies improve the synergy and coordination among different HR activities, resulting in a stronger HRM system. In conclusion, the impact of DHRM practices and digital transformation on the strength of the HRM system is significant and mediated by digital task interdependence. DHRM practices and digital transformation improve efficiency, effectiveness, data quality, collaboration, and communication within HRM. These benefits are further amplified by digital task interdependence, which enhances integration, coordination, and agility within the HRM system. By leveraging digital technologies and promoting digital task interdependence, organizations can strengthen their HRM systems and improve overall HR effectiveness. Also, electronic government is one of the necessities of today's world, which many countries seek to establish. The innovative municipality is based on the development of digitalization in municipalities and the electronicisation of human resource management measures based on using advanced software and hardware technologies based on networks and telecommunications to exchange resources and financial information electronically, which does not require physical presence. There are no customers, employees, or clients in the branch. According to the findings of the research, it can be stated that municipalities with an approach aligned with the organization's strategy, the dimensions of human resource management, and the benefits of digital transformation can provide the basis for the optimal implementation of electronic human resource management to strengthen the overall human resource

management system. Municipalities must be aware of digital transformation, implement digital human resource management that encourages employee behaviors, and strengthen the power of the HRM system in search of superior performance by establishing the interdependence of digital tasks between different organizational units. One of the most critical parts that can contribute to the strength of Tehran's municipal systems is its human resources management system. Therefore, along with the electronic management of human resources, it is critical to create a platform for digital transformation in terms of preparing the fields needed for digitalization. In addition, while achieving a powerful human resource management system can be designed to facilitate communication between different departments of municipalities and thus make daily work easy, in a city with a traditional structure, this is doomed to failure. Therefore, the need for the requirements of digital transformation is doubly felt. Also, considering the interdependence of digital tasks, performing tasks and affairs electronically in municipalities can play an important role in the connection between digital transformation and electronic human resources management.

AUTHOR CONTRIBUTIONS

A. Gholipour reviewed and supervised the article; H.R. Nematollahi carried out the software part and methodology; N. Mohammadesmaeili performed editing and interpretation of the results; H. Mohammadi did the literature review and collaboratively with H.R. Nematollahi conceptualized the model and wrote the entire 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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ABBREVIATIONS (NOMENCLATURE)

AI	Artificial Intelligence
AMOS	Analysis of Moment Structures
AVE	Average Variance Extracted
CR	Composite Reliability
DHRM	Digital Human Resource management
DT	Digital Transformation
DTI	Digital Task Interdependence
HR	Human Resources
HRM	Human Resources Management
HRMSS	Human Resources Management System Strength

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ORIGINAL RESEARCH PAPER

Exploring the role of place attachment in shaping urban development meanings in peripheral settlements

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ABSTRACT

BACKGROUND AND OBJECTIVES: This study investigates the intricate connections that exist between place attachment, urban development meanings, and acceptance in urban peripheral settlements. The research aims to gain a better understanding of how people perceive and respond to urban development scenarios in the periphery using the tripartite frameworks of place attachment and the disruption-response model.

METHODS: Utilizing a mixed-methods approach, this study examines people's perceptions and reactions to four hypothetical urban development scenarios by combining qualitative interviews with key participants and then quantitative surveys administered to 256 adult residents of selected peripheral settlements in the rapidly developing city of Malang, Indonesia.

FINDINGS: The findings from the qualitative phase, reveal diverse dimensions shaping the meaning of urban development, encompassing economic, social, cultural, livelihood, and environmental impacts. The survey results' exploratory factor analysis reveals latent factors that capture diverse perspectives on development scenarios, from societal and environmental harm to economic modernization and advancement. The structural equation model reveals that place attachment emerges as a significant predictor of urban development scenario meanings, although the relationship varies across different scenarios. Furthermore, the level of acceptance of urban development scenarios mediates the relationship between place attachment and interpretations, influencing perceptions of economic, social, and environmental impacts. Subsequently, the implications of these findings for existing literature were discussed.

CONCLUSION: This study fills a gap in the disruption-response model by illuminating the interpretation process and showcasing the interplay of place attachment, urban development meanings, and acceptance in peripheral city settlements. Limitations of the study were discussed, and future studies were proposed.

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INTRODUCTION

In the contemporary context of urban development, the intricate interplay between communities and their evolving environments has assumed paramount importance (Gu, 2019). These transformations, though often viewed as positive, can also lead to solastalgia, contributing to a decline in overall well-being (Galway et al., 2019; Phillips and Murphy, 2021). Conversely, rapid urban development predominantly occurs in peripheral settlements of cities (Portnov and Pearlmutter, 1999), particularly evident in developing nations like Indonesia (Firman, 2002). As cities expand and urban development reshapes the landscapes of peripheral settlements, understanding how residents perceive these changes becomes increasingly imperative. Place attachment, characterized by the cognitive, emotional, and behavioral bond individuals form with their surroundings (Scannell and Gifford, 2010), emerges as a pivotal factor in understanding how residents perceive environmental changes (Devine-Wright, 2009; van der Star and Hochstenbach, 2022). The degree of neighborhood place attachment significantly shapes their perceptions, attitudes, and responses as environmental changes unfold (Lewicka, 2011). The significance of place attachment in confronting environmental changes stems from its capacity to serve as a safeguard for community identity, cultural heritage, and a shared sense of belonging (Junot et al., 2018). Conversely, a weak place attachment may fuel resistance, anxiety, and potentially even displacement in response to environmental changes (von Wirth et al., 2016). Disruption in place attachment occurs when environmental changes create enough power to make deep changes in place attachment dimensions (Brown and Perkins, 1992). Time spent, subjective perceptions, and objective physical characteristics of residential complexes are three key factors directly impacting place attachment (Motalebi et al., 2023). Changes in these factors are posited as potential disruptors of place attachment. Among these, time spent in a place has been identified as the most influential factor in developing place attachment (Lewicka, 2011), followed by changes in subjective physical characteristics (Reese et al., 2019), and objective physical attributes (Jacquet and Stedman, 2014). As urban development reshapes the landscapes of peripheral settlements, it holds significant potential to disrupt the place attachment of residents in these areas. Understanding the dynamics of place

attachment from a process-oriented perspective is essential for advancing scientific knowledge in this field (Lewicka, 2011). Studies related to disruption in place attachment have primarily been examined in various settings, including stable rural communities (Raymond et al., 2010), evolving urban neighborhoods (B. Brown et al., 2003; von Wirth et al., 2016), and shrinking rural regions (van der Star and Hochstenbach, 2022). Furthermore, research has predominantly focused on urban and rural areas. Additionally, much of the existing place attachment research has investigated environmental changes resulting from war (Boğaç, 2009; Lewicka, 2008), disasters (Clarke et al., 2018; Zheng et al., 2019), and climate change (Scannell and Gifford, 2013). As a concept rooted in the relationship between people and place, with a focus on place meaning (Stedman, 2003), place attachment has the potential to significantly influence the interpretation of changes in a place. However, the role of place attachment in shaping the interpretation of urban development in peripheral areas remains relatively understudied. This study aims to explore the influence of place attachment on the interpretation of urban development scenarios in peripheral settlements, offering insights into how urban peripheral communities respond to urban development as a disruptor of their place attachment. By elucidating how place attachment influences perceptions of and responses to urban development, this study endeavors to inform strategies and interventions aimed at fostering sustainable development practices that preserve community identity and well-being in peripheral urban areas.

Place attachment and interpretation of environmental change

Place attachment is conceptualized through three dimensions of PPP (the person dimension, the psychological process dimension, and the place dimension) (Scannell and Gifford, 2010). Operationalizing place attachment typically involves psychological dimensions such as place affect, place identity, and place dependence, as outlined by Cole et al. (2021) and Scannell and Gifford (2013). These concepts are integral components within the disruption-response framework, serving as direct inputs into the interpretive processes of environmental changes (Mihaylov et al., 2020). Individuals' perceptions of urban development are



Fig. 1: Conceptual framework of the first hypothesis



Fig. 2: Conceptual framework of the second hypothesis

not solely influenced by the objective nature of the occurrence; rather, they are also shaped by their place attachments, which can either foster local acceptance or opposition to urban development. Studies have indicated that place attachments play a significant role in the explanation of social acceptance of energy proposals (Devine-Wright, 2009; Vorkinn and Riese, 2001). Place attachments can even act as barriers to communication regarding environmental disruptions (Scannell and Gifford, 2013). The interpretive process often involves the analysis and interpretation of various sources of information, experiences, and contexts (Devine-Wright, 2009). The concept of place meaning holds central importance within the framework of place attachment (Stedman, 2003). It encompasses the socially constructed and negotiated boundaries of a place, along with the qualities and attributes that imbue it with a distinct meaning and identity in the perception of its inhabitants (Lewicka, 2011). However, it is contended that changes in environmental meaning possess the potential to intersect with place meaning, as the alignment of change with place meanings determines its acceptance or rejection (Mihaylov *et al.*, 2020). For example, responses opposing certain environmental projects (Devine-Wright and Howes, 2010) or supporting others (Devine-Wright, 2011) are heavily influenced by these meanings. Conversely, urban development endeavors typically adhere to sustainability objectives as their main meaning (Wei *et al.*, 2015), which commonly align with its fundamental pillars of development (Murphy, 2012; Sabatini, 2019). Consequently, it is argued that the acceptance or rejection of different urban development projects and the disruptions they entail depend not only on the projects themselves but also on their meaning to the local community.

Building upon this premise, the research aims to systematically evaluate two hypotheses. Hypothesis 1; the role of place attachment as a determining factor in shaping the distinctive meanings associated with urban development projects, particularly those implemented in peripheral urban areas (Fig. 1). It is envisaged that the dynamics of meaning generated by these projects will interact with place attachment in varied and possibly unpredictable ways. Consequently, the influence of place attachment on the meaning of urban development may be contingent upon specific project contexts. Hypothesis 2; it is posited that in cases where a significant association between place attachment and the meaning of urban development is not observed, there may exist a mediating variable influencing this relationship. Urban development acceptance, reflective of the community's acceptance of change and the compatibility of such change with place meanings (Mihaylov *et al.*, 2020), is proposed as a potential mediator (Fig. 2). This study endeavors to furnish empirical evidence to substantiate these hypotheses and shed light on the nuanced interplay between place attachment, urban development meanings, and acceptance.

MATERIALS AND METHODS

This study mainly employs quantitative methods, utilizing hypothetical urban development scenarios in surveys. This cross-sectional approach is chosen to mitigate the potential influence of coping mechanisms on the role of place attachment in shaping the perception of urban development. However, recognizing that meaning inherently involves qualitative aspects (Rapoport, 1990), this study also integrates qualitative methodology. Therefore, as a whole, the research employed a mixed-methods

approach, integrating qualitative and quantitative techniques. The integration of both quantitative and qualitative methods enhances the richness and depth of the research findings, offering valuable insights for theory development and practical implications. The hypothetical urban development scenarios were selected based on several considerations: Firstly, they needed to concentrate on fixed features of the environment. Secondly, they were selected for their high likelihood of occurring in the research locus environment, yet they should not have transpired within the boundaries of the research settlements. Additionally, the scenarios were required to have a significant, widespread impact across settlements, affecting the entire population. They also needed to be easily comprehensible by the general public, making them potentially applicable to other similar settings. Importantly, the scenarios were devoid of any political or religious elements and were neutral towards any particular groups. To obtain a comprehensive understanding, multiple scenarios were employed to assess model consistency and validate the research framework. Thus, the study selected four distinct urban development scenarios that had not yet materialized in the study locations: 1) the emergence of formal housing (G. Brown *et al.*, 2004; Puspitasari, 2013); 2) the emergence of new city streets (Song *et al.*, 2016); 3) the loss of public open space (Harun *et al.*, 2015); and 4) the loss of trees or other vegetation (Fatma and Deguchi, 2016; Lavy and Zavar, 2023). The sampling strategies for each stage are distinct. During the qualitative phase, peripheral settlement leaders serve as primary participants and undergo in-depth interviews. These key participants are chosen to represent residents of the neighborhood, as they often recognize and represent public opinion on various occasions. In the quantitative phase, surveys are administered to the research sample, which comprises residents of the peripheral settlement. Criteria were set, including individuals aged 18 and above, residing in the study sites for a minimum of two years, to ensure that respondents' place attachment was sufficiently established (Clark *et al.*, 2015), facilitating a deeper understanding of their perceptions and responses to urban development scenarios. The sampling method involved a priori power analysis conducted using the *g*power* program (Faul *et al.*, 2007), which calculated an N of 54 to detect a medium effect size of 0.5, deemed appropriate for the mean, with a

power of $1-\beta = 0.95$. To ensure an adequate number of respondents, it was recommended to recruit a minimum of 54 respondents for each hypothetical scenario as an independent variable condition. Hence, for the four urban development scenarios, a minimum of 216 respondents are required. Respondents completed the questionnaire in their homes under the observation of the researcher, who led them through the process of involvement. The respondents were also shielded by the researchers so that their answers were free of outside interference. A total of 256 adult residents (128 from each hamlet) were recruited for the study. Four of the 256 individuals in the study had to be eliminated because they completed the questionnaire in an evident way by answering the question trap incorrectly. This question is intended to confirm that respondents are reading the questions rather than simply marking off the answers. 53% of the 252 individuals who identified as female. Their age was 37.6 years old on average (SD = 12.65). Farmers made up the bulk of respondents (37.7%), followed by workers in the private sector (27.7%), and self-employed (21.8%). Others were civil servants who had retired, were looking for jobs, were in school, or were doing something else. The typical resident of the town stayed for 29.20 years (SD = 16.18). The study locus was urban periphery settlements situated within a rapidly developing city as its focal point. The chosen settlements were chosen with specific criteria: they should have historical roots predating the city's urban development, existing before the establishment of the city itself. If multiple settlements were considered, they needed to belong to the same subculture. The research site chosen for this study is Malang City, situated in East Java, Indonesia. Malang City is recognized as one of Indonesia's largest and fastest-growing cities, particularly on its outskirts (Mahendra and Pradoto, 2016). To ensure the effectiveness of the study, respondents were required to reside in peri-urban settlements that had experienced minimal influence from Malang City's urban development initiatives. From the 41 inner-city periphery settlements identified within Malang, two settlements were chosen as representative study sites: Baran Tempuran and Baran Tlogowaru (Fig. 3). The decision to include two settlements was driven by the insufficient number of eligible research respondents from a single settlement. However, given that both settlements belong to the same subculture and share similar settings, their data

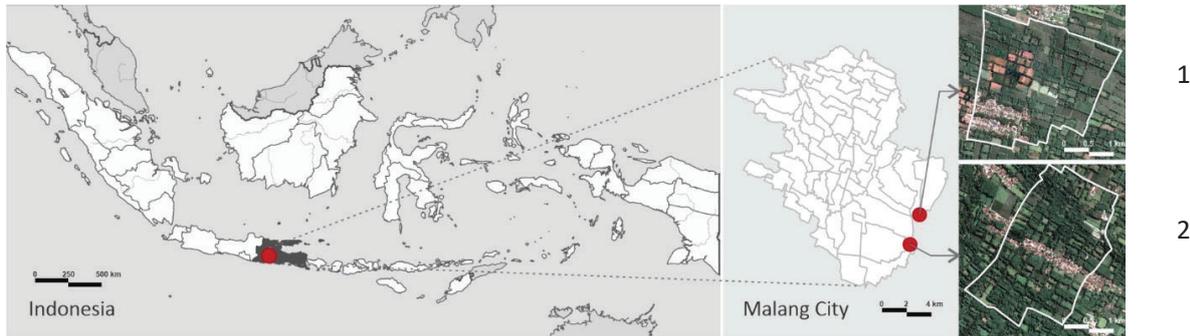


Fig. 3: Location and map of Baran Tempuran (1) and Baran Tlogowaru (2)

were amalgamated for analysis.

To assess the meaning of urban development scenarios, a qualitative stage was conducted through in-depth interviews. The main question posed during these interviews was, “What do you perceive as the meaning of urban development that will occur in your settlement?” The interview responses were subsequently subjected to exploratory coding, drawing upon categories of urban development (Basiago, 1999; Giddings *et al.*, 2002) and sustainable urban growth in peripheral areas (Portnov and Pearlmutter, 1999). The outcomes of this coding process were then utilized as indicators in the questionnaire. Utilizing the same question from the qualitative phase and incorporating it into the questionnaire, respondents were asked to provide answers by assessing these indicators on a 6-point Likert scale. To assess place attachment, a 19-item place attachment scale adapted from previous studies (Scannell and Gifford, 2013, 2017) was utilized. Respondents provided their responses on a 6-point Likert-type scale, with 1 indicating strong disagreement and 6 denoting strong agreement. Some indicators were adopted by incorporating the Indonesian local concept to address the concept of place attachment according to previous research suggestions (A. F. Nazaruddin, 2017; F. Nazaruddin *et al.*, 2023). The total place attachment was computed using the mean of the subscales. The scale demonstrated Cronbach’s alpha values of 0.86 indicating excellent reliability. The level of acceptance of urban development scenarios was assessed using a single indicator: “happy with the scenario.” Respondents rated their level of acceptance on a 6-point Likert scale. The statistical analysis employed in the research was Exploratory Factor Analysis (EFA), which delved into the meaning of urban development scenarios. EFA was chosen

for its ability to uncover latent factors capturing multifaceted views on development scenarios without bias. Before conducting Exploratory Factor Analysis, data underwent Parallel Analysis to detect patterns of variation. Items with weak or unclear relationships to any specific factor were removed to enhance focus on the underlying factors. The indicators were required to demonstrate significance with the Kaiser Meyer Olkin Measure of Sampling Adequacy (KMO-MSA) > 0.5 and Bartlett’s test significance $p < 0.001$, validating the appropriateness of exploratory factor analysis (Williams *et al.*, 2010). Subsequently, model testing was carried out using regression analysis and mediation in Structural Equation Modeling (SEM) with the JASP software, renowned for its reliability and open-source nature (Faulkenberry *et al.*, 2020). SEM was chosen as the most suitable analysis for model testing (Kline, 2016). All mediation analyses in this paper were performed 10,000 times using bootstrapping. The goodness-of-fit indexes for the model used were Comparative Fit Index (CFI) > 0.95, Tucker-Lewis Index (TLI) > 0.95, Root Mean Square Error of Approximation (RMSEA) < 0.5, and Goodness of Fit Index (GFI) > 0.95. These indexes and their scores are deemed as evidence for model suitability (Byrne, 2001).

RESULTS AND DISCUSSION

The results of the qualitative phase and coding analysis unveiled themes encompassing the economic, social, cultural, livelihood, and environmental impacts of urban development. These themes resonate with the meaning of urban development found in previous research (Parris and Kates, 2003; Portnov and Pearlmutter, 1999), which align with the four pillars of sustainable development (Sabatini, 2019). To

Table 1: EFA of the meaning of urban development scenario #1

Factor Loadings Scenario #1	economic improvement and modernization
Increase the economy (economy)	0.759
Modernization (supporting culture)	0.756
Add social (social input)	0.612
Damage to the environment (environmental impact)	-0.48
Bad social influence (negative social impact)	-0.404
Add beauty (positive environmental impact)	0.361
The old culture is lost (culture transformation)	-0.35

Note: MSA: 0.712. Bartlett's test: P <.001. RMSEA 0.121 (RMSEA 90% Conf 0.044 – 0.195)

Table 2: EFA of the meaning of urban development scenario #2

Factor Loadings Scenario #2	social and environmental damage	social and cultural growth
Bad social influence (negative social impact)	0.723	
Add beauty (positive environmental impact)	-0.578	
Damage to the environment (environmental impact)	0.47	
Add new culture (cultural infusion)		0.627
Add social (social input)		0.55
Modernization (supporting culture)		0.449
The old culture is lost (culture transformation)		0.32

Note: MSA: 0.631. Bartlett's test: P <.001. RMSEA 0.0 (RMSEA 90% Conf 0.0 – 0.84)

elaborate, the themes are delineated as follows:

1. Social: Encompasses social inputs and effects.
2. Cultural: Involves cultural infusion, cultural transformation, and modernization.
3. Economy: Pertains to economic progress.
4. Environmental impact: Encompasses both positive and negative environmental effects.

The results of the quantitative phase of the research reveal the following regarding the meaning of urban development Scenario #1 (the emergence of formal housing): The indicator of cultural infusion has been removed, and the remaining indicators displayed a KMO-MSA of 0.712 and Bartlett's test indicated significance with $p < 0.001$ from parallel analysis, indicating suitability for EFA. EFA unveiled a single latent factor, explaining 31% of the variance. The factor loading indicates that residents perceive formal housing developments as a means to economic improvement and modernization for their neighborhoods. This factor structure is perceived to have both advantages and disadvantages. Consequently, based on the indicators of scenario #1, the research interprets it as "Economic Improvement and Modernization". (Table 1).

The meaning of urban development Scenario

#2 (the emergence of new city streets) is as follows: After removing the indicator of economic progress for adjustments, the remaining indicators displayed a KMO-MSA of 0.631, with Bartlett's test indicating significance at $p < 0.001$. EFA uncovered two latent factors for the meaning of urban development scenario #2. The first factor reflects residents' concerns about the negative societal and environmental impacts caused by city street developments. The second factor pertains to the cultural and social infusion aspect. The first factor accounts for 19% of the variance, while both factors together explain 34.3% of the variance. Interpretively, scenario #2 signifies 'social and environmental damage' for the first factor and 'social and cultural growth' for the second, based on the constituent indicators (Table 2).

The meaning of urban development Scenario #3 (the loss of public open space) is as follows: After removing the indicator representing cultural transformation, the remaining questioned indicators displayed a KMO-MSA of 0.658, with Bartlett's test indicating significance at $p < 0.001$. Parallel analysis results suggest that EFA was valid for the remaining indicators. EFA identified two latent factors for scenario

Table 3: EFA of the meaning of urban development scenario #3

Factor Loadings Scenario #3	modernization and improvement of socio-economy	destroying the society and environment
Modernization (supporting culture)	0.728	
Add social (social input)	0.698	
Increase the economy (economy)	0.527	
Add beauty (positive environmental impact)	0.45	
Add new culture (cultural infusion)	0.318	
Bad social influence (negative social impact)		0.675
Damage to the environment (environmental impact)		0.572

Note: MSA: 0.658. Bartlett's test: $P < .001$. RMSEA 0.05 (RMSEA 90% Conf 0.0 – 0.16)

Table 4: EFA of the meaning of urban development scenario #4

Factor Loadings Scenario #4	modernization and economic development
Modernization (supporting culture)	0.854
Increase the economy (economy)	0.753
Add social (social input)	0.43
Add beauty (positive environmental impact)	0.411
Bad social influence (negative social impact)	-0.3
Damage to the environment (environmental impact)	-0.205
The old culture is lost (culture transformation)	-0.035

Note: MSA: 0.66. Bartlett's test: $P < .001$. RMSEA 0.0 (RMSEA 90% Conf 0.0 – 0.117)

#3. The first factor represents public open space loss as a symbol of modernization and socio-economic enhancement. Conversely, the second factor reflects the scenario's negative societal and environmental impact. The first factor accounts for 26% of the variance, with both factors combined explaining 39% of the variance. Interpreted as "Modernization and Socio-Economic Enhancement" for the first factor and "Societal and Environmental Damage" for the second, based on scenario indicators (Table 3).

The meaning of urban development Scenario #4 (the loss of trees or other vegetation) is as follows: The cultural infusion indicator was deleted, and the indicators in question have indicated exploratory factor analysis validity with KMO-MSA of 0.660 and Bartlett's test $p < 0.001$. EFA on observed indicators unveiled a single hidden factor. Various indicators highlight strong associations with modernization and economic improvement through loading factors. Conversely, negative components signify scenario #4's drawbacks. Interpreting scenario #4, considering its indicators and pros and cons, it can be labeled as 'Modernization and Economic Development.' This factor accounts for 25.6% of the variance (Table 4).

The place attachment scale indices were created by initially reverse-coding negatively phrased items.

The scale items had no missing data. To facilitate interpretation, the items on the scale were summed and averaged, ensuring that scores remained on a continuum spanning from 1 to 6. Residents in all four scenarios indicated relatively high degrees of place attachment, with mean scores ranging from 5.147 to 5.301 (Fig. 4).

In the correlation analysis of the sample's demographic characteristics with place attachment, several key findings emerge. Firstly, the length of stay exhibits a positive correlation with place attachment, indicating that longer stays are associated with higher levels of attachment to the place. Secondly, family status demonstrates a positive correlation with place attachment, suggesting that larger family sizes are linked to higher levels of attachment to the place. Thirdly, education level shows an inverse correlation with place attachment, indicating that individuals with lower levels of education tend to exhibit higher levels of attachment to the place. Lastly, the proximity of income source to the location exhibits a positive correlation with place attachment, indicating that individuals whose income sources are closer to their place of residence tend to have higher levels of attachment to the place. However, gender, age, and source of income do not show significant correlations

The role of place attachment in shaping urban development meanings

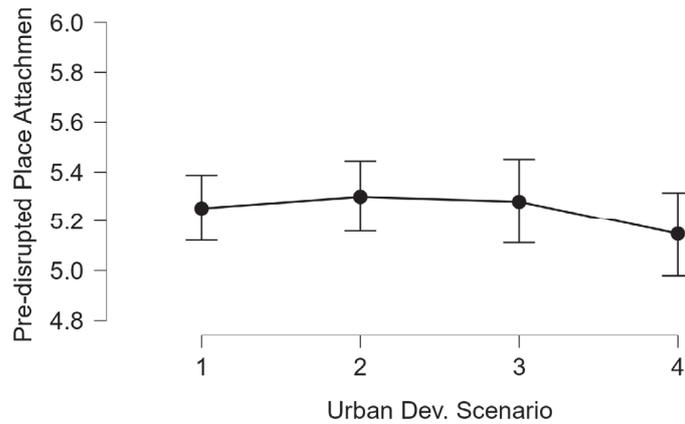


Fig. 4: Descriptive plot of place attachment in four scenario groups (source: ANOVA analysis)

Table 5: Pearson’s correlations demographic data of the respondents with Place attachment

Variable	Place Attachment	
Age	0.123	
Length of Stay	0.347	***
Family Status	0.206	***
Gender	0.027	
Source of Income	0.101	
Education	-0.231	***
Location of Income	-0.169	**

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

Table 6: Paired Samples T-Test place attachment in four scenario groups

Measure 1	Measure 2	t	df	p
Place Attachment Group Sc #1	- Place Attachment Group Sc #2	-0.338	58	0.737
Place Attachment Group Sc #1	- Place Attachment Group Sc #3	-0.577	58	0.566
Place Attachment Group Sc #1	- Place Attachment Group Sc #4	0.992	58	0.325
Place Attachment Group Sc #2	- Place Attachment Group Sc #3	0.202	66	0.840
Place Attachment Group Sc #2	- Place Attachment Group Sc #4	1.21	58	0.231
Place Attachment Group Sc #3	- Place Attachment Groop Sc #4	1.54	58	0.129

with place attachment in this context (Table 5).

The paired sample T-test analysis conducted on all four groups revealed no significant impact on group placement of the attachment scale. This uniformity of place attachment results across all groups, regardless of the scenario group that occurs, indicates that there is no significant difference. Therefore, the data results may be regarded as the same across all scenarios (Table 6).

The acceptance of urban development scenario #2 was shown to be the most favorable among the other situations, with a mean score of 4.97 and a standard deviation of 1.015 (Fig. 5).

Regression: First hypothesis

The results of the regression analysis using Structural Equation Modeling (SEM) following the conceptual framework of the first hypothesis are as follows:

For urban development scenario #1, the regression analysis indicated that place attachment did not significantly predict the meaning of urban development scenario #1, labeled “Economic Improvement and Modernization” (p = 0.578) (Table 7). This indicates that people who feel strongly about their community are more likely to support policies that encourage economic growth, however, because

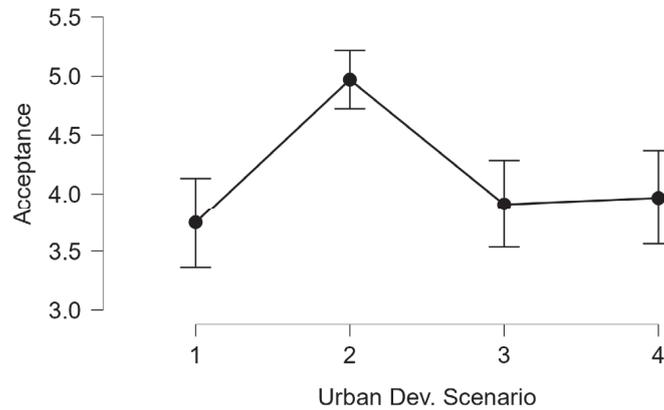


Fig. 5: Descriptive plot of Acceptance of the scenarios (source: ANOVA analysis)

Table 7: Regression coefficients of place attachment and the meaning of scenario #1

Scenario #1 Regression coefficients						95% CI		Std
Predictor	Outcome	Est.	Std. Error	z-value	p	Lower	Upper	All
Place Attachment	Economic Improvement and Modernization	0.023	0.041	0.556	0.578	-0.058	0.103	0.017

Note: CFI = 0.969, TLI = 0.966, RMSEA = 0.077, GFI = 0.93



Fig. 6: The result of the path model in Scenario #1 for the first hypothesis

this is not statistically significant, the evidence for this is weak.

For urban development scenario #2, the results of the regression analysis are that place attachment did not significantly predict “Social and Environmental Damage” from the meaning of urban development scenario #2 ($p = 0.085$). This suggests that individuals with a strong connection to their place are less likely to engage in actions that harm their communities. However, the evidence for this relationship is weak, as it is not statistically significant. On the other hand, place attachment did significantly predict “Social and Cultural Growth” ($p = 0.001$) (Table 8). This implies that residents with a strong attachment to their place are more likely to experience favorable social and cultural growth.

For urban development scenario #3, the results of the regression analysis show that place attachment significantly predicted the latent factors “Modernization and Improvement of Socio-Economy” ($p < 0.001$) and “Destroying Society and the Environment” ($p < 0.001$)

from the meaning of urban development scenario #3 (Table 9). This indicates that individuals with a strong place attachment are more likely to support policies that foster modernization and socio-economic growth. However, even if a change is advantageous to the community as a whole, individuals with high place attachment may be less open to it. Additionally, they might be more inclined to oppose laws that, in their opinion, threaten the environment or alter their way of life.

For urban development scenario #4, the results of the regression analysis indicate that place attachment was also a significant predictor of the significance of urban development scenario #4, labeled “Modernization and Economic Development” ($p < 0.001$) (Table 10). Therefore, individuals who feel a stronger attachment to a place are more likely to favor modernization and economic growth. All regression analyses demonstrated favorable goodness-of-fit indexes, affirming the suitability of the model.

The regression analyses suggest that the

Table 8: Regression coefficients of place attachment and the meaning of scenario #2

Scenario #2 Regression coefficients		Est.	Std. Error	z-value	p	95% CI		Std All
Predictor	Outcome					Lower	Upper	
Place Attachment	Social and Environmental Damage	-0.062	0.036	-1.724	0.085	-0.132	0.008	-0.133
Place Attachment	Social and Cultural Growth	0.132	0.041	3.251	0.001	0.053	0.212	0.286

Note: CFI = 0.971, TLI = 0.968, RMSEA = 0.076, GFI = 0.941

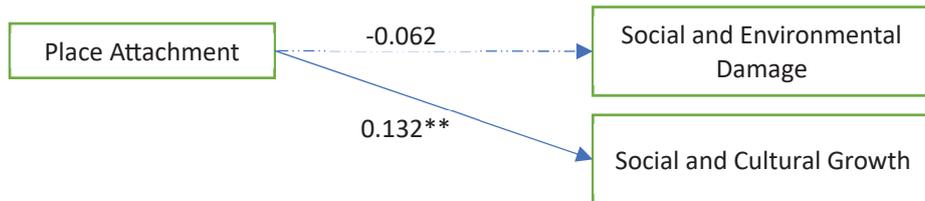


Fig. 7: The result of the path model in scenario #2 for the first hypothesis

Table 9: Regression coefficients of place attachment and the meaning of scenario #3

Scenario #3 Regression coefficients		Est	Std. Error	z-value	p	95% CI		Std All
Predictor	Outcome					Lower	Upper	
Place Attachment	Modernization and Improvement of Socio-Economy	0.093	0.021	4.505	< .001	0.052	0.133	0.189
Place Attachment	Destroying Society and the Environment	-0.307	0.044	-6.940	< .001	-0.394	-0.22	-0.398

Note: CFI = 0.991, TLI = 0.990, RMSEA = 0.077, GFI = 0.975

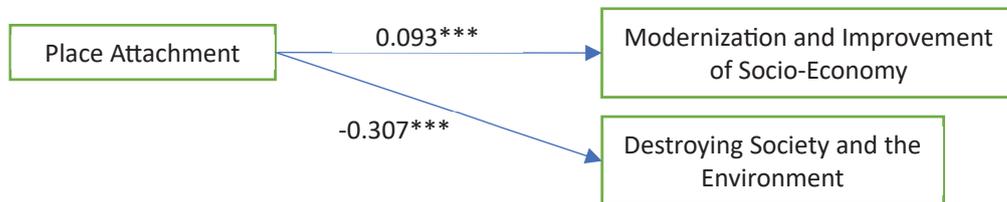


Fig. 8: The result of the path model in scenario #3 for the first hypothesis

relationship between place attachment and the meaning of urban development is mostly significant, but not always. Therefore, the results partially support the first hypothesis.

Regression: Second hypothesis

The results of the regression analysis using Structural Equation Modeling (SEM) following the conceptual framework of the second hypothesis are as follows:

A deeper examination of the non-significant relationship between Place Attachment and Economic Improvement and Modernization in scenario #1 was conducted, considering the possibility of a mediation

variable: acceptance of urban development scenarios ('happy with scenario #1'). Upon involving the acceptance variable, the regression coefficient for the direct effect of Place Attachment on Economic Improvement and Modernization was positive and statistically significant according to the data (Table 11). However, the regression coefficient was negative and statistically significant for the indirect effect of Place Attachment on Economic Improvement and Modernization via acceptance of scenario #1. This implies that, through acceptance of scenario #1, Place Attachment had an indirect negative impact on Economic Improvement and Modernization. The mediation effect was significant, as indicated by the

Table 10: Regression coefficients of place attachment and the meaning of scenario #4

Scenario #4 Regression coefficients						95% CI		Std
Predictor	Outcome	Est.	Std. Error	z-value	p	Lower	Upper	All
Place Attachment	Modernization and Economic Development	0.313	0.053	5.915	< .001	0.209	0.417	0.298

Note: CFI = 0.979, TLI = 0.976, RMSEA = 0.083, GFI = 0.950



Fig. 9: The result of the path model in scenario #4 for the first hypothesis

Table 11: Regression coefficients of place attachment, acceptance, and the meaning of scenario #1

Scenario #1 Regression coefficients						95% CI		Std	
Predictor	Outcome	path	Est.	SE	z-value	p	Lower	Upper	All
Place Attachment	Economic Improvement and Modernization	A	0.317	0.081	3.93	< .001	0.159	0.475	0.23
Happy with scenario #1	Economic Improvement and Modernization	B	0.625	0.068	9.13	< .001	0.491	0.759	0.77
Place Attachment	Happy with scenario #1	C	-0.476	0.092	-5.192	< .001	-0.656	-0.296	-0.281

Note: CFI = 0.97, TLI = 0.966, RMSEA = 0.75, GFI = 0.928



Fig. 10: The result of the path model scenario #1 for the second hypothesis

p-value of < 0.001, and the confidence interval values confirmed it (Table 12).

Based on the provided data, it can be inferred that there is a negative relationship between Place Attachment and acceptance of scenario #1 (Path C: -0.476, $p < 0.001$). This means that individuals who report higher levels of Place Attachment tend to be less accepting of scenario #1. Additionally, both Place Attachment (Path A: 0.317, $p < 0.001$) and acceptance of scenario #1 (Path B: 0.625, $p < 0.001$) have significant positive relationships with Economic Improvement and Modernization. While both Place Attachment and acceptance of scenario #1 positively influence perceptions of economic improvement and modernization, the effect of acceptance of scenario #1 is notably stronger. This implies that an individual's acceptance of the scenario plays a significant role in shaping their perception of its benefits. However, the negative interaction effect between Place

Attachment and acceptance of scenario #1 suggests that the positive effect of acceptance of scenario #1 on economic improvement and modernization is reduced when Place Attachment is high. This suggests that their Place Attachment influences their perception of the scenario's positive impact on economic and cultural factors by negatively influencing the level of acceptance of scenario #1. Less accepting individuals perceiving scenario #1 will have a more positive impact on the factors. The mediation of acceptance of the urban development scenario was also applied in the non-significant relationship between Place Attachment and the urban development scenario #2's meaning; 'Social and Environmental Damage.' When considering the acceptance variable, the direct influence of Place Attachment on the definition becomes statistically non-significant ($p = 0.165$) (Table 13). Scenario #2 acceptance exhibits a significant negative mediation effect, implying an indirect negative impact of Place

Table 12: Defined parameters from mediation analysis of regression coefficients in scenario #1

Defined parameters					95% CI		Std
Name	Estimate	Std. Error	z-value	p	Lower	Upper	All
Direct (A)	0.317	0.081	3.93	< .001	0.129	0.445	0.23
Indirect (B*C)	-0.298	0.066	-4.496	< .001	-0.393	-0.134	-0.216
Total	0.019	0.042	0.467	0.64	-0.058	0.105	0.014

Attachment on its interpretation as ‘Social and Environmental Damage’ through Scenario #2. A low p-value below 0.001 and confidence interval values highlight the substantial mediation effect (Table 14).

The data suggests a positive relationship between Place Attachment and acceptance of scenario #2 (Path C: 0.486, $p < 0.001$). This suggests that people who report higher levels of Place Attachment are more accepting of scenario #2. Place attachment (Path A: 0.317, $p < 0.001$) and acceptance of scenario #2 (Path B: -0.371, $p < 0.001$) have insignificant positive relationships with the meaning of scenario #2 in terms of Social and Environmental Damage. This suggests that their Place Attachment influences their perception of the scenario’s negative impact on social and environmental factors by positively influencing the level of acceptance of Scenario #2. More accepting individuals perceiving scenario #2 will have less damage to the factors. In conclusion, the regression analysis supports the second hypothesis, indicating that Place Attachment plays a significant role in shaping individuals’ perceptions of urban development scenarios, with the level of acceptance acting as a mediator. The correlation analysis of demographic data with place attachment suggests that several factors serve as predictors of attachment to residential places. Specifically, residence length, education level, presence of children, and mobility, along with its range, demonstrate significant correlations with place attachment. The analysis indicates that newer residents, those with higher levels of education, and individuals with greater mobility tend to exhibit lower levels of concern or engagement with urban development scenarios. These findings align with previous notes by Lewicka (2011), which highlight the importance of these factors in shaping attachment to place. Interestingly, in this research context, age does not appear to be significantly correlated with place attachment. This finding suggests that, contrary to expectations based on previous literature, age may not play a significant role in determining attachment to residential places in this particular context. The

existing literature on the relationship between place attachment and the acceptance of environmental projects, highlighted by previous studies (Devine-Wright, 2009; Devine-Wright and Batel, 2017; Hou et al., 2019), has emphasized the role of place attachment in explaining local acceptance or opposition to environmental projects within communities. This research contributes to expanding upon these insights by demonstrating that place attachment influences the level of acceptance of urban development projects within peripheral communities. Furthermore, the level of acceptance acts as a mediator of the relationship between place attachment and interpretations of urban development scenarios. The findings also indicate that high levels of place attachment result in dynamic levels of acceptance or rejection depending on the type of urban development encountered, which in turn can shape perceptions of whether the urban development has a positive or negative impact. If environmental change is perceived as potentially disrupting place attachment (Devine-Wright and Howes, 2010), as previous research stated that objective physical characteristic have a direct impact on place attachment (Motalebi et al., 2023), then this research suggests that each urban development scenario may lead to varying degrees of disruption. The interpretation of environmental change, as highlighted in the disruption-response framework (Mihaylov et al., 2020), underscores the role of place attachment in shaping how individuals perceive and respond to changes in their environment. This research offers a deeper understanding of these interpretation mechanisms, particularly in the context of urban development in city peripheral settlements. The findings suggest that acceptance of urban development acts as a bridge between place attachment and the meanings attributed to urban development. In dealing with urban development in peripheral settlements, which is often seen as an inevitable part of progress, the research model reveals that environmental changes are indeed given certain meanings, but these meanings are not directly influenced by place

Table 13: Regression coefficients of place attachment, acceptance, and the meaning of scenario #2

Regression coefficients							95% CI		Std
Predictor	Outcome	path	Est.	Std. Error	z-value	p	Lower	Upper	All
Place Attachment	Social and Environmental Damage	A	0.07	0.05	1.389	0.165	-0.074	0.124	0.095
Happy with scenario #2	Social and Environmental Damage	B	-0.371	0.096	-3.869	< .001	-0.552	-0.176	-0.665
Place Attachment	Happy with scenario #2	C	0.486	0.062	7.862	< .001	0.348	0.59	0.369

Note: CFI = 0.994, TLI = 0.993, RMSEA = 0.40, GFI = 0.961

Table 14: Defined parameters from mediation analysis of regression coefficients in scenario #2

Defined parameters							95% CI		Std
Name	Estimate	Std. Error	z-value	p	Lower	Upper	All		
Direct (A)	0.07	0.05	1.389	0.165	-0.074	0.124	0.095		
Indirect (B*C)	-0.18	0.051	-3.531	< .001	-0.271	-0.071	-0.246		
Total	-0.11	0.037	-2.995	0.003	-0.218	-0.074	-0.15		



Fig. 11: The result of the path model in scenario #2 for the second hypothesis

attachment at the pre-disruption stage. Instead, this relationship is mediated by the level of acceptance of the urban development scenario, measured through feelings of enjoyment towards the scenario. Thus, the interpretation of environmental change not only relies on the level of place attachment but is also influenced by the level of acceptance of the urban development scenario. The awareness that environmental change is unavoidable and will eventually occur prompts residents of peripheral city settlements to make prior considerations. These considerations subsequently influence the meaning attributed to environmental changes. These findings suggest that making sense of environmental change is a dynamic process that can commence even before the change occurs.

CONCLUSION

The research draws several key conclusions from the findings. Firstly, the qualitative phase highlights diverse dimensions shaping the definition of urban development, emphasizing its inherent complexity and diversity. Variability emerges in the quantitative phase, where the interpretation of urban development

scenarios varies across different scenarios. Secondly, the precise relationship between place attachment and these interpretations also fluctuates. Nonetheless, it becomes evident that place attachment can significantly contribute to the interpretation of urban development scenarios, thereby aligning with the first hypothesis. Thirdly, the relationship between place attachment and these interpretations is mediated by the level of acceptance of the urban development scenarios, thereby confirming the second hypothesis. The research results further demonstrate that the level of acceptance and its impact on the interpretation of urban development scenarios vary. However, these findings confirm the mediation principle. The dynamics and influence of place attachment on the acceptance of urban development scenarios are plausible, possibly because respondents anticipate these scenarios and the developments that occur in the areas surrounding them. They are unavoidable changes that respondents who live in peripheral city settlements cannot deny. Recognizing the impact of place attachment and acceptance levels on the interpretation of urban development scenarios is critical for understanding

community reactions to such projects and the factors that shape them. In conclusion, place attachment plays an important role in how people perceive and accept the inevitable changes in their environment. This study offers a nuanced understanding of the interplay between place attachment and the interpretation of urban development in peripheral areas of cities. By acknowledging a variety of perspectives, stakeholders can ensure that urban development initiatives align with the diverse needs and aspirations of local communities. Furthermore, the research highlights the importance of variables urban planners and developers must recognize. By incorporating these attachments into the planning process, practitioners can create more inclusive and sustainable development strategies that resonate with local communities. Efforts to promote acceptance of development initiatives should prioritize engaging with communities, addressing concerns, and involving residents in decision-making processes. This proactive approach may involve strengthening place attachment through initiatives such as promoting community cohesion, preserving green spaces, and supporting local cultural activities. It can also foster receptivity to urban development initiatives perceived as enhancing rather than threatening residents' sense of belonging and identity. Investigating the effects of urban development on place attachment after it has occurred or during and after the disruption phase would indeed be a valuable extension of this research. With the premise that attachment at these stages can be predicted by the interpretation of environmental change. As a result, the relationship between place attachment and the meaning of urban development may be bidirectional. By examining how urban development influences place attachment over time, researchers can gain insights into the long-term impacts of development on individuals' emotional connections to their surroundings. Understanding this bidirectional relationship can provide valuable information for urban planners and policymakers, helping them anticipate and mitigate potential disruptions to place attachment caused by development projects. Several limitations to this study warrant acknowledgment. Firstly, the inclusion of hypothetical questions in the research design may limit the generalizability of the findings, as they may not fully capture real-world behaviors. Future studies could benefit from employing longitudinal approaches to validate the results and better understand how attitudes and perceptions evolve. Secondly, while efforts were

made to select representative settlements, the study's reliance on data from only two settlements may restrict the generalizability of the findings. Future research should aim to include a more diverse sample of peripheral communities to ensure the broader applicability and robustness of the insights gained. Thirdly, the scope of urban development meanings examined in the study could be expanded to include more dimensions. By including additional indicators, the variance percentage could potentially be increased, allowing for a more accurate representation of the various aspects of urban development meanings. Addressing these limitations in future research endeavors will be crucial for advancing our understanding of the relationship between place attachment and the interpretation of urban development scenarios, as well as for informing more effective and sustainable urban planning practices.

AUTHOR CONTRIBUTIONS

The study was carried out by F. Nazaruddin as a component of his doctoral dissertation, under the guidance of A. Hayati and P. Setijanti. The study was designed by all of the authors, who also oversaw its general planning and direction.

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CONFLICT OF INTEREST

Concerning the publication of this work, the authors declare that they have no potential conflicts of interest. Furthermore, the writers have direct knowledge of all ethical concerns, such as redundancy, plagiarism, misbehavior, double publication or submission, data fabrication or falsification, and informed consent.

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ABBREVIATIONS

Bartlett's test	Statistical test that is used to test for homogeneity of variances
CFI	Comparative Fit Index.
TLI	Tucker-Lewis Index.
RMSEA	Root Mean Square Error of Approximation.
GFI	Goodness of Fit Index
Z-Value	A measure of how many standard deviations a value is from the mean of a distribution.
p	Probability value
95% CI	95% Confidence Interval
Std	Standard
Std Error	Standard Error
Est	Estimate
n	Sample size
T-test	A statistical test that is used to compare the means of two independent groups
df	Degrees of Freedom
MSA	Mean Square due to the Anova Effect
SD	Standard Deviation
RMSEA 90% Conf	RMSEA 90% Confidence Interval

Cronbach's alpha	A measure of the internal consistency of a reliability scale.
M	Mean

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ORIGINAL RESEARCH PAPER

Gridlock gloom: A geographical analysis of commuters' perceptions on traffic congestion

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ABSTRACT

BACKGROUND AND OBJECTIVES: One of the most challenging aspects of city living is traffic congestion. The multitude of vehicular modes and their sheer volume coupled with inadequate road infrastructure unable to keep up with the escalated travel demand of Kolkata is a major cause of concern. Recognizing the significant toll on commuters' time and health, the research aims to identify the root causes of congestion across fifteen selected Traffic Intersection Points, explore its multifaceted impacts on the environment, economy, and society, and propose solutions to alleviate this pressing issue effectively.

METHODS: This study employed a mixed-method approach. An on-site survey with 375 regular commuters in Kolkata was conducted, utilizing questionnaires and focus group discussions. The survey gathered data on travel patterns, socio-demographic information, and perceptions of traffic congestion. The Garrett Ranking method and Relative Importance Index (RII) were employed to evaluate the significance of various contributing factors, their impact on commuters, and potential solutions. Statistical analysis using Microsoft Excel and SPSS 26 complemented the data analysis, with cartographic visualizations providing spatial insights. Additionally, the Wilcoxon Signed-Rank Test validated the differences in travel times during congested and free-flowing traffic conditions.

FINDINGS: The results revealed that the commuters' average daily travel delay owing to congestion is approximately 17 minutes. Utilizing Garrett score ratings, the most significant obstacles to smooth traffic flow were identified as intersectional conflicts (66.19) and curbside parking (64.75). Following the same methodology, increased reliance on personalized vehicles (69.87) and encroached road space (64.3) were attributed to rush hour saturation, whereas political rallies (71.36) and demonstrations (59.74) contributed to unprecedented incidents. Work schedule disruptions and hearing anomalies were the most common offshoots of this hazard. Relative Importance Index (RII) scores highlighted the consensus among commuters emphasizing the economic, environmental, and social impact of congestion, with particular emphasis on enhanced fuel consumption (RII=1), decreased economic opportunities (RII=0.96), worsened pollution levels (RII=0.91), and reduced family time (RII=0.93). Congestion pricing (RII=0.88) and ride-sharing (RII=0.87) emerged as the most viable strategies to mitigate congestion. Furthermore, Garrett ratings indicated training of drivers (63.74) and road users (61.03) along with parking management (63.51) to be the most desired areas of improvisation suggested.

CONCLUSION: Implementing the 'Avoid, Shift, Improve' framework in conjunction with a 'people-first' mentality would encourage sustainable urban living by placing a premium on public transport, land use planning, and technological improvements to reduce traffic congestion and enhance commuter well-being in Kolkata.

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INTRODUCTION

Transportation has historically functioned as a crucial intermediary, nurturing seamless connections between disparate regions and enabling the efficient flow of goods (Janic, 2017). Effective transport networks significantly enhance accessibility for individuals, promoting their interaction with various land-use activities within specified zones (Falcochio & Levinson, 2015; Afrin & Yodo, 2020). However, the escalating demand for transportation services, spurred by the pervasive global urbanization trend, has led to an increasingly complex urban transportation landscape. The sheer volume and diversity of traffic flows, involving both resident and transient populations, pose significant challenges (Chakraborty & Gupta, 2015). The rapid growth of private vehicle ownership, rising population densities, and sometimes suboptimal management of public transportation infrastructure have created a scenario of constrained urban mobility (Rao & Rao, 2012). One of the most critical manifestations of these challenges is urban traffic congestion, a permeating issue that significantly disrupts urban life (Ali & Faraz, 2013). As traffic volume increases, each additional vehicle progressively hinders the movement of others, ultimately surpassing the maximum capacity of the roadway, and triggering congestion (OECD, 2007). Therefore, congestion can be defined as a temporal phenomenon characterized by an excess of vehicles attempting to utilize a route beyond its capacity to accommodate them, to maintain an acceptable service level Bull, 2003 (Bull, 2003; Rothenberg, 1985). In contrast to periods of lower demand, this discrepancy between the system's capacity and the transportation demand resulted in a pronounced increase in travel times (Ortzar & Willumsen, 2011; Bates *et al.*, 2001). Consequently, congestion not only elevates travel costs and man-hour losses but also harbors significant adverse implications for commuters' physical and psychological well-being, causing stress, frustration, and even health risks (Higgins *et al.*, 2017). Furthermore, inadequate road signage, encroachment by informal vendors, and inefficient traffic management exacerbate these issues. Within the context of mixed traffic comprising motorized and non-motorized means, particularly prevalent in developing countries, maneuverability is often compromised. This compromised maneuverability

triggers a domino effect of adverse environmental impacts including enhanced fuel consumption, heightened emissions of air pollutants, and amplified noise pollution, all of which contribute to escalating environmental costs (Fattah *et al.*, 2022). These combined socioeconomic and environmental impacts, threaten commuters' overall well-being in almost all metropolitan cities. The case of Kolkata, situated on the River Hooghly's eastern bank, exemplifying these challenges, is no exception. It is India's third-most populous metropolis and accommodates approximately 4,496,694 people (Chandramouli & General, 2011). The city's unplanned development expanding over an area of 206.08 square kilometers, poses formidable logistical challenges for the Kolkata Municipal Corporation (KMC), with traffic management being a key area of concern. The Ola Hyperdrive 2019 infographics, as reported by the Times of India in 2020, elucidate discernible differentials in the average traffic speed across India's principal urban centers, directly correlating it with the experienced congestion levels. Hyderabad emerges as the pre-eminent city in terms of traffic fluidity, boasting an average speed of 24.5 kilometers per hour (kmph), succeeded closely by Chennai (23.1 kmph) and Delhi (23.5 kmph). Mumbai and Bengaluru follow suit with relatively lower average speeds of 22.7 kmph and 21.2 kmph, respectively, while Kolkata exhibits the most sluggish pace of 19.4 kmph. Factors like infrastructure, population density, and urban planning initiatives may likely be attributed to such speed differences. With 21,825 people per square kilometer, Kolkata has a higher propensity to exacerbate its traffic woes in comparison to National Capital (7435 people per square kilometer), Bengaluru (11933 people per square kilometer), or Chennai (10,906 people per square kilometer). Besides, the intricate mix of transportation modes, ranging from modern automobiles to traditional hand-pulled rickshaws, operating within a limited road space of 7 percent of the total area, creates severe congestion (Pucher *et al.*, 2005). This phenomenon has its roots in the booming market of Light Motor Vehicles (LMV) within the city. Of particular note is the substantial density of cars (LMVs) in Kolkata, which is quantified at 432 cars per kilometer according to a 2022 report by the Times of India. This figure typifies how their proliferation contributes to the dynamics of congestion, even

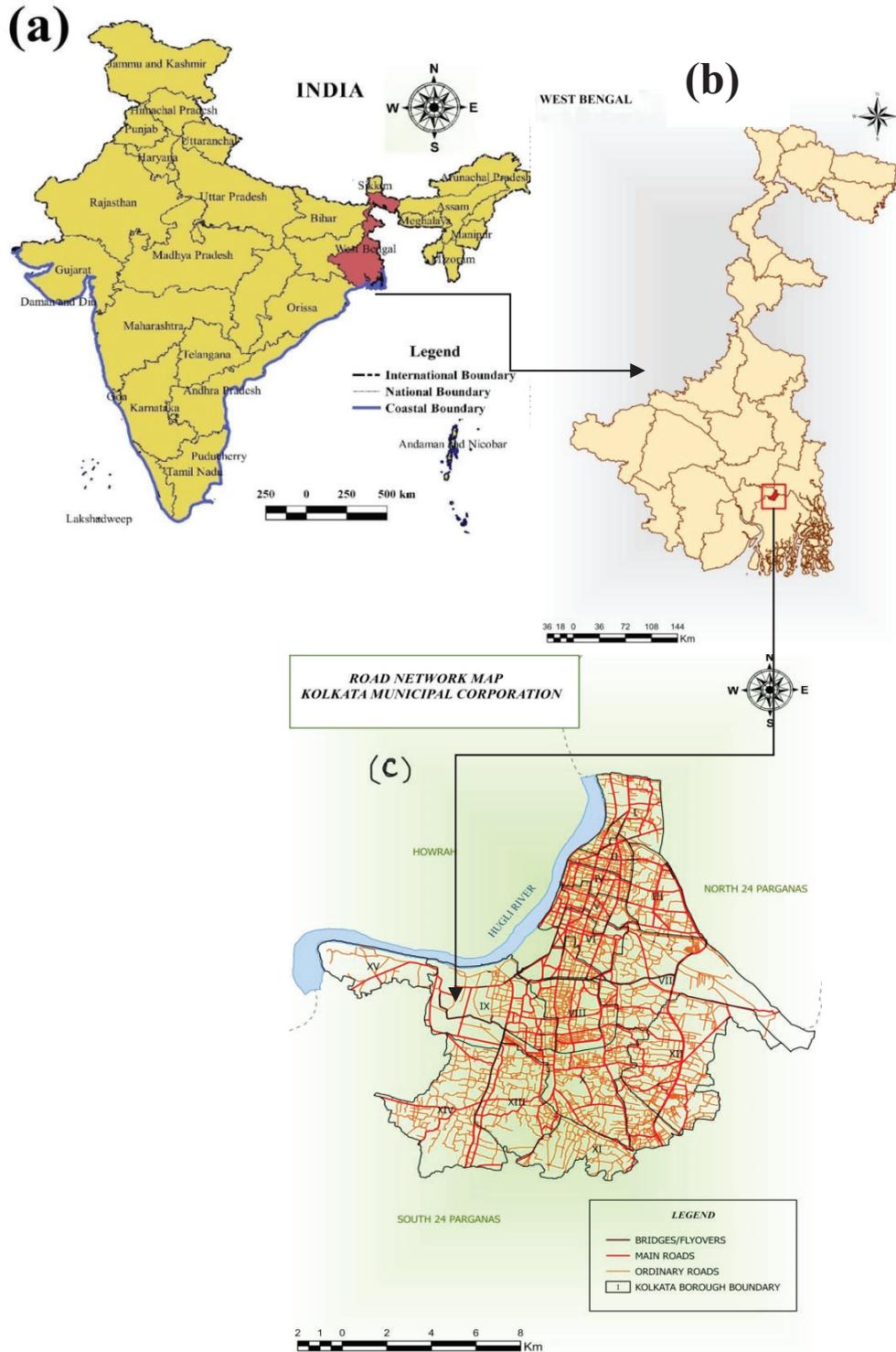


Fig. 1: Geographic location of the study area: a) India b) West Bengal c) Kolkata Municipal Corporation

surpassing Bengaluru (210 cars per kilometer). An exceptionally high vehicular density of 2448 vehicles per square kilometer, was reported by The Economic Times, in August 2023. Additionally, studies by the transport department, cited by the Times of India in 2021, indicate that the use of nearly 24 percent to 38 percent of carriageways for parking has plummeted the average traffic speed by 25 percent. The recorded average vehicular speed was 18.7 km/hr in 2022 and was considered to be the slowest of all 154 Indian cities studied by the National Bureau of Economic Research (Akbar, P. *et al.*, 2023). An analysis conducted by Mint on 300 arterial roads across six major metropolitan cities in 2019 further revealed that a 10-kilometer commute in Kolkata takes approximately 39 minutes, a 63% increase over the national average of 24 minutes. This extended commute time is a direct consequence of reduced vehicular speed on major roadways, with commuters experiencing an average daily delay of 15 minutes. These significant delays contribute to elevated fuel consumption and heightened stress levels among those commuting. The absence of rigorous research investigating commuters' perspectives on the multifaceted causes of congestion, and its subsequent socioeconomic impacts, hinders policymakers' efforts to develop effective mitigation strategies in Kolkata. This knowledge gap presents a significant obstacle to sustainable urban development, as unchecked traffic congestion has the potential to paralyze the municipal transportation system (Singh, S.K., 2012). Hence, understanding public perceptions and preferences is crucial for designing initiatives that resonate with commuters and encourage behavioral shifts toward congestion-reducing practices. By exploring commuter perceptions in two key domains—first, on nature and causes of traffic congestion along Kolkata's main roads—and second, assessing how congestion impacts commuters' time use, and overall being, the study attempts to fill the existing gap. Therefore the primary goal of this study is to learn more about commuters' perceptions on the prevailing causes and social-economic impacts of traffic congestion along the city's major thoroughfares. Addressing traffic congestion is essential to protect both environmental sustainability and the well-being of urban populations (Bigazzi & Clifton, 2015). Hence, by grasping commuter preferences and understanding the socioeconomic ramifications of congestion, this

research has the potential to shape policy development, offering evidence-based recommendations for initiatives that align with commuters' needs and priorities. It seeks to enrich the existing research by investigating the interplay of socioeconomic and psychological factors influencing commuters' receptiveness to congestion-alleviation measures. Through the analysis of these intricate dynamics, the research aims to provide practical recommendations and empirical understanding that can be extrapolated to similar congested urban environments fostering collaboration and knowledge exchange within the global urban planning community. Overall, in response to the critical challenge of traffic congestion, this study aims to comprehensively examine the relative importance of the key factors identified in causing and exacerbating traffic by employing ranking methodologies and statistical analysis to quantify the influence of each factor. In addition, drawing on the findings of the preceding analyses, the study tends to propose a set of actionable strategies geared towards alleviating this pressing issue and paving the way for a more efficient and sustainable urban transportation system. To achieve these objectives, an on-site research survey was conducted along the three most significant road stretches under the upkeep of Kolkata Municipal Corporation—namely Acharya Jagadish Chandra Bose Road (AJC Bose Road) and its continuation as Acharya Prafulla Chandra Road (APC Road), Central Avenue continuing till DeshapranSasmal Road passing through intermediary stretches of Ashutosh Mukherjee Road and Shyama Prasad Mukherjee Road and Eastern Metropolitan Bypass Corridor. Fifteen Traffic Intersection Points (TIPs) were strategically chosen (Fig. 2) from the aforementioned stretches for an in-depth analysis of commuter perspectives. The data collection period spanned from October 10, 2022, to December 20, 2022. The details of the TIPs (Table 1) are as follows:

MATERIALS AND METHODS

Data collection and survey design

This study delves into the complexities of traffic congestion in Kolkata, examining commuter perspectives on the challenges they face. To explore the complexities underlying urban gridlock in Kolkata and capture commuter narratives, this study employed a structured survey approach. The study focused on

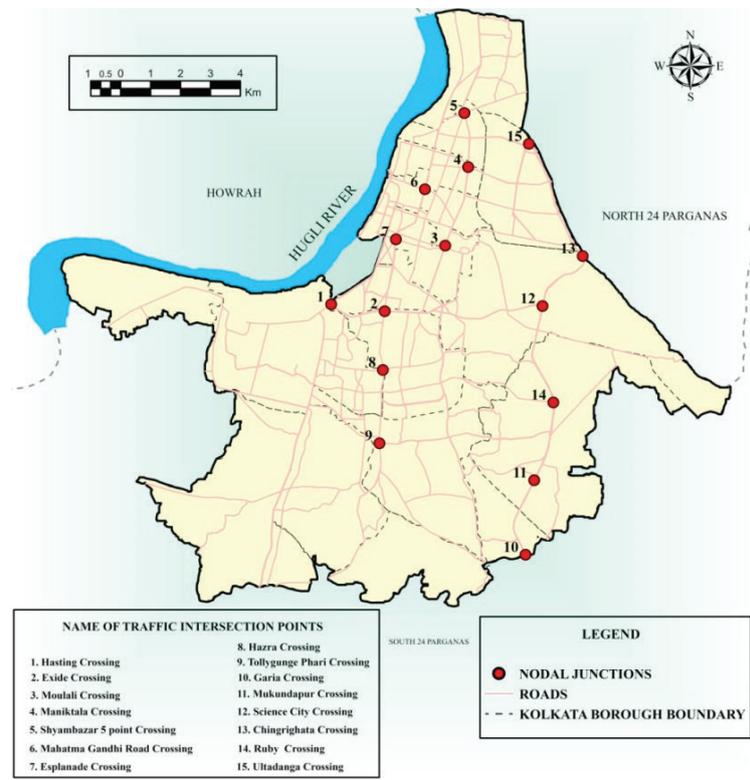


Fig.2: Location of the TIPs in the study area

Table 1: Details of the selected TIPs in KMC

Sl. no.	Nodes or names of the TIPs (Crossings)	Latitude	Longitude	Ward Number	Borough Number
1	Hastings Crossing	22°32'38" N	88°19'48" E	75	9
2	Chowringhee/Exide Crossing	22°32'30"N	88°20'50"E	63	7
3	Moulali Crossing	22°33'41"N	88°22'2"E	53	5
4	Maniktala Crossing	22°35'7"N	88°22'29"E	32	3
5	Shyambazar5 point Crossing	22°35'54"N	88°22'15"E	11	2
6	Mahatma Gandhi Road Crossing	22°34'43"N	88°21'38"E	23	4
7	Esplanade Crossing	22°33'48"N	88°21'4"E	46	6
8	Hazra Crossing	22°31'25"N	88°20'47"E	83	8
9	Tollygunge Phari Crossing	22°30'5"N	88°20'42"E	89	10
10	Garia Crossing	22°28'1"N	88°23'32"E	110	11
11	Mukundapur Crossing	22°29'23"N	88°23'43"E	109	12
12	Science City Crossing	22°32'34"N	88°23'55"E	64	7
13	Chingrighata Crossing	22°33'28"N	88°24'42"E	57	7
14	Ruby Crossing	22°30'48"N	88°24'6"E	107	12
15	Ultadanga Crossing	22°35'38"N	88°23'9"E	13	3

regular commuters who traversed the 15 identified TIPs for at least a year. A bilingual (English and Bengali) questionnaire was administered to a sample of 375 respondents (25 per junction) across three major thoroughfares. Purposive random sampling was employed to ensure the sample reflected a

diverse range of commuters using these intersections. Recognizing potential literacy variations, the survey was conducted as face-to-face interviews with diverse commuter groups. Before the interviews, participants were provided with a clear explanation of the study's overall purpose. Additionally, clear definitions were

offered for any technical terms or specific language used within the questionnaire. This ensured informed participation and the provision of accurate responses. The interviews explored commuters' understanding of the nature and causes of congestion and analyzed the consequences of congestion on their well-being in KMC. The selection of Kolkata (Figs. 1 and 2) as a research area on traffic congestion stems from its unique confluence of historical, infrastructural, and social factors that contribute to the problem. Rapid urbanization has outpaced the capacity of the city's colonial-era transportation infrastructure, resulting in Kolkata becoming one of the slowest cities globally in terms of traffic speed. Its ranking as sixth among the world's ten foremost slow cities, as divulged in 'Kolkata Now' in October 2023, speaks volumes about the daily struggles encountered by the commuters. Hence, to fulfill the objectives, a comprehensive understanding of commuter travel patterns and their responses to congested roads is crucial. By analyzing these factors, the study aims to illuminate the underlying causes and consequences of gridlock within KMC. Additionally, this knowledge would serve as a vital foundation for policymakers, encouraging them to develop targeted interventions to ensure better design and effective implementation of solutions to reduce traffic congestion.

Analytical framework

Data from each interview was organized in Microsoft Excel and subsequently imported into SPSS 26 for analysis. Based on their personal experiences, the respondents ranked factors contributing to the varying nature of congestion, perceived threats associated with congestion, and consequent perils affecting their well-being due to prolonged exposure. Descriptive statistics were employed to summarize the data using frequency and percentage distributions. Additionally, the Garrett Ranking Technique, a quantitative method, was utilized to analyze the rankings. This technique, developed by Henry Garrett in 1969, calculates a percentage score for each item based on individual rankings. The formula for calculating the percentage score is as stated below (Eq. 1)

$$\text{Percentage Score} = \frac{100(R_{ij} - 0.05)}{N_j}, \quad (1)$$

Where, R_{ij} = Rank of i^{th} item by the j^{th} individual,

and N_j = a number of items Ranked by a j^{th} individual. Building upon the data obtained from commuter rankings, the research utilized Garrett's Ranking Technique to convert the percentage positions into numerical scores from Garrett's Table (Garrett & Woodworth, 1973). For each factor contributing to congestion, perceived threats, and individual consequences, participants' scores were summed and averaged. Consequently, factors with higher average scores were deemed to hold greater significance allowing identification of the most critical issues associated with traffic congestion in Kolkata. Following the same ranking approach, participants were presented with various mitigation strategies from different bibliographic sources, deemed valuable by researchers and potentially significant to commuters. Utilizing the same formula as in the previous analysis, the score values helped to determine the areas of highest priority for addressing congestion-related concerns. To delve deeper into the analysis, the Likert Scale (Likert, 1961) was employed to allow respondents to rank the importance of both the perceived repercussions of congestion and the proposed mitigation strategies. Responses were collected on a 5-point scale, ranging from "Strongly Disagree" to "Strongly Agree" for assessing the severity of congestion effects, and "Very Helpful" to "Not at all helpful" for evaluating the suitability of proposed solutions. This ordinal data (ranked data) was then used to calculate ratios and the Relative Importance Index (RII) facilitating further analysis by quantifying the relative importance assigned to different factors (Sambasivan and Soon, 2007; Olojede et al., 2017). The formulae for which is as follows (Eq.2)

$$\text{RII} = \frac{\sum W}{A * N}, \quad (2)$$

Where W = weights as assigned on the Likert scale by each respondent in a range from 1 to 5, A = Highest weight (here it is 5), and N = Total number in the sample. To assess the impact of congestion on travel times and to statistically determine whether travel times during Free-Flow (FF) and Congested Flow (CF) differed significantly, the Wilcoxon Signed-Rank Test for matched pairs was employed. This non-parametric test was chosen as it was suitable for analyzing paired data (travel times under different conditions for the same individuals), set at a significance level

Table 2: Socio-demographic profile of sample commuters in KMC (computed by the authors based on sample design)

Categories	Groups	No. of sample Respondents (n)	Percent of sample Respondents
Gender	Male	234	62.4
	Female	141	37.6
Age group (Years)	15-29	109	29.1
	30-44	152	40.5
	45-59	89	23.7
	60-74	25	6.7
Levels of Education	Primary	3	0.80
	Upper Primary	17	4.5
	Secondary	38	10.1
	Higher Secondary	60	16
	UG	149	39.7
	PG	98	26.1
Income (INR)	Ph.D	10	2.7
	≤25,000	206	54.9
	25001– 50,000	89	23.7
	50,001– 75,000	46	12.3
	75,001– 100,000	24	6.4
	Above 100,000	10	2.7

of 0.01 and offered an efficient alternative to the inapplicable t-test (Bagabaldo et al., 2017).

RESULTS AND DISCUSSION

Brief profile of sample respondents

This study delves into the socio-economic and demographic characteristics of 375 commuters in KMC, aiming to identify variations in their travel patterns and experiences. The analysis provides a nuanced understanding of the intricate relationship between socioeconomic factors and travel behavior. By dissecting these subtleties, the research enables a comprehensive analysis of the challenges faced by daily commuters, offering valuable insights for ensuing analysis.

The data (Table 2) reveals a well-dispersed sample across age groups (15-74 years) with gender distribution skewed towards males (62.4%). The highest representation is observed in the age group of 30-44 (40.53 percent) suggesting a focus on working professionals, followed by the other age groups of 15-29 years, 45-59 years, and 60-74 years. In terms of attainment of education, a significant portion of the commuters hold undergraduate degrees (26.33 percent), followed by those having higher secondary and postgraduate degrees (16.83 percent and 16 percent). Intriguingly, the income distribution highlighted a heterogeneous socio-economic spectrum where most respondents (54.9%)

earned less than 25,000 INR, followed by a gradual decrease in frequency with rising income brackets. The inclusion of commuters across diverse socio-economic backgrounds ensured a comprehensive analysis.

Travel characteristics

While exploring the travel characteristics of the commuters in KMC, diverse aspects of their daily transportation routines were revealed. Factors like modal preferences, average trip frequency, distance covered, and the time lost during commuting provided an extensive picture. With a mean value of 3.7 and a standard deviation of 1.59 (Table 3), the average daily trip frequency found among the sampled commuters stipulated moderate variability of travel patterns. This variation is likely linked to factors like lifestyles, employment patterns, and access to transportation. The mean value suggests that, on average, individuals in Kolkata make approximately 4 trips per day. Interestingly, gender disparities emerge, with men exhibiting a higher average trip frequency (3.99) compared to women (3.22), which could be attributed to occupational differences or job patterns influencing mobility needs.

A significant finding in Table 4 was respondents earning less than 25,000 INR (36 percent) tend to make fewer trips (average 2 trips), potentially due to financial constraints limiting non-essential travel.

Commuters' perceptions of traffic congestion

Table 3: Details of travel characteristics of the respondents

Travel Characteristics	n	Minimum	Maximum	Mean	Std. Deviation
Daily Average Trip Frequency	375	1	6	3.70 (4)	1.589
Average Distance traveled (kilometers)	375	2.0	22.0	7.683	3.9090
Average time lost (minutes)	375	3	40	16.41	6.492

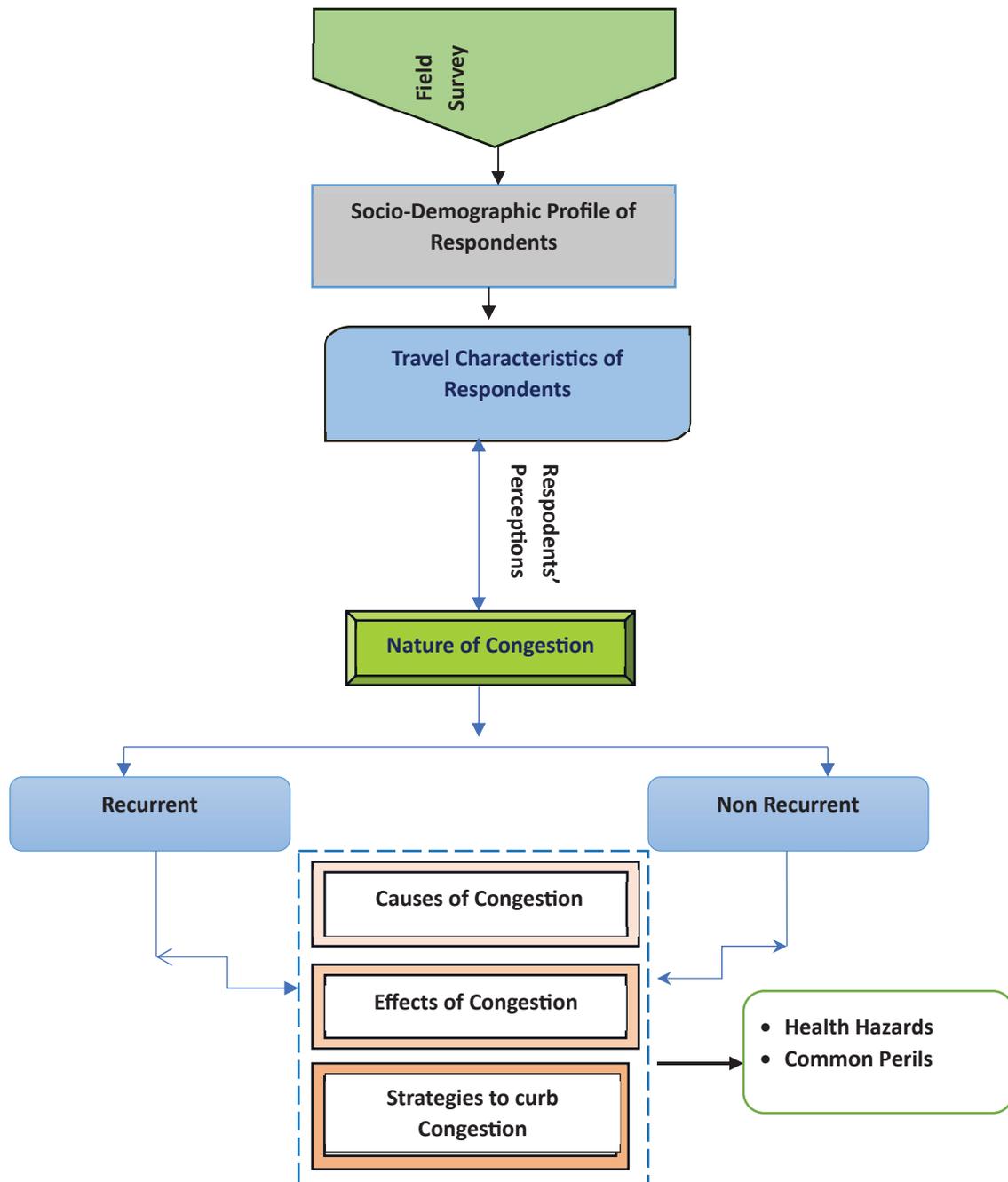


Fig. 3: Methodological flowchart

Conversely, higher income groups particularly those earning between 25000-49999 INR (37 percent) and 50000- 74999 INR (39 percent) exhibit a higher average trip frequency (average 4 trips) with significant portions falling into the 4-trip and 6-trip categories, suggesting greater travel flexibility.

An analysis of commuting distances revealed a significant variation among respondents in Table 3, with distances ranging from a mere 2 kilometers to a substantial 22 kilometers. The average distance traveled, at 7.68 kilometers, indicates a moderate commute for most respondents. Given the time and effort required to traverse longer distances, it became imperative to investigate the reciprocal relationship between the distances traveled and average trip frequency. Within an average distance of 10 kilometers travel, the lion's share of commuters (104 out of 139) undertook only 2 trips per day whereas people commuting between the range of 2 to 4 times a day exhibit a more varied distribution throughout several distance categories, with a significant fraction (103 out of 142) covering within 5-15 kilometers. Commuters who travel more frequently (4-6 trips) typically cover shorter distances (within 5 kilometers), which could exacerbate traffic congestion in places with high population densities,

whereas, those traveling beyond 20 kilometers find it difficult to take up more than 2 trips in a day. These findings are consistent with the notion of a free-flow traffic scenario, where fewer obstacles along the way result in reduced travel time, enabling commuters to reach their destinations more quickly (Maparu & Pandit, 2010). In the context of KMC, traffic flow often reaches saturation levels, leading to recurrent congestion, particularly during morning and evening rush hours, posing a major problem. The disparity in travel time between commuting under free flow conditions and congested flow conditions ranges from 3 to 40 minutes, with an average loss of 16.41 minutes and a standard deviation of 6.492 (Table 3). To analyze the paired observations of travel time in FF and CF conditions, the Wilcoxon Signed Rank Test was employed. This non-parametric test was deemed more appropriate due to the unmet assumptions of normality in the paired observations. The test yielded a highly significant p-value of 0.000, based on 375 matched sample observations, providing compelling evidence against the null hypothesis. The practical consequences of the results obtained from the Test highlight a statistically significant difference in trip times under the two flow conditions (FF and CF conditions). This was presented by the test statistic of

Table 4: Cross tabulation results between income groups to daily average trip frequency (computed by the authors)

		Daily average trip frequency					Total	
		1	2	4	5	6		
Income groups (INR)	<25000	Count	14	60	84	0	48	206
		% within Income groups	6.8%	29.1%	40.8%	0.0%	23.3%	100.0%
		% of Total	3.7%	16.0%	22.4%	0.0%	12.8%	54.9%
	25000-49999	Count	0	33	33	4	19	89
		% within Income groups	0.0%	37.1%	37.1%	4.5%	21.3%	100.0%
		% of Total	0.0%	8.8%	8.8%	1.1%	5.1%	23.7%
	50000-74999	Count	0	9	18	4	15	46
		% within Income groups	0.0%	19.6%	39.1%	8.7%	32.6%	100.0%
		% of Total	0.0%	2.4%	4.8%	1.1%	4.0%	12.3%
	75000-99999	Count	0	20	0	0	4	24
		% within Income groups	0.0%	83.3%	0.0%	0.0%	16.7%	100.0%
		% of Total	0.0%	5.3%	0.0%	0.0%	1.1%	6.4%
	>99999	Count	0	3	7	0	0	10
		% within Income groups	0.0%	30.0%	70.0%	0.0%	0.0%	100.0%
		% of Total	0.0%	0.8%	1.9%	0.0%	0.0%	2.7%
Total		Count	14	125	142	8	86	375
		% within Income groups	3.7%	33.3%	37.9%	2.1%	22.9%	100.0%
		% of Total	3.7%	33.3%	37.9%	2.1%	22.9%	100.0%

70500 and the standardized test statistic of 16.894, derived by dividing the test statistic by the standard error (2086.502). It is interesting to note (Table 5) that, across all road conditions, the majority of respondents (34.7%) reported a loss of 10 and 19 minutes of travel time while commuting, followed by another 32% reporting a loss between 20 and 29 minutes. The data unmistakably shows a significant degree of variation in commuter travel times, influenced by factors such as the condition of roadways, transit choices, and infrastructure quality. The variations in the frequency of trips, travel distances, and the amount of time lost are a reflection of the reduced speed profile of the major thoroughfares of the city. This demonstrates the intricacy of the transportation network and its interplay in understanding the dynamics of traffic congestion.

Since the efficiency and caliber of road infrastructure greatly influence the flow of vehicles, the condition of roads emerges as a significant aspect to be considered. Analysis of surveyed commuters' opinions regarding the sampled road segments leading to selected TIPs within Kolkata reveals pertinent insights (Fig. 4). A substantial portion of

responses revealed that the majority of roads were either classified as 'Mixed' (35.20 percent) or 'Uneven or Bumpy' (30.13 percent). Together, these two make up 65.33 percent of the total, suggesting a significant proportion of the condition of the roads is to be believed subpar in their optimal levels of utilization and maintenance. Thus, the prevalence of slower-moving traffic inescapably raises the possibility of traffic jams. The fact that 19.20 percent of the commuters opined the roads to be 'full of potholes' insinuated an increased likelihood of road accidents and further deterioration of road infrastructure quality endorsing the intricate relationship between road condition, traffic congestion, and road safety in Kolkata.

Interestingly in Table 6, a substantial portion of sampled commuters comprising 9.3 percent and 14.4% of the sampled commuters, commuting between 5 to 10 kilometers, and within 5 kilometers, respectively, experienced uneven or bumpy roadways. Mixed road conditions, on the other hand, were reported to be encountered by 7.7%, 21.3%, and 35.2% of the commuters undertaking journeys for less than 5 kilometers distance, within 5–10 kilometers

Table 5: Cross tabulation results between the condition of the road to daily average journey time lost (minutes) (computed by the authors)

Condition of Road		Time lost in minutes (average)					Total
		<10	10-19	20-29	30-39	40-49	
Bumpy	Count	14	37	51	8	3	113
	% of Total	3.7%	9.9%	13.6%	2.1%	0.8%	30.1%
Mixed	Count	47	43	39	3	0	132
	% of Total	12.5%	11.5%	10.4%	0.8%	0.0%	35.2%
Pot-hole riddled	Count	25	25	22	0	0	72
	% of Total	6.7%	6.7%	5.9%	0.0%	0.0%	19.2%
Smooth	Count	17	25	8	8	0	58
	% of Total	4.5%	6.7%	2.1%	2.1%	0.0%	15.5%
Total	Count	103	130	120	19	3	375
	% of Total	27.5%	34.7%	32.0%	5.1%	0.8%	100.0%

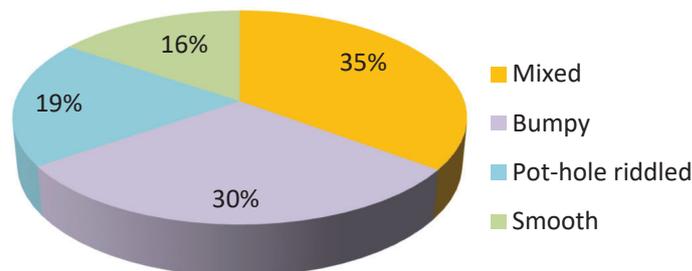


Fig.4: Condition of roads as perceived by commuters' (2022) (Source: Prepared by the authors based on field survey data, October-December, 2022)

Table 6: Cross-tabulation results between the condition of the road and to daily average journey time lost (minutes) (computed by the authors)

		Distance travelled in kilometers (average)					Total	
		<5	5-0.99	10-14.99	15-19.99	≥20		
Condition of Road	Bumpy	Count	35	54	12	12	0	113
		% of Total	9.3%	14.4%	3.2%	3.2%	0.0%	30.1%
	Mixed	Count	29	80	19	4	0	132
		% of Total	7.7%	21.3%	5.1%	1.1%	0.0%	35.2%
	Pot-hole riddled	Count	21	42	4	0	5	72
		% of Total	5.6%	11.2%	1.1%	0.0%	1.3%	19.2%
	Smooth	Count	18	36	4	0	0	58
		% of Total	4.8%	9.6%	1.1%	0.0%	0.0%	15.5%
Total		Count	103	212	39	16	5	375
		% of Total	27.5%	56.5%	10.4%	4.3%	1.3%	100.0%

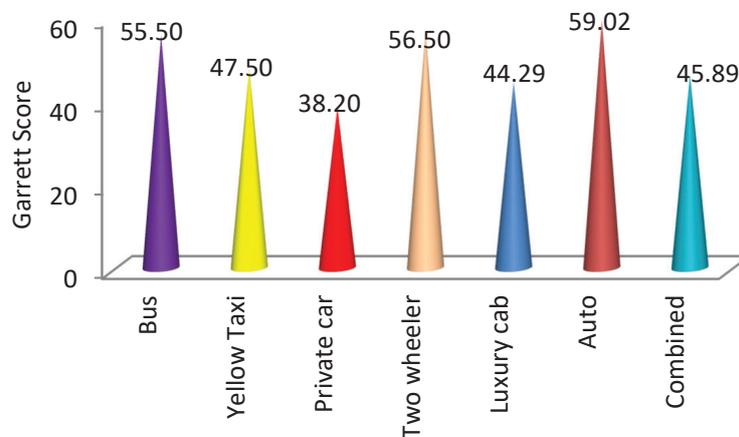


Fig. 5: Preferred daily mode of conveyance by commuters (2022) (Prepared by the authors based on field survey data, October-December, 2022)

and 10–15 kilometers distance respectively. The state of the roads not only affected the average trip distance but also significantly affected the amount of time lost when commuting. Due to different road conditions, the majority of respondents (35.2%) lost time, indicating a considerable level of discomfort. A time range between 10 to 19 minutes was cited to be wasted by the respondents (18%) traveling through mixed (11.2%), pothole-ridden (6.7%), and bumpy (9.9%) road conditions. Individuals navigating through these uneven road surfaces (13.6 percent) experienced a varied range of time losses, with the highest incidence occurring within the 20-29-minute timeframe. The mixed road conditions (10.4 percent), within the same timeframe, followed closely. Pothole-filled roads were a frequent occurrence for commuters (5.6%) covering fewer than 5 kilometers, which greatly increased their journey times. Conversely, smoother facilitated comparatively faster

travel times. Within the major TIPs of the KMC area, commuter mobility preferences and behaviors and mobility preferences are greatly influenced by the complex interaction between their income levels and the form of transportation they choose. The Garrett ratings (Eq. 1), which are allocated to each mode of transport and represent commuters favored or preferred daily means of conveyance, reflect this preference for various modes of travel (Fig. 5). With a Garrett score of 59.02, auto-rickshaws were the mode with the highest score among the others, followed by two-wheelers (56.5) and buses (55.5). This suggests that people have a noticeable preference for smaller, more agile auto-rickshaws, especially in crowded settings. Buses, despite being extensively used, face challenges in providing satisfactory services in coherence with increased demand and restricted maneuverability, thereby contributing to congestion. Nearly 27% of commuters with incomes below

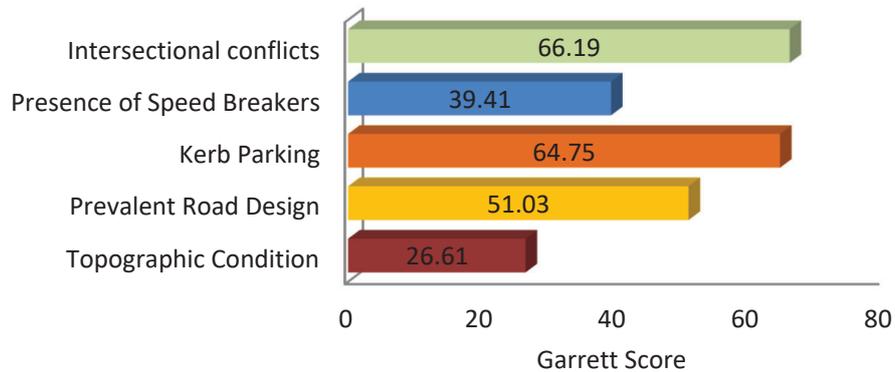


Fig. 6: Commuters' perception of dominant barriers affecting smooth traffic flow (2022) (Prepared by the authors based on field survey data, October-December, 2022)

50,000 INR and nearly 29percent of commuters with incomes below 25,000 INR select two-wheelers as their major mode of transportation for daily travel. For commuters in the same economic brackets, auto rickshaws appear to be the most convenient mode of transportation after buses. Depending on the financial situation, luxury taxis and private vehicles receive substantially lower Garrett ratings of 38.20 and 44.29 as mean scores, respectively, from the commuters, suggesting a lower degree of desire when traveling daily.

Rising travel demand necessitates an expansion of KMC's road infrastructure to accommodate the growing number of vehicles (Chakraborty, 2018). With the second-highest automobile ownership rate in India (61 cars per 1,000 residents), KMC experiences slower motorized traffic flow on major thoroughfares. The high density of automobiles has contributed to a chaotic mix of motorized and non-motorized transportation modes in the streetscape. An analysis of commuter perceptions on key barriers to TIPS along KMC's major road corridors reveals a clear hierarchy of hindrances (Fig. 6). The most significant barrier, with a mean Garrett score of 66.19 is intersectional conflicts, reinforcing the substantial impact of high total vehicular flow on the carrying capacity of the road. curb parking (64.75), acknowledging the detrimental effects of on-street parking on vehicle mobility follows next. Moreover, prevalent road design, with a mean score of 51.03, exhibits the adverse consequences of the haphazard development of city thoroughfares rooted

in colonial history, serving as a significant contributor to impediments in smooth vehicular flow. While the presence of speed breakers (ranked fourth with a score of 39.41) and topographic conditions (ranked fifth with a score of 26.61) are perceived as lesser obstacles, their impact on traffic flow can by no means be disregarded.

Causes of congestion

Traffic congestion, recurrent or non-recurrent, in KMC, arises from a complex interplay of factors that collectively impede the smooth flow of vehicular movement. Recurrent congestion, typically associated with rush hour commutes (8:30 AM - 11:00 AM and 4:30 PM - 7:30 PM), is primarily driven by an increase in the number of vehicles on the road that tends to obstruct the way of one another using the same road space at the same time. Non-recurrent congestion, on the other hand, involves less predictable, sporadic events such as car malfunctions, collisions, erratic behavior of individual drivers, road construction, adverse weather conditions, protests, and large gatherings that temporarily disrupt traffic flow and diminish road capacity (Falcocchio & Levinson, 2015; Chakraborty & Gupta, 2014). The commuter opinion poll results, (Fig. 7) demonstrated interesting trends about the factors contributing to this kind of phenomenon. Notably, the proliferation of personalized vehicles emerges as the most significant factor for recurrent congestion, as evidenced by its highest mean score (69.87). Both male (37%) and female (20%) commuters concur on its paramount

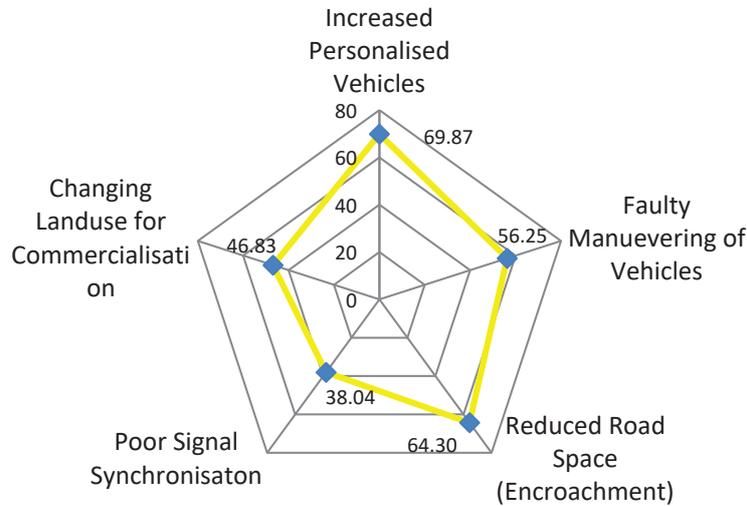


fig. 7: Commuters' perception of major factors leading to recurrent congestion (2022) (Prepared by the authors based on field survey data, October-December, 2022)

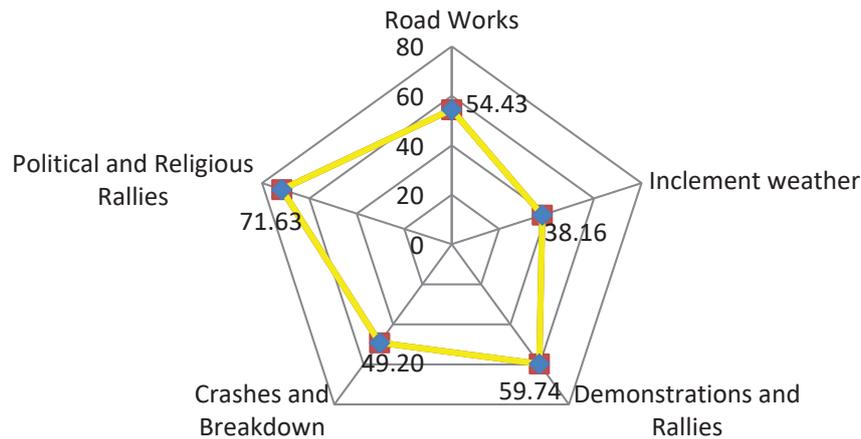


Fig. 8: Commuters' perception of major factors leading to non-recurrent congestion (2022) (Prepared by the authors based on field survey data, October-December, 2022)

importance highlighting its significant effect on congestion. Limited road space due to encroachment by vendors and street hawkers (mean score 64.30) emerged as the second most concerning issue. Improper vehicle maneuvering (mean score 56.25) trailed by poor traffic signal synchronization (mean score 46.83), and land-use changes for commercial purposes (mean score 38.04) were perceived as additional contributors of recurrent congestion reflecting the multidimensional nature of their perceptions.

While comprehending the causes of irregular or

non-recurrent traffic congestion (Fig. 8) political and religious protests emerged as the most disruptive factor with the highest mean score, (71.63). This was closely followed by demonstrations and rallies (59.74). Road construction (54.43) collisions/breakdowns (49.20), and inclement weather (38.1) were ranked as third, fourth, and fifth, contributing factors respectively.

Commuters in Kolkata face a complex web of factors contributing to traffic congestion. Heavy traffic volumes, inadequate public transport options, and a strong preference for personal vehicles,

Table 7: RII on effects of congestion on commuters' perception (computed by the authors)

sl. no.	Major effects of congestion	RII score
1	Excess fuel consumption by car	1.00
2	Hinders availing opportunities	0.96
3	Reduces time spent with family	0.93
4	Enhances noise pollution	0.93
5	Wastes individuals' productive capacity	0.92
6	Enhances air pollution	0.89
7	Causes tension and sweating to reach a destination	0.87
8	Combative temperament and behavior	0.82
9	Restrains building social relationships	0.81
10	Impatient behavior on the road	0.80
11	Causes headaches and physical discomfort	0.73
12	Cause a sense of suffocation	0.68
13	Enhances the risk of accidents	0.65

particularly two-wheelers, all play a significant role in creating gridlock. The elevated Garrett score provides a quantitative measure of congestion severity. As the commuters navigate these challenges in the bustling urban environments, the ramifications of traffic congestion on their daily lives become readily apparent. Extended travel times, increased fuel consumption and heightened levels of stress and fatigue are all tangible consequences of disorderly traffic conditions (Ajayi & Olawole, 2018).

Effects of congestion

To understand the relative severity of various consequences arising from traffic congestion in Kolkata, a Relative Importance Index (RII) as indicated by Eq. 2 was employed. The results (Table 7) shed light on the significant implications perceived by commuters. Excess fuel consumption emerged as the most impactful consequence, with an RII score of 1.00. The stop-and-start nature of congested traffic significantly increases fuel consumption. Furthermore, prolonged idling and inefficient engine operation contribute to heightened levels of air and noise pollution, as evidenced by the high RII scores of 0.89 and 0.93, respectively. The upshots of congestion extend far beyond detrimental environmental impacts. Commuters highlighted a significant decrease in their ability to capitalize on various opportunities due to congestion, reflected in the high RII score of 0.96 for hindrance to availing opportunities. This unrealized potential leads to a decline or waste in individual productivity, underlined by the RII of 0.92. Additionally, the adverse psychological and social impacts of congestion

surfaced, with notably high mean scores assigned to reduced family time (0.93) and its consequential impact on creating social bonds (RII=0.81) suggesting a hindrance to social interaction. Impatience and irritable behavior (RII=0.82), emerged as significant repercussions both within family dynamics and on the road. The rush to reach destinations, leading to heightened tension and perspiration (RII=0.87), physical discomfort, including headaches (RII=0.73), and at times, an increased risk of accidents (RII=0.65), were also identified as significant health risks associated with congestion. The multi-faceted and interconnected nature of the effects of congestion, as mirrored through the findings emphasizes the urgent need for holistic and integrated approaches to address the problems stemming from urban traffic congestion in Kolkata.

A rigorous analysis was undertaken to explore the health hazards and safety risks associated with traffic congestion in Kolkata, both of which are considered integral aspects of the broader consequences experienced by commuters. This analysis aimed to rank these concerns based on their perceived severity from the commuters' perspective.

Common associated perils

Through Garrett ratings, the common hazards associated with TIPs are further substantiated by their causative elements (Fig. 9). The assessment pinpointed several serious risks that commuters plying through these junctions experience. The most impactful consequence, with a mean score of 71.49, is work schedule disruption, emphasizing its detrimental impact on individuals' productivity.

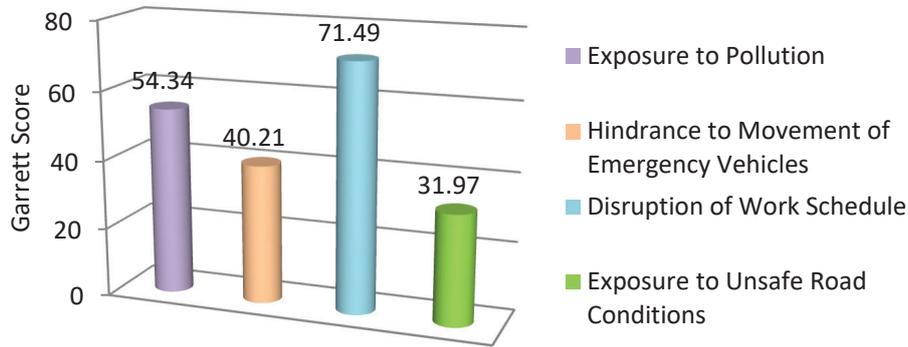


Fig. 9: Commuters' perception of common perils associated with traffic congestion (2022) (Source: Prepared by the authors based on field survey data, October-December, 2022)

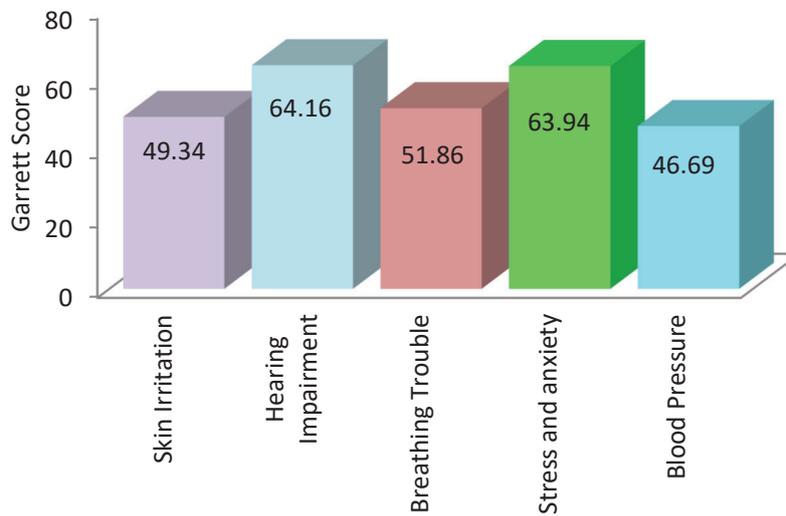


Fig. 10: Commuters' perception of common health hazards resulting from traffic congestion (2022) (Prepared by the authors based on field survey data, October-December, 2022)

Following closely and ranked second is the concern about exposure to pollution, reflected in a mean score of 54.34. This advocates a major concern for both deteriorating air quality and noise pollution caused by unrestrained honking. The hindrance to movement of emergency vehicles, scoring 40.21 was ranked third emphasizing the critical importance of maintaining efficient traffic flow to ensure prompt emergency response. Lastly, with a score of 31.97, exposure to hazardous road conditions may be linked to an increased likelihood of accidents, anxiety about reaching one's destination on time, increased fuel consumption by vehicles, and physical discomfort.

Health hazards

Commuters traversing crowded corridors face a spectrum of health risks (Anciaeset *al.*, 2017). An analysis of perceived health hazards, utilizing Garrett scores, revealed a distinct hierarchy of concerns (Fig. 10). Topping the list with a mean score of 64.16 is hearing emerged as the most prominent health concern indicating a severe impact of traffic-related noise on commuters' well-being. Stress and anxiety come in second, with a mean score of 63.94, speaking volumes about the adverse mental health implications that congestion has on commuters' lives, at times, inhibiting the growth of social bonds and family

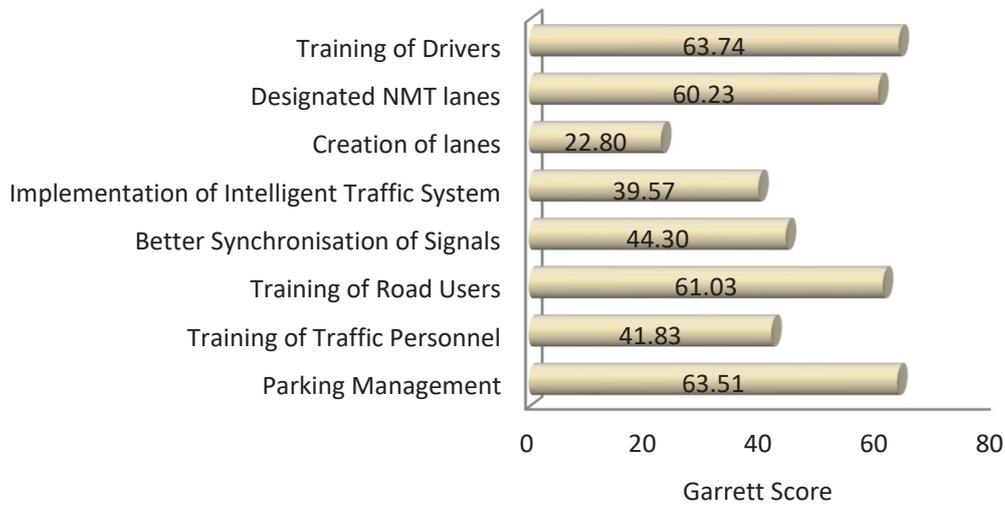


Fig. 11: Suggested areas of improvisation by commuters (2022) (Prepared by the authors based on field survey data, October-December, 2022)

ties. Breathing trouble and skin irritation with mean scores of 51.86 and 49.34 trials as third and fourth-ranked issues of health concern respectively. This hints towards prolonged exposure to environmental toxins and pollutants.

The cross-tabulation reveals distinct patterns in the relationship between health hazards and age concerning traffic congestion in Kolkata Municipal Corporation. Across various age groups, different health concerns emerge as predominant. Primarily, the threat of hearing anomaly looms large among commuters across all other age groups in nearly similar proportions (approximately 45 percent). For example, people between the ages of 15 and 29 are more susceptible to hearing impairment (47.7 percent) and stress and anxiety (45.9 percent) indicating that congestion has a substantial effect on their auditory and mental health. Meanwhile, those aged between 30-44 years are more prone to blood pressure issues, indicating a potential physiological response to the stressors associated with commuting. A wide age range seems to be affected by respiratory issues, with peaks seen in those between the ages of 15 to 29 and 45 to 59, suggesting a widespread risk to respiratory health at various phases of adulthood. Additionally, skin irritation is notable among commuters aged 30-44, potentially linked to prolonged exposure to environmental pollutants.

Recommended areas of improvisation and viable strategies

This more complex view of the perceived effects of congestion offers chances for focused interventions meant to improve overall passenger well-being while traveling across these vital intersections (Orru *et al.*, 2016). As prioritization of areas for improvement is crucial an analysis of the ranking of these areas would reveal insights into designing viable strategies as calculated by Garrett scores (Fig. 11). Foremost, with a mean score of 63.74, enhancing driver training emerges as a critical intervention, emphasizing the imperative of improving drivers' awareness and abilities to promote safe and effective traffic management. Parking management comes next, with a mean score of 63.51, favoring the importance of practical parking solutions at these crossings. Furthermore, with mean scores of 61.03 and 60.23, the introduction of road user education and the creation of lanes dedicated to Transportation (NMT) ranked third and fourth, respectively, indicating the necessity of improved infrastructure to guarantee the safety of pedestrians and cyclists. Subsequently, measures such as better signal synchronization (mean score 44.03), specialized training for traffic personnel (mean score 41.83), and the implementation of advanced traffic systems (mean score 39.57) were identified as areas for improvement. It's plausible

Table 8: Relative Importance Index on strategies to curb congestion by commuters' perception (computed by the authors)

Sl. no.	Strategies to curb congestion	RII score
1	Congestion charging	0.88
2	Ride-sharing	0.87
3	Wider lanes	0.85
4	Right of way for pedestrians	0.85
5	Route management	0.80
6	Improved public transport	0.78
7	Public-private partnership	0.76
8	Sustainable livable initiatives	0.72
9	Integrated corridor management	0.67
10	Commuter tax benefits	0.62

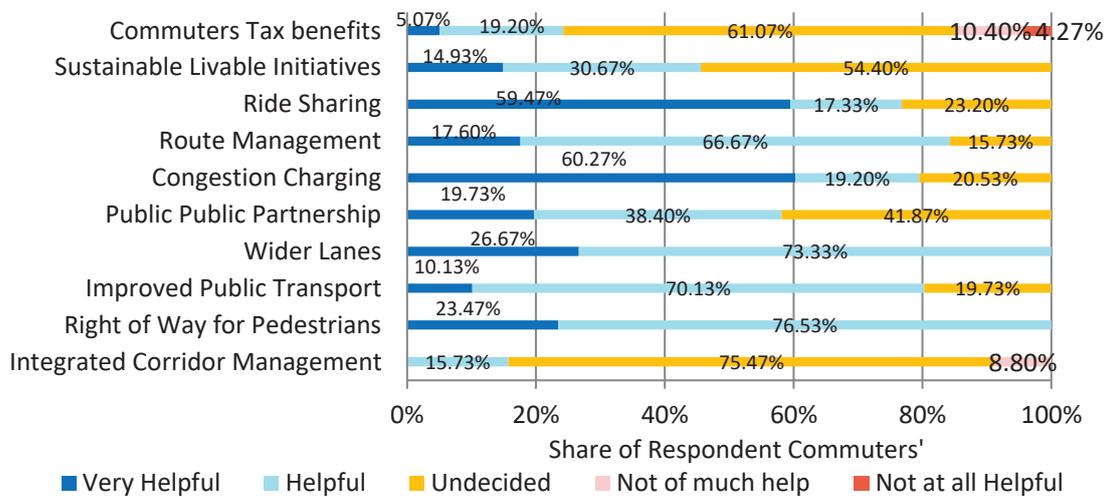


Fig. 12: Viability profile of strategies to curb congestion by commuters' perception (Prepared by the authors based on field survey data, October-December,2022)

that the undervaluation of operational benefits may stem from limited experience with supply-side improvement initiatives in urban settings like Kolkata.

To effectively tackle traffic congestion a diversified strategy that addresses previously identified areas for improvement is necessary. An analysis of commuter opinions on congestion relief measures using the RII (Table 8) reveals differential priorities (Anciaes et al., 2017). Congestion pricing has been recommended as the most practical approach, with a RII of 0.88. This demonstrates the perceived benefits of pricing mechanisms in discouraging driving during peak hours, thereby alleviating traffic congestion (Chakrabarty & Gupta, 2014). With a score of 0.87, ride-sharing indicates its potential as a significant decongestion strategy by maximizing vehicle

occupancy and reducing traffic volume. Additionally, prioritizing the pedestrian right of way and wider lanes, with an RII of 0.85, spells the importance of investing in pedestrian-friendly infrastructure. The provision for improved public transport and public-private partnerships, having RIIs of 0.78 and 0.76 respectively are next deemed crucial as a means to promote environmentally friendly modes of transport and collaborative approaches between government entities and private stakeholders to enhance transportation infrastructure and services. Conversely, the low ratings for integrated corridor management (RII=0.67) and commuter tax benefits (RII=0.62) reinstated that there was still a lack of awareness among the general public about supply-side management techniques.

CONCLUSION

In the context of the KMC and its struggle with traffic congestion, the scenario echoes a global trend observed in many of the cities of developing countries. Regrettably, like its counterparts, KMC has been emulating car-centric development patterns, exacerbating issues related to noise pollution, air pollution, greenhouse gas emissions, and accidents. The fact that the city still lacks a secure Non-Motorized Transportation infrastructure highlights the necessity of a paradigm change. The prioritized sequence of mean scores and ranks revealed in this study can serve as a crucial tool for policymakers and urban planners, aiding in the formulation of a comprehensive roadmap to understand commuters' priorities. To address the challenges, decision-makers must swiftly transit to a sustainable future, embracing strategies beyond the simplistic notion of 'building way out of congestion.' Instead, a dedicated and sustainable approach, informed by techniques like congestion pricing, ride-sharing programs, wider lanes, improved public transportation, and insights from developed nations' experiences with 'complete streets,' can offer more workable and long-lasting solutions to KMC's particular congestion issues. Implementing the 'Avoid, Shift, Improve' concept within KMC can offer a holistic approach to tackle urban transport difficulties and alleviate traffic congestion. By increasing accessibility and reducing journey distances, the 'Avoid' strategy—which combines land use and transportation planning, mixed-use development, and ICT utilization—can aid in minimizing needless travel. With a focus on public transportation and non-motorized options, the 'Shift' method encourages people to switch from owning private automobiles or motorcycles to more environmentally friendly modes of transportation. This approach advances a sustainable urban mobility paradigm by improving inter-city transit and putting travel demand management programs into place. The effective application of the 'Avoid' and 'Shift' techniques might greatly improve sustainable urban mobility and lessen traffic in a densely populated metropolis such as Kolkata. Complementing the previous strategies, the 'Improve' approach concentrates on technology improvements such as smart transportation systems, higher car efficiency requirements, and better fuel quality. Incremental advantages, while not immediately perceived,

do contribute to long-term improvements in the economy, environment, and society. In keeping with the suggestion made in the 'Bangkok 2020 Declaration' to implement a 'people-first' approach, KMC's initiatives should prioritize commuters' welfare first and promote sustainable urban life. A thorough and practical strategy to reduce traffic congestion and maintain the overall sustainability of urban transport in the area is provided by embracing a 'people-first' mindset in conjunction with the 'Avoid, Shift, Improve' framework.

AUTHOR CONTRIBUTIONS

A. Mukherjee performed the literature review, took samples for the study, analyzed and interpreted the data, prepared the manuscript text, and edited the manuscript. A K M Anwaruzzaman supervised and performed the corrections reviewed the article and controlled the results of the research.

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CONFLICT OF INTEREST

The author(s) 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)

KMC	Kolkata Municipal Corporation
RII	Relative Importance Index
TIPs	Traffic Intersection Points
FF	Free-Flow
CF	Congested Flow
LMV	Light Motor Vehicles
Kmph	Kilometers per hour

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ORIGINAL RESEARCH PAPER

Sustainable development of united territorial communities during the conflict: turning challenges into opportunities

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ABSTRACT

BACKGROUND AND OBJECTIVES: In the context of global challenges and local conflicts, the sustainable development of united territorial communities took on special importance. Amid military conflict, united territorial communities encountered numerous economic, social, and environmental problems. This research builds on resilience and sustainable development theories. It proposes that with appropriate support, united territorial communities can evolve into hubs of innovation and entrepreneurship even under conditions of conflict. The study necessitated the creation of strategies and programs for sustainable development and adaptation to new conditions, positing that united territorial communities, with proper development and support, could harness these challenges to foster significant entrepreneurial and innovative activities. The study's objective was to analyze the potential of united territorial communities for innovation and sustainable development in conflict conditions and to develop recommendations for supporting entrepreneurship and infrastructure development.

METHODS: To achieve the objective, a variety of methods were utilized, including multi-regression, multifactor, correlational, and comparative analysis. All analyses were carried out using STATISTICA software (version 13).

FINDINGS: The research results confirmed the hypotheses, indicating the significant potential of united territorial communities for initiating innovative projects and developing entrepreneurial initiatives. Specifically, it was discovered that the level of institutional capability and sustainable development could increase by 43.7% with the integration of effective support programs. Crucial elements impacting sustainability were pinpointed, with investments in environmental projects showing an 85% variance, socio-demographic stability exhibiting a 92.8% variance, and the development and implementation of programs for small and medium-sized business development reflecting a 92.9% variance. This demonstrated the potential for enhancing the budget efficiency of territorial communities by up to 56.4%, representing a substantial incentive for recovery and progress in the post-conflict period.

CONCLUSION: Recommendations included developing targeted programs to support innovations in the agricultural sector, tourism, and eco-initiatives, which could catalyze attracting investments and improve the quality of life in territorial communities. The importance of integrating modern technologies, supporting local entrepreneurship, and developing infrastructure were key elements for the sustainable development of united territorial communities in conflict conditions. The developed recommendations could facilitate the formation of effective development strategies for territorial communities.

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INTRODUCTION

In the context of global challenges and local conflicts, the sustainable development of United Territorial Communities (UTCs) becomes particularly significant for ensuring food security, employment, and the preservation of natural resources. This study draws upon resilience and sustainable development theories, particularly those discussed by Folke et al. (2010), Walker (2002), and Hansen (2014), to explore how UTCs can transform adversities from military conflicts into opportunities for innovation and entrepreneurship. Despite the potential threats to sustainability posed by wartime conditions, which can jeopardize the growth of these communities through the destruction of infrastructure and natural resources, and loss of livelihoods, UTCs have shown resilience. Historically, numerous countries experiencing armed conflicts have seen their territorial communities unite to face these challenges, emerging as hubs of entrepreneurial ventures and sustainable growth. Over recent decades, these conflicts have endangered the livelihoods of residents, leading to employment losses, destruction of infrastructure, degradation of nature, and the halting of agricultural activities. However, wartime conditions can jeopardize the sustainability and growth of these communities. Despite the hurdles posed by military actions, UTCs hold the potential to convert challenges into opportunities for entrepreneurship and sustainable development. Over recent decades, numerous countries have experienced armed conflicts and military actions that have profoundly impacted UTCs. These conflicts endanger the livelihoods of residents, leading to employment losses, destruction of infrastructure, degradation of nature, and the halting of agricultural activities. Yet, despite these obstacles, UTCs can emerge as hubs of innovation, entrepreneurial ventures, and sustainable growth amidst military conflict. This study aims to uncover opportunities and strategies to bolster the sustainable development of UTCs during and after military conflicts. The research zeroes in on analyzing the effects of military actions on the communities in the Sumy region of Ukraine, pinpointing potential growth or recovery areas, and opportunities to support local entrepreneurship. To fulfill the stated objective, the study will undertake the following tasks:

- Analyse the impact of military conflicts on the communities in the Sumy region of Ukraine and their economy;
- Identify opportunities for initiating growth or recovery in these areas;
- Investigate tools and programs that support the sustainable development of communities in the Sumy region of Ukraine under military action conditions.

Based on a literature review and previous studies, the following hypotheses were posited:

H1. Territorial communities can evolve into centers of innovation and entrepreneurship during conflicts with the implementation of effective sustainable development programs.

H2. Efforts to preserve and develop infrastructure in these areas are crucial for the revival and sustainable growth of the communities.

This research seeks to validate these hypotheses and discover avenues to achieve sustainable development goals in the UTCs of the Sumy region of Ukraine amid military conflict.

Literature review

The core concepts of sustainable development in UTCs under conflict include supporting the viability and self-sufficiency of these communities. A key idea is the integration of sustainable development principles into the planning and recovery of UTCs post-conflict. This encompasses the conservation of natural resources, infrastructure recovery, support for local entrepreneurship, and ensuring access to education and healthcare for the residents of UTCs (Raja et al., 2022; Shcherbak et al., 2020a).

Core concepts and approaches to sustainable development in UTCs

This section delves into the essential principles and diverse theoretical-practical approaches to sustainable development in UTCs, particularly in conflict contexts. It underscores the importance of embedding sustainable development principles into the planning and recovery processes, focusing on conserving natural resources, developing infrastructure, and bolstering local entrepreneurship and access to crucial services. In contemporary theory and practice, at least seven theoretical-practical approaches to sustainable development in UTCs have been identified (Shkoda et al., 2023):

The first approach

Sustainable development concepts for UTCs. The Food and Agriculture Organization (FAO) study emphasizes the necessity of incorporating sustainable development principles into the planning and recovery of UTCs post-conflict (Acunzo and Vertiz, 2014).

The second approach

Sustainability strategies for UTCs. Advocates of this theory (Roldan et al., 2023), examining ecological, social, and economic aspects of sustainability in these communities, highlight their crucial role in achieving balanced regional development.

The third approach

Interaction between UTCs and urban areas for sustainability. This approach explores the potential for global sustainability through the interaction between UTC and urban processes, considering various urbanization aspects and the rural-urban relationship in sustainable development (Gutierrez-Velez et al., 2022).

The fourth approach

Environmental sustainability in UTCs defines this as the outcome of rural-urban interactions, employing methods and strategies to enhance the environmental situation, especially in water resources, land restoration, waste management, and renewable energy use, based on various indicators and policy recommendations (Ilina and Shpyliova, 2021).

The fifth approach

Social inclusion in UTC development is predicated on social engagement in UTC development and addressing the issue of social participation misperception, resulting in some groups being undervalued and considered socially excluded due to confusion over “social inclusion,” (Shcherbak et al., 2024) “social capital,” and “civic activity” (Shortall, 2008; Shcherbak et al., 2020b).

The sixth approach

Tourism and sustainable development in UTCs focus on the relationship between tourism and sustainable development, promoting tourism as a catalyst for their balanced and sustainable economic,

social, and environmental development (Hussain et al., 2023; Rodríguez-Darias and Díaz-Rodríguez, 2023; Mwesiumo et al., 2022).

The seventh approach

Resource management in UTCs emphasizes effective natural and human resource management to achieve sustainable development and optimal resource utilization to support agriculture and other activities (Leder, 2022; Harrington, 2016; Emtage and Herbohn, 2012; Walker, 2002; Loevinsohn et al., 2002; Higgins and Lockie, 2002).

Sustainable development goals and strategies for UTCs in conflict

This subsection explores specific goals and strategies for achieving sustainable development in UTCs during and after conflicts (Kumar, 2018). It reviews prior studies and theoretical frameworks, emphasizing the significance of safety, resilience, economic activity, environmental sustainability, social inclusion, education, healthcare, and infrastructure recovery as vital elements for the sustainable advancement of UTCs amidst adversities. Previous research in transforming UTCs under conflict has demonstrated that sustainable development goals can still be pursued during wartime (Pereira et al., 2022; Beckmann and Reimer, 2014). These goals focus on ensuring the sustainability and progress of UTCs in military conflict contexts. Potential sustainable development goals for UTCs in wartime may include: Ensuring safety and resilience a primary and crucial goal in providing security for residents of UTCs. This may encompass measures for protection against military threats and delivering humanitarian aid to affected individuals (Kajus et al., 2022). Conserving natural resources is essential as UTCs often serve as hubs for agricultural activities and are rich in natural resources. Promoting sustainable usage of these resources and preventing their destruction and facilitating their recovery after conflicts are vital objectives (Petrescu-Mag et al., 2018; Shan et al., 2017). Supporting local entrepreneurship by facilitating conditions for its development can preserve employment (Jahanshahi et al., 2020) and ensure economic resilience in UTCs (Lee, 2023; Stevanović, 2016; Bruton et al., 2021). Entrepreneurship plays a key role in the sustainable development of UTCs, as initiating new businesses and fostering existing

ones can provide employment, enhance economic activity, and ensure social stability. Supporting local entrepreneurship is a critical element of a sustainable development strategy. Ensuring access to education and healthcare. Maintaining operational educational and medical facilities is crucial during wars or other crisis force majeure situations (pandemic, natural disasters, etc.) to ensure population development and health (Beyene *et al.*, 2023; Shcherbak *et al.*, 2021). Preserving the cultural heritage and traditions of UTCs is an important goal to support their resilience and identity (Denton, 2017; Zhu *et al.*, 2021). Engaging international humanitarian aid, donors, and humanitarian organizations is crucial for providing necessary resources and assistance to UTCs in challenging times (Solana-Solana, 2010). Reintegration and recovery of UTCs, including the restoration of infrastructure, economy, and social services, become crucial after the conflict's end (Gignoux and Menéndez, 2016). Conflict can significantly impact UTCs, leading to infrastructure destruction, job losses, and economic changes. Analyzing the conflict's impact on various aspects of community life is essential to develop recovery and support strategies. These studies underline the importance of reintegration and recovery of UTCs' post-conflict, including infrastructure, economy, and social services restoration, and provide recommendations for achieving this sustainable development goal. The study, addressing the tasks of analyzing the impact of military conflicts on UTCs and their economy, identifying opportunities for growth or recovery, and investigating supportive tools and programs for sustainable development under conflict conditions, was conducted in the Sumy region of Ukraine from January to June 2023.

MATERIALS AND METHODS

Research methodology

To test the hypothesis for validity, a methodological approach consisting of the following steps is proposed:

- **Step 1** involves a detailed case study analysis of UTCs that have experienced military conflicts to uncover innovative and entrepreneurial activities initiated during these challenging times. We analyze existing support programs and infrastructure development projects to understand their roles in the recovery and sustainable development of these

communities. Primary data collection is carried out through surveys among representatives from the UTCs, experts in sustainability and innovation, and participants in various support programs.

- **Step 2** leverages statistical methods to analyze the collected data, aiming to establish correlations between the presence of innovative and entrepreneurial activity in UTCs and the implementation of support programs and infrastructure projects. This step is crucial for understanding the direct impacts of these initiatives on sustainable development outcomes.

- **Step 3** focuses on synthesizing insights from the data analysis to formulate concrete recommendations for enhancing the effectiveness of future development initiatives, particularly in post-conflict recovery scenarios within UTCs. This involves proposing targeted support measures that can address identified gaps and leverage opportunities for growth and sustainability.

Conducting a case study analysis of UTCs affected by military conflict

The selection of the research method involves using a combination of quantitative and qualitative methods for data collection and analysis, including surveys of UTCs, observations on the implementation of programs, and analysis of available statistical data. Sources of information for this study include official reports from the Express Releases Publication Calendar (2023) Main Statistical Office in Sumy Oblast, scientific articles (Prohorovs, 2022; Akimov, 2022), and interviews with experts and representatives of UTCs. The scope of the study includes the analysis of implemented development programs, statistical data on UTCs, and the study of the impact of conflict on the economy and infrastructure of UTCs. The evaluation of methods and tools for analysis was conducted with consideration of their effectiveness and the ability to identify connections between different factors. Data collection and processing include statistical analysis, content analysis, and categorization of information for further comparison and conclusions regarding the impact of support programs on the sustainable development of UTCs after the end of the conflict. To enhance the methodological rigor of the case study analysis on UTCs affected by military conflict, it is crucial to specify the sample size and selection criteria. The study engaged a sample size of approximately 400 respondents, representative of the Sumy region's demographic and

Table 1: System of indicators influencing the sustainable development of UTCs in the Sumy region

Indicators	Conventional designation
Gross Product of the United Territorial Community, million UAH.	X1.1
Infrastructure losses, million UAH.	X1.2
The share of wages in the expenditures of the general fund, %.	X1.3
The revenues of the general fund per capita, UAH. (financial potential of UTC)	X1.4
Expenditures of the general fund per capita, UAH.	X1.5
Capital expenditures per capita (UAH).	X1.6
The share of capital expenditures in the total amount of expenditures, %.	X1.7
Some entrepreneurship entities.	X1.8
Some individual entrepreneurs.	X1.9
Individual entrepreneurs, led by women, share in % of the total number.	X1.10
Population as of 01.01.2023, people.	X2.1
Some general secondary education institutions.	X3.1
Some cultural and educational institutions.	X3.2
Some recreational facilities.	X3.3
Some restaurant businesses.	X3.4
Some cultural-national heritage sites.	X3.5
Losses in agriculture and land resources, million UAH.	X4.1
Losses of the forest fund, million UAH.	X4.2
A rating of institutional capacity and sustainable development.	X5.1
A presence of SME development programs.	X5.2
Budget efficiency of UTC.	X5.3

socio-economic diversity. Respondents were selected using a purposive sampling technique to include a wide range of impacted stakeholders such as local business owners, government officials, and residents directly affected by the conflict. Data sources were comprehensive, including not only official reports but also scientific articles and firsthand interviews with these stakeholders. This approach ensured a balanced view of the impacts across different social and economic layers within the community, providing a robust basis for analyzing the effectiveness of development programs and the broader economic and infrastructural impacts.

Collection and preliminary processing of statistical data

Statistical data that can impact the achievement of sustainable development goals in UTCs during wartime include:

Economic data: Gross Regional Product (GRP), unemployment rate, market opportunities, economic structure (agriculture, industry, services), and other data regarding the economic situation. These data indicate the economic impact of the conflict on UTCs and their recovery opportunities.

Demographic data: population size, age group distribution, population structure (male, female,

children), migration level (displacement), and ethnic composition. This data helps assess the war’s impact on the population of UTCs and identify the need for social programs and services.

Social data: education level, access to medical services, poverty level, and security. This data helps identify the social needs of residents in UTCs and develop social support programs.

Environmental data: environmental condition, pollution level, access to natural resources. These data are important for ensuring sustainability and environmental protection in UTCs, especially during war.

Political data: the impact of political factors, including the presence of conflict, political stability, and governance, on UTCs and their ability to implement sustainable development programs.

All these initial data were collected and normalized. Conditional indicators were previously collected to determine their impact on the sustainable development of UTCs (Table 1).

Evaluation of analysis methods and tools

The initial data collected are normalized to ensure comparability across different scales and measures. This normalization involves converting all indicators into a dimensionless form, allowing for more accurate

Table 2: Results of factor analysis on the impact of individual indicators on the sustainable development level of UTCs (STATISTICA 13 listing)

Variable	Factor Loadings (Unrotated) (data). Extraction: Principal components. Marked loadings are >0,700000			
	Factor 1	Factor 2	Factor 3	Factor 4
X _{1.1}	0,733	-0,306	0,041	-0,004
X _{1.2}	-0,829	-0,371	-0,315	-0,170
X _{1.3}	0,153	0,256	0,364	0,173
X _{1.4}	0,757	-0,393	-0,268	0,051
X _{1.5}	-0,791	-0,350	-0,086	-0,080
X _{1.6}	-0,228	-0,346	-0,447	0,469
X _{1.7}	0,099	-0,019	-0,489	0,134
X _{1.8}	0,918	-0,259	0,150	0,066
X _{1.9}	0,929	-0,254	0,167	0,009
X _{1.10}	-0,129	-0,176	-0,124	-0,597
X _{2.1}	-0,234	0,928	0,191	-0,132
X _{3.1}	0,120	-0,112	0,968	0,008
X _{3.2}	-0,417	0,427	0,098	0,087
X _{3.3}	0,109	0,059	0,702	0,307
X _{3.4}	0,014	-0,110	0,873	-0,098
X _{3.5}	-0,172	0,167	0,032	0,112
X _{4.1}	-0,356	-0,108	-0,291	-0,855
X _{4.2}	-0,364	-0,093	-0,286	-0,849
Exp.Var	5,541	3,151	2,177	1,367
Prp.Totl	0,388	0,275	0,181	0,076

statistical analyses such as factor analysis, regression analysis, and cluster analysis. These methods help identify key factors influencing sustainability and pinpoint specific areas for intervention. Normalization of the initial data involves converting all indicators into a dimensionless form using Eq. 1:

$$z_{ij} = \frac{x_{ij} - \bar{x}_j}{S_j} \tag{1}$$

where x_{ij} – is the j -th indicator of the state of the i -th UTC; \bar{x}_j – is the average value of this indicator for all UTCs; S_j – the standard deviation of this indicator for all UTCs.

Application of statistical methods for data analysis

Statistical analysis is conducted using the STATISTICA software package, applying techniques such as factor analysis to determine which indicators most significantly impact the sustainable development levels of UTCs. The results of this factor analysis help clarify the relationships among various factors and guide the development of targeted interventions. During the initial phase of data analysis, it was identified which indicators influence the sustainable development level of UTCs. This was done using factor analysis with the application of the Statistica software package. The results of this analysis are presented in Table 2.

The results of the factor analysis are interpreted as follows: the indicators that have an impact on the process are highlighted by the program in red, while those that do not have an impact are in black. Thus, Table 2 indicates that not all indicators have an impact on the sustainable development level of UTCs. Specifically, the share of wages in the expenditures of the general fund ($x_{1.3}$); capital expenditures per capita ($x_{1.6}$); the share of capital expenditures in the total amount of expenditures ($x_{1.7}$); individual entrepreneurs who are women ($x_{1.10}$); the number of cultural and educational institutions ($x_{3.2}$); the number of objects of cultural-national heritage ($x_{3.5}$) do not affect the level of sustainable development of UTCs. To address the need for a detailed discussion on how military conflicts specifically affect various dimensions of sustainability, it is crucial to recognize that conflict not only disrupts infrastructure, as indicated by the substantial factor loading of -0.829 but also significantly impacts social and economic stability. This manifests through direct damage to physical assets, disruptions in local economies, and strains on social services, all of which compound the challenges faced by united territorial communities in maintaining sustainable development. These disruptions require targeted recovery strategies that not only focus on physical rebuilding but also on restoring the social fabric and economic vitality

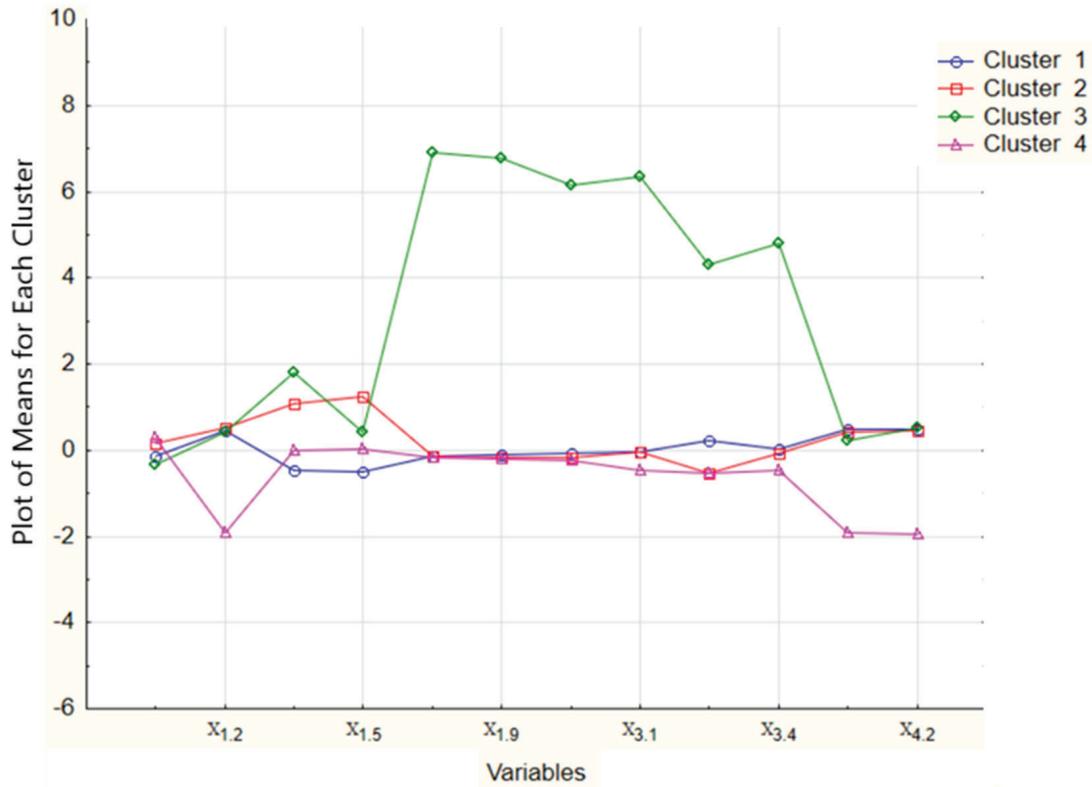


Fig. 1: The average values of the indicators of the state of UTCs in Sumy region. STATISTICA 13 listing

of these communities. Cluster analysis was used to determine how many clusters of different levels of sustainable development of UTCs were obtained and which communities entered each cluster. The construction of clusters was carried out by minimizing the root mean square deviation of all indicators (Eq. 2):

$$\min \left[\sum_{i=1}^k \sum_{x(j) \in S_i} \|x^{(j)} - \mu_i\|^2 \right] \quad (2)$$

where $x^{(j)} \in R^n$; $\mu_i \in R^n$; μ_i – the centroid (center) of cluster R_i . Next, the centroid R_i of the cluster is determined by the principle of minimizing the root mean square deviations of indicators from the cluster centroid using Eq. 3:

$$\mu_i = \frac{1}{S_i} \sum_{x^{(j)} \in S_i} x^i \quad (3)$$

The recalculation is completed when the μ_i values

do not change, which is done using Eq. 4:

$$\mu_i^{step t} = \mu_i^{step t+1} \quad (4)$$

where $step t$ – is the previous iteration, and $step t+1$ – is the current iteration. Discriminant analysis is used to determine potential growth points and development vectors of each cluster using Eq. 5:

$$K_i = \sum_{i=1}^n b_i \times a_{ij} \rightarrow \max \quad (5)$$

where i – is the cluster number; n – is the number of clusters; a_{ij} – the specific weight of the impact of indices. Regression analysis is used to confirm or refute hypotheses. Statistical tests such as the t-test and F-test (analysis of variance) are used to assess the statistical significance of each regression coefficient and the model as a whole. If the p-value is less than the set significance level (usually 0.05), the hypothesis can be accepted. By integrating a robust

methodological approach with detailed data analysis, this research aims to provide actionable insights and practical recommendations for enhancing the sustainability of UTCs in post-conflict scenarios, thereby contributing to their long-term resilience and development.

RESULTS AND DISCUSSION

Analysis of the condition of UTCs in conflict situations

To analyze the condition of UTCs in conflict situations, the method of cluster analysis was applied, and clusters of UTCs were calculated. For each cluster, a chart was created, displaying the average values of the indicators for the UTCs. The chart highlights the main indicators, and each cluster is represented by a different color or symbol for visual identification (Fig. 1).

The list of clusters included in each of the four

clusters is presented in Tables 3-6. The composition of the first cluster of UTCs in the Sumy region is shown in Table 3. The composition of the second cluster of UTCs in the Sumy region is shown in Table 4. The composition of the third cluster of UTCs in the Sumy region is shown in Table 5. The composition of the fourth cluster of AUTCs in the Sumy region is shown in Table 6.

Visualization of the results of the condition of UTCs in conflict situations

Visualization of the location of each territorial community by its level of development in the coordinate system: Economic-Environmental Development Level / Socio-Demographic Development Level is presented in Fig. 2.

Analysis of the obtained results allows for the comparison of the condition and characteristics of

Table 3: Composition of the first cluster (STATISTICA 13 listing)

Members of Cluster Number 1 (Data nor) and Distances from Respective Cluster Center. A cluster contains 29 cases			
Case No.	Distance	Case No.	Distance
UTC1	0,386	UTC27	0,335
UTC2	0,645	UTC28	0,553
UTC5	0,867	UTC29	0,309
UTC7	0,498	UTC30	0,439
UTC9	0,403	UTC32	0,507
UTC10	0,322	UTC34	0,284
UTC12	0,262	UTC35	0,335
UTC13	0,456	UTC38	0,337
UTC14	0,371	UTC39	0,460
UTC15	0,398	UTC41	0,400
UTC18	0,346	UTC43	0,425
UTC20	0,981	UTC47	0,534
UTC21	0,463	UTC48	0,348
UTC24	1,127	UTC49	1,669
UTC26	0,321		

Table 4: Composition of the second cluster (STATISTICA 13 listing)

Members of Cluster Number 2 (Data nor) and Distances from Respective Cluster Center. A cluster contains 11 cases			
Case No.	Distance	Case No.	Distance
UTC4	0,336	UTC37	0,263
UTC6	0,300	UTC40	0,385
UTC19	1,234	UTC44	0,219
UTC25	0,259	UTC46	0,434
UTC33	0,439	UTC51	0,343
UTC36	0,615		

Table 5: Composition of the third cluster (STATISTICA 13 listing)

Members of cluster number 3 (data nor) and distances from respective cluster center cluster contains 1 case	
Case No.	Distance
UTC42	0,00

Table 6: Composition of the fourth cluster (STATISTICA 13 listing)

Members of cluster number 4 (data nor) and distances from respective cluster center. A cluster contains 10 cases			
Case No.	Distance	Case No.	Distance
UTC3	0,362	UTC22	0,398
UTC8	0,363	UTC23	0,823
UTC11	0,564	UTC31	0,351
UTC16	0,681	UTC45	0,395
UTC17	0,216	UTC50	0,350

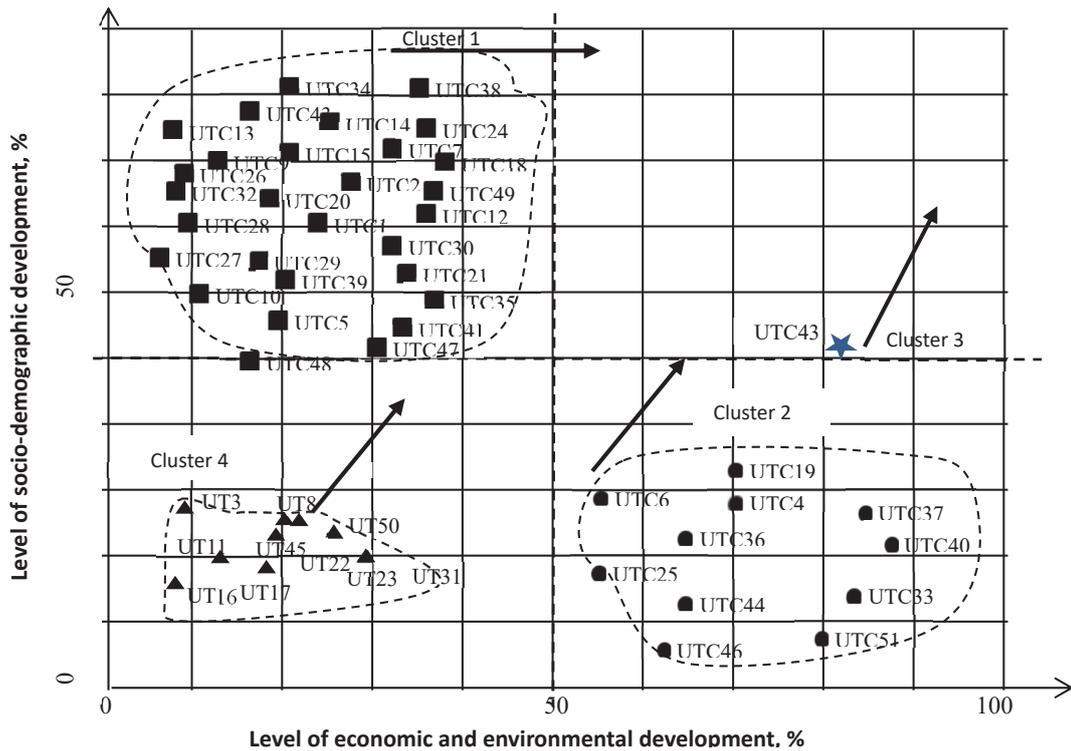


Fig. 2: Matrix for assessing the current state of UTCs in the Sumy region

UTCs in each cluster, identifying which clusters have similar characteristics and which are distinct (Table 7).

Analysis of the data in Table 7 helps to identify the main trends and issues in the condition of UTCs under conflict conditions. Such analysis enables an understanding of the diversity of UTCs and isolates the main features of each cluster for further refinement of development strategies and crisis management.

Validation of hypotheses

The evaluation of the two proposed hypotheses was conducted using multi-regression analysis.

Validation of H1

The results of the multi-regression analysis with a correlation coefficient of Multiple R = 0.66138664 and an F-value = 2.462285 at a p-value of 0.017270 indicate the statistical significance of the model for predicting the rating of institutional capability and sustainable development (dependent variable $X_{5,1}$). The R^2 value of 0.43743229 shows that approximately 43.74% of the variability of the dependent variable can be explained by the variability of the independent variables in the model. Among the significant coefficients, $X_{3,1}$ ($b^* = 1.02$) for the number of general secondary education institutions and $X_{3,4}$ ($b^* = 0.831$)

Table 7: Results of cluster analysis. Determining the composition of UTC clusters in Sumy region (STATISTICA 13 listing)

United Territorial Communities (UTCs) of the Sumy region	Cluster number / Number of UTCs	Identification of the level of sustainability of UTCs
Andriyashivska (UTC1); Bezdrytska (UTC2); Boromlianska (UTC5); Burynska (UTC7); Verkhni Syrovatska (UTC9); Vilshanska (UTC10); Hlukhivska (UTC12); Hrunska (UTC13); Druzhbivska (UTC14); Duboviazivska (UTC15); Kyrykivska (UTC18); Konotopka (UTC20); Korovynska (UTC21); Lebedynska (UTC24); Mykolaivska (Bilopilskyi district) (UTC26); Mykolaivska (UTC27); Myropilska (UTC28); Nedryhailivska (UTC29); Nyzhniosyrovatska (UTC30); Okhtyrka (UTC32); Putivska (UTC34); Richkivska (UTC35); Sveska (UTC38); Seredyno-Budska (UTC39); Stepanivska (UTC41); Trostianetska (UTC43); Chupakhivska (UTC47)§ Shalyhinska (UTC48); Shostkinska (UTC49)	1 /29	Low level of economic and environmental development High level of socio-demographic development
Berezivska (UTC4); Bochechkivska (UTC6); Komyskanska (UTC19); Lypovodolynska (UTC25); Popivska (UTC33); Romenska (UTC36); Sadvivska (UTC37); Synivska (UTC40); Khmelivska (UTC44); Cherechchynska (UTC46); Krolevetska (UTC51)	2 /11	High level of economic and environmental development Low level of socio-demographic development
Sumyskaya (UTC42)	3/1	High level of economic and environmental development High level of socio-demographic development
Bilopilka (UTC3); Velykopysarivska (UTC8); Vorozhbianska (UTC11); Esmanska (UTC16); Znob-Novhorodska (UTC17); Krasnopilska (UTC22); Yampilka (UTC23); Novoslobidska (UTC31); Khotynska (UTC45); Yunakivska (UTC50)	4/10	Low level of economic and environmental development Low level of socio-demographic development

Table 8: Validation of H1 through multi-regression analysis of the development level in UTCs in the Sumy region

Regression Summary for Dependent Variable: $X_{5,1}$ (Data nor)						
N=51						
R= 0,66138664 R ² = 0,43743229 Adjusted R ² = 0,25977932						
F(12,38)=2,4623 p<0,01727 St. Error of estimate: 0,86036						
	b*	Std.Err. of b*	b	Std. Err. of b	t(30)	p-value
Intercept			0,000	0,120	0,000	1,000
X _{1,1}	0,223	0,182	0,223	0,182	1,225	0,228
X _{1,2}	0,399	0,508	0,399	0,508	0,784	0,438
X _{1,4}	0,049	0,260	0,049	0,260	0,186	0,853
X _{1,5}	-0,100	0,272	-0,100	0,272	-0,366	0,716
X _{1,8}	-0,620	2,003	-0,620	2,003	-0,310	0,759
X _{1,9}	-0,026	2,779	-0,026	2,779	-0,009	0,993
X _{2,1}	-0,769	1,201	-0,769	1,201	-0,640	0,526
X _{3,1}	1,022	0,687	1,022	0,687	1,488	0,145
X _{3,3}	-0,315	0,173	-0,315	0,173	-1,819	0,077
X _{3,4}	0,831	0,307	0,831	0,307	2,713	0,010
X _{4,1}	-0,408	0,455	-0,408	0,455	-0,896	0,376
X _{4,2}	-0,234	0,442	-0,234	0,442	-0,530	0,599

for the number of restaurant establishments indicate their significant positive impact on the rating of institutional capability and sustainable development. Also important are X_{1,1} (b* = 0.223) for the gross product of the community and X_{1,2} (b* = 0.399) for infrastructure losses, highlighting the importance of economic and infrastructure factors (Table 8).

Data in Table 8 confirm H1, suggesting that UTCs can transform into centres of innovation and

entrepreneurial activity during a conflict if effective sustainable development programs are implemented. Special attention should be given to the development of educational and restaurant infrastructure as key factors in enhancing institutional capability and sustainable development. Based on these results, it is recommended to focus on the development and implementation of comprehensive programs that include support for educational initiatives,

development of the restaurant business, and infrastructure restoration to promote sustainable development of UTCs in the Sumy region, even in the context of military conflict.

Validation of H2

Results of the multi-regression analysis with a high correlation coefficient (Multiple R = 0.75154353) and significant F-statistic level (F = 4.109977) at a p-value of 0.000408 indicate the statistical significance of the model for predicting the budget efficiency of the community (dependent variable $X_{5,3}$). The determination coefficient ($R^2 = 0.56481768$) suggests that the model explains approximately 56.48% of the variability of the dependent variable, which is relatively high. Significant coefficients in the model, such as $X_{1,4}$ ($b^* = 1.28$) on general fund income per capita, $X_{3,1}$ ($b^* = 0.497$) on the number of general secondary education institutions, and $X_{4,2}$ ($b^* = 0.280$) on forest fund losses, indicate their positive impact on the budget efficiency of the community. Negative coefficients, such as $X_{1,5}$ ($b^* = -0.84$) on general fund expenditures per capita and $X_{2,1}$ ($b^* = -0.35$) on population size, may suggest that high expenditures and a decrease in population size negatively affect budget efficiency (Table 9).

The results (Table 9) confirm H2, which posits that measures for the preservation and development of infrastructure in UTCs can be key to their recovery and sustainable development. Particularly important is the positive impact of the financial potential of the community ($X_{1,4}$) and the development of educational

infrastructure ($X_{3,1}$), indicating the need for investments in these areas to enhance the efficiency and sustainable development of UTCs. Based on these results, to achieve greater budget efficiency and sustainable development of UTCs in the Sumy region, it is recommended to focus on developing and implementing programs aimed at increasing general fund income per capita, developing educational infrastructure, as well as reducing general fund expenditures per capita and increasing attention to the preservation of natural resources.

Development of directions and programs for the development and recovery of UTCs in the Sumy region

For each of the four clusters of united territorial communities in the Sumy region, the following directions and programs for development and recovery can be proposed (Table 10).

To enhance recommendations and specify steps that local authorities or organizations can take to implement them, including policy changes, specific program development, or partnership opportunities, the following actions can be proposed:

Cluster 1: Encouraging economic activity may include developing support policies for small and medium-sized businesses in agriculture through tax incentives or subsidies, and partnerships with agrotechnology companies to implement innovative agricultural technologies.

Cluster 2: Attracting youth and professionals could involve creating municipal scholarship and grant programs for education and internships, and

Table 9: Validation of H2 through multi-regression analysis of the development level in UTCs in the Sumy region

N=51	Regression Summary for Dependent Variable: $X_{5,3}$ (Data nor)					
	R= 0,75154353 R ² = 0,56481768 Adjusted R ² = 0,42739169 F (12,38) =4,1100 p<0,00041 St. Error of estimate: 0,75671					
	b*	Std.Err. of b*	b	Std. Err. of b	t(30)	p-value
Intercept			0,000	0,106	0,000	1,000
X _{1,1}	0,148	0,160	0,148	0,160	0,927	0,360
X _{1,2}	-0,156	0,447	-0,156	0,447	-0,348	0,730
X _{1,4}	1,284	0,229	1,284	0,229	5,609	0,000
X _{1,5}	-0,843	0,239	-0,843	0,239	-3,522	0,001
X _{1,8}	-0,277	1,762	-0,277	1,762	-0,157	0,876
X _{1,9}	0,109	2,444	0,109	2,444	0,045	0,965
X _{2,1}	-0,351	1,057	-0,351	1,057	-0,333	0,741
X _{3,1}	0,497	0,604	0,497	0,604	0,824	0,415
X _{3,3}	0,064	0,152	0,064	0,152	0,422	0,675
X _{3,4}	-0,074	0,270	-0,074	0,270	-0,274	0,785
X _{4,1}	0,032	0,400	0,032	0,400	0,080	0,937
X _{4,2}	0,280	0,389	0,280	0,389	0,721	0,475

Table 10: Development directions and recovery programs for territorial communities of the Sumy region

Cluster	Development directions	Recovery Programs
Cluster 1: Low level of economic-ecological development, high level of socio-demographic development	Stimulating economic activity, and support for SMEs in agriculture. <i>Technologies:</i> Crop yield optimization software and precision farming.	Implementing environmental projects, focusing on resource conservation and green tourism development. <i>Technologies:</i> Precision agriculture for sustainable farming, eco-tourism apps.
Cluster 2: High level of economic-ecological development, low level of socio-demographic development	Empowering youth and professionals. <i>Technologies:</i> Online job portals and AI for talent acquisition; e-learning and teleconferencing for expanded connectivity.	Developing public health with new medical centers and preventive programs. <i>Technologies:</i> Telemedicine for remote consultations and health monitoring wearables.
Cluster 3: High level of both economic-ecological and socio-demographic development	Integrating with global economies to access new markets. <i>Technologies:</i> E-commerce platforms and blockchain for secure transactions. Emergency programs for infrastructure recovery and meeting basic needs.	Enhancing educational infrastructure with new institutions and distance learning. <i>Technologies:</i> E-learning platforms and teleconferencing for virtual classrooms.
Cluster 4: Low level of both economic-ecological and socio-demographic development	Boosting local governance and public participation. <i>Technologies:</i> E-government platforms and mobile voting apps.	Enhancing global connectivity and trade. <i>Technologies:</i> Advanced e-commerce and blockchain
	Mobile clinics for remote healthcare, solar water purification.	Assisting vulnerable populations with local and international resources. <i>Technologies:</i> Crowdfunding platforms and AI-driven resource allocation.
		Creating loan and grant programs for innovation and environmental projects. <i>Technologies:</i> Blockchain for transparent funding and mobile banking apps.
		Establishing cultural and sports centers to boost community engagement. <i>Technologies:</i> Online platforms for virtual events and fitness apps for sports challenges
		Enhancing social protection and support for young families. <i>Technologies:</i> Social welfare systems and online counseling services
		Enhancing economic, ecological, and management literacy. <i>Technologies:</i> Online learning platforms and educational apps for financial skills.

collaborating with technology startups to develop remote work platforms, which will improve socio-demographic development.

Cluster 3: Integration with European and international economic structures might include creating specialized economic zones that attract foreign investments and improve access to international markets through digital trade platforms.

Cluster 4: Developing infrastructure in

emergencies may involve government programs for infrastructure restoration and renewal, using international aid, and partnerships with nonprofit organizations to provide necessary services to the population, as well as implementing technologies to improve access to medical and educational services in remote areas.

These actions will help not only in the recovery and development of communities after conflicts but

also in creating sustainable and viable conditions for their long-term growth.

Discussion

The results of this research highlight the importance of a comprehensive approach to the sustainable development of UTCs, reflecting previous theoretical and practical developments in this field. In particular, the value of educational initiatives and the development of small and medium enterprises are emphasized, aligning with the conclusions of FAO (Acunzo and Vertiz, 2014), which indicate the necessity of integrating sustainable development principles into territorial community development planning. The analysis of the relationship between rural and urban processes in the context of sustainable development (Gutierrez-Velez *et al.*, 2022) also proved relevant to this study, highlighting the potential of UTCs as centers of innovation and entrepreneurship, even in conflict situations. The importance of environmental sustainability in UTCs is also reflected in the results (Ilina and Shpyliova, 2021), as well as social inclusion (Shcherbak *et al.*, 2020), for achieving balanced development. This indicates the need for the development and implementation of integrated programs that consider economic, social, and environmental aspects of territorial community development. Tourism in UTCs, according to studies by Hussain *et al.*, (2023) and Rodríguez-Darías and Díaz-Rodríguez (2023), is identified as playing a key role in the sustainable development of these communities, as confirmed by the results. Supporting and developing tourism within UTCs can contribute to economic activity and the preservation of the cultural heritage of these communities. Overall, the findings indicate a need for the development of a holistic policy aimed at supporting the sustainable development of UTCs through the integration of economic, environmental, and social strategies. This includes measures to support local entrepreneurship, conserve natural resources, develop education and health care, and attract international support to achieve sustainability and recovery after conflicts. Developing long-term sustainability strategies post-conflict requires a focused commitment to stable support from national and international organizations, which can provide the necessary resources and expertise. Continuous support from such entities plays a critical role in

maintaining development and adapting communities to new challenges, fostering their sustainable growth and improving quality of life. Practical steps to ensure ongoing assistance include establishing long-term partnerships with key donors, developing transparent funding mechanisms, and coordinating efforts to implement specific sustainable development projects. The implementation of sustainable development policies should be accompanied by mechanisms for monitoring and evaluating investment effectiveness, ensuring sustainable recovery, and integrating the efforts of all stakeholders into community life.

Limitations and directions for future research

This study is primarily focused on the Sumy region, which limits the generalizability of the findings to the other areas without similar contextual analyses. Future research should aim to replicate this study in various contexts to enhance the robustness and applicability of the results. Additionally, while the research employs quantitative methods, integrating qualitative data could provide deeper insights into the subjective experiences of community members, offering a more comprehensive understanding of the challenges and opportunities in sustainable community development during military conflicts. It is recommended that future studies explore these dimensions to build on the foundational work presented here.

CONCLUSIONS

The research demonstrates significant potential for United Territorial Communities (UTCs) to foster innovation and entrepreneurial activity, even in conditions of military conflict. Hypothesis H1, positing that UTCs can transform into centers of innovation and entrepreneurship by implementing effective sustainable development programs, was confirmed. For instance, the indicator "Gross Product of the United Territorial Community" has a factor loading of 0.733, indicating a significant influence of economic activity on sustainable development. Hypothesis H2, suggesting the importance of measures to preserve and develop infrastructure for the recovery and sustainable development of UTCs after conflict, was also confirmed. The indicator of infrastructure losses shows a high negative factor loading (-0.829), underscoring the critical impact of military actions on infrastructure and the necessity of targeted

recovery strategies. Infrastructure, education, and healthcare investments are key elements ensuring long-term sustainability and development. The research results uncover significant opportunities for UTCs during and after conflicts. It is confirmed that with proper support and the implementation of targeted programs, UTCs are capable of not only withstanding challenges associated with conflicts but also transforming them into opportunities for sustainable development. Future research prospects include expanding the analysis to a broader range of territorial communities, studying the impact of different conflict adaptation strategies, and developing and testing innovative models of support for entrepreneurship and sustainable development in UTCs. An important direction for future research is analyzing the impact of global climate change on the resilience of UTCs and developing adaptive response strategies. The conclusions of this research may contribute to the formation of effective strategies for the sustainable development of UTCs, especially in conditions of military conflicts and global challenges. Although the study primarily focuses on the Sumy region, the findings can also be applied to other regions of Ukraine, particularly those close to active conflict zones, considering similar challenges and conditions. Furthermore, the study demonstrated that to ensure long-term resilience and development of territorial communities, it is crucial to consider not only economic and infrastructure aspects but also to integrate a deeper analysis of psychological and social dimensions of community resilience in conflict zones. This will provide a more holistic view of community needs and their sustainable development. To enhance the understanding and effectiveness of the interventions suggested, future research directions could include conducting longitudinal studies to monitor the long-term impacts and successes of these interventions in the United Territorial Communities. Additionally, expanding the scope of the research to include more regions would help to verify the generalizability of the findings and potentially uncover region-specific variables that could influence the effectiveness of sustainable development strategies. This study's findings are not only relevant to the Sumy region but also provide a methodological framework that can be adapted to investigate similar issues in other regions, offering valuable insights for researchers focusing on community resilience and

sustainable development in conflict-affected areas worldwide.

AUTHOR CONTRIBUTIONS

V. Shcherbak led the conceptualization, supervised the project, and administered the project activities. M. Lyshenko was responsible for developing the methodology and drafting the original manuscript. S. Tereshchenko validated the study findings and contributed to the review and editing of the manuscript. V. Yefanov conducted a formal analysis. K. Vzhytynska carried out the investigation and was in charge of visualization. A. Pietukhov managed resources and curated data. V. Yatsenko handled the software aspects of the research.

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CONFLICT OF INTEREST

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

%	Percentage
AI	Artificial Intelligence
apps	Applications
E-	Electronic
Eq.	Equation
Expl.Var	Explanatory Variable
FAO	The Food and Agriculture Organization
Fig.	Figures
F-value	Fisher’s criterion for testing the null hypothesis fulfillment
GIS	Geographic Information System
GRP	Gross Regional Product
IoT	Internet of Things
Multiple R	The multiple correlation coefficient between three or more variables
Prp.Totl	Percentage of the total variance explained
R ²	Coefficient of determination
SMEs	Small and Medium-sized Enterprises
STATSTICA	Statistical analysis software package
UAH	Hryvnia
UTCs	United Territorial Communities
TC	Territorial Communities
Var	Variable
VR	Virtual reality

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ORIGINAL RESEARCH PAPER

Analyzing the impact of equitable urban service distribution on citizen mobility: a spatial justice perspective

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ABSTRACT

BACKGROUND AND OBJECTIVES: Achieving spatial-place justice in the distribution of urban services is a significant goal for urban planners. It involves ensuring fair and equitable access to resources and services in a physical space so that all individuals can benefit equally from the facilities and opportunities provided in that space. The unfair distribution of urban services has curtailed the presence of pedestrians and limited the daily mobility of citizens, making cities low-mobility environments. To address this issue, urban managers can identify local community issues, create equal opportunities, and promote public participation. By doing so, they can achieve spatial equity in local communities and provide opportunities for equality and justice. This research aims to investigate the relationship between the fair spatial-place distribution of urban services and the mobility of citizens in the Navid and Ab o Bargh areas of Mashhad.

METHODS: This study utilizes a descriptive-analytical approach to investigate spatial justice. Data was collected using the spatial justice questionnaire based on the Likert scale and the International Physical Activity Questionnaire. Researchers assessed the questionnaire's reliability using Cronbach's alpha test and its validity using the content validity coefficient of the item formula. The researchers employed several statistical methods to explore the relationship and correlation between the components of spatial justice and mobility, prioritized the indicators of spatial justice by neighborhoods, and compared the prioritization of the components of spatial justice affecting mobility.

FINDINGS: The results revealed a significant relationship between access to urban services and the mobility of citizens in the studied areas. As such, the positive correlation in the Ab o Bargh area was confirmed for all indicators (functional index (0.466), environmental indicator, (0.384) index aesthetic indicator (0.145). The results suggested a direct relationship between the balanced spatial distribution of urban services and enhanced mobility of citizens in the study area.

CONCLUSION: Research results show a direct relationship between spatial justice and citizen mobility in the city. Spatial justice means the fair distribution of facilities and services between different urban areas and equal access to them by citizens. As a result, citizen mobility in the city is influenced by spatial justice. In other words, Inappropriate distribution of services in the city can cause social differences among citizens. The difference between privileged and underprivileged neighborhoods is in the amount of benefit from urban services. By improving the quality of research indicators in the form of policies and urban planning interventions in all neighborhoods, spatial justice can be realized.

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INTRODUCTION

The growing urban population, improper planning, and inefficient management have aggravated inequality in the distribution of urban facilities and services. This trend is manifested by urban poverty, inefficient local management, informal settlements, and environmental pollution in the form of social-spatial imbalances (Zarabi and Mousavi, 2010). The non-optimal distribution of services in different urban areas and neighborhoods gives rise to problems brought on by social and economic injustices and inequalities (Esmailpoor and Shakibamanesh, 2019). Spatial justice and mobility are closely related concepts that intersect in various ways. Spatial justice refers to the fair distribution of resources and opportunities in space, taking into account the socio-economic conditions of different groups of people (Setianto and Gamal, 2021). Mobility, on the other hand, is the ability to move freely and easily within a space, which is essential for accessing resources and opportunities (Rocco, 2014). While the proper and fair distribution of urban services in temporal and spatial dimensions would contribute to the fulfillment of spatial justice of services in cities. Spatial justice, with its democratic approach to space, seeks to ensure equality of all residents to access resources, services, opportunities, and infrastructure, regardless of ethnic, racial, gender, biological, and religious differences. It is achieved by the participation of residents of urban settlements in decision-making (hafeznia et al., 2015). By exploring inequalities in the distribution of urban facilities and services and recognizing the spatial pattern of injustice, it is possible to contribute to the fair and balanced distribution of social and public services, alleviate spatial injustices, and ensure improved quality of urban life and sustainable development (Ahmadi and Shamsipour, 2020). The concentration of urban services and facilities in certain areas and therefore their deficiency in other areas can undermine spatial justice in the distribution of urban services, thereby thwarting the realization of social justice as one of the fundamental pillars of sustainable development. Moreover, the concentration of service centers in specific areas causes a rift in cities, leading to the influx of the consumer population to the areas that have access to more services, which in turn gives rise to issues such as environmental pressure, traffic, noise pollution, air pollution, etc. (Kalantari et al., 2013). In their research,

urban planners point out the link between the form and appearance of built environments and the unbalanced distribution of urban services (Tonkiss, 2020). This study aims to investigate the relationship between the spatial distribution of urban services and the mobility of citizens in the Navid and Ab o Bargh areas of Mashhad. The dependent variable is mobility, and the independent variable is the qualities of the neighborhood's perceived environment, both of which are linked to the establishment of spatial justice and mobility. To attain the goal, the interrelationship and significance of selected variables and mobility, as one of the main steps of this study, are studied. Nowadays, spatial justice and mobility are challenging issues in the world and have been one of the most important concerns of researchers and experts. Over time, various research has been conducted on the subject of spatial justice, each of which seeks to address issues and problems from a different perspective. The importance of the subject, articles, and studies available on the Scopus scientific database, one of the most comprehensive and reputable scientific databases, were reviewed, and the keywords of spatial justice and physical mobility were searched (Fig. 1). The search results indicate that more than 1000 valid articles have been published on this topic so far. These studies have had an upward trend since 2000. Urban design can lead to justice in communities through small actions. According to the results of the research conducted on the amount of research in the Scopus scientific database, the subject of urban design and spatial justice and its relationship with physical mobility has had an upward trend. However, the examination of the frequency of research conducted indicates that research conducted by researchers around the world has been limited. Given the limited research background, the role of urban design as a prominent factor in creating justice-oriented communities is more felt than ever. Therefore, this study can play a role in defining the position of urban design and its capacities to create justice-oriented urban communities by expressing the dimensions of a resilient society and promoting physical mobility. This study was conducted in the Ab o Bargh and Navid Neighborhoods of Mashhad in Iran in 2023.

Background of research

Pourahmad et al., (2023) conducted a study

(2022) in an article entitled “Sustainability analysis of urban neighborhoods with emphasis on spatial social justice in Maragheh, measured social capital and spatial equity of citizens. According to their results, urban infrastructure and facilities can increase citizens’ satisfaction and contribute to the proper distribution of services and thus play an important role in increasing social capital. *Jian et al., (2020)* in their research titled “Spatial Justice in Public Open Space Planning” argued that open spaces, as the most valuable assets of the city and local community, are closely linked to the improved physical and mental health of citizens. This research also explored issues related to spatial justice in three dimensions: physical justice, social justice, and right to the city, presenting a framework for examining spatial justice. *Ahmadi and Shamsipour (2020)* article entitled “Analysis of the Spatial Distribution of Public Services in Terms of Spatial Justice Approach (Case study: Bojnourd)” studied the access of citizens to public services in urban areas. According to their findings, Bojnourd struggles with the severe shortage of public service centers. Also, this deficiency is unfairly distributed in urban neighborhoods, which has brought to the fore inequality and injustice in neighborhoods. *Saeedi Monfared et al., (2020)* In their paper titled “Exploring the Physical and Functional Components Affecting Spatial Justice in Marginal Settlements”, study physical and functional factors affecting spatial justice in the core of urban poverty in Mashhad. Their results showed that physical diversity is a key determinant factor in ensuring spatial justice in marginal settlements. *Lorraine et al., (2019)* in a study titled “Who Has Access to Urban Green Spaces?” Access to urban green space has been studied from the perspective of spatial equity in 10 U.S. metropolitan areas. Their findings showed that there was a positive correlation between access to urban green spaces and income, as well as a negative correlation between green space and the status of racial minorities. *WHO (2017)* published a report entitled “Towards more physical activity in cities” highlighting the importance of boosting mobility to prevent deaths from non-communicable diseases. This report stressed that individual, social, built, and natural environmental factors have a significant bearing on people’s physical health. *Mohammadi et al., (2012)* in their study, titled “Spatial Analysis of Distribution and Access to Urban Services in Urban Areas of Ardabil with Spatial

Justice Approach,” examined the level of citizens’ access to commercial uses in Ardabil neighborhoods. The results showed that there is general inequality in access to commercial land use in urban areas of Ardabil and consequently low sustainability. According to the theoretical literature and background of the research, there is no consensus on spatial justice indicators, despite numerous studies in the field. Previous studies have examined spatial justice in various applications such as sports, green space, or single-use. However, in this research, we have attempted to present a comprehensive model encompassing all aspects of functional, aesthetic, and environmental experimentation. This study uniquely explores the relationship between spatial equity in privileged and underprivileged neighborhoods and its impact on physical mobility in urban spaces and the physical health of city residents. The study’s findings can be utilized by urban planners, designers, and policymakers to improve spatial justice in low-income neighborhoods, promoting the well-being and physical health of citizens.

MATERIALS AND METHODS

Survey design and data collection

The questionnaire used in this study consisted of three main parts. The first part includes the definition of spatial justice, physical mobility, and socio-demographic information such as education level, occupation, age, and gender. The second part included questions that indicate spatial justice indicators affecting physical mobility in three functional, aesthetic, and environmental components on a five-point Likert scale to obtain information on the influencing variables, namely access to public transportation stations, access to open space and entertainment, and so on. The Likert scale ranged from one to five, which refers to a range from “very little” to “very much”. The third part included the International R which has validity and reliability. Before asking the respondents to answer all the questions in the three above-described main parts, the trained interviewers informed respondents about the purposes of the study and explained clearly all the specific terms used in the content of the questionnaire, to make sure the respondents understood. The questionnaire was pretested and had minor changes before conducting the actual survey. Then a survey of residents was conducted and analyzed.

Analytical framework

This is an applied study that adopts a descriptive-analytical research method. The data was gathered from 588 questionnaires on spatial justice and physical activity. Data analysis was conducted using a two-sample independent t-test, Pearson correlation, regression, Friedman test, and t-test in SPSS software. The sample size was determined by Cochran's formula (based on the population size). To strike a balance between the samples based on the population of each neighborhood, 338 and 250 questionnaires were distributed in the Ab o Bargh and Navid neighborhoods, respectively. The questionnaires explored indicators of spatial justice in the distribution of urban services and their effect on mobility. To evaluate the validity of the research, the content validity coefficient of the item method was utilized. A questionnaire was then designed and distributed to 20 experts in urban planning to discuss all research indicators. The validity of the questionnaire was also rated as desirable (CVCI = 80). Cronbach's alpha test was utilized to investigate the reliability of the questionnaire ($\alpha = 0.94$). To test the normal distribution of the variables, the Kolmogorov-Smirnov test was used, with the results confirming the normal distribution of variables in the three functional, environmental, and aesthetic indicators. Confirming the normal distribution of data using the Kolmogorov-Smirnov test is crucial. If the data doesn't follow a normal distribution, our statistical analysis results may be incorrect and lead to inaccurate decisions. Therefore, performing the Kolmogorov-Smirnov test can help us ensure the accuracy and reliability of our statistical results.

RESULTS AND DISCUSSION

Spatial justice

The concept of spatial justice has been the subject of scholarly attention since the early 1820s, and in 1970, informed by Rawls's studies, it made its way to geography and urban planning (Godillon, 2011). Zhian *et al.*, (2020) cite Lefebvre as saying that city dwellers have a specific spatial right that includes fair participation in the process of creating urban space, the right to access facilities and privileges, the right to prevent spatial segregation, and the right to access public services. Spatial justice is a theory that underlines respect for the equal rights of individuals, protecting human and social values (Annabestani and

Hosseini, 2018).

Spatial justice in the city

Spatial justice is a type of social justice that ensures equal access and use of services for all people. From the perspective of social justice, spatial justice requires the formulation of laws that allocate urban services equally to all citizens. Social justice hampers or mitigates deprivation and economic inequalities (Uwayezu and De Vries, 2018). It can be contended that spatial justice in the city is the most important factor in the distribution of urban services (Chianeh *et al.*, 2015). Space is the intersection of all urban events and issues, and spatial justice can be seen as the gravity center of all types of justice in urban planning, which is independent of other forms of justice (economic, social, and environmental) and seen as the heart of justice movements in the city. Therefore, spatial justice is inalienable from social justice (Cardoso and Breda-Vázquez, 2007). Fig. 2 shows the concept of justice and its types in the city from different perspectives.

Solution for improving citizens' mobility in the city using spatial justice

Improving the mobility of citizens in a city using spatial justice involves ensuring that all social groups have fair and equitable access to transportation services and opportunities. Here are some ways to achieve this:

Promote public transportation

Encouraging the use of public transportation can help reduce traffic congestion and air pollution while providing affordable and accessible transportation options for all citizens (Tzanni *et al.*, 2022).

Encourage walking and cycling

Promoting walking and cycling can help reduce reliance on cars and provide healthy and sustainable transportation options for citizens. This can be achieved by creating safe and accessible pedestrian and cycling infrastructure, such as sidewalks, bike lanes, and bike-sharing programs (Tzanni *et al.*, 2022).

Ensure equitable distribution of transportation services

Ensuring that transportation services are distributed fairly and equitably across different

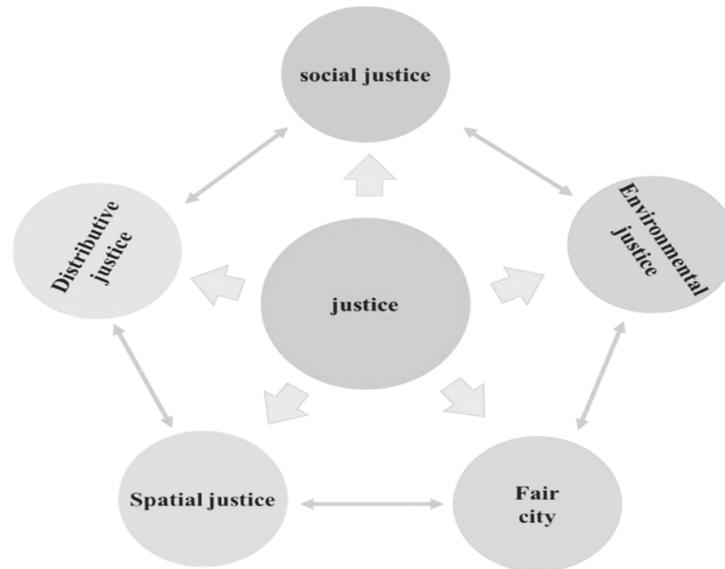


Fig. 2: Interrelationships of the concept of justice from various perspectives

neighborhoods and social groups can help reduce spatial injustice in mobility. This can be achieved by analyzing the social-spatial unevenness of benefits and dis-benefits for different social groups and taking steps to address any disparities. Consider the needs of diverse urban actors: Recognizing and examining the mobility needs, experiences, values, and practices of diverse urban actors can help ensure that transportation policies and interventions are inclusive and equitable. This can involve engaging with citizens and community groups to understand their transportation needs and preferences (Verlinghieri et al., 2020). Overall, improving the mobility of citizens in a city using spatial justice involves promoting equitable access to transportation services and opportunities for all citizens, regardless of their social group or neighborhood.

Types of spatial justice

Spatial justice is the common thread that connects social justice in the city and urban planning. Social inequalities prompt a sense of marginalization and fear in residents. Urban justice means that all profits and losses are equally distributed among the residents Fig. 3 shows the types of justice and their meaning in the city.

Criteria to ensure spatial justice

Spatial justice means the distribution of urban services proportional to the needs and merits of citizens. In the distribution of municipal services, priority is given to disadvantaged and vulnerable people.

In connection to urban spatial justice, the following criteria can be mentioned.

Equality of opportunities

It means equal opportunities in accessing and using urban uses, services, and information, as well as valuable social interests in space, legal interests of plans, and urban projects (Ghaderi Hajat et al., 2022). Also, equal access to urban services should be informed by the ability and merit of the residents (Pourkhaksar, 2020).

Transparency

To raise the local community and citizens' awareness of the benefits and harms of implementing urban development programs, it is essential to sufficiently inform them (Rafieian et al., 2019).

Difference

Focus on spatial-temporal identity, function, and

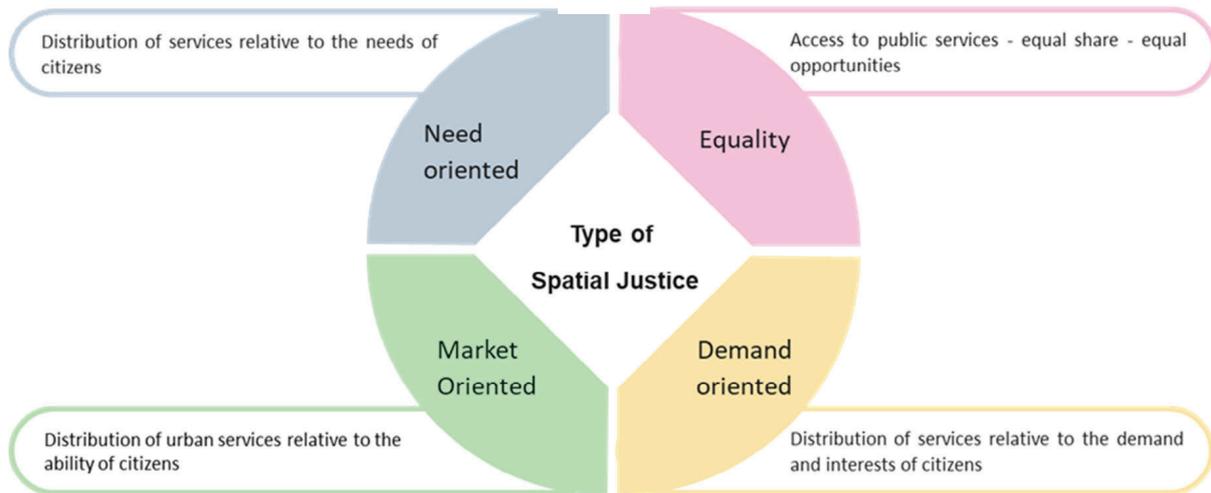


Fig. 3: Types of spatial justice in the city (Cho, 2003), (Rostami, 2011)

different economic, social, and cultural conditions of districts and urban areas at the time of making plans to provide urban services (Pourkhaksar, 2020).

Negation of marginalization

It indicates the assertion of the oppressed groups, which can deter the marginalization of the indigent and low-income groups (Afsharnia et al., 2019).

Freedom

Participation of citizens in decision-making and the citizens' right to equal choices for daily activities (Dadashpoor et al., 2015).

Stability and durability:

The growth of inequalities over time and their consolidation in many areas calls for continuous and sustainable measures (Pourkhaksar, 2020).

Participation

Determining the fate of citizens and the city and active participation of citizens in the re-creation of space (Mirgholami et al., 2018).

Diversity

The term diversity means different things to urban planners and urban designers. For urban designers, it implies different types of construction, and for urban planners, it suggests mixed land use, diverse social and cultural groups, and diverse ethnic,

gender, age, and income groups (Alvandipour, 2016). For those who consider diversity as a key criterion, the greatness of the city lies in encouraging people to move towards public open spaces and interaction (Young and Allen, 1990).

The concept of distributive justice

Edward Soja (2009) believes that distributive inequalities are the clearest expression of spatial justice. Spatial justice is the chain link between social justice and space. Distributive justice focuses on the fair distribution of resources among diverse members of a society, the fair allocation of distributed resources, the distribution process, and the pattern of distribution in society. The main focus of distributive justice is firstly on relative poverty and income distribution among people and then on economic and social transactions (Dadashpoor and Rostami, 2010). Distributive justice is entwined with principles and issues such as justice, need, welfare, and merit (Bozorg, 2010). Distributive justice is also used to describe environmental benefits and the effects of environmentally destructive places and locations on humans and societies (Francesca et al., 2022).

Structural justice

Structural justice imparts different meanings and denotes diverse but sometimes identical criteria in different schools of thought. In Marxism, people like Lefebvre accentuate the generality of the

The effect of spatial justice on the mobility of citizens

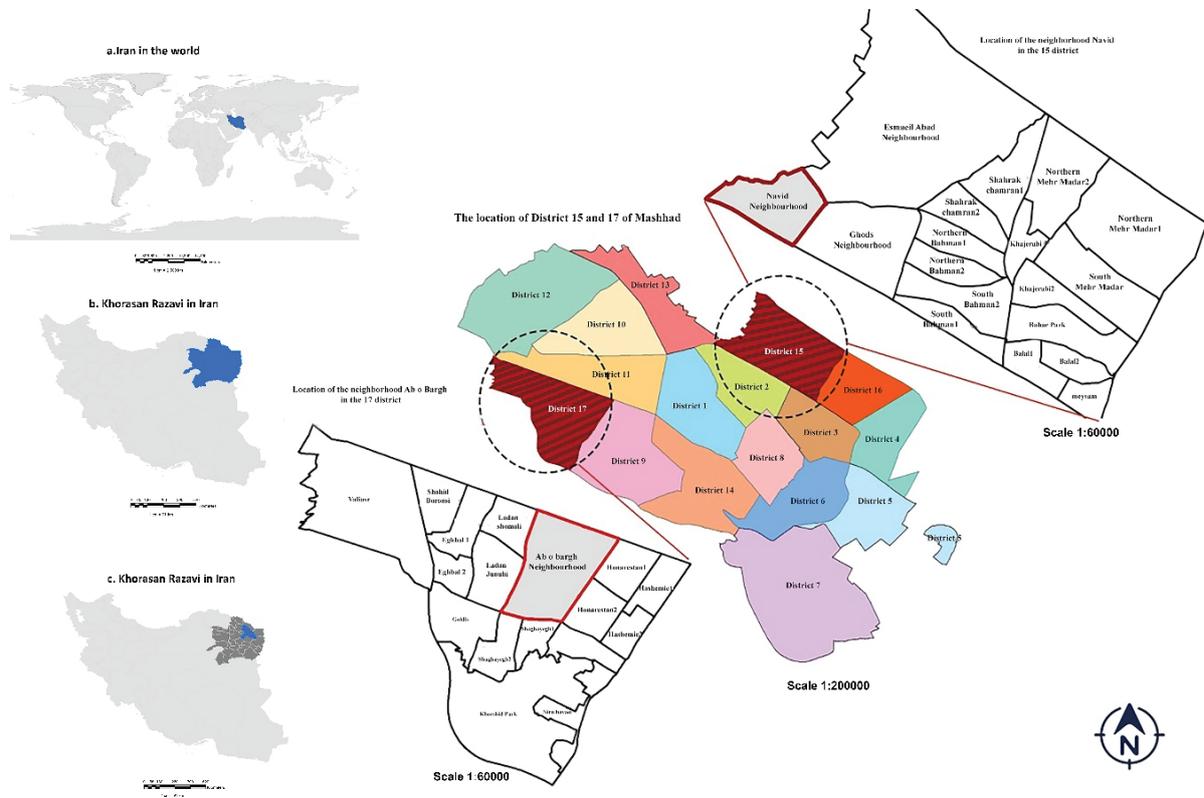


Fig. 4: Location of the research area in the world, country, and metropolis of Mashhad

space, participation, and creation of the new space (Lefebvre, 1996). Neo-Marxists such as David Harvey see structural justice as the right to participation, need, and public interest (Harvey, 1997). However, Edward Soja searches for structural justice in freedom, equality, and democracy (Soja, 2009). In Liberalism, structural justice is concerned with difference, equality, and freedom, and John Rawls is one of the main advocates of this school (Rawls, 1971). Nonetheless, neoliberalism proponents like Susan Feinstein sum up structural justice in equality, democracy, and diversity (Harvey and Potter, 2009).

The scope of the research

The study area covered two known areas of the Mashhad metropolis, the Ab o Bargh, and Navid neighborhoods. These two areas are distinct in terms of urban form, building density, type of access, and socioeconomic status. Located in district 17 of Mashhad municipality, Ab o Bargh is home

to a population of about 31021 people. Regarding the planning areas of Mashhad, it is situated in the southwest. Navid neighborhood, located in District 15 of Mashhad Municipality, is also situated in the northeast planning areas of Mashhad city. This area has a population of about 3431 people (peiravi et al., 2021a, 2021b). Fig. 4 shows the geographical location and scope of the research in the Mashhad metropolis.

Environmental qualities and their components

Environmental quality is the outcome of three indicators of functional, empirical - aesthetic, and environmental quality of cities. Functional quality, which involves ensuring proper mobility and access to sidewalks, entertainment, gatherings in the urban space, etc. in the city, guarantees the vitality and richness of the spatial experience of the city. The empirical-aesthetic quality deals with the perceptual, cognitive, and environmental preferences of people about urban spaces. Environmental quality

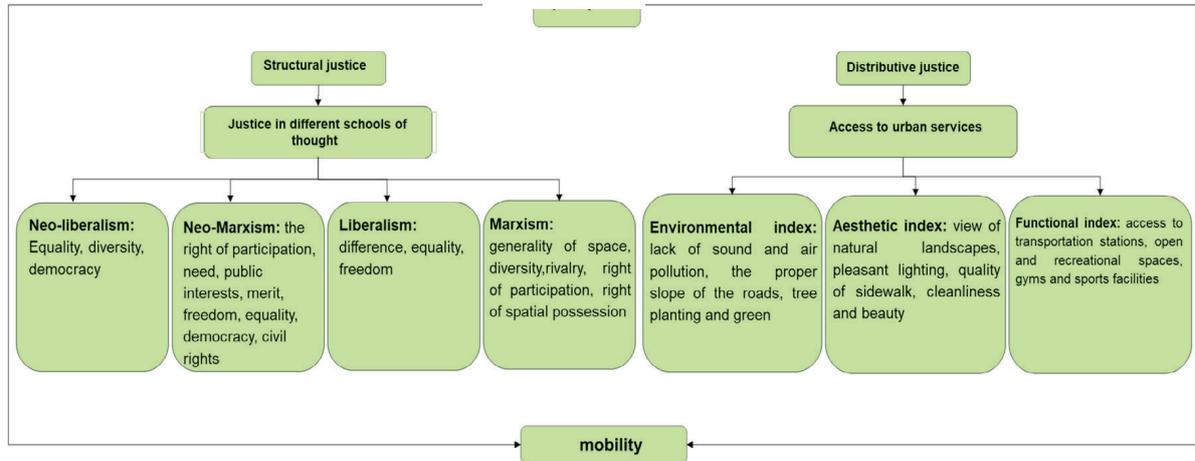


Fig. 5: The effect of spatial, distributive, and structural justice on mobility

Table 1: Results of the principal component analysis with varimax rotation

Variable/index	Variable	Mean	SD	T	Df	Sig
Functional	Ab o Barg	17.27	2.45	56.189	588	0.001
	Navid	7.34	1.54			
Environmental	Ab o Barg	16.97	2.48	48.038	588	0.001
	Navid	8.34	1.60			
Aesthetic	Ab o Barg	18.05	2.07	33.062	588	0.001
	Navid	12.76	1.67			

is associated with urban ecology and how natural resources such as land, water, etc. are exploited in urban plans (Golkar, 2001). Each of these indicators can influence the mobility of citizens from the perspective of spatial justice in the urban space. Using the theory of justice (distributive and structural), Fig. 5 presents the relationship between mobility and functional quality, and cognitive and environmental beauty.

1- Function and mobility index: It includes activities that are conducted to do daily activities or achieve a specific goal. In the planning and design of urban areas, it is of utmost importance to stress the principle of pedestrian circulation to boost mobility. Considering factors such as radius of access, urban services, optimal time interval, permeability, flexibility, compatibility of urban form with uses, harmony of adjacent uses, safety, etc., can encourage residents to walk and thus increase their mobility and physical activity.

2- Aesthetic index and mobility: The incorporation

of aesthetic principles spaces such as sidewalk quality, cleanliness and beauty, lighting, visual proportions, human scale, and readability in the design of urban can increase citizens' willingness to walk and attend urban spaces.

3- Environmental index and mobility: Urban design qualities geared toward characteristics of the natural environment, like climate comfort, clean air, and the proper slope of roads encourage mobility and walking among citizens.

Two-sample independent T-test

To compare the status of residents of Navid and Ab o Bargh neighborhoods in terms of spatial justice, the two-sample independent t-test was used. The findings are outlined in Table 1, based on Fig. 5. As suggested by the results, the residents of Navid and Ab o Bargh neighborhoods differ in spatial justice, and on average, the three study indicators are higher in Ab o Bargh than in Navid neighborhood.

Regarding the performance index, the construction

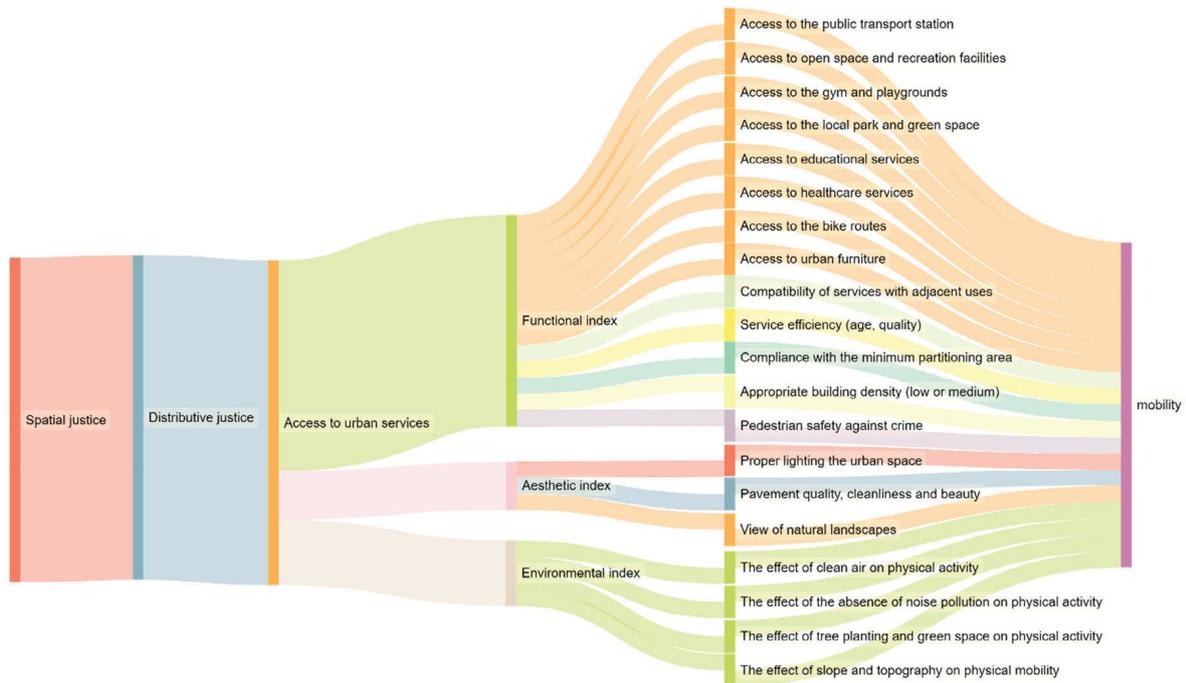


Fig. 6: Conceptual model of research

trend of the Ab o Bargh neighborhood is modern, and it is classified as one of the developed areas of Mashhad. The main uses of the neighborhood are residential, revolving around active commercial and administrative axes. In terms of access to the Light Rail Transit (LRT) transportation system, the citizens have access to LRT stations in the neighborhood, and the radius of spatial access to the LRT station is on average 234 m with a time interval of 2 min and 56 seconds. There are also dotted and linear public open and green spaces within the area with an average spatial distance of 233 m and a time interval of 2 min and 55 seconds. Educational and medical uses are also on average at a spatial distance of 327 m and 513 m with a time interval of 4 min and 55 seconds, and 6 min and 25 seconds, respectively. The attendance of different age groups, especially young people, and the commute of children and adolescents to educational centers, children's playgrounds with suitable facilities, daily visits of citizens to commercial complexes to meet their demands, and the extensive use of green space have turned this neighborhood into a lively and dynamic center (peiravi et al., 2021b), thereby encouraging walking and mobility of citizens.

The analysis of indicators in the Navid neighborhood exhibited that restricted municipal services and improper distribution of services have been effective in undermining distributive and structural justice. In this neighborhood, there are no stations to access LRTs. The bulk of the land use is dedicated to horticulture and agriculture, along with urban and commercial buildings. In this neighborhood, there is a mean spatial distance of 252 m to green space, 950 m to medical use, 193 m to the bus station, and 638 m to the sports facilities, which reflect the paucity of service uses in Navid neighborhood compared to the Ab o Bargh. As regards the aesthetic index, the magnificent views of the Binaloud Mountains (tourist attraction), the watercourses, the desirable quality of the sidewalk, and the cleanliness of the urban space, as well as proper lighting have encouraged the mobility of the citizens. As for the environmental index, the mobility of the Ab o Bargh neighborhood is higher due to its green space with a satisfactory functional radius, access to public transportation (LRT), and Binaloud Heights as opposed to the Navid neighborhood, which has a relatively constrained green space, and fewer natural attractions (peiravi et

Table 2: Two-sample independent T-test and comparison of *mobility* of citizens

Independent Variable	Variable	Mean	SD	T	Df	Sig
Mobility	Ab o Bargh	19.35	2.07	58.734	588	0.001
	Navid	10.29	1.48			

Table 3: correlation coefficient and significance of *spatial justice* and *mobility* based on the Pearson model

Variable/index	Mobility	
	R (Correlation)	Sig (Significance)
Functional	0.466	0.000
Environmental	0.384	0.000
Aesthetic	0.145	0.000

Table 4: Coefficient of regression test for the effect of spatial justice components on mobility

Variable/index	R	R ²	R ² adj	F	Sig	B	Std	Beta	T	Sig
Constant value	0.896	0.802	0.801	790.151	0.001	1.833	0.447	-	0.948	0.001
Functional						0.422	0.032	0.466	13.152	0.001
Environmental						0.353	0.034	0.384	10.363	0.001
Aesthetic						0.216	0.044	0.145	4.877	0.000

al., 2021a). In Table 2, a comparison has been drawn between variables of mobility in two study areas.

Strength of Correlation Test

In measuring the correlation between variables, values close to 1 indicate a stronger correlation. Table 3 outlines the correlation between spatial justice indicators and citizens' physical mobility based on the Pearson Correlation model. Accordingly, more favorable indicators of spatial justice promote physical mobility in citizens. Table 3 shows the correlation between the functional index and physical mobility (0.466), between the environmental index and physical mobility (0.384), and between the aesthetic index and physical mobility (0.145). Therefore, since the correlation value is close to 1, it can be inferred that the components of physical activity and mobility are correlated.

Regression test

To estimate the impact of each independent variable on the dependent variable (mobility), the stepwise multivariate regression analysis was used. The results of the regression suggest the relationship between the independent and dependent variables, as outlined in Table 4, based on the one-way analysis of variance, is linear, indicating that independent variables can explain the changes in the dependent variable (mobility), and therefore the regression model is confirmed. The

regression results for the variable of the impact of spatial justice components on mobility neighborhood showed that the functional component (0.466), environmental component (0.384), and aesthetic component (0.145) directly influenced mobility. The results suggest that variables of functional, aesthetic, and environmental indicators justify the changes in physical mobility. When the Beta coefficient is positive and close to 1, it shows the impact of the dependent variable (physical movement) on the independent variable (functional, aesthetic, environmental components).

Friedman's test for prioritizing spatial justice components on physical mobility

As outlined in Table 5, there is a significant difference between the mean ranks of the items related to spatial justice ($P < 0.01$) and ($\chi^2 = 742.543$). Pavement quality, cleanliness, and beauty have the highest average rating in the Ab o Bargh neighborhood, which has had the most significant impact on the physical mobility of citizens. Access to educational services use has the lowest on the physical mobility of citizens. In the Navid neighborhood, the highest average rating is for the index of air cleanliness, and the lowest average rating is related to the index of access to the bike routes. Table 5 presents the prioritization of indices in terms of spatial justice.

Table 5: The results of the Friedman test for the prioritization of *spatial justice* indicators

Index	Items	Mean ranks	
		Ab o Bargh	Navid
Functional	Access to the public transport station	9.77	8.87
	Access to open space and recreation facilities	9.80	7.59
	Access to the gym and playgrounds	9.30	10.33
	Access to the local park and green space	11.32	5.45
	Access to educational services	8.34	5.26
	Access to healthcare services	8.39	6.68
	Access to the bike routes	8.91	5.00
	Access to urban furniture	8.73	5.80
	Compatibility of services with adjacent uses	10.88	11.14
	Service efficiency (age, quality)	10.03	13.81
	Compliance with the minimum partitioning area	11.16	14.24
	Appropriate building density (low or medium)	9.10	14.87
	Pedestrian safety against crime	13.73	9.19
Environmental	The effect of clean air on physical activity	9.55	16.68
	The effect of the absence of noise pollution on physical activity	9.47	16.06
	The effect of tree planting and green space on physical activity	9.43	11.36
	The effect of slope and topography on physical mobility	11.22	16.05
Aesthetic	Proper lighting the urban space	13.20	10.51
	Pavement quality, cleanliness and beauty	14.95	13.02
	View of natural landscapes	12.72	6.08
Chi-Square		742.543	2407.596
DF		19	19
Sig		0.000	

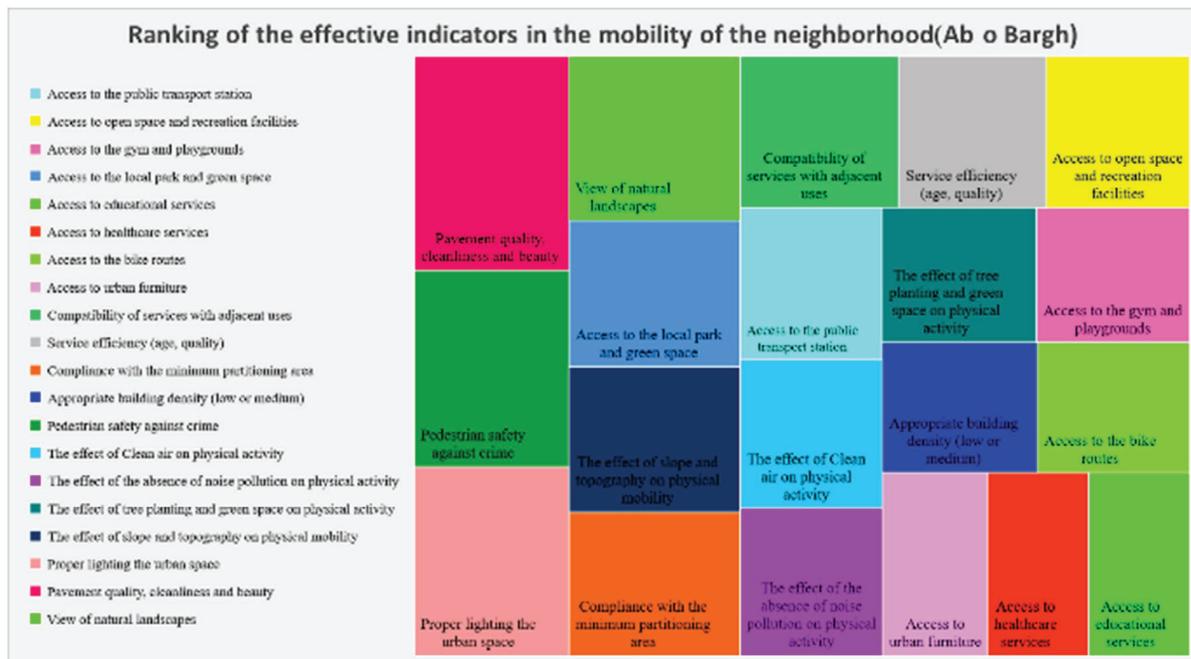


Fig. 7: Ranking of the influencing indicators in the mobility of the low-income neighborhood (Navid)

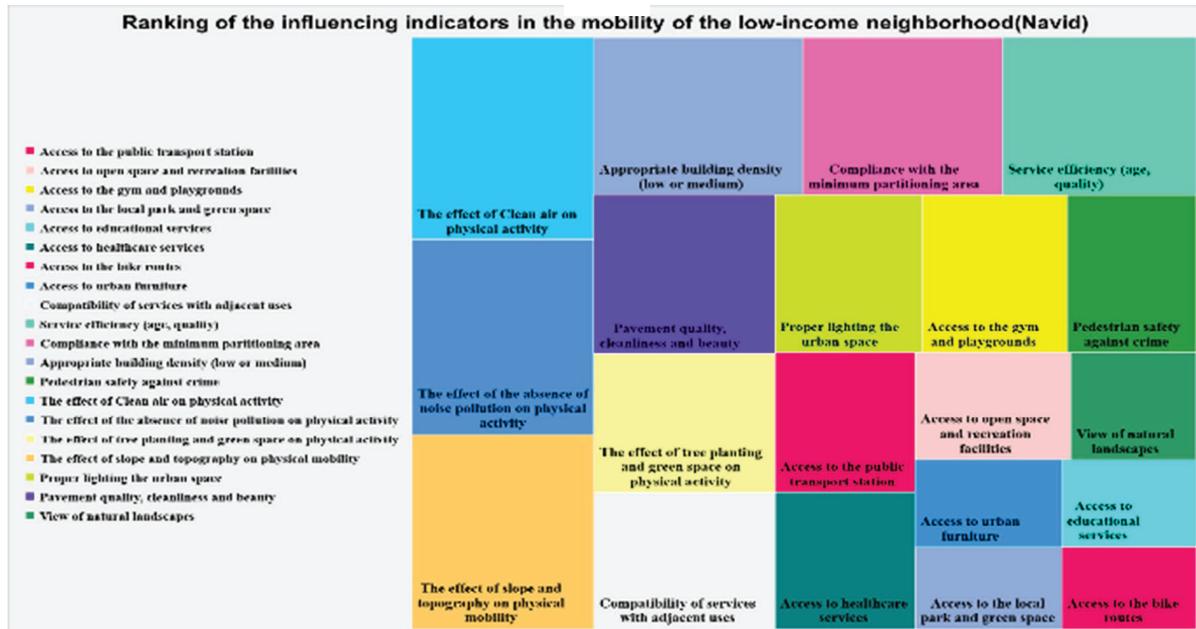


Fig. 8: Ranking of the effective indicators in the mobility of the neighborhood (Ab o Bargh)

Table 6: Prioritization of sub-criteria of variables using One-Sample T-test

Variable	Component	Mean		T		Sig	prioritize	
		Ab o Bargh	Navid	Ab o Bargh	Navid		Ab o Bargh	Navid
Spatial justice	Functional	17.2663	7.3400	17.2663	7.3400	0.00	2	3
	Environmental	16.9763	8.3400	16.9763	8.3400	0.00	3	2
	Aesthetic	18.0562	12.7680	18.0562	12.7680	0.00	1	1

Prioritizing sub-criteria of variables using One-Sample T-test

The analysis of indicators by T-test for greater clarity and comparison is presented in Table 6.

The data in Table 6 shows that the aesthetic index has a higher average than other indices in the water and electricity neighborhood and Navid. Therefore, paying attention to aesthetic principles in the design of urban spaces, such as the quality of sidewalks, cleanliness and beauty, lighting, visual proportions, human scale, and legibility, leads to an increase in citizens' desire to walk and be present in urban space. Also, to show the priority of the indicators in influencing mobility, Fig. 9 is presented.

The research has shown that increasing physical mobility in urban areas can reduce and prevent non-communicable disease-related deaths, and improve

the physical health of citizens. Access to public services is one of the main factors in enhancing citizens' physical and mental health. However, the unequal distribution of public services among urban neighborhoods leads to inequality and injustice in citizens' access to urban facilities and services. As a result, mobility in deprived areas is reduced. Therefore, urban planners and designers should always consider providing optimal access to urban spaces for the residents of underprivileged areas. In this study, according to the presented comprehensive research model, a comparative comparison has been made between the two neighborhoods of Ab o Bargh and Navid regarding aesthetic, functional, and environmental components. Among the innovations of this research, we can point out the development of a comprehensive research model based on the

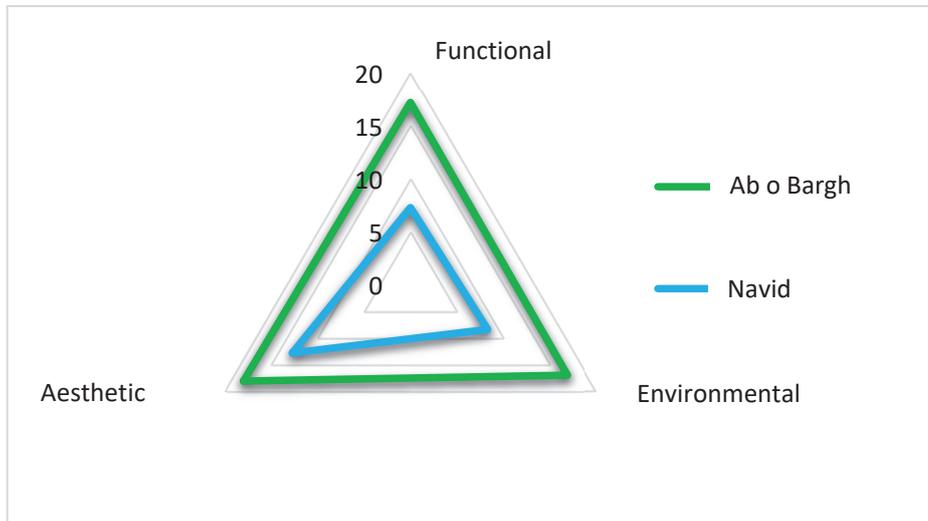


Fig. 9: Prioritization of sub-criteria of variables using One-Sample T-test

components of urban design, spatial justice, and physical mobility. The opinions of citizens as the main users of services and urban spaces between two underprivileged and privileged neighborhoods have been investigated and evaluated, and the results indicate that the amount of public services and mobility in underprivileged neighborhoods is less than that of privileged neighborhoods. The distribution of urban services among different neighborhoods is not fair and often leads to neglect of underprivileged areas, resulting in social gaps and violence. Therefore, it is crucial to optimize access to urban services in all localities to encourage walking and equitable mobility. Currently, there is a significant difference between neighborhoods that enjoy access to urban services and those that are deprived of these services. This inequality and unfairness often lead to feelings of mistrust, violence, and isolation in low-income neighborhoods. To prevent such unfavorable conditions, measures should be taken in all neighborhoods to ensure that all people can benefit from city services equally. This optimization is of great importance and should be taken seriously. By providing equal opportunities for access to urban services, it is possible to help create social balance in society. Therefore, all sections of society and city officials must work together to ensure that this becomes a reality and no region is deprived of

this right. Improving access to urban services will encourage people to walk and move more equitably, ultimately improving the quality of life and well-being of citizens. Urban planners and designers can promote spatial justice and mobility by providing a comprehensive model that considers functional, experimental, aesthetic, and environmental dimensions and examines the relationship between spatial justice in rich and poor neighborhoods and its impact on physical mobility.

CONCLUSION

Spatial justice is the idea of ensuring that services and opportunities in urban spaces are distributed fairly and equally. Each person and area of the city has different needs and facilities, and if these are not distributed fairly and equally, social and economic gaps between people and urban areas will increase. This can lead to social and economic inequalities and can result in increased insecurity, crime, economic incapacity, and unequal access to basic services such as education, health, and treatment. Moreover, increasing social and economic distance can intensify social tensions and contradictions, leading to social anomalies and differences between people and groups. On the other hand, the lack of proper distribution of urban services in localities forces people to travel to other areas using personal

transportation to meet their needs. This not only creates environmental problems but also causes citizens to be immobile in urban spaces, ultimately affecting their physical and mental health. The present study discusses the evaluation and comparison of spatial justice and its impact on mobility in two neighborhoods, one privileged and the other underprivileged. By conducting a systematic review, the study explains the factors that influence spatial justice and mobility. These factors were investigated using T-tests of two independent samples, Pearson's correlation, regression, Friedman, and T-test in the two neighborhoods. The investigation and results of this research show that there is a correlation between mobility and spatial justice concerning the investigated indicators. Studies and tests have shown that there is a strong connection between spatial justice indicators and the mobility of residents. In other words, neighborhoods with higher levels of spatial justice tend to have higher mobility and walking rates. Regression analysis results reveal that spatial justice indicators explain changes in residents' mobility in terms of three components: functional, experimental, aesthetic, and environmental. Moreover, these results show that residents' mobility affects spatial justice. The T-test of two independent samples indicates that the level of spatial justice in the water and electricity neighborhoods is higher than that in Navid, in terms of the three components mentioned earlier. As a result, these two neighborhoods differ in terms of mobility and walking, with the water and electricity neighborhood having a higher rate of walking due to its development, natural landscapes, and urban facilities and services. Enhancing spatial justice and researching its components in low-income areas remains a major challenge for urban planners and managers. The results of Friedman's test indicate that the water and electricity neighborhood has better quality indicators than the Navid neighborhood. The quality indicators are sidewalk quality, cleanliness, beauty, pedestrian safety against crime, proper lighting of urban spaces, view of natural scenery, access to bicycle paths, access to urban furniture, access to local park and green space, access to educational services, access to public transportation station, access to open space, and recreational facilities. On the other hand, the Navid neighborhood has a more favorable condition in indicators with low building density, the efficiency

of services (age, quality), compliance with minimum separation area, compatibility of services with nearby uses, the impact of air and noise pollution on physical mobility, the impact of trees and green space on physical mobility, the effect of slope and topography on physical mobility, access to the gym and sports field. However, it can be said that the low distribution of absorbent services and the provision of their needs from other localities can be a factor for the clean air and low noise pollution in these localities. The possibility of mobility in cities, and specifically in Mashhad, depends on the urban management system and the methods used for urban development plans, urban planning, urban design, and citizens' health. This means that mayors, city planners, architects, urban designers, and construction workers all play a role in improving the material and spiritual quality of people's lives and the improvement of their living space. It is important to take executive measures such as organizing urban affairs through attractive activities and strengthening sidewalks to improve the quality of life of the elderly and disabled. Additionally, parks and green spaces should be strengthened and urban furniture should be improved to encourage greater mobility among citizens. To promote spatial justice in deprived neighborhoods, several solutions can be implemented.

1. Developing social and economic infrastructure can help to increase the sense of security and social interaction in an area. This includes creating open and recreational spaces, local parks and green spaces, and cultural, educational, and sports centers.

2. Developing services that encourage walking is essential to creating a healthy and sustainable community. This includes improving access to public transportation stations, bicycle paths, and urban furniture, and ensuring that services are compatible with nearby uses. Other important factors include the efficiency and quality of services, safety of pedestrians against crime, reduction of air and noise pollution, proper lighting of urban space, sidewalk quality, cleanliness, and beauty.

3. Improving health and treatment facilities is crucial to improving the health conditions of the society. Providing appropriate health and treatment facilities and services to people in these areas can help in this regard.

4. Increasing cooperation and coordination between people and local institutions is important to

strengthen trust and solidarity in society. Establishing communication and cooperation between people and local institutions can help in this regard.

5. Creating employment opportunities is vital to increase the income and economy of society and reduce the level of poverty and inequality. Providing job and business opportunities in these areas can make a significant difference.

AUTHOR CONTRIBUTIONS

All authors contributed to the study's conception and design. Material preparation, data collection, and analysis were performed by Mahdiah Razmaramina, Morteza Nazarabadian, and Ali Asghar Pilehvar. The first draft of the manuscript was written by Morteza Nazarabadian and all authors commented on previous versions of the manuscript. All authors read and approved the final 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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ABBREVIATIONS

α	Cronbach's alpha
CVCI	Content Validity Coefficient of Item
DF	Degrees of freedom
LRT	Light rail transit
R^2_{adj}	adjusted R-squared
R^2	Coefficient Of Determination
R	Correlation
R	Regression
SD	Standard Deviation
Sig	Significance
SPSS	Statistical package for social science
T-test	T student
T	Two independent sample t-test
U.S.	United States
WHO	World Health Organization
χ^2	Chi-Square

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ORIGINAL RESEARCH PAPER

A study on the position of workplace identity of employees

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ABSTRACT

BACKGROUND AND OBJECTIVES: Multiple organizational concepts are paramount in the workplace. Workplace Identity is one among them. It is a multidimensional concept that explores one's self-concept and understanding of their occupational roles. It is a concept of immense significance that directly impacts various organizational behavior aspects, such as job involvement, employee commitment, workplace learning, and stress management. The concept is indispensable for any individual as it helps tide over the pervasive uncertainties and tribulations in any organization. The Saudi economy is in a deep transition phase. It is all set to leap forward in terms of quality and quantity. Against this backdrop, if it is to face the multiple inherent challenges successfully, it requires a healthy band of the working class who are aware of and have a relatively high level of workplace identity. However, a fair review of the literature shows that scant evidence exists about the position of Workplace identity among the Saudi working class. The proposed study intends to fill this gap in the literature. The study intends to identify the level of the important concept of Workplace identity among the Saudi workforce-both male and female. It also intends to examine the relationship with human capital.

METHODS: A quantitative research design was employed for the study. Data for the study was collected randomly from Saudi Arabia and India. 210 samples were from Saudi Arabia, and 248 were from India. Regression was employed to analyze the collected data using SPSS (version 22.0).

FINDINGS: The study found that human capital contributes to workplace identity as the value of the F statistic was 15.978 which is significant. In addition, the results show that females have a higher workplace identity. The results also indicate significant differences (0.01 level) between the Indian and Saudi samples in all the factors and the overall workplace identity.

CONCLUSION: The study provides inputs toward future directions in making the Saudi workforce competitive and dynamic. The study's findings, which are useful for academics and practitioners, are also expected to trigger further studies in this hitherto

DOI: [10.22034/IJHCUM.2024.04.08](https://doi.org/10.22034/IJHCUM.2024.04.08) unexplored area of organizational behavior.



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INTRODUCTION

The business world is undergoing rapid changes and is highly transitional and transformational. As a result, it is highly volatile, uncertain, complex, and ambiguous. The tensions arising out of this situation are also unprecedented. The concept of identity is an effective heuristic tool to address such employee tensions (Tietze and Musson, 2010). With the “new normal,” where work and organizations have spread beyond temporal and spatial boundaries and become unbounded, employee identity has assumed greater importance and manifold consequences (Tajpour and Razavi, 2023). Further, this spread has demanded a recasting of the broader spectrum of social and organizational relationships, magnifying the need for identity. Against this backdrop, Workplace Identity (WI) assumes significance (Janeswar and Sulphrey, 2021). The concept of WI has its origins in the early 2000s. It originated from the broader concept of identity, which has wide application in social and behavioral research. It is one of the many important terms that describe organizational behaviors (Albert *et al.*, 2000). Generally, it is a multilayered and multidimensional phenomenon describing an individual’s self-concept in the work setting (Bothma *et al.*, 2015). Buche (2003) defined it as “A socially constructed representation of an individual’s self-perception of his/her interactions within the employment environment.” WI is a set of actions and cognitions about the claims of individuals about “what work is and what it is not” (Bothma *et al.*, 2015). Over a while, elements of WI get embedded and intertwined with the norms, values system, and culture of their respective organizations (Oliver *et al.*, 2010). Despite the short existence of WI, substantial literature about this new concept has accumulated, sufficient enough to give the required directions for future research. WI is indispensable as it helps tide over the pervasive uncertainties and tribulations in any organization. The study is intended to be conducted among Saudi Arabian samples. The Saudi economy is in a deep transition phase. It is all set to leap forward in terms of quality and quantity. Against this backdrop, if it is to face the multiple inherent challenges successfully, it requires a healthy band of the working class who know and have a relatively high level of WI. However, a fair review of the literature shows that scant evidence exists about the position

of WI among the Saudi working class. There exists a gap in the literature regarding WI, particularly in the context of the Saudi Arabian workforce. While WI has garnered attention in organizational research, there is limited empirical evidence on its prevalence, characteristics, and implications within Saudi organizations. Furthermore, there is a lack of comparative studies examining WI levels between Saudi Arabia and other countries, as well as its relationship with human capital in the Saudi context. The proposed study intends to fill this gap in the literature, and the objectives are set against this backdrop. Thus the study intends to identify the WI level among the Saudi workforce and examine if it is different from another country. The identity differences based on gender are also sought to be examined. Finally, it is also intended to identify its relationship with human capital. The following research questions are framed for the research

1. *What are the WI levels among the Saudi Arabian workforce, and how does it compare to other countries?*

2. *How does WI relate to human capital indicators (e.g., skills, qualifications, experience) among Saudi workers?*

3. *How does WI contribute to navigating Saudi organizations’ uncertainties and challenges amid rapid economic and societal transitions?*

By addressing these research questions, the proposed study aims to bridge the existing gap in the literature by providing empirical insights into WI among the Saudi Arabian workforce. The contribution of this research lies in its ability to fill a significant gap in the literature regarding WI. Additionally, it seeks to offer valuable implications for organizational practice and policy in Saudi Arabia and beyond, particularly in the context of workforce development and organizational adaptation to dynamic environments.

Theories of Identity

This section discusses identity theories that have emerged and evolved. The history of modern identity theories finds its origin in James (1890). According to his theory grounded in psychology, identity flows from one of the three primary facets: spiritual, material, and social. As per this theory, the quest for identity is associated with “one’s search for meaning, belongingness, and control” (Ashforth

and Pratt, 2003). After that, several other theories have elucidated the concept, the prominent one being the identity theory. This theory is based on and developed from two research streams, namely psychoanalytic and social psychology traditions (Hogg *et al.*, 1995; Kirpal, 2004). These two streams developed different theories. Two theories explaining identity formation have been proposed under the broad umbrella of Identity Theories – Social Identity Theory (SIT), and Role Identity Theory (RIT). Both SIT and RIT discuss two different perspectives on self-concept. According to these two theories, developed simultaneously in psychology and social psychology, dealing with the societal environment is considered the product of individual behavior and social structure (Stets and Burke, 2003). SIT proposes that individuals assume identities from their various memberships. The group here is a “collective of similar people” (Hogg and Ridgeway, 2003). Identity thus manifests from various inter-group processes and membership in such groups. This theory thus considers identity to arise due to an individual’s membership in a specific societal group or category. Social Cognitive Theory (SCT), which is closely associated with SIT, focuses on the different categories of individuals, mostly based on either stereotyping or the differences they may have. The theory also attempts to elucidate how social categorization enables individuals to perceive and behave as members of social groups (Abrams and Hogg, 2004). Another theory that has application in the current study is the Human Capital Theory (HCT). Human capital has its moorings in the HCT, which suggests that education, training, and experience are investments that make individuals productive and lead to greater economic output (Carneiro *et al.*, 2010; Serneels, 2008). Human Capital Theory has thus promoted education as a critical factor in boosting economic growth by endorsing that it “helps develop skills of work, that is, improves the capacity of the worker to be productive” (Sweetland 1996). Thus, HCT assumes that education improves the productive capacity of individuals and emphasizes how education increases the productive capacity of employees.

Workplace identity

Despite the recent origin, WI has many definitions. Baugher (2003) and Kirpal (2004) proposed early

definitions for WI. Most of these definitions agree that WI is “a multilayered and multidimensional phenomenon that describes one’s self-concept and understanding of it in terms of the work role.” While Witt *et al.* (2002) defined WI as “the work-relevant target with which the individual primarily identifies.” Wrzesniewski and Dutton (2001) defined it as a holistic conception of a cognitive process that describes people’s attributes at work. It is also a set of actions and cognitions. Elsbach (2006: 99) defined WI as “an individual’s central and enduring status and distinctiveness categorizations in the workplace”. These definitions propose that WI has certain qualities, like being a multilayered and multidimensional, socially constructed distinctive conception of the self at the workplace. Kirpal (2004) identified three dimensions of WI- structural, social, and individual psychological components. The structural dimension is the paradigm of work influenced by the way the employment patterns are embedded within the culture. The social dimension involves interactions with others at the workplace and in groups. This dimension could include indicators like occupational/career identity and organizational identity. Finally, the individual-psychological dimension involves an individual’s identity orientation. This dimension focuses on the individual’s career history, professional development, and perception of work.

Workplace Identity in job settings

Various factors influence WI. Evidence suggests that work facets, like work and team roles, professional identification, job identification, etc., influence WI (Lloyd, Roodt, and Odendaal, 2011; Sulphey, 2019). In addition, Jnaneswar and Sulphey (2021) found workplace spirituality and Long-Term Orientation (LTO) to be antecedents of WI. Several studies have identified the need for WI in the current organizational settings (Adams and Crafford, 2012; De Braine and Roodt, 2011). For instance, Adams and Crafford (2012) found WI to help employees identify strongly with their organizational values and culture. It also established the vital psychological links between individuals and their work, thereby aiding in developing employee engagement (Leidner, 1991) and enhancing productivity. Further, those having strong WI facilitate work engagement and commitment toward organizational goals,

which could boost productivity (De Braine and Roodt, 2011). Hence, organizations should strive wholeheartedly to inculcate a strong sense of WI in their employees. WI has a positive association with constructs like Organizational Citizenship Behavior (OCB) (Feather and Rauter, 2004), multiple commitments (Baruch and Cohen, 2007), group commitment (Rotondi, 1975), leadership (Sulphey and Jasim, 2022), and cooperative behavior at the workplace (Dukerich *et al.*, 2002). Bothma and Roodt (2012) examined the relationship between WI and engagement and found a positive relationship. In addition, the study also found a significant negative relationship between WI and turnover intentions.

WI has a profound positive impact on multiple work outcomes. A few of them include job satisfaction (Cortini, 2016), job involvement (Hogg, 2007), job commitment (Cohen, 2003; Baruch and Cohen, 2007), and various other commitments like positional, task, and group (Baruch and Cohen, 2007). It also significantly mediates the relation with error avoidance (Maier and Brunstein, 2001). A study by Van Knippenberg and Sleebos (2006) found that organizational membership positively affects the self and contributes to self-conception. In addition, Mael and Ashforth (1995) found that those with high WI exhibited lower levels of attrition as they had a higher level of interest in the workplace. The overall organizational performance is also positively impacted by WI. Whetten (2007) found commitment, group identification, and WI to occur congruently. Further, this is a continual and ongoing process in which changes to one person may impact others. Culture and identity have a close connection. Ahlgren and Tett (2010) found that identity interacted with culture in several ways. Dukerich *et al.* (1996) identified identities related to national and occupational status.

Human capital

Any business is essentially defined by its physical capital. However, describing the workforce from the perspective of the company's unique human resources offers a more nuanced perspective. (Akerlof and Kranton, 2005). Economists and social scientists use the word "human capital" to refer to critical personal traits in the business process. Human capital is described as "the stock of productive skills,

talents, health, and expertise of the labor force, just as physical capital is the stock of plant, equipment, machines, and tools," according to Goldin and Katz (2019). It has a precise and intricate connection to the production process, claims Becker (1964). In addition, many social scientists define human capital as education and expertise. (Flamholtz and Lacey, 1981; Serneels, 2008; Carneiro *et al.*, 2010). Further, productive people make more money and are more employable. (Carneiro *et al.*, 2010). Thus, productivity and efficiency can enhance the cognitive stock of human capability, which comes from innate abilities and investment in human beings. Formal schooling is, therefore, an investment in human capital, which is more valuable than material capital (Becker, 1964; Woodhall, 1997). According to HCT, education and practice are two ways to build human capital (Serneels, 2008). Human capital also includes schooling, age, and work experience and contributes to a person's total stock. According to Ployhart and Moliterno (2011), human capital development occurs due to the conversion of individual-level knowledge, skills, and dispositions across organizational levels. Technology plays a vital role in human capital development (Tajpour *et al.*, 2018; Arabiun *et al.*, 2024). A thorough understanding of human capital would provide identity, purpose, and meaning beyond just economic concepts of worth, claim Cafferkey *et al.* (2021). Methot *et al.* (2018) state that human capital may result in relational identification. They also contend that implementing a relational identity strategy in HRM would improve formal organizational structure and strengthen HR strategies. According to Shaw *et al.* (1998), the human capital group would enable improved employee retention. Furthermore, WI aids in meaningful comparisons between various organizational levels compared to individual and group levels of human capital. (Sluss and Ashforth, 2008). Based on these, human capital is hypothesized to be significantly related to WI. The study intends to determine whether the Saudi workforce's WI level differs from others. It also examines the gender-based identity disparities in WI. Another objective is to examine its connection with HC. Data for the study was collected from among gainfully employed Saudi and Indian samples. The data collection period was for eight weeks starting June 2023.

Table 1: Descriptive statistics

	Job centrality	Self-identity	Job fit	Collective identity	WI
Mean	13.19	13.37	10.98	10.94	48.47
Median	13.00	14.07	12.01	12.01	51.00
Std. Deviation	3.58	3.18	3.17	3.20	11.43
Minimum	4.0	4.0	3.0	3.0	17.0
Maximum	20.0	20.0	15.0	15.0	70.0
Alpha	0.971	0.907	0.933	0.942	0.922

MATERIALS AND METHODS

Survey design and data collection

A quantitative research design was adapted to conduct this study. WI was measured using the WI Scale (WIS), developed and validated by Sulphey (2020). The scale has 14 items under four factors on a five-point scale. The factors are Job centrality, Self-identity, Job fit, and Collective identity. The scale enjoys robust validity and reliability. Earlier studies have reported Cronbach Alpha of over 0.80 (Suphey, 2019; Jnaneswar and Sulphey, 2021). Sample items include: "I am valued because of my work" and "My values and organizational values match each other". Additionally, the questionnaire sought data on demographics, including age, gender, qualification, experience, and place of residence. Google Docs was used to capture just online data. A personal appeal and a link to the English-language survey were sent to several social media groups that prospective responders were members of. All responders were guaranteed confidentiality in their responses. There were no personal questions on the questionnaire. Hence informed consent was obtained from the respondents. Since all items were made mandatory, every response was complete in every way, and hence, none called for rejection. Data was randomly collected from Saudi Arabia (experimental group) and India (control group). The link to the questionnaire was forwarded to a few social media groups in which the potential respondents were members. A total of 458 responses were collected over 10 weeks. 210 samples were from Saudi Arabia, and 248 were from India. The present study selected India to compare the Saudi workforce as India is a multicultural nation, following the earlier survey of Sulphey, 2019; Alreck and Settle, 1995). All the respondents were gainfully employed in a variety of organizations. For example, manufacturing, service (including banking), and higher education institutions are among the several kinds of organizations.

According to Krejcie and Morgan (1970), sampling adequacy can be assumed with 384 responses from a population of one million. They contend that the sample size requirement grows at a declining rate as the population grows. It eventually reaches a plateau and stays steady at above 380. Further, the benefits are negligible after 380 samples. (Alreck and Settle, 1995). Hence, sampling adequacy can be assumed in the current study. The demographics were diverse. For instance, the sample included 240 males and 216 females. The ages ranged from 18 to 67 years, with an average age of 33.98. The respondents' overall experience ranged from less than a year to 41 years. The average experience was 10.58 years. In line with earlier studies (for instance, Flamholtz and Lacey, 1981; Serneels, 2008; Carneiro et al., 2010), age, qualification, and experience were considered human capital.

RESULTS AND DISCUSSION

Descriptive statistics, correlation results, and regression results

The Descriptive statistics are presented in Table 1. It can be observed from the table that all the alphas are above the stipulated level of 0.70 stipulated by Nunnally (1978), confirming reliability. In addition, the Average Variances Extracted (AVE) were 0.756 for Job centrality, 0.785 for Self-identity, 0.724 for Job fit, and 0.711 for Collective identity. Hair et al. (2013) and Barclay et al. (1995) stipulated a minimum value of 0.50 for AVE, which is met in the current instance.

t-test was conducted to examine the first hypothesis, that there existed a significant difference between the samples of Saudi and Indians regarding WI. The results are presented in Table 2.

The results indicate significant differences (0.01 level) between the Indian and Saudi samples in all the factors and the overall WI. This finding is indeed of great significance. Next, the study

Table 2: Results of t-test

	Locale	N	Mean	Std. Deviation	t-value
Job centrality	India	248	14.657	2.9952	10.65**
	Saudi	210	11.452	3.4475	
Self-identity	India	248	14.500	2.7353	8.99**
	Saudi	210	12.033	3.1386	
Job fit	India	248	12.290	1.8076	10.85**
	Saudi	210	9.419	3.6753	
Collective identity	India	248	12.472	1.7142	13.12**
	Saudi	210	9.119	3.5662	
WI	India	248	53.919	7.0775	12.98**
	Saudi	210	42.024	12.2163	

** significant at 0.01 level

Table 3: Results based on gender

Variable	Nationality	Gender	N	Mean	Std. Deviation	t-value
WI	Saudi Arabian	Male	95	32.284	7.364	15.697 **
		Female	113	50.292	8.912	
	Indian	Male	145	53.269	7.435	1.724 NS
		Female	103	54.835	6.466	
	Combined	Male	240	44.963	12.664	7.425 **
		Female	216	52.458	8.147	

** Significant at 0.01 level

Table 4: Correlation results

	Job centrality	Self-identity	Job fit	Collective identity	Workplace Identity	Human Capital	Mean	Standard Deviation
Job centrality	1	.593**	.658**	.645**	.840**	.136**	13.19	3.58
Self-identity		1	.704**	.689**	.851**	.174**	13.37	3.17
Job fit			1	.803**	.903**	.181**	10.97	3.16
Collective identity				1	.895**	.154**	10.93	3.19
Workplace Identity					1	.184**	48.47	11.43
Human Capital						1	47.03	18.85

** Significant at 0.01 level

N = 456

examined if there is any difference in WI based on gender, and the results are presented in Table 3. It can be observed that significant differences existed between the two countries based on gender. Further, an examination of the mean values shows that the WI of Saudi samples was lower than that of Indian. The causative factors of this finding are aspects that need to be examined in future works.

Another aim was to investigate whether human capital can have a relationship with WI. Correlation and regression were done to achieve this objective. The analysis of correlation results (Table 4) showed a significant positive correlation between the two variables (r -value of 0.184), indicating the relationship between the variables. Similar results were also

evident in the regression analysis. Table 5 presents the r values, the means, and the standard deviations.

A full model regression was also fitted with human capital and WI. The outcomes of full model regression are shown in Table 5.

As indicated by the results, a variation (.034) in WI is explained by the independent variables, namely Human capital. To test its significance Analysis of Variance (ANOVA) technique was applied, and the value of the F statistic was 15.978. This value is significant. As a result, it may be concluded that the regression model is adequate. The independent variable was tested for its significance. It was found that the variable is significant. Thus, the study finds that human capital contributes to WI.

Table 5: Regression results

	Model	Unstandardized Coefficients		t	Sig.
		B	Std. Error		
1	(Constant)	43.220	1.413	30.578	.000
	Human capital	.112	.028	3.997	.000

a. Dependent Variable: WI R2 = .034 F = 15.978 Sig = 0.00

Discussion

WI is the central and enduring status and distinctiveness categorization of individuals in the workplace. It is a concept that has gained research focus across various disciplines, such as psychology, sociology, and management (Sulphey, 2019; Jnaneswar and Sulphey, 2021). The results are discussed against the backdrop of the human capital theory. Human capital involves valuable personal characteristics of the individual in the business process (Carneiro et al., 2010; Serneels, 2008). Social scientists’ interest in human capital started recently and has surged in the last few decades. The study’s moorings are in social identity theory and human capital theory. According to the SIT, individuals adopt identities from their various memberships in social groups, which is a “collective of similar people” (Hogg and Ridgeway, 2003; Abrams and Hogg, 2004). Thus, identity is derived from various inter-group processes and associations with such groups. The human capital theory, which focuses on diverse knowledge, skill, and economic value, had its initial application in the value of education (Becker, 1964; Carneiro et al., 2010; Schultz, 1961). However, this theory is now applied to a broad range of organizational and behavioral paradigms (Carneiro et al., 2010; Serneels, 2008). Thus, the current study’s findings are also in line with this. The study intended to compare the level of WI of Saudi employees viz a vis Indian employees. This objective examined if ethnic and cultural identities could influence WI. The results of the study presented some interesting findings. A comparison between the Saudi and Indian samples showed a significant difference at 0.01 level, with a t-value of 12.98. The mean values were 53.919 for Indian samples and 42.024 for Saudi samples. Empirical studies have also been done on ethnic and cultural identities at work (Ahlgren and Tett, 2010; Dukerich et al., 1996). Employee identity stress has been found to rise with cultural identities (Slay and Smith, 2011). The Indian

culture has multiple variances, with extremely high population growth, different ethnicities, and the resultant severe competition. Thus, through ethnic assignment and ethnic identification, ethnic identities become more salient and have a more significant impact on working experiences (Kenny and Briner, 2013). Similarly, Holvino (2010) found that the intersections of race, ethnicity, and gender influence WI construction. This finding substantiates the findings of Whetten (2007). In addition, internal organizational processes like daily practices also shape WI. Further, Foldy (2012) found that WI construction occurs by either an individual or the organization without intentional effort. It was also intended to compare the WI based on gender. The results show that the Saudi Arabian sample had a significant difference at 0.01 level in terms of gender. The t-value was 15.697. The female samples had high mean values of 50.292, and the males had 32.284. This result is significant given that an orthodox patriarchal system exists in Saudi society. No significant differences were evident in the Indian sample based on gender (t-value of 1.724 and a mean value of 52.269 for males and 54.835 for males). Despite no significant difference, it is noteworthy that females had higher mean values, as in the case of the Saudi sample. A skimming of the literature shows that it is natural for individuals to bring their nonwork selves and individualities to the workplace (Adams and Crafford, 2012; Baruch and Cohen, 2007; Berg, 2002). This also includes identification with social categories, such as gender differentials. Empirical evidence suggests that females deal with their identities by emphasizing beneficial aspects in any given circumstance or adjusting to fit in their respective organizations. (Moore, 1999). Females actively negotiate their identities to escape marginalization, frequently gaining from it (Trehewey, 1999), which could be why they have high WI scores, particularly in Saudi Arabia, where the social settings are different. Hence, the findings

are in tandem with the empirical evidence (Whetten, 2007). However, it must be mentioned that the study contradicts the findings of Chattopadhyay *et al.* (2004), who proposed that males are more likely to identify with their demographic category based on self-enhancement motives, resulting in higher identity. The study has both theoretical and practical implications. First, the study has helped enrich the literature on WI. Mostly, scant literature exists based on samples from Saudi Arabia. This is the first study in this direction. Given the diversity in applying theory and research on identity and WI, there is a need for a systemic and integrative approach (Abrams and Hogg, 2004; Carneiro *et al.*, 2010; Serneels, 2008). This research has contributed to unifying the various theoretical perspectives on identities. The study also calls for investment in WI and supporting organizational socialization for the employees, particularly newcomers. In addition, the study also helped to know the impact of different work and nonwork identities like locale and gender. Multiple studies have dwelled on the importance of WI on satisfaction with the job, especially with expert employees (Porter *et al.*, 1974; Bothma and Roodt, 2012; Serneels, 2008), denoting its importance in any organization. The study suggests that organizations operating in culturally diverse contexts, such as Saudi Arabia and India, should prioritize cultural sensitivity training programs for employees and managers. Given the significant impact of WI on employee satisfaction and organizational outcomes, organizations should invest in tailored organizational socialization programs, especially for newcomers. Organizations should recognize and embrace the reality that employees bring their non-work selves and individual identities to the workplace. In addition, understanding and respecting cultural differences can help mitigate identity stress and foster a more inclusive work environment. The study underscores the importance of continued research and scholarship on WI, particularly in underrepresented regions such as Saudi Arabia. Future research endeavors should focus on exploring the dynamics of WI in diverse cultural contexts and its implications for organizational practices and policies.

Limitations and scope for further research

Probable limitations of the research include

the sample used for the study. First, the sample was collected based on its cross-sectional nature. This could have caused constraints to the research, as inferring a causal connection between the variables would not be possible. The sample was limited to Saudi Arabia and India. Both are developing economies. Samples from developing countries could also be included, as this will help to understand whether economic prosperity affects WI. The study also raises various other questions that present scope for further research. First, there is scant evidence about how different identities interact. There is also scope to examine the different identities, like organizational and occupational identifications, since no evidence exists as to why strong identification with one's occupation prevents individuals from involving the organization in their identities or vice versa (Miscenko *et al.*, 2017). Another area that can be examined is the relationship between employees' work and personal identities. Additionally, examining how identities develop over time could also be done. Finally, future research may also examine why individuals develop WI, which spreads to create a corporate identity (Marique and Stinglhamber, 2011).

CONCLUSION

This study examined the level and difference between the WI among Saudi and Indian employees. It also examined the relationship between WI and HC. In addition, the effects of locale, gender, and human capital on WI were also examined. WI helps to tide over the multiple uncertainties in the organizational environment and has a profound positive impact on various work-related outcomes. The study of identity has become a hotly debated subject in corporate and management studies. WI helps to understand the self and complex social interaction that individuals have at the workplace. The study has found that WI differs between the employees of the two countries in all the factors. It also found a significant positive correlation between the WI and HC. The findings are consistent with the available theoretical and empirical evidence. The study has provided identity researchers with a more consistent and structured grasp of how specific demographics and human capital affect WI by discussing theoretical perspectives and practical approaches. The study's conclusions have major

practical significance in organizational settings and are extremely ideal in the current business scenario. WI will act as a catalyst to improve individual task performance and overall organizational performance if it is present at substantially higher levels in members. The present study is expected to be a catalyst in inducing more empirical examination in this area.

AUTHOR CONTRIBUTIONS

S. Faisal performed the literature review, and research design, analyzed, and interpreted the data, and prepared the manuscript text, 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>ANOVA</i>	Analysis of Variance
<i>B</i>	Regression coefficients
<i>F</i>	Fisher test
F_t	Predicted value
<i>HCT</i>	Human capital theory
<i>LTO</i>	Long-Term Orientation
<i>N</i>	Sample size
<i>OCB</i>	Organizational Citizenship Behavior
<i>R</i>	Pearson correlation coefficient
R^2	Coefficient of determination
<i>r-value</i>	Pearson correlation coefficient
<i>RIT</i>	Role Identity Theory
<i>SCT</i>	Social Cognitive Theory
<i>SIT</i>	Social Identity Theory
<i>SPSS</i>	Statistical Package for the Social Sciences
<i>WI</i>	Workplace Identity

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ORIGINAL RESEARCH PAPER

Unveiling the shadows: investigating the substance use among street children

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ABSTRACT

BACKGROUND AND OBJECTIVES: Street children are a global phenomenon affecting urban areas with varying degrees of severity. These vulnerable children face significant challenges, including the lack of basic rights, educational opportunities, and social integration. Substance use compounds their difficulties, often serving as a coping mechanism in their harsh environment. While existing research has predominantly focused on substance use among street children in Asia and Latin America, there is a notable gap in understanding within the African context, particularly in Nigeria. This study aims to address this gap by investigating substance usage patterns among street children in Nigeria. The objective is to inform the development of targeted interventions and policies to support street children better and address the underlying causes of substance use in their communities.

METHODS: Accidental sampling was utilized to recruit 384 street children from nine Data Delineated Areas in three selected cities. Data collection involved the administration of interviewer-administered questionnaires, which gathered information on socio-economic characteristics, substance knowledge, and usage among street children. The collected data underwent analysis using frequency counts, chi-square tests, and binomial logistic regression.

FINDINGS: The study found that the predominant substances used by street children were alcohol (60%), nicotine (40%), and cannabis (35%). Although addiction evidence was limited, the prevalence of multiple drug and substance use was notable. The binomial logistic regression results indicated that certain demographic and situational factors were associated with a decreased likelihood of drug use among street children. Specifically, children aged 4 to 10 years (90%, $P = 0.000$), females (80%, $P = 0.000$), school attendees (70%, $P = 0.000$), those spending fewer than 8 hours on the street (60%, $P = 0.000$), those sleeping at home (70%, $P = 0.000$), and those from relatively stable families (60%, $P = 0.0001$) were less likely to engage in drug use.

CONCLUSION: The study underscores the importance of adopting a holistic approach to address substance use among street children. By aligning urban and regional planning with general recommendations, policymakers can address the interconnected social, economic, physical planning, and educational factors contributing to substance use. Through targeted interventions and policies, stakeholders can provide effective support to street children and mitigate substance use within their communities, ultimately improving their well-being and prospects for the future.

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INTRODUCTION

The problem of street children presents a pressing social issue that demands immediate attention and decisive action. Despite concerted efforts to tackle this phenomenon, it continues to persist and even worsens in many urban areas worldwide (Ogunkan, 2024; Vameghi et al., 2023; Obimakinde and Shabir, 2023). At its core, the issue of street children encompasses several critical aspects that must be addressed comprehensively. The sheer number of children living and working on the streets is alarming. This pervasive problem spans urban centers globally, with varying degrees of severity, yet it remains a persistent issue affecting the lives of countless children. Street life is a modality of existence and an adaptive stress response observed among vulnerable groups residing in impoverished conditions globally (Reid, 2023; Roks et al., 2021). This phenomenon primarily impacts children, particularly in developing nations (Ogunkan and Adeboyejo, 2021; Kaime-Atterhogi, 2012; Aptekar, 2001; Faloore, 2009). While street activities present opportunities for income generation (Gunhidzirai, 2023; Ofosu-Kusi, 2023) and a semblance of freedom (Ojebuyi and Ajao, 2023), they simultaneously compromise the dignity and well-being of children, resulting in detrimental effects on their physical, mental, emotional, moral, and overall health (Obimakinde and Shabir, 2023). Numerous studies have extensively documented the challenges faced by street children globally (Ogunkan, 2024; Vameghi et al., 2023; Obimakinde and Shabir, 2023; Ojebuyi and Ajao, 2023; Mishra et al., 2020; Kobulsky et al., 2020, Omit). These studies consistently reveal the absence of protection in an environment devoid of the safety inherent in traditional workplaces, despite the necessity of driving many street children to work. The harsh conditions of street culture, coupled with influences from sex workers, drug lords, and professional thieves, expose these children to counterproductive behaviors (Rizzini and Lusk, 1995). The unrestrained freedom characterizing street life further reinforces detrimental habits, including smoking, gambling, substance use, and prostitution (Ndlovu and Tigere, 2022; Chikoko et al., 2022). Street children are minors who endure life on the streets, detached from conventional family structures and social support systems. Deprived of necessities, these children navigate the harsh urban terrain, often resorting to unconventional means to

fulfill their needs. In this struggle for survival, drugs become an enticing escape from the harshness of their daily existence. The constant exposure to the street environment increases the vulnerability of street children to a poignant and often overlooked issue - their involvement in substance use. These vulnerable young souls, grappling with the harsh realities of life on the margins, find themselves entangled in a web of substance abuse that further exacerbates their already precarious circumstances. The term "substance" encompasses psychoactive substances that alter cognitive and sensory functions. Alarming, an estimated 25-90 percent of global street children engage in substance use (World Health Organization (WHO), 2012). This vice is often initiated with legal substances like inhalants, cigarettes, and alcohol, which are readily accessible in many countries (Ayenew et al., 2020). However, substance use has evolved into a significant impediment to the prospects of street children leading stable, content, and fulfilling lives, posing serious threats to their mental and physical health and hindering their reintegration into communities and broader society. Despite extensive research on substance use among street children, the majority of studies focus on Asia and Latin America (Tuladhar, 2002; Pagare et al., 2003; Carvalho et al., 2006; Moura, 2012, among others). Except for a study in a Nigerian local government (Egwuaba & Adeyi, 2023), few investigations within Africa (Kayembe, 2008; Buruh, 2014; Bah, 2018; Jakaza and Nyoni, 2018, among others) have been conducted outside Nigeria. Despite the considerable research conducted on street children within major Nigerian urban centers, this particular gap in the existing literature demands urgent consideration. Consequently, this study endeavors to address this gap by investigating the socio-economic profiles of street children, as well as their patterns of substance use and the types of drugs they encounter, within chosen cities in Southwestern Nigeria during the year 2023.

Statement of problem

The plight of street children represents an urgent social concern that requires immediate attention and decisive action. Despite concerted efforts to address this issue, it continues to persist and escalate in numerous urban areas worldwide (Ogunkan, 2024; Vameghi et al., 2023; Obimakinde & Shabir, 2023). At

its core, the problem of street children encompasses several crucial dimensions that necessitate a comprehensive approach. Understanding the underlying causes and factors contributing to the phenomenon of street children is paramount for effective intervention. Poverty, family dysfunction, urbanization, conflict, and social exclusion are primary drivers that compel children onto the streets and perpetuate their presence there (Ogunkan, 2024; Obimakinde & Shabir, 2023). Street children face a myriad of vulnerabilities and risks, including exposure to violence, exploitation, substance abuse, and inadequate access to essential services such as education, healthcare, and shelter (Ogunkan, 2024; Vameghi *et al.*, 2023; Obimakinde and Shabir, 2023; Ayenew, Kabeta and Woldemichael, 2020; Moura *et al.*, 2012). These vulnerabilities perpetuate a cycle of marginalization and deprivation, hindering their development and prospects for a stable future. The experience of living and working on the streets profoundly impacts their well-being, depriving them of basic rights and opportunities for growth, education, and social integration. Moreover, the presence of street children has broader societal implications, including increased social unrest, crime rates, and strain on social services (Obimakinde and Shabir, 2023). Addressing this issue necessitates not only a focus on the individual well-being of street children but also broader societal responses and interventions. However, despite efforts to support street children, interventions often face numerous challenges, including inadequate resources, lack of coordination among stakeholders, stigma and discrimination, and gaps in policy and implementation (Ojebuyi and Ajao, 2023; Ogunkan, 2021). The issue of drug use among street children further complicates their already challenging circumstances. Drug use among these vulnerable youth is prevalent in many urban areas worldwide, serving as a coping mechanism to alleviate the harsh realities of street life. Factors such as poverty, lack of parental supervision, exposure to violence, and easy access to drugs contribute to their susceptibility to substance abuse (Carvalho *et al.*, 2006; Martijn & Sharpe, 2006). Drug use poses significant risks to the physical and mental health of street children, leading to addiction, malnutrition, infectious diseases, mental health disorders, and overdose-related fatalities (Ndlovu and Tigere, 2022; Chikoko *et al.*, 2022). Moreover, involvement in drug

use becomes intertwined with survival strategies, perpetuating a cycle of exploitation and dependence. Street children face numerous barriers to accessing support and intervention services for drug abuse, including lack of awareness, stigma, and challenges in accessing healthcare (Ogunkan, 2024; 2021). Addressing drug use among street children requires a comprehensive and integrated approach that prioritizes harm reduction, access to appropriate treatment and support services, and holistic interventions addressing underlying factors. Efforts must extend beyond individual-level interventions to encompass broader societal responses addressing the root causes and structural factors contributing to substance abuse among street children. Only through concerted and collaborative action can we hope to break the cycle of poverty, marginalization, and substance abuse among street children. It is on this note that this study examines substance use among street children in Southwestern Nigeria in 2023.

MATERIALS AND METHODS

Research design

The study adopts a quantitative research design to systematically analyze substance use among street children. The utilization of quantitative methods proves particularly advantageous given the extensive and diverse nature of the street children population under investigation, allowing for the generalizability of findings (Muijs, 2022). This approach is recognized for its suitability in ensuring an objective and accurate analysis, effectively mitigating biases inherent in the research process (Borgstede and Scholz, 2021; Kandel, 2020). Consequently, the application of quantitative analysis in investigating substance use among street children establishes a methodologically robust and objective framework. This method enables researchers to draw reliable conclusions, discern patterns, and contribute valuable insights. The outcomes, rooted in quantitative rigor, can serve as a foundation for informing targeted interventions and policies designed to address substance use challenges within this vulnerable population.

Instrument of data collection

The primary tool employed for data collection is the questionnaire. Recognizing the need for careful consideration in crafting a questionnaire tailored for street children, the researchers prioritized ethical

considerations. This involved securing informed consent from both the street children and, when applicable, their legal guardians. Emphasis was placed on the voluntary nature of participation, ensuring confidentiality, and guaranteeing anonymity. Acknowledging the paramount importance of sensitivity to language and culture when engaging with street children, the questions were meticulously formulated. The language used was tailored to be appropriate for the age group and cultural background of the participants. The questions were intentionally kept concise and engaging, avoiding the use of complex terminology. The study adopted an “interviewer-administered” or “assisted” survey administration approach (Liu *et al.*, 2022; Rahman, Lee, Ireen and Ahmed, 2021) where, the researcher directly posed questions and filled out questionnaires for children who faced challenges in reading, writing, or comprehending the questionnaire. This approach was chosen to ensure inclusivity and accessibility for all participants. Throughout the questionnaire, a non-stigmatizing tone was maintained to foster an environment conducive to honest responses. The researchers were mindful of the potential vulnerabilities of street children and aimed to create a respectful and supportive space for their participation in the study.

Sampling procedure

The participants of this research, specifically street children, were identified at key locations such as junctions, motor parks, and markets. The selection of these research sites was purposeful, guided by existing studies indicating a higher concentration of street children in these areas (Ogunkan, 2018). Consequently, three significant junctions, the most frequented markets, and the busiest motor parks in Ibadan, Akure, and Osogbo were purposively chosen (Table 1). Through accidental sampling, a total of three hundred and eighty-four (384) street children were included in the study, following their voluntary agreement to participate. The sample size

of 384 street children was selected purposefully to encompass diverse socio-economic backgrounds across key locations in the studied urban centers. This ensures representation and statistical power to detect significant associations between variables. Accidental sampling facilitated recruitment from areas known for high street child concentrations, with participants voluntarily agreeing to participate, upholding ethical standards. This sample size balances feasibility with statistical robustness, enabling comprehensive insights into substance use patterns among street children.

Data analysis

Descriptive statistics, such as frequencies for categorical variables and measures of central tendency and dispersion for continuous data, were calculated. To explore the relationship between socioeconomic variables and substance use, bivariate analysis using the chi-square test was conducted. The choice of the chi-square test is informed by its suitability for analyzing categorical data, its capability to evaluate the independence of variables, its non-parametric foundation, its effectiveness with large sample sizes, its straightforward application and interpretation, and its adaptability to various research contexts. These characteristics make it an ideal starting point for exploring the relationship between socioeconomic variables and substance use in bivariate analyses. Subsequently, a logistic regression model, with a significance level of probability value (p-value) < 0.25 at 95% confidence, was employed to evaluate the strength of association among the variables under examination. This model provided insights into predicting the likelihood of street children engaging in substance use. The computation of Odds Ratios (OR) was facilitated by selecting reference categories for each variable, shaping a model that emphasizes potential protective factors. Notably, an odds ratio lower than 1 signifies a level of protection against substance use within this context. Logistic regression models are selected due to their proficiency in

Table 1: Selected locations and research subjects

Locations	Ibadan	No	Akure	No	Osogbo	No	Total
Markets	Gbagi-Dugbe Market	59	Oja-Oba Market	69	Igbona Market	43	170
Junctions	Dugbe junction	40	Post Office Junction	13	Ola-Iya junction	46	99
Motor Parks	Gbagi-Ogunpa Motor Park	55	Benin Garage Motor Park	35	Ogbomoso Garage Motor Park	24	114
Total		154		117		113	384

Table 2: Socio-economic characteristics of street children

Variables	Frequency	Percent
Gender		
Male	259	67.5
Female	125	32.5
Age		
4-10 yrs	116	30.1
11-14 yrs	183	47.7
15-17 yrs	85	22.2
Categories		
Home Sleeping	258	67.1
Street Sleeping	126	32.9
Schooling Status		
Schooling	243	63.2
Drop out	89	23.3
Never enrolled	52	13.5
Daily Income		
Below N200	107	27.9
N200- N 500	81	21.2
N501- N1000	109	28.5
N1001- N1500	48	12.4
Above N1500*	39	10
Parent Marital Status		
Married	202	52.6
Divorced	74	19.3
Widowed	46	12.0
Separated	35	9.1
Never Married	27	7.0
Hours on the Street		
8 hours and above	223	58
Less than 8 hours	161	42

managing binary outcome variables, calculating odds ratios, addressing non-linear associations, controlling for potential confounders, offering predictions, handling diverse predictor variables, and preserving result interpretability. These capabilities make it exceptionally appropriate for research focused on examining and predicting substance use behaviors among street children.

RESULTS AND DISCUSSION

Demographic profile of street children

384 street children participated in the study, comprising 259 males (67.5%) and 125 females (32.5%). The age distribution ranged from 4 to 17 years, with the predominant age group being 11-14 years, constituting 47.7% of the total. A substantial portion (63.3%) of the respondents were enrolled in school, while 23.3% had discontinued their education, and 13.5% had never attended formal schooling. An examination of parental marital status revealed that more than half (52.6%) of the street children

originated from conjugal families. Approximately 19.3% hailed from single-parent households, with 9.1% having parents separated but not divorced, and 7% coming from single-parent homes. Twelve percent had experienced the loss of both parents due to widowhood. In terms of daily work hours, the majority (58%) of the sampled street children engaged in work for at least eight hours per day, while around 42% worked fewer than eight hours (Table 2).

Knowledge and engagement in substance use

Nearly all the surveyed street children across the three cities (97%) affirmed awareness of drugs and substances, yet the prevalence of usage was notably lower than their knowledge. Among the children acknowledging familiarity with drugs, less than one-third (30.2%) confessed to engaging in substance use. This trend suggests that substance use is relatively less common than the stereotypical association with street children globally (Gaidhane *et al*, 2008; Kliewer and Murelle, 2007).

Table 3: Types and frequency of substance use

Substance	0/ month	Once/ month	2-3/ month	Once/ week	2-3/ week	4-6/ week	Everyday
Alcohol	3 (2.7%)	16 (13.5%)	29 (25.3%)	27 (23.2%)	13 (11.2%)	17 (14.8)	12 (10%)
Nicotine	59 (50.9%)	4 (3.1%)	10 (8.9%)	14 (11.7%)	6 (5.5%)	8 (7.3%)	15 (12.8%)
cannabis	64 (54.8%)	7 (5.7%)	16 (13.5%)	16 (13.8%)	3 (2.9%)	7 (6%)	4 (3.1%)

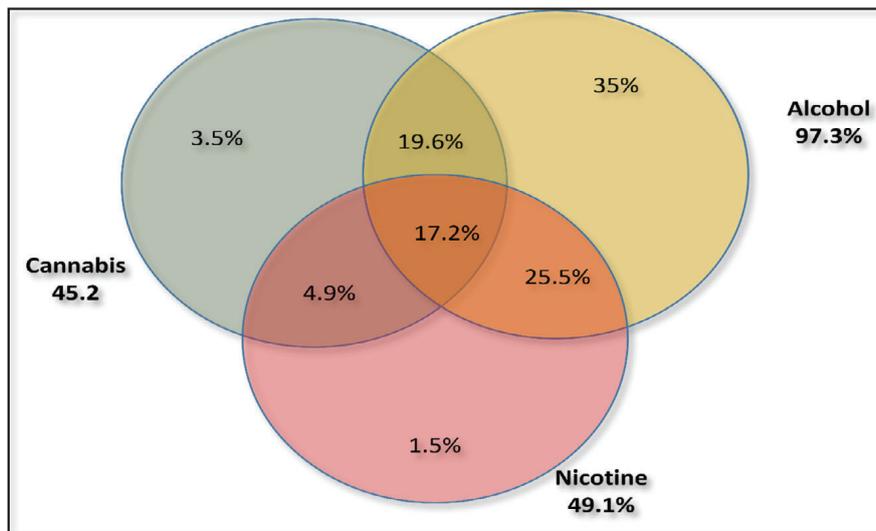


Fig. 1: Overlaps of substance use among street children

Categories of substance use

The psychoactive substances utilized by street children exhibit diversity, encompassing various types. However, based on the WHO (2012) classification, these substances fall into categories such as alcohol, opioids, hypnotosedatives, nicotine, hallucinogens, stimulants, cannabis, and inhalants. Nevertheless, in this study, it was observed that street children were primarily engaged in the use of three major categories of drugs or substances: alcohol, nicotine, and cannabis (Table 3).

Despite the acknowledged possibility of under-reporting, especially concerning substance use among street children, a comparison with findings from other countries (Carvalho et al., 2006; Kliever and Murrelle, 2007; Moura et al., 2012) reveals insights into the habituation patterns, as illustrated in Fig. 1. The data suggests limited evidence of addiction, with 35.9%, 25.5%, and 12.1% reporting heavy use of alcohol, nicotine, and cannabis, respectively. Additionally, 61.4%, 23.6%, and 33.1% reported

frequent use of alcohol, nicotine, and cannabis, while 2.7%, 50.9%, and 54.8% of drug-using street children claimed to have never tasted alcohol, nicotine, or cannabis. However, there is an overlap in the usage of substances among street children, as depicted in Fig. 1.

Fig. 2 illustrates the overlap of substance abuse among street children. Out of the 384 surveyed street children, 116 (30.2%) were engaged in one or more forms of substance abuse. Within this group, 97.3% were alcohol users, 49.17% were nicotine users, and 45.2% were cannabis users. Notably, 67% of substance users reported the use of multiple substances, with only 17.2% engaging in alcoholism, nicotine, and cannabis simultaneously. To identify the associated factors of substance use among street children, socio-economic variables were cross-tabulated with the incidence of substance use among children, as presented in Table 4.

The results reveal a noteworthy trend among participants without a history of drugs/substance

Table 4: Characteristics of street children by substance use

Drug/ Substance use	Yes	No	Total	X ² value	P-value
Gender					
Male	50.2	49.8	100		
Female	10.2	89.8	100	58.887	0.000
Age					
4-10 yrs	12.2	87.8	100		
11-14 yrs	29.3	70.7	100		
15-17 yrs	56.6	43.4	100	94.170	0.000
Categories					
Home Sleeping	22.3	77.7	100		
Street Sleeping	46.3	53.7	100	47.610	0.000
Schooling Status					
Schooling	18.5	81.5	100		
Drop out	40.9	59.1	100		
Never enrolled	65.5	34.5	100	106.867	0.000
Parents' marital status					
Married	22.2	77,8	100		
Divorced	46.1	53,9	100		
Widowed	36.8	63.2	100		
Separated	31.9	68.1	100		
Never Married	32.7	67.3	100	32.878	0.000
Hours on the Street					
Less than 8 hours	20.5	79.5	100		
8-12 hours	32.1	67.9	100	29.698	0.000
Above 12 hours	42.1	57.9	100		

Table 5: Binomial logistic regression for variables associated with substance use

Variable	Category	B	S.E	Wald	df	Sig.	Exp(B)
Gender	Female	-1.531	.211	52.543	1	.000	.216
	Male	Reference					
Age	4-10 yrs	-2.235	.250	79.834	1	.000	.107
	11-14 yrs	-1.147	.190	36.460	1	.000	.317
	15-17 yrs	Reference					
Categories	Home Sleeping	-1.101	.163	45.849	1	.000	.333
	Street Sleeping	Reference					
Schooling status	Schooling	-2.121	.231	84.033	1	.000	.120
	Drop out	-1.008	.251	16.107	1	.000	.365
	Never enrolled	Reference					
Parents' Marital Status	Married	-1.095	.201	29.613	1	.000	.335
	Single	-.381	.268	2.022	1	.155	.683
	Widowed	-.598	.301	3.959	1	.047	.550
	Never Married	-.562	.330	2.899	1	.089	.570
	Divorced	Reference					
Hours Spent on the street	Less than 8 hours	-1.030	.192	28.652	1	.000	.357
	8-12 hours	-.425	.193	4.834	1	.028	.654
	Above 12 hours	Reference					

use: a higher percentage were female (89.8%), aged between 4 and 10 years (87.8%), home sleeping (77.7%), attending school (81.5%), and hail from relatively stable families (77.8%). Bivariate analysis, using the chi-square test, was conducted to examine the significant association of these variables with substance use. The obtained chi-square values in

Table 4 underscore a substantial association between all the examined variables with substance use. To deepen our understanding, a logistic regression model was employed to assess the strength of the relationship between the evaluated variables in predicting the likelihood of street children engaging in substance use (Table 5).

Table 5 briefly presents the results of the binomial logistic regression, revealing that, except for “single” and “never married” variables, all evaluated factors attained significance with varying strengths and directions of association. Remarkably, age, particularly within the 4 to 10-year range, exhibited the most potent inverse connection with substance use. Children within this age bracket were found to be up to 90% ($P = 0.000$) less likely to engage in drugs or alcohol compared to the reference group (15–17-year-olds). This underscores that despite the early introduction of children to the streets, they are less likely to embrace street culture fully and, consequently, less prone to substance use (Sorsa *et al.*, 2002; Gaidhane *et al.*, 2008; Moura *et al.*, 2012). Conversely, an increase in age correlated with elevated substance use, as evidenced by a 70% ($P=0.0001$) reduced likelihood of substance use among children aged 11 to 14 compared to their older counterparts. This finding aligns with previous research indicating that advancing age diminishes the protective factor against substance use in children (Moura *et al.*, 2012). Contrary to existing literature suggesting that both genders of street children face similar risk behaviors (Moura *et al.*, 2012), this study identified gender as one of the influential factors determining substance use. The logistic regression model indicated that females were 80% ($P = 0.000$) less likely to engage in substance use than their male counterparts. This discrepancy could be attributed to the physical, emotional, and psychological challenges of street life, making females less adept at coping with its demands. Consequently, they are usually introduced to street life more gradually and tend to exit the street earlier in their adolescent lives, before becoming deeply ingrained in street culture. The schooling status of street children emerged as another crucial factor with a robust inverse association with substance use. School-attending street children exhibited a 70% ($P = 0.000$) reduced likelihood of involvement in substance use compared to their non-enrolled counterparts. Even “drop-out” street children, while more susceptible than their schooling peers, were 60% ($P = 0.000$) less likely to engage in substance use than street children who were never enrolled in school. The total hours spent on the street emerged as a significant factor related to drug use. Children spending less than 8 hours on the street were 60% ($P = 0.000$) less likely to be

substance users than those spending over 12 hours, while those spending 8 to 12 hours were 30% less likely than their peers spending more than 12 hours. This underscores the association between prolonged exposure to street life and increased vulnerability to substance use, as confirmed by existing literature (Milburn *et al.*, 2009; Moura *et al.*, 2012). Moreover, a robust connection was identified between street children’s sleeping arrangements and substance use. Home-sleeping children were found to be 70% ($P = 0.000$) less likely to engage in substance use than their street-sleeping counterparts. The logistic model further affirmed that a relatively stable family diminishes children’s likelihood of substance use by 60% ($P = 0.0001$) compared to those from broken homes.

Discussion of the findings

This study elucidates several crucial aspects of substance use among street children in Southwestern Nigeria, drawing on existing literature for support. Firstly, the study reveals that the prevalence of substance use among street children in this region is relatively low compared to other regions, such as Latin America, Asia, and some African countries (Manrique-Millones, 2021; Morojele, Ramsoomar, Dumbili and Kapiga, 2021; Munawar, Choudhry, Hadi and Khan, 2020). This difference is attributed to cultural, religious, and policy factors, including strong social support networks and limited drug accessibility. This implies that public health interventions in Southwestern Nigeria may prioritize other pressing issues affecting street children while still addressing substance use concerns. However, despite the lower prevalence, it is imperative to focus policy attention on this sub-group due to their interactions with non-drug-taking individuals on the street, posing a potential risk of influencing others into substance usage (Aderinto, 2000). Furthermore, the study highlights that there is little evidence of addiction among the sampled street children and no evidence of hard drug use. However, the arbitrary categorization of drugs into “hard” and “soft” lacks clear criteria or definitions and lacks scientific support. Soft drugs, perceived as less physically and mentally addictive and less harmful, can still cause serious health issues such as liver disease, impaired brain function, and various types of cancer (Mishra *et al.*, 2015; WHO, 2020). This calls for a more

nuanced approach to drug classification, along with comprehensive public health and education initiatives that address the risks associated with all types of drug use. Additionally, the study underscores the concern that soft drugs can serve as gateway drugs to harder substances for street children in the study area. This study also underscores the precarious nature of multiple substance use among street children and its associated mental and physical health implications. Evidence suggests that the effects of combined substance use differ from those of single substance use. For instance, the combined use of nicotine and marijuana increases the availability of nicotinic acetylcholine receptors in certain brain regions more than either substance alone. This heightened interaction between substances amplifies health risks, including respiratory issues, cardiovascular problems, and mental health disorders.

Additionally, the combined use of alcohol and nicotine has neurological consequences that differ from the use of either substance alone (Brody *et al.*, 2016; Jacobsen *et al.*, 2007; Meyerhoff *et al.*, 2006; Ceballos *et al.*, 2006). This is due to their interactions with different neurotransmitter systems in the brain, enhanced activation of reward pathways, increased neurotoxicity, and heightened risk of addiction. The study emphasizes that school attendance serves as a protective factor against substance use among street children. Those attending school are less likely to be involved in substance use compared to their counterparts who have never enrolled in schooling, aligning with findings in previous studies (Carvalho *et al.*, 2006; Martijn and Sharpe, 2006; Kliewer and Murrelle, 2007). This is because School provides a structured environment, educational opportunities, social integration, and empowerment, which reduce the likelihood of substance use. Additionally, the research indicates that the total time spent on the street by children is associated with drug use. The more hours a child spends on the street, the more they are immersed in street culture and vulnerable to substance use, aligning with existing literature (Ayenew, Kabeta, and Woldemichael, 2020; Moura *et al.*, 2012). Reasons for this association include exposure to street culture, lack of supervision and support, and the use of drugs as coping mechanisms. Another significant finding is the link between sleeping arrangements and substance use

among street children. Street-sleeping children are more susceptible to substance use compared to their counterparts who sleep at home, attributed to factors such as exposure to inclement weather conditions, lack of adequate sleeping places, easy access to drug trafficking and sales, and peer pressure (Osei Asibey, Marjadi and Conroy, 2023; Auerswald, 2009). Finally, the study emphasizes the protective role of relatively stable families in preventing children's engagement in substance use. Specifically, the study highlights that children from households where both parents stay married are less likely to indulge in substance use. This finding resonates with existing literature, underscoring the importance of family stability, even if marked by violence, as preferable to complete familial exclusion for children exposed to various forms of adversity from an early age. (Obimakinde and Shabir, 2023; Moura *et al.*, 2012).

Recommendations

Based on the findings of the study, these recommendations are offered as specific practical solutions to the problem of drug/substance use among street children. The study emphasizes that although the prevalence of substance use among street children in this region is relatively low compared to other areas, it is still crucial to prioritize policy attention on this subgroup due to their potential influence on others. Recommendations include the development of targeted prevention programs, ensuring access to support services, community engagement, increasing education and awareness, and advocating for policy changes. By implementing these recommendations, policymakers and stakeholders can effectively mitigate the risks associated with substance use among street children and promote healthier outcomes. The study reveals little evidence of addiction or hard drug use among sampled street children. It also critiques the arbitrary categorization of drugs into "hard" and "soft," highlighting the need for comprehensive substance use education. Despite perceptions of soft drugs being less harmful, they can still pose serious health risks. Therefore, the recommendation is to implement holistic substance use education programs to provide accurate information and promote informed decision-making among street children.

Integrated substance use prevention and intervention programs

Given the study's findings regarding the potential for soft drugs to act as gateway drugs to harder substances among street children, as well as the risks associated with multiple substance use, it is recommended that the integrated substance use prevention and intervention programs tailored to the needs of street children should be developed and implemented. These programs should address both the individual and environmental factors contributing to substance use, provide education about the risks of using multiple substances, and offer support services for those struggling with substance use disorders.

By implementing this recommendation, policymakers, healthcare providers, and community organizations can work together to address the complex issues surrounding substance use among street children and promote healthier outcomes for this vulnerable population.

Comprehensive screening and treatment programs

In light of the study's highlighting of the risks linked to multiple substance use among street children and its effects on their mental and physical health, it is recommended to establish comprehensive screening and treatment programs specifically designed for street children engaging in multiple substance use. These programs should incorporate multidisciplinary teams comprising healthcare professionals, social workers, and counselors. Their role would involve assessing the unique needs of each child and offering customized interventions such as detoxification, counseling, and access to mental health services.

Enhanced access to education

Based on the study's emphasis on the protective role of school attendance against substance use among street children it is recommended that Implement measures to improve access to education for street children, including initiatives to remove barriers to school enrollment and retention. This could involve providing financial assistance for school fees, offering transportation support, and addressing other socio-economic factors that may hinder school attendance.

Outreach and support programs

Given the research findings indicating a link

between the total time spent on the street by children and their engagement in drug use, it is recommended to establish targeted outreach programs specifically tailored for street children who spend prolonged periods on the streets. These programs should offer access to various supportive services, including counseling, substance abuse education, and healthcare, to address the root causes contributing to substance use. Implementing these recommendations can mitigate risks associated with prolonged street presence and substance use among children, promoting their well-being and offering pathways to a healthier future.

Safe shelter provision

Considering the notable correlation discovered between sleeping arrangements and substance use among street children, it is advised to prioritize the provision of safe and secure shelters for these vulnerable youth. These shelters should offer protection from adverse weather conditions and ensure sufficient sleeping spaces to guarantee the comfort and safety of the children. Additionally, it is crucial to ensure that street children accessing these shelters have comprehensive access to support services, encompassing counseling, substance abuse education, and healthcare. These services play a pivotal role in addressing the root causes contributing to substance use and offering essential assistance to children in need.

Strengthening family bonds

Recognizing the crucial role of stable family structures as a protective factor against children's substance use, parents should intensify their supervisory efforts. Continuous monitoring of children's activities, fostering strong parent-child relationships, engagement in constructive activities, and maintaining open dialogue contribute significantly to a supportive family environment that deters involvement in substance use.

Urban and regional planning implications

The study holds significant implications for urban and regional planning. The findings of the study unveil critical aspects that warrant attention in the planning and development of urban spaces. Here are some implications for urban and regional planning:

- *Inclusive social services planning*

Urban planners need to incorporate inclusive social services planning that caters to the needs of vulnerable populations, including street children. This involves designing and implementing social programs, rehabilitation centers, and shelters aimed at addressing the root causes of street life, such as poverty, family instability, and lack of educational opportunities.

- *Safe public spaces*

The study highlights the role of street environments in influencing substance use among children. Urban planning should focus on creating safe and well-monitored public spaces that discourage risky behaviors. This includes designing recreational areas, parks, and community centers that provide alternatives for children, promote positive engagement, and discourage substance abuse.

- *Economic opportunities in urban development*

Enhancing economic opportunities for low-income families is identified as a crucial factor in preventing and resolving streetism. Urban and regional planners should integrate strategies for economic development within the urban fabric, ensuring that job opportunities and support systems are accessible to vulnerable communities. This may involve zoning policies that encourage local businesses and industries.

- *Community-based awareness programs*

Urban planning initiatives should collaborate with public health agencies to implement community-based awareness programs on substance abuse. Planning for community centers and facilities that can host educational campaigns and workshops would contribute to raising awareness among both children and adults.

- *School infrastructure and accessibility*

Given the preventive role of education in the study, urban planning should prioritize the development of school infrastructure and ensure accessibility for all children. Zoning regulations and educational planning should work hand in hand to establish schools in strategic locations, making education readily available to children from diverse backgrounds.

- *Family-centric planning*

The study underscores the importance of stable family structures in protecting children from substance use. Urban planning should incorporate family-centric approaches by promoting housing policies that strengthen family bonds. Creating affordable housing and supportive social services within urban areas contributes to family stability.

- *Integrated policies*

Urban and regional planning should advocate for integrated policies that address social issues comprehensively. Policies focused on poverty alleviation, education, and public health should be interconnected to provide a holistic approach to mitigating the factors that contribute to substance abuse among street children.

- *Public safety measures*

The study emphasizes the vulnerability of street-sleeping children to substance use. Urban planning should prioritize public safety measures, including secure sleeping arrangements for vulnerable populations. This may involve the provision of safe shelters and accommodations.

CONCLUSION

This study investigated the socio-economic profiles and substance use patterns among street children in Southwestern Nigeria in 2023, shedding light on their socio-economic backgrounds and the factors contributing to their engagement in substance abuse. By adopting a quantitative research design, the study ensures systematic and rigorous analysis, enabling researchers to draw reliable conclusions and inform targeted interventions and policies. Through meticulous data collection using questionnaires, the study captured a comprehensive picture of the socio-economic characteristics of street children, revealing significant insights into their demographics, schooling status, parental marital status, and daily work hours. This detailed profiling lays the groundwork for a nuanced understanding of the factors influencing substance use among this vulnerable population. One notable finding of the study is the relatively low prevalence of substance use among street children compared to global trends, challenging stereotypical perceptions. Despite high awareness of drugs, less

than one-third of the surveyed children reported engaging in substance use. This discrepancy between awareness and actual usage underscores the need for targeted interventions to prevent substance initiation among street children. Moreover, the study identifies alcohol, nicotine, and cannabis as the primary substances used by street children, highlighting the diverse range of psychoactive substances encountered in their environment. By categorizing substance use patterns, the study provided valuable insights into the prevalence and frequency of drug consumption, enabling policymakers to tailor interventions to address specific substance-related challenges. The findings also revealed significant associations between socioeconomic variables and substance use among street children. Factors such as age, gender, schooling status, hours spent on the street, and sleeping arrangements emerge as key determinants of substance use behavior. The integration of urban and regional planning implications with general recommendations offers a comprehensive strategy to create environments that foster the well-being of street children. By prioritizing safe spaces, economic opportunities, education, family support, and awareness, urban planners, policymakers, and stakeholders can work together to mitigate the factors contributing to substance abuse and contribute to the overall development of vulnerable populations in urban areas. This collaborative and holistic effort is essential for creating sustainable solutions and fostering inclusive urban development. The study's findings provide valuable insights for policymakers, Non-Governmental Organisations (NGOs), public health professionals, educators, urban planners, and community members. Policymakers can use the data to formulate evidence-based policies targeting substance abuse among street children, while NGOs can tailor interventions to better suit the needs of this population. Public health professionals can develop targeted campaigns and treatment programs, educators can implement preventive measures in schools, and urban planners can create safer environments. Community members can gain awareness and support initiatives to improve the well-being of street children.

AUTHOR CONTRIBUTIONS

D.V. Ogunkan was responsible for data collection, analysis, and interpretation, as well as the preparation

of Tables and Figures, and the final manuscript. A.T. Adeboyejo contributed to the literature review, created additional Tables, and edited the manuscript. D.O. Adejumobi conceptualized the research design and conducted additional quantitative analysis. T.B. Giwa assisted with the literature review and manuscript preparation

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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

NGOs	Non-Governmental Organisations
OR	Odd Ratio
<i>p</i> -value	Probability value
WHO	World Health Organization

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ORIGINAL RESEARCH PAPER

The mediating effect of job satisfaction in the relationship between wages, appreciation, recognition, and promotion on employee performance

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ABSTRACT

BACKGROUND AND OBJECTIVES: The manufacturing industry is the foundation of the Malaysian economy. The manufacturing industry in Malaysia is diverse, but it has consistently demonstrated superiority in several industries, including semiconductors, pharmaceuticals, medical technology, oil and gas, and the processing and management of palm oil and rubber. Businesses may find themselves in a very hazardous situation if their employees are dissatisfied. Improving employee performance can help an organization increase its production volume and productivity. A lack of worker satisfaction can lead to disinterest and an inability to achieve specific goals. When new employees notice a pay disparity, dissatisfaction, disengagement, and disloyalty arise. It happens when workers believe they are being mistreated or unfairly treated. Businesses must prioritize the well-being of their employees because it is more important to retain them than to let them go. To remain competitive, the organization must keep qualified or competent staff motivated. The study aims to determine the mediating effect of job satisfaction in the relationship between wages, appreciation, recognition, and promotion on employee performance among employees at a multinational semiconductor company in Melaka.

METHODS: For this investigation, the quantitative method was used to analyze information using partial least squares structural equation modeling. This study's sample size is 137, based on the partial least squares structural equation modeling sample size recommendation for an 80% statistical power. Employees of multinational semiconductor companies in Melaka received 142 questionnaires. The partial least squares structural equation modeling sample size table determines the sample size in this study, which combines convenience and nonprobability sampling. The relationship between the variables is determined through hypothesis testing. partial least squares structural equation modeling was used to analyze the data.

FINDINGS: As a result, all eleven hypotheses were evaluated based on the variables- wages, appreciation, recognition, promotion, and job satisfaction have a positive and significant relationship with employee performance. The hypotheses have been accepted with a p-value ranging from 0.005 to 0.048. For direct relationship, the hypothesis from 1-7, there is a positive correlation ($t = 2.993$ to $t=4.521$, $p \leq 0.005$) between wages, appreciation, recognition, promotion, job satisfaction, and employee performance. Therefore, hypotheses 8-11 show an indirect relationship (mediating effect) that positive correlation with a significant p-value of 0.010 to 0.048 between an independent variable (wages, appreciation, recognition, and promotion), mediating variable (job satisfaction), and dependent variable (employee performance).

CONCLUSION: The study provides empirical evidence and conceptual proof that the establishment of policy recommendations derived from the findings should consider Malaysian legal regulations. The management by objectives policy was implemented to improve organizational performance by establishing well-defined goals that management and employees can agree on. The management by objectives approach is a technique for inspiring workers through constructive management techniques because the management objectives approach can increase communication between management and employees. As a result, the management strategy contributes to improving employees' wages, appreciation, recognition, promotion, job satisfaction, and performance.

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INTRODUCTION

Malaysia's manufacturing industry excels in various sectors, including semiconductors, pharmaceuticals, medical technology, oil and gas, palm oil, and rubber processing. With increasing global demand, the Global semiconductor market is projected to reach US\$617 billion in 2024 (Burkacky *et al.*, 2022), with multinational companies like Texas Instruments, Infineon Technologies, and Vishay Semiconductor in Melaka. The COVID-19 pandemic, which hit nearly a year ago, is expected to cause the world's worst recession since the Great Depression in 2020. In Malaysia, there are reports of a semiconductor factory in Batu Berendam, Melaka, being forced to reduce production capacity due to the outbreak (Global Platform for Sustainable Cities, World Bank, 2019). From an industrial perspective, social sustainability can be achieved through human development, encompassing training, education, fair compensation, a healthy work environment, and a strong company culture (Ullah *et al.*, 2021). Therefore, the key theoretical perspective, this study significantly enhances understanding and comprehension of motivation and satisfaction theories in the manufacturing industry of developing countries like Malaysia. One of the most crucial objectives of an organization in recent times has been to effectively manage its workforce by promoting positive attitudes such as higher output, job satisfaction, and performance while discouraging negative attitudes like high employee turnover, absenteeism, and abnormal behavior at work (Prasetya *et al.*, 2023). Moreover, poor job satisfaction management can lead to high staff turnover, unhappiness due to low organizational commitment, excessive absenteeism, and low productivity (Khairunnisa *et al.*, 2022). Despite being permitted to operate, 60% of the workforce was instructed not to visit the factory, which impacted supply. A prominent semiconductor factory in operation is Infineon Technologies, and they have issued a warning about the impact of the semiconductor chip shortage on the smart car industry, the company's main product. The containment measures implemented are in response to the COVID-19 pandemic that has hit the global economy. In this situation, employee job satisfaction has been a major focus of research for industrial and organizational psychologists. People's

job satisfaction levels indicate how much they enjoy their work (Ali *et al.*, 2021). The concept emphasizes how essential employees are to a business and how important it is for them to be satisfied, motivated, and productive. Haryono *et al.*, (2020) highlight the significant impact of reward and job satisfaction on employee and organizational performance, prompting ongoing studies and future research to explore this relationship. In today's globalized world, there is a growing focus on enhancing employee performance and job satisfaction to enhance management in manufacturing organizations. Andreas (2022) suggests that a highly competitive firm must take various steps to adapt to the rapid external changes in Europe. Management should consider factors like rewards, organizational systems, and recognition to improve employee motivation and job satisfaction, ultimately leading to improved performance within the company (Hidayat *et al.*, 2022). Multinational semiconductor companies in Melaka prioritize employee retention for long-term market survival. Employees' dissatisfaction with their current roles and desire to leave multinational semiconductor companies in Melaka is primarily due to inadequate pay (Asaari *et al.*, 2019). Organizations are developing innovative and efficient methods to engage their workforce (Chanana *et al.*, 2021). Employee satisfaction is determined by aligning compensation expectations with expectations, as satisfied employees are more likely to stay with a company, whereas dissatisfied employees may seek new opportunities. The manager-employee connection has an impact on employee satisfaction, and inadequate communication skills can result in subpar work output (Ceylan and Yavas, 2020). Khan *et al.*, (2021) highlight that a lack of appreciation is a significant factor contributing to occupational psychological suffering. Recognition is crucial for the success and sustainability of organizational transformation, serving as a foundation for learning organizations and a source of mobilization and engagement (Alrawahi *et al.*, 2020; Andavar and Ali, 2020; Sobaih and Hasanein, 2020). A study of the United Kingdom construction industry found that recognizing and rewarding employee effort is the most crucial organizational action for performance boosters (da Cruz Carvalho *et al.*, 2020). A company's success relies heavily on its employees' willingness to utilize their skills, knowledge, and creativity

for the business's benefit. Paying employees well can enhance productivity, drive, loyalty, and work satisfaction (Ali *et al.*, 2021). Workers invest significant time, effort, and skills in pursuit of compensation or recognition for their performance and output (Rinny *et al.*, 2020). As a result, the study identifies gaps in many industries in a different context. There are several studies conducted in the West thus far. Studies on Western workers' motivation and rewards may differ from those of Eastern nations like Malaysia due to differences in organizational culture, technical development, economic position, social and religious elements, political patterns, and managerial styles. The contribution of this study is appreciating employees' efforts is crucial for enhancing work performance and productivity. Research is essential to understand motivational factors and job satisfaction as a theoretical contribution. By identifying positive impact factors, employers can better understand and support employees, ultimately improving overall performance and job satisfaction. This study fills a knowledge, literature, and methodology gap in multinational semiconductor companies in Melaka by analyzing job satisfaction through wages, appreciation, recognition, and promotion and its impact on employee performance. It is a guideline for future research, examining new factors and approaches.

Literature review

Employee satisfaction significantly impacts their performance, leading to regular attendance, hard work, adaptability, and eagerness to complete tasks. The quality and drive of a manufacturing company's human resources determine its effectiveness and quality. Low job satisfaction can negatively impact job performance and product quality, negatively impacting the manufacturing sector (Nurlaila, 2022). Management can improve employee performance and job satisfaction by implementing wages that reflect their contribution to the company, their families, and society (Sudiardhita *et al.*, 2018). Continual feedback, including acknowledgment, constructive criticism, and positive feedback, can significantly enhance employee performance and satisfaction, increasing engagement (El Masri and Suliman, 2019). Employee dissatisfaction stems from the fairness of pay based on the work

performed, with many claiming they deserve higher compensation for the job (Alrawahi *et al.*, 2020). Wage satisfaction refers to an individual's satisfaction with their compensation when their perception of salary aligns with their expectations (Putri *et al.*, 2024). Wages are a crucial component of employee compensation and a significant source of inspiration and stimulation (Ali *et al.*, 2021). Promotion in a hierarchical workplace raises an employee's rank, indicating higher performance standards, access to resources, prestige, proficiency, and higher pay and perks. Employees are primarily interested in work promotions as they highlight job components with job descriptions and job dynamics (Rinny *et al.*, 2020). Flipó's hypothesis in Ogini (2020) suggests that promotion refers to the transition to a job with greater prestige and responsibility. Recognition and intrinsic benefits significantly influence employee attitudes and work output. Employees desire a competitive salary, appreciation, and consideration of their contributions. Businesses should prioritize staff recognition to enhance morale and motivation (Musangi *et al.*, 2023; Haryono *et al.*, 2020). Job performance and employee appreciation are closely linked, with high performance resulting from a combination of work-related talent and motivation. Appreciation boosts morale, improves productivity, and is a motivational tool (Febrianti and Se, 2020; Syamsir, 2020). UAE employees, despite financial incentives, prefer stimulating work environments over stressful ones, which can lead to low job satisfaction (Alblooshi, 2021). The employer's treatment of respect is the most significant predictor of job satisfaction in the United States. The job's financial aspects, including pay, benefits, company culture conformity, employee value, and organizational ties, are crucial factors to consider. A study in Bangladesh found that enhancing the working environment through better facilities significantly enhances job satisfaction (Taheri *et al.*, 2020). Paais *et al.*, (2020) highlight that in Indonesia, enhancing job satisfaction requires enhancing motivation, leadership, and organizational culture among employees. Job satisfaction increases employee performance in Indonesia, while low pay, hazardous working conditions, long hours, and poor safety records in China lead to lower performance and organizational efficiency (Siriattakul *et al.*, 2019). Malaysian organizations face job satisfaction

and performance reduction due to pressure, lack of motivation, low pay, and inadequate leadership. Inspiring employees, recognizing their abilities, and ensuring employees are aware of the organization's standards and objectives can improve job satisfaction (Vinh *et al.*, 2022; Haryono *et al.*, 2020; Shah *et al.*, 2020). Younger employees are more productive when offered more rewards and growth opportunities. Malaysia's high turnover rate is due to job satisfaction issues, family distractions, work pressure, stress, and inadequate pay. Western workers' job satisfaction and performance may differ from Malaysia (Asaari *et al.*, 2019; Wolor *et al.*, 2020). Research shows job satisfaction significantly impacts employee retention, performance, and job interest, as per studies by Andreas (2022), and Rinny *et al.*, (2020). In the Malaysian context, organizations face reduced job satisfaction and performance due to work pressure, lack of motivation, low pay, and inadequate leadership (Shanmugam *et al.*, 2022). Employees who are inspired are more content with their work and work harder, leading to higher productivity output. Companies that acknowledge and value their employees' abilities and expertise can boost job satisfaction, while employees who are fully aware of the organization's standards and objectives can maintain business efficiency. The study initially conducted in Western countries suggests that rewards and work motivation among Western employees may differ from those in Eastern countries like Malaysia (Muhammad Hasmi, 2019). Previous studies in Malaysia have primarily examined work-life balance, leadership style, working conditions, and person-job fit as factors influencing job satisfaction (Prasetio *et al.*, 2019). This study explores variables like wages, promotion, recognition, and appreciation to improve human resource practices, aiming to increase job satisfaction and provide a competitive advantage for businesses. The empirical gaps for this study are depicted in Table 1.

Hypothesis, variable terms, and theoretical foundation

Analytical framework

Jobsatisfaction is an emotional state resulting from an individual's assessment of their job experiences, as defined by Locke *et al.* (1976). Organizations must enhance employee job satisfaction by developing

systematic rules and processes and improving motivation and satisfaction through an incentive system. Job performance and actual performance refer to an employee's actual work performance or accomplishment, encompassing both quantity and quality of work in line with their assigned duties (Andreas, 2022). Spilerman *et al.*, (1999) define promotion as the transfer to a position with greater prestige and responsibility. Constructive criticism, such as employee appreciation, can be seen as a strategy to improve an employee's behavior or emphasize the achievement of a specific task. Assari *et al.* (2019) define wages as the monthly or annual remuneration paid to employees. Employers can enhance employee performance and motivation by providing competitive wages, incentives, promotions, and job security. Hypotheses 1, 2, and 8 indicate that the hygiene theory positively influences wages, job satisfaction, and employee performance. Conceivably, hygiene theory can relate to wages, supervision, security, and working conditions, while motivators focus on achievement, responsibility, and job satisfaction, and insufficient salaries can lead to job dissatisfaction (Innoyatova, 2021). Research by Lee *et al.*, (2022) shows that job discontent among employees who do not receive enough compensation and welfare benefits results in poor performance and attitudes. Rahman *et al.*, (2022) suggest that companies prioritize employee satisfaction and performance by providing appropriate wages and ensuring a positive work environment. Employers should promote job satisfaction and performance and provide suitable wages to employees within the organization (Amin, 2021). Hypothesis 3, 4, 9, and 10 suggest that incentive theory positively impacts employee appreciation, recognition, job satisfaction, and performance. Some writers emphasize the importance of expressing gratitude or appreciation to employees as a motivating tool to them (Syamsir, 2020). Ali *et al.*, (2021) identify a lack of appreciation as the second leading cause of occupational psychological suffering. Hassan *et al.* (2020) highlight stress tolerance as a crucial factor for managers to manage demanding work environments effectively. Human resources management techniques like motivation, recognition, incentives, appreciation, and career possibilities may have an impact on job satisfaction, which is crucial for productivity and performance and requires social involvement

Table 1: Empirical gaps of the study

Author / Year	Contextual Gaps	Knowledge Gaps	Contribution	Findings
Díaz et al. (2023)	Costa Rican companies in <u>Central America</u>	Emotional wage -> job satisfaction	The post-Covid-19 era emphasizes the importance of enhancing human talent management practices by focusing on improving job satisfaction and internal customer motivation through emotional pay. In today's globalized market, companies can generate significant added value by being more innovative, creative, and competitive.	The study found that inferentially emotional pay positively influences job satisfaction, aligning with the research objective. The coefficients suggest an acceptable value for the theoretical model to be significant, with a RMSEA of 0.095 > (0.05 to 0.08).
Marsinah et al. (2023)	T. Wilmar Food Jambi, Indonesia	Work Wages -> employee performance	A company's success is determined by its effective management of resources and human resources. Good performance enables the achievement of individual and organizational goals, and various work motivation factors improve employee performance.	The analysis reveals that wages significantly impact employee performance, with 85% of positive responses and 97% of positive responses indicating that higher wages lead to better performance.
Magdalena et al. (2024)	PT Wahana Ottomitra Multiartha Tbk	Mutation and Promotion -> job satisfaction -> employee performance	Mutations and promotions should be based on objective assessments of employee achievements, allowing them to develop their potential. Human resources are vital assets in institutions, but their availability is useless if not competent and committed.	The correct mutation significantly increases job satisfaction among employees of PT Wahana Ottomitra Multiartha Tbk, indicating that mutation is a key factor in job satisfaction. PT Wahana Ottomitra Multiartha Tbk has shown that mutations, when conducted correctly, significantly improve employee performance. PT. Wahana Ottomitra Multiartha Tbk's employee performance is significantly influenced by job satisfaction, indicating that higher job satisfaction can enhance performance. Mutations directly influence employee performance at PT. Wahana Ottomitra Multiartha Tbk, with job satisfaction having a smaller impact.
Iskandar et al. (2024)	Tourism Industry	Training Effectiveness -> Work Environment -> job satisfaction -> employee performance	The government and private sector manage tourism infrastructure, including hotel accommodations, restaurants, and attractions. This efficiency creates job opportunities and boosts the local economy. Travel agents play a crucial role in planning and organizing tours.	The study reveals that work satisfaction and soft skills training positively impact employee performance, while improving the work environment has a negative impact, suggesting that addressing job satisfaction and developing soft skills is crucial for enhancing performance.

and appreciation (Herrera et al. 2018; Silvia et al. 2021). Recognition and gratitude are key strategies for meeting employees' needs and achieving job satisfaction, as suggested by (Ramya et al, 2023 and Zaid et al., 2021). Nevertheless, hypotheses

5, 6, and 11 suggest that expectations theory positively impacts promotion, job satisfaction, and employee performance. Vroom's Expectancy Theory suggests that employees are more likely to work harder if they believe their efforts will yield positive

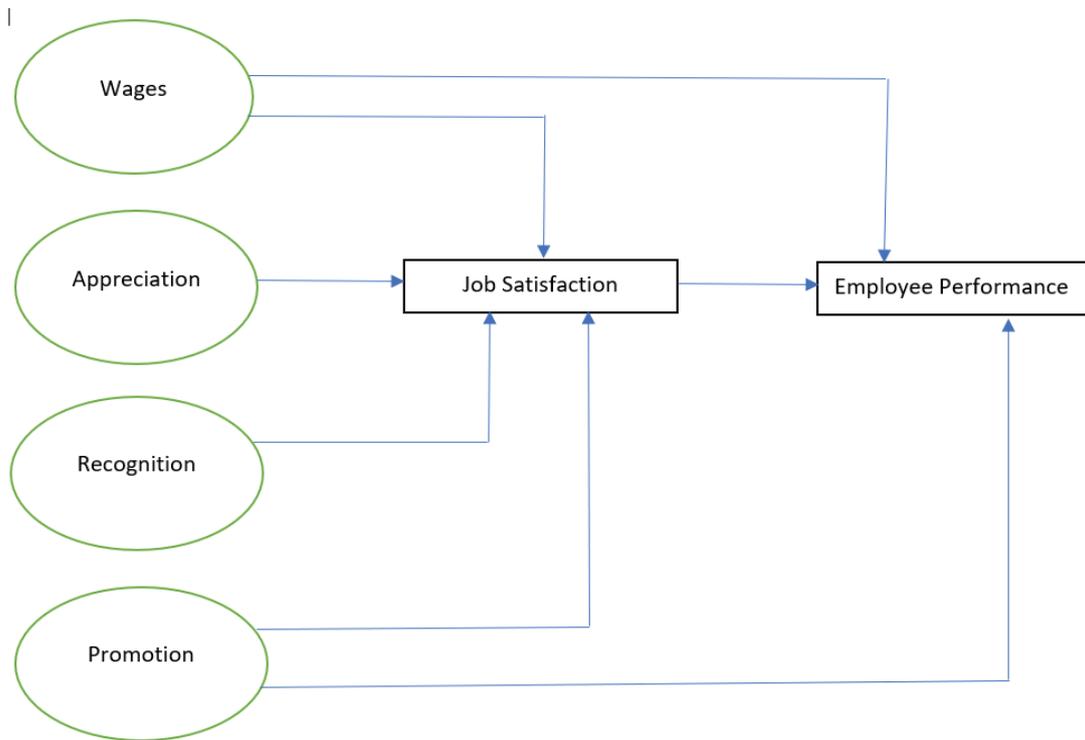


Fig. 1: The conceptual model discovers the mediating effect between motivation factors, job satisfaction, and employee performance.

results (Tiwari *et al.*, 2023). According to Asaari *et al.*, (2019), promotions can enhance workers' perception of their work as fulfilling and fascinating. Companies investing in performance-related investments can enhance workforce performance, reduce career concerns, and boost work satisfaction and organizational productivity (Lee *et al.* 2022). Razak *et al.* (2018) assert that job satisfaction is influenced by one's satisfaction with promotions, and a more methodical promotion system leads to increased job happiness and productivity. Lee *et al.*, (2022) found that promoted workers have high expectations for further promotion and are satisfied with their corporate promotion system's chances. The expectation theory suggests that individuals may be motivated to perform better for promotion, reflecting their diverse wants and motivations (Khan *et al.*, 2021). Promotions significantly impact employee performance and job satisfaction by enhancing or expanding an employee's knowledge and skill set. The conceptual framework for this study is depicted in Fig. 1.

The conceptual model discovers the mediating

effect between motivation factors, job satisfaction, and employee performance in Fig. 1. Herzberg's theory reveals that organizational policies, working conditions, and employer quality are key causes of employee dissatisfaction, while intrinsic factors like personal development and achievement drive motivation and well-being (Bhagwandeem, 2021). Job satisfaction significantly impacts employee performance, quality, productivity, and customer satisfaction. Studies show that happy employees exhibit positive attitudes, operate effectively, and are influenced by wages, appreciation, recognition, and promotion. Alrawahi *et al.*, (2020) identified salary, promotion, recognition, and organizational policy as key factors influencing employee job satisfaction. Herzberg's theory posits that job satisfaction is based on self-psychological factors such as pay, recognition, and motivation. Herzberg's fundamental wants and motives can inspire humans to work tirelessly and produce their best work. In today's competitive market, employee performance and job satisfaction are essential for organizations to meet their objectives. Ismail Hajiali *et al.*, (2022)

found that employees' work pleasure is directly linked to their performance. Employers often prioritize extrinsic rewards over intrinsic ones for employee motivation, as intrinsic rewards like gratitude and recognition boost motivation and output. Leaders must understand employees' needs, following Maslow's hierarchy of requirements. Adams' Equity Theory emphasizes fair inputs and outputs for employee satisfaction and performance, emphasizing procedural justice in human resources procedures for overall organizational success. [Mira et al., \(2019\)](#) identified employee relations, empowerment, promotion, incentives, recognition, training, development, and social support as crucial factors influencing job satisfaction and output. Equity theory helps employees understand fair treatment and motivation, particularly in the manufacturing sector, resulting in financial compensation, additional perks, incentives, and flexible work arrangements ([Khan et al., 2021](#)). The manufacturing industry significantly impacts employee morale, productivity, efficiency, and turnover, providing employers with insights into employee expectations to enhance performance. Vroom's expectation theory (1964) focuses on the relationship between performance, selection, and work satisfaction. [Van Eerde and Thierry \(1996\)](#) praised Vroom's theory as a popular motivational theory that explains the process and rationale behind human decision-making. [Silvia et al., \(2021\)](#) study explores the relationship between motivation, satisfaction, and performance, highlighting that human resource management techniques like job recognition and appreciation can impact employee satisfaction. [Ali et al., \(2021\)](#) expectation theory is used to understand employee expectations. However, Locke's Range of Affect theory examines how employees value various aspects of work, including co-worker relationships, pay, promotion, and supervision. A study by [Dugguh et al., \(2014\)](#) found that job satisfaction directly influences performance, with compensation and benefits being the most significant components. This theory helps identify variables affecting job satisfaction and discontent. The body of knowledge determines wage, appreciation, recognition, and promotion practices as essential factors influencing job satisfaction and employee performance in a semiconductor company in Melaka in 2024.

MATERIALS AND METHODS

Survey design and data collection

The research was primarily an explanatory study. Explanatory research tests hypothesized variables using explanatory techniques to explain the reasons behind their association based on research objectives ([Vira Anisya et al., 2021](#)). The research aimed to establish a genuine relationship between variables in a natural, non-contrived context, resembling real-world settings. The study utilized a deductive approach to test its hypotheses using quantitative techniques and closed-ended questionnaires, ensuring the validity of the theory and hypothesis. The study targets employees in multinational semiconductor companies in Melaka, including 8,000 in Infineon Melaka, 2000 in Texas Instruments, and 1000 in Vishay Semiconductor as of January 2023. This study focuses on the 11,000 employees in the multinational semiconductor industry in Melaka, employed by three companies. A survey was conducted on 130 employees of multinational semiconductor companies in Melaka, collecting data through questionnaires. The study employs a cross-sectional time horizon, collecting data primarily through a single questionnaire to obtain quantifiable parameters. In this study, non-probability and convenience sampling methods are used, obtaining samples based on the availability and convenience of respondents. Convenience sampling has limitations and biases that can impact the reliability and generalizability of findings so it offers several benefits such as its affordability, efficiency, and ease of implementation. Therefore, the recruitment process for convenience sampling (respondent) is random, involving individuals present in public spaces, streets, or workplaces. This study uses reflective measurements to gauge job satisfaction and employee performance. Statements such as "My job satisfaction affects my performance" and "Satisfaction with company promotion influences my performance" are used to represent latent variables. The study uses six latent variables: employee performance, job satisfaction, wages, appreciation, recognition, and promotion, as depicted in [Fig. 2](#). The questionnaire development is presented in [Table 2](#). As a result, questionnaires and surveys are effective research tools used by researchers in both academic and industrial settings to

Motivating factors and employee performance

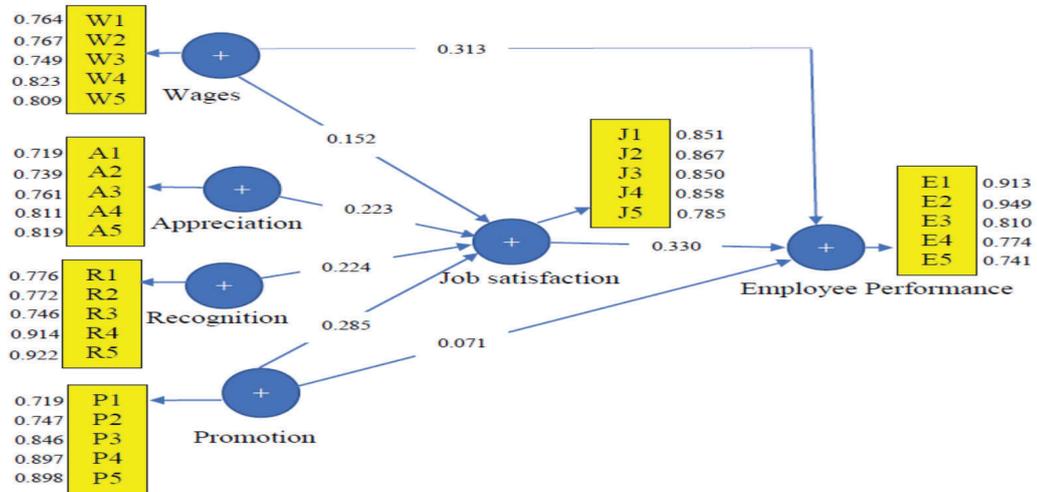


Fig. 2: The structural model – path coefficient

Table 2: Result of the respondent’s profile

Demographic	Categories	Frequency	Percentage (%)
Gender	Male	73	53.3
	Female	64	46.7
Age	20 and below	7	5.1
	21-30 years old	48	35.0
	31-40 years old	53	48.7
	41-50 years old	22	16.1
	51 and above	7	5.1
Working Experience	2 years and below	25	18.2
	3-5 years	27	19.7
	5-10 years	41	29.9
	More than 10 years	44	32.1
Position	Executive	76	55.5
	Non-Executive	61	44.5

collect targeted data for analysis and study. The study utilized a self-administered online questionnaire for data collection. The online survey was created using Google Forms and sent to respondents via WhatsApp and email. Surveys were distributed to multinational semiconductor employees in Melaka via a convenience sample approach via instant text-messaging mobile platforms, ensuring low contamination and high response rates. This study uses a Likert scale with five levels of agreement, utilizing closed questions designed for quicker and easier responses. The questionnaire uses a Likert-style rating system, with respondents rating their agreement or disagreement with statements on a 5-point scale, with neutral points indicating a neutral opinion. The study examines demographic profiles, employee performance, job satisfaction,

wages, appreciation, recognition, and promotion in multinational semiconductor companies in Melaka. It uses a 5-point Likert scale to select responses. The research also explores the mediating variable, job satisfaction, and the influence of these variables. The Partial Least Squares Structural Equation Modeling (PLS-SEM) model was selected for indirect measurement of constructs through indicators and latent variables, accounting for measurement errors and requiring fewer samples for small sample sizes, making it suitable for assessing structural equation models. The outer model in PLS-SEM analyzes latent variables and their measured indicators, evaluating construct reliability and validity and demonstrating relationships between constructs and indicator variables. The sample size was determined using Cohen’s (1992) formula. Cohen (1992) proposed

Table 3: Result of the reliability and validity analysis

Construct	Measurement Items	Outer Loadings	Composite Reliability	Cronbach's Alpha	AVE
Employee Performance	EP1: I feel happy to do my best at work.	0.913	0.924	0.875	0.797
	EP2: My performance is based on my job satisfaction.	0.949			
	EP3: My immediate supervisor is encouraging me to perform well.	0.810			
	EP4: My level of job satisfaction affects my performance.	0.774			
	EP5: My job is exciting, and I am satisfied with my job.	0.741			
Job Satisfaction	JS1: I feel satisfied with my wages.	0.851	0.822	0.818	0.732
	JS2: I feel satisfied when I was appreciated for my efforts.	0.867			
	JS3: I feel satisfied when I was recognized in my job.	0.850			
	JS4: I feel satisfied when I was promoted in my job.	0.858			
	JS5: I tend to perform well when I feel satisfied with my job.	0.785			
Wages	W1: I am satisfied with my salary package.	0.764	0.754	0.918	0.754
	W2: My company provides a salary based on experience and performance.	0.767			
	W3: I am satisfied with my job because of the salary that I were offered.	0.749			
	W4: I will perform well if I am satisfied with my salary.	0.823			
	W5: My performance is based on the salary provided by the company.	0.809			
Appreciation	A1: I am satisfied with the praise and appreciation provided by my company.	0.719	0.707	0.894	0.703
	A2: My company provides appreciation based on the performance.	0.739			
	A3: I am satisfied with my job because I get enough appreciation from the company.	0.761			
	A4: I will perform well if I am satisfied with the appreciation provided by the company.	0.811			
	A5: My performance is based on the appreciation provided by the company.	0.819			
Recognition	R1: I am satisfied with the recognition provided by my company.	0.776	0.707	0.894	0.703
	R2: My company provides recognition based on the performance.	0.772			
	R3: I am satisfied with my job because I get enough recognition from the company.	0.746			
	R4: I will perform well if I am satisfied with the recognition provided by the company.	0.914			
	R5: My performance is based on the recognition provided by the company.	0.922			
Promotion	P1: I am satisfied with the promotion provided by my company.	0.719	0.934	0.919	0.640
	P2: My company provides promotions based on performance.	0.747			
	P3: I am satisfied with my job because I get timely promotion from the company.	0.846			
	P4: I will perform well if I am satisfied with the promotion provided by the company.	0.897			
	P5: My performance is based on the promotion provided by the company.	0.898			

the smallest sample size required in a PLS-SEM model to detect a minimum R2 value of 0.10, 0.25, 0.50, or 0.75 at 1%, 5%, and 10% significance levels. This investigation requires 124 samples to achieve R2 values of 0.10 with a 5% error rate and 80% statistical power due to the maximum of four independent variables. The study used a convenience sampling approach, resulting in a 96.5% response rate, and distributed 130 questionnaires instead of the required minimum of 124 in January 2024. This study examines the mediating effect of job satisfaction on wages, appreciation, recognition, promotion, and employee performance, evaluating both measurement and structural models in Fig. 2.

RESULTS AND DISCUSSION

Descriptive statistics and analysis for variables entering the analysis

Table 2 presents a demographic profile summary from a sample of 137, including gender, age, working experience, and position. Table 2 shows that 53.3% of respondents are males and 46.7% are females. The majority of respondents are between the ages of 31 and 40, with 53 in this group, 48 in the 21 to 30 age group, 22 in the 41 to 50 age group, and 7 in the 20 to 29 age group. The majority of respondents have more than ten years of experience, followed by those with 5-10 years, 3-5 years, and less. The questionnaires were completed by 76 executives and 61 non-executives.

Reliability and validity analysis

Internal consistency reliability measures the closeness of indicators measuring the same construct, with higher values indicating better reliability levels. Hair et al., (2021) found that reliability ratings between 0.60 and 0.70 are acceptable for exploratory research, while values between 0.70 and 0.90 range from satisfactory to good. Table 3 displays Cronbach's alpha and composite reliability results, indicating a Cronbach's alpha value of 0.818

to 0.919 and a composite reliability value of 0.640 to 0.797. Convergent validity evaluates the construct's ability to explain the variability in its indicators, whereas outer loadings in reflective measurement models represent estimated relationships. According to Hessler et al., (2015), factors with loading values less than 0.5 should be dropped, as outer loadings of 0.7 or higher are highly satisfactory. Table 3 shows all outer loadings are above the 0.70 threshold, indicating adequate indicator dependability, with E2 having the highest loading at 0.949 and A1 and P1 having the lowest at 0.719. Hair et al., (2021) suggest that an acceptable Average Variance Extracted (AVE) of 0.50 or higher indicates that the construct explains 50% or more of the variance in the indicators. The current study's constructs meet the minimum requirement of an AVE value of 0.50, as per Fornell and Larcker's (1981) research.

Structural Model Results

Collinearity increases when there are two or more highly correlation-driven indicators in a formative measurement model. Table 4 reveals that the structural model assessment technique has all Variance Inflation Factors (VIFs) below the threshold of 5. The structural model does not significantly address the issue of collinearity among the predictor constructs. Hair et al., (2021) suggest that a VIF of 10 is acceptable, while others suggest a maximum limit of 5 and the highest possible level of 10.

Analysis of path coefficient, r-square, f-square, and q-square

The coefficient of determination (R2) indicates how much variation in an endogenous construct is explained by its predictor constructs. An R-square value of 0.50 indicates the independent variable can explain 50% of the dependent variable's variation. Cohen (1992) suggests that R-square values for endogenous latent variables are 0.26 (substantial), 0.13 (moderate), and 0.02 (weak). Structural model

Table 4: VIF value

	Job Satisfaction	Employee Performance
Wages	2.428	2.007
Appreciation	2.115	
Recognition	2.231	
Promotion	2.370	2.219
Job satisfaction		2.112
Employee performance		

Table 5: Path coefficient, R-square, F-square and Q-square

	Hypothesis	Path Coefficient	Standard Deviation	T Statistics	p-value	r-square	f-square	q-square
H1	Wages -> Employee Performance	0.313	0.097	3.101	0.007			
H2	Wages -> Job Satisfaction	0.152	0.091	3.881	0.031			
H3	Appreciation -> Job Satisfaction	0.223	0.132	2.993	0.042	0.580	0.520	0.615
H4	Recognition -> Job Satisfaction	0.224	0.132	2.993	0.042			
H5	Promotion -> Job Satisfaction	0.285	0.114	3.337	0.005			
H6	Promotion -> Employee Performance	0.071	0.128	4.107	0.011			
H7	Job Satisfaction -> Employee Performance	0.330	0.099	4.521	0.027			
H8	Wages -> Job Satisfaction -> Employee Performance	0.317	0.103	3.996	0.010			
H9	Appreciation -> Job Satisfaction -> Employee Performance	0.382	0.117	3.722	0.048	0.406	0.306	0.674
H10	Recognition -> Job Satisfaction -> Employee Performance	0.382	0.117	3.722	0.048			
H11	Promotion -> Job Satisfaction -> Employee Performance	0.413	0.121	4.003	0.031			

variables can be influenced by various factors, and eliminating an external variable can alter the dependent variable. The removal of exogenous variables from a model results in changes in the R-square or F-square. Cohen (1992) uses the f-square to determine the effect size, with medium values being 0.15 and large values being 0.35. The Q-square, a statistical measure of model relevance, evaluates the model's predictive relevance, with a score greater than 0 indicating good relevance. The model's predictive significance is confirmed by Q-square values above zero, indicating proper rebuilding and well-organized constructs, as demonstrated by the Blindfolding method in PLS-SEM.

Summary of discussion findings

The study investigates the mediating effect of job satisfaction on the relationship between wages, appreciation, recognition, and promotion, and the dependent variable, employee performance. The study, conducted among employees of multinational semiconductor companies in Melaka, presented

and analyzed statistical outputs, with the findings summarized in Table 6.

The t-statistics value is 3.101, exceeding the 1.96 threshold, and the p-value is 0.007, below the 0.05 threshold, confirming the acceptance of hypothesis 1. The hypothesis test indicates a significant positive correlation between wages and employee performance. Assari et al., (2019) emphasize the importance of enhancing employee motivation and satisfaction through competitive wages, incentives, promotion, and job security for improved performance. The p-value of H2 is 0.031, below the threshold of 0.05, while the T statistics value is 3.881, exceeding the threshold of 1.96. Hypothesis 2 is accepted, indicating that employees in multinational semiconductor companies in Melaka are satisfied with their jobs due to a good wage. The hypothesis test indicates a significant correlation between wages and job satisfaction, suggesting that enhancing this element can boost employee motivation and productivity (Hassan et al., 2020). Andavar and Ali (2020) suggest that a wage increase can serve as a motivating factor to boost

Table 6: Summary of discussion findings

Hypothesis	Decision	Results
H1: A positive correlation between wages and employee performance.	Positive (p-values= 0.007)	Hypothesis Accepted
H2: A positive correlation between wages and job satisfaction.	Positive (p-values= 0.031)	Hypothesis Accepted
H3: A positive correlation between appreciation and job satisfaction.	Positive (p-values= 0.042)	Hypothesis Accepted
H4: A positive correlation between recognition and job satisfaction.	Positive (p-values= 0.042)	Hypothesis Accepted
H5: A positive correlation between promotion and job satisfaction.	Positive (p-values= 0.005)	Hypothesis Accepted
H6: A positive correlation between promotion and employee performance.	Positive (p-values= 0.011)	Hypothesis Accepted
H7: A positive correlation between job satisfaction and employee performance.	Positive (p-values= 0.027)	Hypothesis Accepted
H8: Job satisfaction positively influences the relationship between wages and employee performance.	Positive (p-values= 0.010)	Hypothesis Accepted
H9: Job satisfaction positively influences the relationship between appreciation and employee performance.	Positive (p-values= 0.048)	Hypothesis Accepted
H10: Job satisfaction positively influences the relationship between recognition and employee performance.	Positive (p-values= 0.048)	Hypothesis Accepted
H11: Job satisfaction positively influences the relationship between promotion and employee performance.	Positive (p-values= 0.031)	Hypothesis Accepted

employee satisfaction. The P value for H3 is 0.042, below the threshold of 0.05, while the T statistics obtained are 2.993, exceeding the threshold of 1.96. Appreciation has a significant impact on job satisfaction, as demonstrated by [Syamsir \(2020\)](#), emphasizing the importance of expressing gratitude to employees for motivation. Appreciation is a crucial aspect of professional relationships, personal development, and maintaining mental wellness at work, as it is the second most common cause of occupational psychological suffering ([Ali, 2021](#)). The t-statistics value exceeds the threshold of 1.96, while the p-value is 0.042, which is lower than 0.05 for hypothesis 4. The hypothesis test indicates a significant correlation between recognition and job satisfaction. Increasing workplace productivity and efficiency increases employee satisfaction because everyone wants to be recognized by their managers, coworkers, and clients ([Chandrawaty and Widodo, 2020](#)). Hypothesis five indicates a significant correlation between promotion and

job satisfaction. The study found that promotion positively impacts job satisfaction, with a T statistic value exceeding the 1.96 threshold and a p-value below 0.05. Promotions can motivate employees to work harder and more effectively to enhance their skills, as per [Assari et al., \(2019\)](#). Employers should prioritize timely promotions to maintain employee satisfaction and motivation, as suggested by [Dermawan and Tanuwijaya \(2023\)](#). The study found that promotion significantly impacts employee performance, with a P value of 0.011 and a T statistic of 4.107, which is lower than the threshold value of 1.96 for H6. Employees are primarily interested in work promotions as they highlight job dynamics and other components provided in line with the job description. [Haryono et al., \(2020\)](#) study reveals that job promotion significantly and positively impacts employee performance. The SMART-PLS software yielded t-statistics for H7 at 4.521, exceeding the threshold value, and a p-value of 0.027, below the 0.05 threshold. Job satisfaction significantly impacts

employee performance, as evidenced by a significant correlation found in the hypothesis test. Kumari *et al.* (2021) study revealed that job satisfaction significantly impacts employee performance, with satisfied employees performing better than dissatisfied ones. Management should implement effective strategies to boost employee satisfaction, enabling them to perform their duties effectively and achieve maximum performance. The study found a positive mediating effect of job satisfaction on wages and employee performance, with a p-value of 0.010 and a t-statistics value of 3.996 for H8. Supervisors should prioritize this aspect as it can enhance staff enthusiasm and productivity (Hassan *et al.*, 2020). Muhammad Hasmi *et al.*, (2019) study reveals wages are the most significant factor in enhancing job satisfaction and employee performance, surpassing other factors like promotions, job security, working conditions, and other benefits. For hypothesis 9, the t-statistics value is 3.722, exceeding the threshold value of 1.96, and the p-value is 0.048, which is less than 0.05. Recognizing employee engagement in the business can enhance performance and provide an effective non-monetary intrinsic incentive, making appreciation a valuable response to employee contributions. The T statistics value is 3.722, exceeding the threshold of 1.96, and the p-value is 0.048, below the 0.05 threshold for hypothesis 10. The hypothesis test indicates a significant link between recognition, job satisfaction, and employee performance, indicating that employees desire to be remembered by their employers, coworkers, and clients (Chandrawaty and Widodo, 2020). A United Kingdom survey of construction industry professionals (da Cruz Carvalho *et al.*, 2020) found "recognition of their efforts" as the most significant organizational activity or metric. The p-value is 0.031, below the threshold of 0.05, while the t-statistics is 4.003, exceeding the threshold value of 1.96 for hypothesis 11. Rahaman and Uddin (2022) found that timely promotions positively impact job satisfaction and employee performance, suggesting businesses should prioritize timely promotions for employee motivation and contentment.

Practical and theoretical implication

The article explores strategies for businesses to foster a positive work environment, thereby enhancing job satisfaction and enhancing

employee performance. Managers can effectively promote organizational policies and implement measures to ensure employee satisfaction by understanding the identified relationships. This can be utilized by organizations to enhance individual and organizational productivity. Companies should employ strategies such as encouraging managers to participate in employee interactions, promoting problem-solving, providing support, and implementing empathy-building training and development programs. Implementing such interventions can enhance managers' ability to provide appropriate support to their subordinates. Managers are often viewed as role models by their peers, and schemes for rewards and recognition may be established for their helpfulness. A fulfilling work environment and managers who foster a positive work atmosphere can enhance employee performance and job satisfaction, ultimately benefiting the company. In terms of theoretical implication, this study addresses knowledge, literature, and methodology gaps in multinational semiconductor companies in Melaka by analyzing job satisfaction through wages, appreciation, recognition, and promotion. The study's results can serve as a foundation for future research that incorporates mediator variables to understand the impact of these variables on employee performance. The implication provides a valuable guideline for future theoretical and practical or managerial research by guiding researchers to explore new factors and identify additional variables for further study.

Limitation and future research

This study has limitations, including the study focused on four independent variables: wages, appreciation, recognition, and promotion. The study on hygiene factors, superior relationships, leadership, and colleagues in the Malaysian manufacturing industry could be expanded to other states in Malaysia. Firstly, this study utilized the PLS test to assess the mediating effect of job satisfaction on the relationship between wages, appreciation, recognition, and promotion on employee performance. Secondly, the analysis should be conducted using Analysis of Moment Structures (AMOS) and other statistical tools for future research. Thirdly, a survey was conducted

among employees of multinational semiconductor companies in Melaka. Future academics should explore the factors influencing work satisfaction and employee performance in both the public and private sectors to gain a comprehensive understanding of this complex concept. Finally, the quantitative method can be used to collect data differently. Future research could involve group or in-person interviews with respondents to gain a deeper understanding of employee performance. This hybrid approach, combining questionnaires, interviews, and social media monitoring, provides a comprehensive understanding of the analysis's components and may even create a visually appealing presentation.

CONCLUSION

The study confirms a significant positive correlation between wages and employee performance, with a t-statistics value exceeding the 1.96 threshold and a p-value below the 0.05 threshold of hypothesis 1. The p-value of Hypothesis 2 is 0.031, below the 0.05 threshold, and the T statistics value is 3.881, exceeding the 1.96 threshold, confirming the acceptance of Hypothesis 2. The hygiene theory is found to positively impact wage, job satisfaction, and employee performance, according to hypotheses 1, 2, and 8. The study accepts all hypotheses (H1 to H11), recommending a Management-by-objectives policy in all organizations. Perhaps, this study may benefit from incorporating the Vroom Expectancy theory, hygiene theory, incentive theory, and equity theory into MBO policy to enhance organizational performance. Management By Objectives (MBO) is a systematic method for setting objectives that enhance organizational performance and employee satisfaction. The impact of MBO strategy on employee performance and job satisfaction within an organization. The majority of (MBO) literature reviews the steps, implementation methods, and pros and cons of adopting an MBO program. The findings suggest that future policy strategies and recommendations should take into account Malaysian legal regulations on the Management by Objectives strategy. The data indicates that companies should establish rules that foster a positive work environment to ensure job satisfaction. The MBO policy aims to enhance an organization's performance by setting clear, mutually agreed-upon

goals. Management by Objectives policy can foster a sense of pride among employees by assigning goals that align with their abilities, knowledge, and background. Hence MBO is a performance management approach that balances employee and organizational objectives, promoting motivation and empowerment through challenging yet attainable goals. Implementing MBO enhances communication between management and employees, making them feel valued and boosting productivity. Employees who feel appreciated by management tend to perform better. The MBO approach is a management technique that encourages employees through constructive methods. Target management motivates employees to work hard and achieve company goals. Employees who receive bonuses, such as increased income or personal satisfaction, experience increased motivation and performance on an individual basis. Firms with intelligent and motivated employees generally achieve better performance. Employee satisfaction is directly linked to increased productivity and effectiveness within an organization, and a well-designed reward mechanism can significantly enhance this satisfaction level. In this case, Drucker's management by objectives approach is a straightforward method for motivating managers by setting clear goals enhancing a management system involves defining broad goals, defining individual responsibilities, and reviewing accomplishments to assess and reward performance within an organization. The Management by Objectives strategy should incorporate goal-setting techniques to create a conducive work environment that significantly enhances employee performance and satisfaction. Finally, Management by Objective, like other performance appraisal methods, offers organizations competitive advantages in trade, but also has disadvantages that make its application challenging in practice.

AUTHOR CONTRIBUTIONS

D. Kumar performed the literature review, and experimental design, analyzed and interpreted the data. H. Vasudevan prepared the manuscript text and manuscript edition. D. Kumar and H. Vasudevan performed the experiments and literature review, compiled the data, and manuscript preparation. D. Kumar performed the data analysis and findings while H. Vasudevan compiled the data analysis and

findings for the 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

AMOS	Analysis of Moment Structures
AVE	Average Variance Extracted
HP	Hypothesis
<i>p-value</i>	Probability value
R^2_{adj}	Adjusted coefficient of determination
R^2	Coefficient of determination
<i>r</i>	Pearson correlation coefficient
<i>r-value</i>	Pearson correlation coefficient
\bar{Y}	Average of observed data
α	Level of significance
MBO	Management By Objective
PLS-SEM	Partial Least Squares Structural Equation Modeling
VIF	Variance Inflation Factor

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CASE STUDY

Analysis of the 2023 flood scenario for urban disaster management from a strategic management perspective

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ABSTRACT

BACKGROUND AND OBJECTIVES: Analyzing the flood scenario can help identify opportunities and difficulties for enhancing urban catastrophe management procedures and creating more resilient cities facing environmental threats like climate change. The primary goals of the case study were to summarize the key elements of the flood incidents in India between 2000 and 2016 and discuss the 2023 flood scenario in Chennai. This study also suggested technological interventions to ensure preparedness innovatively and recommended a strategic plan to address the issue that would evolve the involvement of all stakeholders in disaster management.

METHODS: A flood disaster analysis was based on meta-analytic and visualization methods. The factors contributing to effective mitigation for such unexpected and unforeseen happenings were considered for elaborate discussion and highlighted in this study. The urban development initiatives and their impact, especially during flood occurrences, were kept for discussion and analysis. The methodology is more qualitative, with references as the basis of analysis and further discussion. The meta-analytic approach ensures to cover all the frames of references that are notable from the perspective of contributing to urban development since urban areas contribute a lot to a nation's economic growth and other developmental aspects.

FINDINGS: The meta-analytic review of the case study contributes to the overall 75 percent of the cases by focusing on governance-level initiatives, precautionary measures, and post-situational steps that were taken to mitigate the issue in a congenial manner. This study identified the consequences and factors that contributed to such occurrences, primarily due to certain factors relevant to urbanization and encroachment effects, as well as other contributing factors that were found common in all occurrences. A framework or model used in this study for urban recovery was also formulated by the authors of this study.

CONCLUSION: These findings enable those strategic decision-makers to support the facts of such occurrences (especially in suburbs or urban areas) or any other incidents of disaster or crisis with crucial information that would pave the way for effective management of incidences and also help in framing policies with developmental perspectives in place while planning to convert suburbs to urban development shortly. The finding of the study supports the gap in overall studies based on flood occurrences and suitable remedies as well.

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INTRODUCTION

The year 2023 etched a grim mark on Chennai. The recorded rainfall was unprecedented and unleashed an urban deluge, leaving the city inundated. An exposed scenario of the city's vulnerabilities, and testing its mettle was witnessed. Yet, from the depths of this crisis arose a story of resilience and adaptation, adding a resolute commitment to a stronger future over devastation. The frequency of flood occurrences in urban areas has been noted in recent years (Rafiq et al., 2016). Those cities that were affected included Ahmedabad, Hyderabad, Delhi, Mumbai, Surat, Kolkata, Jamshedpur, Gurugram, Srinagar, Guwahati, and Chennai during the period from 2000 to 2016. A very recent flood incident was witnessed in Chennai in the year 2023, after 2015. The incidents in Chennai and other places indicate mainly urbanization, encroachments, water logging, and ignored warnings, respectively. Also, it is indicated by Sundarmoorthy et al., (2009). Uncontrolled urban sprawl has had some important consequences for urban floods and blocked natural drainage. In addition, urban lakes were filled and encroached upon. The emphasis on practical knowledge, simulations, and fostering a culture of preparedness showcases the transformative power of education in building communities that are not only aware but actively engaged in their safety and recovery (Jain and Singh 2023). The rapid growth of the metropolis, planned and unplanned, had resulted in the filling up of substantial portions of this once well-managed water management system, and this case, delving into the aftermath of the Chennai floods, offers a nuanced and in-depth exploration of the suburban city's response and recovery efforts. The study also envisaged the previous cases of floods in India from 2000 to 2016. It traces the transcending events as a mere series of chronicles. Further delving into the complex factors being interplayed had given shape to the sub-urban city's journey, from the immediate challenges of rescue and relief to the ongoing quest for long-term urban resilience. The study by Baghel (2016) also analyses the causes and factors behind the flood, the mitigation strategies adopted therein, and the consequences therein. The consequences may be like the Bangladesh floods of 1997 and 1998, which destroyed millions of homes, devastated crops on several million hectares of land, killed over 200,000 farm animals, and caused

enormous damage to the country's economic infrastructure (Mallick et al., 2005). An overall meta-analytic review of the study has been used to analyze and finally draw conclusions from the study. Navigating the labyrinthine complexities of urban disaster management involves a gap examination exposed by the flood, and the subsequent policy reforms undertaken to address it are also focused on in this study (Faisal et al., 2003). The city's commitment to fortifying its urban infrastructure, embracing climate-conscious practices, and empowering its urban communities with knowledge and preparedness is evident. When preparedness is considered, a research paper by Islam et al., (2016) highlights that it is important to enhance the preparedness of digital literacy in flood-prone areas so that schools can take advantage of digital media to get information about flood disasters and also quickly inform the school community to be prepared for disasters. The Mumbai experience would help plan response strategies for other large cities to cope with similar events in the future (Gupta 2007). The causes of flood occurrences were mainly factors that were direct and indirect. The case of the Chennai flood is a direct result of factors such as global climatic change. When there is a change in the weather pattern, heavy rainfall occurrences are witnessed. More than half of the occurrences of disaster had been recorded in Asian areas mainly as highlighted by the work of (Tingsanchali 2012). The situation further worsens due to urbanization initiatives such as encroachments, leaving no space for natural storage, and continuous developmental and redevelopment initiatives with land uses (Ramachandraiah 2011). This study focused on how several factors had combined only to worsen the situation of the flood rather than handling it in a better manner to reduce the loss to a certain extent. Furthermore, this study discussed the causes of the flooding, the damage to Kurnool's water and sanitation infrastructure, and the strategies used by the affected people to cope with the problems during and immediately after the floods. However, a contradictory statement has been argued that many blame this on urbanization and rampant real estate development (Baghel 2016). But a year ago, when rains flooded Gurgaon, the effects were felt the most in rural areas like Kankrola village. There are various types of floods. Floods include river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer

floods, coastal floods, and glacial lake outburst floods. These various classes of floods are generated by different mechanisms (Slam *et al.*, 2016). To focus future research efforts and address important knowledge gaps, it is imperative to identify gaps in the current research on urban disaster management caused by floods. Numerous studies highlight how crucial interdisciplinary approaches are to managing urban disasters like floods (Eshghizadeh, 2024). Further study that effectively integrates perspectives from several disciplines, including hydrology, urban planning, social sciences, and engineering, is required to provide comprehensive solutions (Mei *et al.*, 2018). Although it is well acknowledged that community engagement is a crucial component of urban flood management, little is known about the best ways to involve a variety of stakeholders, especially marginalized and vulnerable communities. According to Pittare *et al.*, (2019), participatory approaches that empower communities and include local knowledge and viewpoints should be the focus of future research. There is a growing demand for study on practical adaptation techniques due to the increasing effects of climate change on urban flooding. The integration of adaptation measures into urban planning and policy frameworks, as well as their long-term effectiveness and scalability, remain little understood (Hallegatte *et al.*, 2020). Accessibility and data availability continue to be major obstacles in the field of urban flood management research. To enable evidence-based decision-making, more complete and standardized datasets are required, along with better access to data sources such as satellite imaging, real-time monitoring data, and socio-economic indicators (Thielen *et al.*, 2018). There is a dearth of knowledge regarding the difficulties associated with implementing policies and governing structures, despite the wealth of research on flood risk management plans and policies. Subsequent investigations must concentrate on the organizational obstacles, policy consistency, and stakeholder collaboration necessary to convert policy objectives into practical measures on the ground (Jiang *et al.*, 2018). When opposed to more general disaster management studies, there are a few special benefits to studying urban disaster management from a strategic management perspective for a particular occurrence like the 2023 flood scenario. In contrast to studies on general disaster management,

which frequently concentrate on theoretical frameworks and overarching concepts, research on the flood scenario of 2023 would examine the particular difficulties, solutions, and results of that specific incident. It would take into account the particulars of the flood, the impacted urban area, the available resources, and the parties concerned. The research findings are made more urgent and useful by this temporal component since it can have a direct impact on current and future crisis management plans. Analyzing the strategic planning, coordination, and execution of organizations, governments, and other stakeholders' responses to disasters is a key component in approaching urban catastrophe management from a strategic management perspective used in this study (Arabiun *et al.*, 2024). The study can pinpoint specific lessons learned, difficulties encountered, and best practices used during the response and recovery stages by concentrating on a particular event, such as the flood of 2015. Future local and international catastrophe preparedness and management plans may benefit from these findings. A study on the flood scenario for 2023 would seek to provide practical recommendations for improving strategic management practices in urban catastrophe management through particular strategies and policies, in contrast to some studies that would mainly concentrate on theoretical frameworks or historical analyses (Comfort 2007; Rathore and Kumar 2019). A study on the flood scenario in 2023 would be specifically tailored to the unique characteristics and challenges of the affected urban area, including nuances of local governance, socio-economic disparities, infrastructure vulnerabilities, and cultural factors that influence disaster management practices and outcomes. Considering the complexity of urban catastrophe management, the study would emphasize the importance of multi-stakeholder participation and collaboration. This collaborative approach gives the submitted ideas more ownership and significance (Norris *et al.*, 2008). The study would highlight the need for continual learning and modification in disaster management protocols, drawing on the flood of 2023 (Faulkner 2001). Some difficulties could surface when considering urban catastrophe management from a strategic management standpoint, especially in light of the projected floods in 2023. It can be difficult to find precise and thorough

information about the flood of 2023, including its causes, effects, and countermeasures. The lack of data could make it more difficult to create strategic management strategies that work (Yuan and Liu 2018). Effective and efficient resource allocation is essential to disaster management. But in the wake of the 2023 flood, scarce resources combined with conflicting agendas could cause problems when allocating resources (Simonoff *et al.*, 2011). Collaboration between numerous authorities and stakeholders is frequently necessary for effective disaster management (Comfort and Wukich 2013). Studying urban disaster management from a strategic management perspective in the context of the projected floods in 2023 may present challenges in many phases, ranging from pre-disaster planning to post-disaster rehabilitation. As decision-makers balance conflicting demands for scarce resources during the response phase, resource allocation issues may surface. The best use of resources to meet the urgent needs of impacted people may be hampered by disagreements over priorities, political issues, or bureaucratic inefficiencies (Simonoff *et al.*, 2011). Throughout the disaster management process, including the response phase, coordination issues between various agencies and stakeholders may occur. Problems can continue during the lengthy phase of rehabilitation and reconstruction while communities work to rebuild and re-establish their means of subsistence in the wake of the 2023 flood. Proactive approaches, including thorough risk assessment, capacity-building programs, stakeholder involvement, and institutional reforms, are needed to address these issues and improve the efficacy of strategic management in urban catastrophe management (Comfort and Wukich 2013). Some stakeholders participating in disaster planning, response, and recovery operations may be impacted by the challenges associated with researching urban catastrophe management from a strategic management perspective in the context of the 2023 flood scenario. The difficulties in managing urban disasters strategically have an immediate impact on communities that are vulnerable to flooding. Urban disaster management agencies under government jurisdiction that oversee infrastructure, public safety, emergency response, and urban planning may face challenges in their strategic management. Enhancing the resilience of urban regions and improving

strategic management methods in disaster management requires collaborative efforts by governments, emergency responders, communities, Non-Governmental Organizations (NGOs), corporate sector actors, and academia to address these concerns. Numerous tactics and interventions have been used in an attempt to address the difficulties in researching urban catastrophe management from a strategic management perspective, especially in light of the projected floods in 2023. It has been suggested that community involvement techniques that strengthen social capital, empower locals, and encourage collaborative decision-making can improve resilience and encourage sustainable disaster management techniques. Urban catastrophe management difficulties are becoming better understood, and creative solutions are being developed, thanks to investments in research, innovation, and knowledge-sharing networks. Through the implementation of these strategies and actions, stakeholders can strengthen urban areas' resilience to future disasters and collaborate to overcome the difficulties associated with researching urban disaster management from a strategic management perspective (Yuan and Liu 2018). The present study does not address coastal flooding caused by storm surges (Kundzewicz *et al.*, 2014), and the type of flood found to be noted in the Chennai case has indicated the relevance of flash floods. The other factors may be due to geomorphological settings and geomorphic effects along with rainfall extremes that have led to flooding (Kale 2003). In-flow and out-flow limits of sewerage also contribute to flooding, as cited in the research work of Ray *et al.*, (2019). The case study's primary goal was to draw attention to the case while highlighting the key aspects of India's historical flood incidents from 2000 to 2016 and discussing the Chennai incident of 2023. The main and secondary goals were determined and thoroughly examined, using reference frames from a variety of research projects about India's floods. There are lots of studies about flood scenarios in urban and suburban environments, but the meta-analytic approach of attempting to explore the study has not been done by many researchers in previous studies. The importance of the study lies in the meta-analytic way of approaching flood issues from a strategic view rather than mere disaster management alone. Thus, the study aims to direct the learners'

attention toward the strategic management elements that need to be taken into account during disasters and the appropriate steps to take to manage them effectively. In December 2023, this study was carried out at the Kalasalingam Academy of Research and Education in Krishnankoil, Tamil Nadu India.

MATERIALS AND METHODS

India experiences severe floods every year that cause millions of people to be displaced, property destruction, and fatalities. Undertake comprehensive case studies of previous flood incidents in particular Indian locations to comprehend the fundamental reasons, susceptibilities, and reactions. This can point out areas that need improvement and offer insightful information about how well-performing current techniques are. The purpose of this case study is to identify and investigate the primary and secondary objectives for improving India's flood resilience. Improving India's flood resilience primarily aims to lessen the susceptibility of ecosystems, infrastructure, and populations to flooding incidents. The secondary goals are to encompass actions like strengthening infrastructure resilience, advancing nature-based solutions, and developing early warning systems, like i) Increasing community preparedness: bolstering community-based flood preparedness and response mechanisms, such as awareness campaigns, evacuation planning, and capacity building, are among the secondary targets. ii) Sustainable Land Use Planning: Enforcing land-use planning laws to reduce development in regions vulnerable to flooding, protect natural floodplains, and encourage resilient urban planning, iii) Climate Change Adaptation: To address future uncertainties and shifting flood patterns, incorporate climate change adaptation methods into flood control planning and infrastructure development (Bahinipati and Patnaik, 2020), and (iv) Ecosystem Restoration: restoring damaged ecosystems, like wetlands, rivers, and coastal regions, to increase their potential to naturally avert flooding and to promote the general health of the ecosystem.

Insights theory on urban disaster management

Research and practice in urban disaster management resulting from floods are guided by various pertinent ideas and frameworks. These ideas shed light on how social and environmental systems

interact, how disasters unfold, and what influences resilience and vulnerability in urban settings. The idea places a strong emphasis on how social and ecological systems are interrelated, how they have coevolved over time, and how human activity and environmental processes interact to shape catastrophe resilience and vulnerability (Folke *et al.*, 2016). A theory that concentrated on the integration of social and technical components of complex systems, like urban infrastructure and catastrophe management, was developed by Javadinejad *et al.*, (2020). The ability of systems to withstand shocks, adjust to changes, and continue operating is the core subject of resilience theory. Resilience theory highlights the value of developing adaptive capacity, encouraging learning, and improving flexibility in the context of urban catastrophe management to deal with and recover from flood disasters (Manyena 2017). Kong (2022) looked at the idea of how complex systems, such as cities and urban networks, self-organize, adapt, and evolve in response to both internal and external stimuli. These theoretical frameworks offer insights into strategies for fostering sustainable development, boosting adaptive ability, and constructing resilience in flood-prone urban regions, as well as conceptual frameworks for comprehending the intricacies of managing urban disasters caused by floods.

The emerging challenges the urban disaster management

Inadequate risk assessment, a lack of strategic planning, or a lack of funding for disaster mitigation measures can all provide challenges during the preparedness stage. When a crisis strikes suddenly, like the flood of 2023, these problems may make it more difficult to respond effectively. As decision-makers balance conflicting demands for scarce resources during the response phase, resource allocation issues may surface. The best use of resources to meet the urgent needs of impacted people may be hampered by disagreements over priorities, political issues, or bureaucratic inefficiencies (Simonoff *et al.*, 2011). Problems can continue during the lengthy phase of rehabilitation and reconstruction while communities work to rebuild and re-establish their means of subsistence in the wake of the 2023 flood. Difficulties like insufficient financial resources, absence of planning for sustainable development, or strained social relations can impede attempts to strengthen

resilience against future calamities and extend the recovery period (Tierney 2019).

Meta-analytic review and visualization method

The various research studies conducted keeping the floods as the basis and their literary reviews are taken as the data for the case study analysis. Further, with the literary surveys done by previous researchers, the perspectives of analysis such as strategic, urbanization and its outcomes, environmental, governance, and mitigating avenues were focused, and results were drawn suitably. The major analysis envisages a meta-analytic approach to analyze the case of the Chennai floods, which occurred in 2023 in particular. Floods and their occurrences in various parts of India have been debated and elaborated from the perspectives of disaster management and precautionary measures, but the execution of the same has not been examined in previous studies. Hence, this case study analyses the possible impact of execution by the public sector (Amarasinghe et al., 2020), and the responses from the general public and other stakeholders are discussed. The samples included in this study are occurrences in India, as the climatic conditions and other similar or common factors were kept in mind when the study was conducted. The stakeholders should enhance the capacity of resilience, as indicated by Dixit (2003) that the vulnerability of people in risk-prone areas must be addressed by enhancing resilience capacity. During December 2023, Chennai witnessed an extraordinary flood, marked by unprecedented rainfall that surpassed any recorded one over a decade. The consequences were severe, with widespread flooding extending across the city and its surrounding suburbs. The incessant rains pushed rivers, lakes, and reservoirs beyond their capacity, triggering a catastrophic overflow. This flood laid bare the inherent vulnerabilities in Chennai's infrastructure, planning, and disaster preparedness. The city, known for its infrastructure designed to withstand conventional weather patterns, struggled to contend with the overwhelming volume of rainfall. The drainage systems were overwhelmed and unable to cope with the flood, leading to extensive waterlogging and subsequent flooding in various parts of the city. The inadequacies that existed in the infrastructure became glaringly apparent as streets turned into waterways, disrupting normal life and

causing significant property damage. Urban planning, a critical aspect of any city's resilience, faced scrutiny in the wake of the floods. Chennai's rapid urbanization and expansion were often noticed to be accompanied by encroachments on water bodies and inadequate land-use planning, which worsened the impact of the flood. The contribution of unregulated urban growth has led to a reduction in natural water absorption areas, leaving the city more susceptible to flooding during periods of heavy rainfall. Preparedness during disasters is a cornerstone of any city's resilience, which has taken a toll. The anticipation of the unforeseen magnitude of the rainfall revealed gaps in the city's response effect eventually. Though warnings from the meteorological department were given, the sheer intensity and prolonged duration of the rainfall exceeded expectations. At this juncture, there is a need for a disaster preparedness strategy that is more robust and adaptive and could account for extreme weather events beyond historical norms. The result of the flooding brought to light an immediate need for comprehensive measures to address the challenges posed by urbanization, climate change, and the limitations of existing infrastructure. The case study of Bhopal long ago had instances of calling upon solutions under uncontrollable situations as indicated in the work of Sundarmoorthy et al., (2009). The scale of the disaster emphasized the importance of re-evaluating and fortifying the city's resilience through innovative planning, infrastructure development, and proactive urban disaster management strategies. In essence, the unprecedented rainfall and subsequent flooding in Chennai in late 2023 were more than a mere natural disaster; they were indeed a wake-up call, urging a critical re-examination of the city's preparedness and adaptability in the face of increasingly unpredictable climatic conditions. The challenges posed by the deluge catalyzed the rethinking and reshaping of Chennai's landscape, to foster a more resilient and sustainable future.

The scientific reason for the Chennai flood

The 2015 Chennai floods were mostly brought in by a confluence of hydrological, climatic, and urban development variables. The unusually high rainfall in a brief amount of time, which overtaxed the city's water management and drainage systems, caused the floods. The North-East monsoon's effect and the development of a low-pressure system over the Bay

of Bengal were two meteorological elements that affected the amount and duration of the rainfall (IMD, 2015). The amount of rainfall that Chennai had during the 2015 monsoon season was too much for the city's drainage infrastructure to handle. Flooding was made worse by the encroachment of water bodies, inappropriate land use planning, and inadequate maintenance of storm water drains, which impeded water flow and resulted in waterlogging in low-lying regions (George *et al.*, 2022). Climate change is thought to play a role in many locations, including Chennai, when it comes to extreme weather events like flooding and high rainfall, even though it is not directly linked to the floods of 2015. Future rainfall events may become more frequent and intense due to rising temperatures and shifting precipitation patterns (Li *et al.*, 2017). A comprehensive strategy that incorporates water management, urban planning, weather forecasting, and disaster preparedness measures is needed to address the fundamental scientific causes of the 2015 Chennai floods.

Influencing the period and geographical area of flood scenario

The issue of flooding in Chennai is not exclusive to any one particular period or place. Flooding can happen during the monsoon season, which is normally from October to December, but it can also happen outside of this time due to changes in rainfall patterns and the consequences of climate change. However, cyclones, depressions, or localized convective storms can cause extreme rainfall events and flooding outside of the monsoon season (George *et al.*, 2022). Chennai's suburban and rural areas are also impacted by flooding, in addition to the city's metropolitan sections. Flooding occurs in both urban and peri-urban settings due to factors like urban sprawl, the invasion of water bodies, and changes to natural drainage patterns (Kadaverugu *et al.*, 2022). Flooding is further complicated by coastal vulnerability, which puts low-lying coastal areas in danger of flooding during storm surges or cyclones (Li *et al.*, 2017). Acknowledging that flooding in Chennai is not limited to a particular time frame or geographic location allows stakeholders to create comprehensive flood management plans that take into account the various elements that increase the region's susceptibility to flooding.

RESULTS AND DISCUSSION

Communities can lessen the vulnerability of people, property, and infrastructure to flooding disasters by integrating flood control infrastructure, early warning systems, community preparedness, ecosystem restoration, research and innovation, and natural flood management. (Oruonye 2012). Furthermore, it is possible to significantly reduce the vulnerability of people, property, and infrastructure to flooding events by incorporating these strategies into comprehensive flood risk management plans (Nkwunonwo *et al.*, 2020) that are customized to meet the unique needs and characteristics of each community (Bahinipati and Patnaik 2020). This will ultimately improve overall resilience and sustainability.

Urban disaster management methods

Flood-related urban disaster management calls for a diversified strategy that includes a range of techniques and tactics to reduce risks, improve readiness, and foster resilience. Early warning systems offer authorities advance notice of flood events through real-time data, monitoring, and forecasting. This allows authorities to promptly issue alerts and coordinate response operations. To spread alerts to communities at risk, Early Warning Systems (EWS) can comprise hydrological monitoring, weather forecasting, risk assessment, and communication channels (Thielen *et al.*, 2018). Zoning laws and land use planning serve to control urban development in flood-prone areas by reducing exposure to and vulnerability to flood hazards. Restricting construction in high-risk locations, safeguarding natural floodplains, and promoting green infrastructure are some measures to increase flood resilience (Jongman *et al.*, 2015). Infrastructure retrofits and upgrades can make cities more resilient to flooding by strengthening drainage systems, erecting flood barriers, and improving stormwater management infrastructure. Permeable pavements and rain gardens are two examples of green infrastructure options that can reduce flood risk while simultaneously having positive environmental effects (Li *et al.*, 2020). Building local resilience requires involving communities in flood risk awareness, preparation, and response activities. To improve community capacity for emergency response and recovery, techniques include participatory workshops, community-based

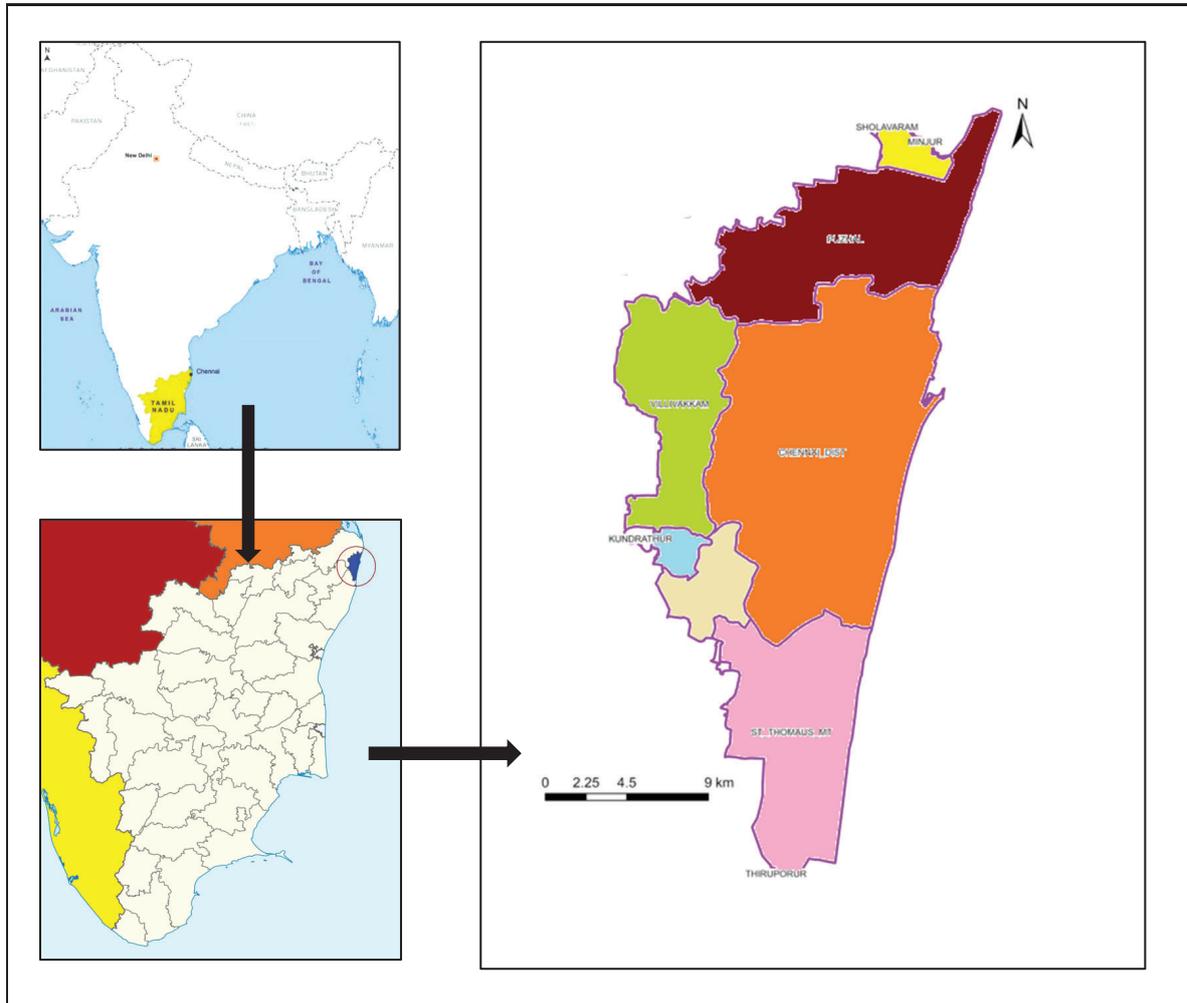


Fig. 1: Geographic location of the study area by INSAT-3D image of Chennai, India

flood risk mapping, and training programs (Koutsovili *et al.*, 2023). Coordination of flood risk management initiatives at the local, regional, and federal levels depends on strong governance structures and policy formulation. Disaster risk reduction can be mainstreamed into urban planning, development, and investment decisions with the aid of integrated approaches that take into account many sectors and stakeholders (Jiang *et al.*, 2018). The increased frequency and severity of floods in urban areas as a result of climate variability and change is the focus of methods for adapting to climate change. These tactics consist of mainstreaming climate issues into urban planning and development processes, ecosystem-based techniques, and resilient infrastructure design (Hallegatte *et al.*, 2020). Urban regions can

better prepare for floods and lessen their effects on infrastructure, people, and the environment by incorporating these techniques into comprehensive flood management plans.

Preparedness and early warning systems

Chennai, being nestled along the Bay of Bengal, has long been accustomed to the seasonal challenges posed by cyclones and heavy rainfall, particularly during the northeast monsoon. This rendering of the geographical positioning of the city is susceptible to the whims of weather, making robust early warning systems imperative for the residents' safety and well-being. However, the floods that unfolded in 2023 brought to light significant deficiencies in these critical urban systems. Fig. 1 indicates the study

area in Chennai during the flood occurrence on December 5, 2023. A synthesis of the various case studies available from the Indian region indicates that often the absolute magnitude of a flood is not as important to the geomorphic effects as the flow stress and competence. Despite Chennai's historical vulnerability to weather-related adversities, the meteorological department, tasked with providing crucial early warnings, found itself grappling with the unprecedented scale of the rainfall (Dixit 2003). The forecasts, although issued, failed to accurately gauge the intensity and prolonged duration of the rainfall that eventually inundated the city. The gap between the predicted and actual weather conditions highlighted a critical flaw in the existing early warning mechanisms. About 80 percent (%) of the total annual rainfall is concentrated during the period, resulting in a very high discharge from rivers, causing extensive damage to life and property. The shortcomings in the forecasting and communication processes were swiftly recognized by authorities, who acknowledged the need for substantial improvements in the city's preparedness for such meteorological events. Amidst the issuance of warnings from the meteorological department, the unexpected severity of the rainfall underscored the urgency of refining the accuracy and reliability of these forecasts. A more sophisticated and adaptive early warning system was the need of the hour to anticipate and communicate the potential risks associated with extreme weather conditions effectively. The focal point for improvement shifted toward enhancing the precision of forecasting models and ensuring the efficient dissemination of timely and comprehensible warnings to vulnerable communities (Henonin *et al.*, 2013).

This involved the incorporation of advanced technologies, such as real-time weather monitoring systems, satellite imagery, and data analytics, to provide more accurate and detailed predictions. Additionally, efforts were directed at improving the communication channels to reach diverse segments of the population, including those in vulnerable areas. The lessons learned from the 2023 floods emphasized the critical role of early warning systems in minimizing the impact of natural disasters. The events prompted a re-evaluation of the existing protocols, the adoption of state-of-the-art technologies, and the development of more effective communication strategies. Chennai's urban journey toward bolstering its early warning

capabilities reflects a commitment to learning from past challenges and implementing measures to better protect its residents from the unpredictable forces of nature. Ultimately, the aim is to transform vulnerabilities into opportunities for improvement, ensuring a more resilient and responsive city in the face of future climatic uncertainties. The mitigation strategies hold importance in an overall manner, and those strategies may be both short-term and long-term. Those short-term measures include sealing off all hydraulic leakage, badly silted-up drains must be cleaned; and the encroachment of retention ponds must be stopped instantly. In the case of long-term measures, build public awareness through non-governmental organizations, undertake awareness campaigns ahead of flood occurrences, land use statutory provisions for all, mandatory floodproofing in buildings, etc.

Response and relief operations

A series of challenges related to the floods in 2023 were unrevealed during the initial response efforts, marked by delays and issues related to coordination among the diverse array of agencies involved. The complexity of the situation, aggravated by the unprecedented rainfall, necessitated a swift and cohesive response, which unfortunately encountered hurdles in the form of disjointed efforts and communication lapses. As the gravity of the situation became more apparent, a collective response gradually took shape. The local government, armed forces, the National Disaster Response Force (NDRF), and volunteer groups stepped forward, coordinating with rescue operations and providing much-needed relief to the affected population. Their combined efforts were crucial in mitigating the immediate impact of the disaster and offering assistance to those stranded in the deluge. However, the scale of the floods proved to be overwhelming, stretching the available resources to their limits. The collaboration among various agencies, though commendable, faced challenges in terms of urban resource allocation, efficient communication, and synchronized efforts. The sheer magnitude of the crisis underscored the necessity for a more streamlined and coordinated approach to manage such large-scale disasters. When looking into the increasing ramifications of such disasters, it has afflicted policy planners, scientists, researchers, academicians, and others

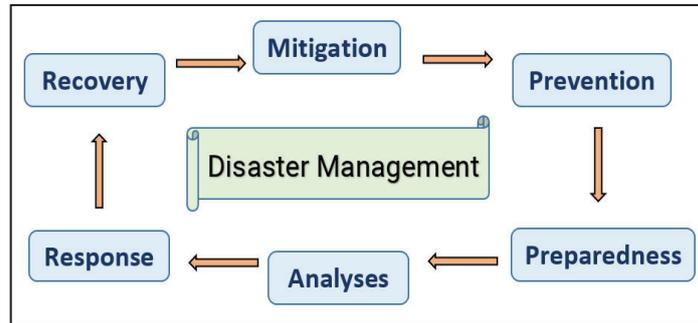


Fig. 2: Tamil Nadu state disaster policy document's disaster management continuum

concerned across the world to find out ways and means to deal with the emerging threats of this typical hydro-meteorological phenomenon (Ranjan 2017). Hence, the need for improved coordination and communication from all sides became evident as the response unfolded. The intricacies of managing a disaster of this scale required not only the commitment of various agencies but also a well-orchestrated collaboration that could efficiently deploy resources, share information, and address the evolving needs of the affected population (Qureshi 2011). This realization prompted a critical examination of the existing frameworks for disaster response.

Policy reforms and institutional strengthening

The comprehensive review of the urban disaster management framework in the aftermath of the Chennai floods reveals a city's commitment to adaptive governance. Recognizing the gaps exposed during the crisis, urban authorities embarked on a proactive journey to refine existing urban policies and formulate new ones. This approach to forward-looking emphasizes the importance of learning from past experiences and ensuring that policies and institutions are better equipped to navigate future disasters. By focusing on clear protocols, efficient coordination mechanisms, and robust governance structures, Chennai is not only addressing immediate concerns but also fortifying its ability to respond to future challenges with agility and effectiveness. Given the particular risks, vulnerabilities, and resources of Tamil Nadu, the state's disaster policy statement would probably include precise tactics, courses of action, and roles for every stage of the disaster management continuum (Fig. 2). To guarantee efficient disaster

management over the whole continuum, these strategies may also address institutional frameworks, collaborations with stakeholders at the state, district, and local levels, and coordination mechanisms (Tajpour and Razavi 2023).

Investment in infrastructure and drainage systems

Strategic investments in urban infrastructure are central to Chennai's goal of building resilience against future flood risks. Upgrading storm water drains, desilting water bodies, and constructing flood-resistant infrastructure are not mere responses to the immediate aftermath of the floods; they represent a commitment to sustainable urban development. Improving drainage systems enhances the city's capacity to manage excess rainfall effectively, preventing waterlogging and flooding. This approach recognizes that infrastructure is about rebuilding and creating a foundation for long-term resilience, aligning growth with environmental considerations. With the high density of population concentration in cities, urban floods are triggered, leading to a significant impact on human life and the economy of the country (Sundaram et al., 2021).

Climate change adaptation

Chennai's recognition of the interconnected challenges arising from climate change and urban development is driving a paradigm shift. The city's commitment to sustainable practices, such as green infrastructure, sustainable land-use planning, and preserving natural water absorption areas, reflects a forward-thinking approach. The lessons learned from the floods catalyze the incorporation of climate considerations into planning and development strategies. This strategic planning not only adapts

Table 1: 24-hour rainfall statistics comparison in Chennai for 2015 and 2023

Station	December 4, 2023 (24 h rainfall)	December 3-5, 2023 (48 h rainfall)	December 1, 2015 (24 h rainfall)
Nungambakkam	24 cm	47 cm	29 cm
Meenambakkam	19 cm	42 cm	35 cm
Tambaram	24 cm	41 cm	49 cm
Chembarambakkam	21 cm	37 cm	47 cm

to the immediate aftermath of the floods but also strategically prepares for a future where climate change could exacerbate the frequency and intensity of extreme weather events. Moreover, the ongoing development strategies must take climate risk into account and address the persistent adaptation deficit (Bahinipati and Patnaik 2020). The concerns about the trends in losses associated with natural disasters in developed countries are magnified when placed in the context of developing nations. Natural hazards result in significant loss of life and serious economic, environmental, and social impacts that greatly retard the development process (Subrahmanyam 1988). The precipitation recorded by the India Meteorological Department (IMD) on December 4, 2023, is presented in Table 1.

From Table 1, it may be observed that less precipitation than on December 1, 2015, based on 24-hour observations. On the other hand, the amount of precipitation was higher on December 3, to 5, 2023, based on 48-hour observations, than on December 1, 2015. The extreme intensity of the rains that battered the city and its suburbs may be seen by looking at IMD’s 48-hour window, which also reveals that the rainfall total exceeded 2015. However, after evaluating the flood damage in Chennai’s urban and suburban areas, it becomes clear that, in contrast to 2023, the flood damage in 2015 was greater because of the Chembarambakkam reservoir’s mishandling on December 1, 2015, when water was unexpectedly released. The Adyar River overflowed due to the massive water release, and this could result in significant flood damage.

Capacity building and training

The post-flood capacity-building initiatives in Chennai showcase a commitment to addressing gaps in disaster response. By placing increased emphasis on training programs for government officials, first

responders, and community volunteers, the city aims to enhance overall preparedness for future calamities. Workshops on disaster management, search and rescue operations, and medical assistance empower individuals and teams with essential skills and knowledge. The grassroots focus on community volunteers not only strengthens local resilience but also contributes to a more coordinated and effective overall response. The commitment to continuous learning and improvement through regular drills and simulations exemplifies an adaptive and resilient response framework (Singh and Kumar 2017). In the case of the National Flood Control Program, which was launched in the country in 1954, since then, sizeable progress has been made in structural and non-structural flood protection measures. A range of experts with crisis and disaster response training may be among the emergency service workers participating in rescue operations. These employees frequently collaborate to offer help and support in times of need. In order to prevent fatalities, reduce injuries, and aid populations impacted by emergencies and disasters, these experts collaborate with public and private groups. Their work is crucial for easing the effects of crises and promoting healing.

Technology integration in urban disaster management

Chennai’s strategic shift towards technology integration in urban disaster management reflects a commitment to innovation. Real-time monitoring systems, satellite imagery, and Geographic Information Systems (GIS) provide decision-makers with timely and accurate information, improving overall decision-making processes during emergencies. The integration of advanced technologies not only enhances situational awareness but also contributes to a more coordinated and collaborative approach among the various agencies involved in disaster response. The post-flood emphasis on staying ahead of evolving climatic conditions showcases

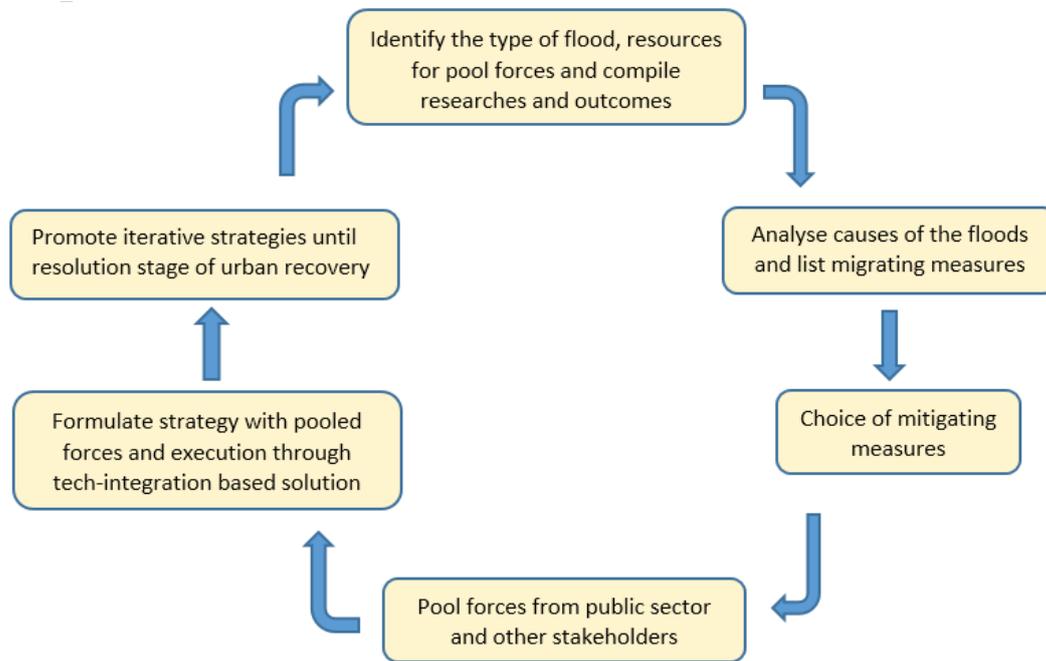


Fig. 3: Proposed strategic management model framework for urban recovery

the transformative power of technology in building a more resilient and adaptive disaster management framework. A study indicated that a machine learning and image processing-based solution is proposed for flood management (Munawar 2020). Hence, based on the framework suggested, machine learning tools or any other appropriate tools suiting the need can be developed to overcome flood-based issues. The floods in Delhi are recorded as a case study by Gosain et al., (2009), where it is mentioned that the city has been experiencing floods of various magnitudes in the past due to floods in the Yamuna and the Najafgarh Drain systems.

Monitoring and evaluation framework

The establishment of a comprehensive monitoring and evaluation framework in Chennai is a significant step towards strengthening urban disaster management (Fig. 3). Regular drills, simulations, and post-disaster assessments contribute to a dynamic and adaptive urban disaster management framework.

By systematically assessing the effectiveness of response mechanisms, authorities gain valuable insights into the overall strengths and weaknesses of their strategies. This evidence-based approach

facilitates informed decision-making, ensuring that the city remains resilient and responsive to evolving risks and challenges. A framework that would resolve such issues should be formulated and executed effectively. Executing aspects such as restoration of existing wetlands, proper planning of urban development, improving preparedness and relief services, and increasing coordination between different provincial and federal departments involved in water management and flood protection are the few steps that can significantly improve the capacity to protect and manage floods in the country (Qureshi 2011).

International collaboration

The international collaboration that emerged in response to the Chennai floods underscores the interconnectedness of global efforts in disaster management. Financial aid, expertise, and technology from various countries and international organizations reflect a shared understanding of the global implications of such disasters. The collaboration goes beyond immediate recovery, contributing to a global dialogue on the importance of preparedness, adaptive strategies, and the role of technology in

mitigating the impact of climate-related events. The support received serves as a testament to the shared responsibility of the global community in addressing the challenges posed by extreme weather events. From an international perspective, similar cases in Pakistan, as elaborated by [Yaqub et al., \(2015\)](#), indicate that flooding is the most overwhelming natural hazard in Pakistan due to diverse ecosystems and occurs mainly due to the heavy monsoon rains throughout the country.

Community education and awareness

Chennai's proactive recognition of the vital role community education plays in disaster management is evident in the initiatives launched post-floods. Educational campaigns, evacuation procedures, emergency contacts, and adherence to building codes form the pillars of urban community engagement. The city aims to empower urban residents with knowledge, establishing a crucial foundation for building resilience at the grassroots level. While elaborating on the strategies to overcome such flood-related issues, attempts were made to efficiently and precisely map villages in the Indian subcontinent during floods via a three-stage approach that uses Polarimetric Synthetic Aperture Radar (PSAR) data. When the deluge occurred in West Bengal (Murshidabad) in 2020, the main aspect to be noted was that the people had lost physical and telephonic contact with the outside world, and food and civil supplies became the first concern of the district administration ([Roy 2000](#)). The people should manage the water resources directly, through gram panchayats, regional panchayats, or, at best, through district panchayats ([Mishra 2001](#)).

Legacy and ongoing urban challenges

Chennai acknowledges its ongoing challenges that require sustained attention despite the significant progress made. The balance between rapid urbanization and sustainable development remains a key challenge, necessitating careful urban planning and strategic initiatives. The same is highlighted as evidence in the study by [Parida and Prasad Das \(2020\)](#), as the results further show that states with better financial development experience higher per capita Gross State Domestic Product (GSDP) growth, supported by additional capital expenditure, enrolment in higher education, better

road infrastructure, and higher urbanization. Ongoing maintenance and upgrading of infrastructure are essential to ensure longevity and resilience, addressing vulnerabilities that could lead to similar disasters. Addressing socioeconomic disparities is integral to building social resilience, and Chennai's commitment to ongoing improvement sets a precedent for other urban cities facing similar challenges ([Sanjeev 2009](#)). The city leverages the legacy of the disaster to shape policies and practices for long-term resilience, emphasizing the importance of an integrated and holistic approach. Thereby, overall flood management policies in general are essential to minimize the adverse impacts of floods on the growth of real per capita Gross Domestic Product (GDP) ([Parida et al., 2021](#)). The study by [Panwar and Sen \(2020\)](#) found floods to have diverse impacts across economic sectors, the extent of which is influenced by the state-wise levels of human development and the underlying intensities of the flooding events. Various reasons, such as heavy rain during monsoon periods, lack of river connectivity, rapid urbanization, and illegal construction in urban areas with inadequate drainage and reservoir systems, are responsible for increasing the risk of exposure to floods in Indian states ([Parida 2020](#)). On the other hand, [Baghel \(2016\)](#) indicated that floods result from the overflow of land areas, temporary backwater effects in sewers and local drainage channels, the creation of unsanitary conditions, the deposition of materials in stream channels during flood recession, the rise of groundwater coincident with increased stream flow, and other problems. In general, it is said to be of great difficulty when it comes to handling the challenges of floods, and due to the loss of the live capacity of reservoirs caused by the entrapping of suspended sediments, flood management faces challenges and in their studies, they have spotted to either manage the flood or, if one is not able to manage, then they have to live with floods ([Ghosh et al., 2023](#)). This study involves research on urban-based flood management to validate the techniques already utilized for managing or handling urban disasters due to flood hazards. Based on real-time data, probabilistic forecasting, and enhanced communication channels, a prior study assessed the effectiveness of the European Flood Awareness System (EFAS) in delivering early flood warnings, to improve flood preparedness and response in urban

areas (Thielen *et al.*, 2018). Koutsovili *et al.*, (2023) investigated the usefulness of integrating local knowledge and viewpoints into flood management plans, as well as the efficacy of participatory mapping in evaluating flood risk at the community level in flood risk assessment and decision-making processes. The usefulness of green infrastructure in lowering the risk of urban flooding by improving infiltration, decreasing runoff, and offering several environmental advantages was investigated by Mei *et al.*, (2018). The integration of environmentally friendly alternatives, such as rain gardens and permeable pavements, into urban planning and development plans is emphasized in this study. Jiang *et al.*, (2021) investigated China's urban flood risk management governance to pinpoint the main obstacles to policy implementation and stakeholder coordination. It also emphasized the necessity of institutional reforms and strengthened governance mechanisms to successfully address urban flood hazards. Guo *et al.*, (2021) assessed the use of emerging technology, nature-based solutions, and conventional engineering techniques to reduce the danger of flooding in metropolitan settings. Li *et al.*, (2022) revealed, in a manner comparable to our work, the impact of climate change on flood risk assessments and prospects for enhancing the precision and dependability of risk assessments through sophisticated modeling approaches and scenario analysis. A few of the studies managed urban disasters caused by flooding by using modern technologies. Wang and Xie (2018) examined the use of remote sensing methods for mapping urban floods and determining the danger of flooding in urban areas. Prashar *et al.*, (2023) evaluated the multifaceted character of urban resilience, taking into account its institutional, social, economic, and physical aspects and the study also looked at a variety of metrics and indicators that are used to evaluate urban flood resilience and guide decision-making. Similar to Wang and Xie (2018), Liu and Ma (2022) looked at how Artificial Intelligence (AI) and Geographic Information Systems (GIS) could be used to control urban floods by anticipating flood hazards, analyzing spatial data, and enhancing decision-making. These recent studies, which cover areas like the integration of AI and GIS, flood control systems, climate change adaptation, remote sensing applications, and urban flood resilience assessment, offer insightful information about current research

findings and trends in urban disaster management due to floods.

Recommendations

The case study suggested the following flood control actions based on its findings:

1. Combining structural and non-structural solutions lowers the danger of flooding.
2. Zoning laws, building rules, and floodplain mapping are used in the implementation of land-use planning regulations to identify high-risk zones and prohibit construction in areas susceptible to flooding.
3. To manage water flow and lessen the effects of floods, physical structures like levees, flood barriers, dams, and reservoirs are built and maintained.
4. Creating and putting into place reliable early warning systems that anticipate floods and promptly notify populations in danger using cutting-edge technology.
5. Providing training on flood response and evacuating techniques, informing communities about the hazards of flooding, and encouraging the creation of community-based flood management plans.
6. Incorporating adaptation strategies into infrastructure design and planning, as well as taking into account the possible effects of climate change on flood hazards.
7. Rehabilitating damaged ecosystems, like wetlands, rivers, and coastal regions, to improve their innate capacity to absorb and store water and reduce flooding.
8. Putting money into research and development to increase resilience to extreme weather occurrences, create innovative solutions for reducing flood risk, and better understand flood dynamics.
9. Increasing readiness and lowering the chance of disaster, invest in early warning systems and emergency response infrastructure.
10. Reducing exposure to flood dangers, enhancing the enforcement of land-use rules, and providing incentives for sustainable development practices.
11. Ensuring long-term viability, incorporating climate resilience concerns into infrastructure planning and design.
12. Giving conservation and restoration of ecosystems top priority to improve natural flood mitigation and support biodiversity conservation.

Limitations of the study

1. Historical data and scenario planning are frequently used in strategic management approaches to predict and get ready for disasters. However, special or unanticipated difficulties that were not taken into consideration in earlier risk assessments or strategic plans might arise in the event of a flood in 2023.

2. Complex socio-economic, political, and environmental variables define urban areas (Torres *et al.*, 2021).

3. The interconnectedness of these systems may be difficult for strategic management approaches to fully grasp and handle, which could leave gaps or oversights in disaster management plans.

4. This uncertainty and risk ambiguity may be difficult for strategic management viewpoints to take into account, which could result in less-than-ideal decision-making and response plans.

5. Coordination and cooperation between many stakeholders, such as local communities, non-governmental organizations, and government agencies, are necessary for effective disaster management (Arabiun *et al.*, 2024).

6. The application of integrated strategic management methodologies, however, may be hampered by institutional fragmentation, competing priorities, and governance issues.

Future scope of this study

Future research on a strategic management approach to managing urban disasters caused by flooding can help in creating an urban population that is more sustainable, adaptable, and resilient to flood hazards.

1. The incorporation of cutting-edge technologies like artificial intelligence, machine learning, remote sensing, and GIS into strategic management frameworks for urban disaster management can be the subject of future research.

2. Research in the future can concentrate on creating frameworks for adaptive risk assessment that take complexity, ambiguity, and changing urban dynamics into consideration.

3. Future studies can look into community-based adaptation strategies, participatory approaches, and citizen science initiatives that improve social cohesion, give people more authority, and make communities more resilient to flooding.

4. New governance frameworks and public-private partnerships that support coordinated action, resource sharing, and knowledge exchange can be the subject of future research.

5. Nature-based remedies, climate-resilient infrastructure design, and policy interventions that improve urban resilience to climate-related risks can all be explored in future research.

6. Research in the future can concentrate on institutional reforms, policy analysis, and capacity-building programs that support institutional resilience, policy coherence, and adaptive governance in the face of urban floods.

7. Future research can help academia, government, business, and civil society work together to co-create knowledge, co-produce solutions, and promote learning at all levels and in various sectors.

CONCLUSION

Numerous studies have been conducted on flood scenarios in urban and suburban environments, but few researchers have attempted to analyze the study using a meta-analytic approach in earlier studies. The meta-analytic approach to the flood challenges from a strategic standpoint, rather than only focusing on disaster management, is what makes the study so important. To assure readiness in a forward-thinking manner, the study aims to analyze all flood events, address the problem from strategic perspectives, and offer technical treatments. The technical intervention that the study recommends supports the scientific approach to solving the problem of evolving the involvement of all stakeholders in disaster management, particularly in metropolitan regions that are critical to the development of the country. Besides pointing out the gaps in previous research on flood incidents and appropriate solutions, the findings of this study also provide support. This case study aims to determine and explore the main and secondary goals for enhancing India's flood resilience. Reducing ecological, infrastructure, and population sensitivity to flooding events is the main goal of increasing India's flood resilience. The initiatives that fall under the category of secondary goals include establishing early warning systems, enhancing the resilience of infrastructure, and improving nature-based solutions. Undertake comprehensive case studies of previous flood incidents in particular Indian locations to comprehend the fundamental reasons,

susceptibilities, and reactions. This can provide useful information about how well-performing current tactics are as well as highlight areas that need development. The case study of the Chennai floods in 2023 provides a comprehensive and integrated model for urban disaster management. Chennai's response exemplifies a commitment to learning, adapting, and building a more resilient and disaster-ready urban environment. Calibration of the flood model is somewhat of a procedure to address the challenges of uncertainty. The city's journey serves as a blueprint for other regions facing similar vulnerabilities, highlighting the importance of proactive policies, sustainable infrastructure, community engagement, and global collaboration. Chennai's commitment to ongoing improvement, evidenced by its acknowledgment of ongoing challenges and proactive strategies to address them, stands as a testament to the transformative power of resilience in the face of adversity. Population increases result in more urbanization, more impervious areas, less infiltration, and greater flood peaks and runoff. The case intends to assess the efficacy of Chennai's pre-flood planning and disaster preparedness measures, focusing on the implementation of principles such as forecasting, scenario planning, and resource allocation. Given the post-flood assessment, one can be in a position to evaluate the assessments conducted to identify the vulnerabilities on the one hand and determine their impact on the other. This also ensures informing future planning efforts and assessing whether Chennai is in a position to embrace the principle of continuous improvement and learn from its experiences. The emergency response does not end with the event but continues through the clean-up and resettlement stages. People will want to know what assistance will be made available, who is responsible, and how to go about seeking that assistance. Public sector authorities should develop clearly defined response policies and programs in advance. Over the years, Chennai has continued to evolve and implement lessons learned. It serves as an inspiration for urban cities worldwide seeking to build a brighter and more resilient future. Using scenario-based technologies to improve emergency response and management plans for flood disasters is one of the study's main conclusions. The study emphasizes the significance of using scenario-based technology to overcome the difficulties associated with flood catastrophes and

enhance the efficacy of urban disaster management by offering a structured framework for decision-making and response planning in the face of flood disasters. The research findings are made more urgent and useful by this temporal component since it can have a direct impact on current and future crisis management plans. Analyzing the strategic planning, coordination, and execution of organizations, governments, and other stakeholders' responses to disasters is a key component in approaching urban catastrophe management from a strategic management perspective. Thus, this case study provides a framework for understanding and addressing the complex challenges associated with floods in India, leveraging insights from diverse research projects and reference frames to inform policy and decision-making. By prioritizing the main and secondary goals outlined in this case study and implementing recommended strategies, India can enhance its resilience to floods, protect vulnerable communities, and build a more sustainable and resilient future. The study can pinpoint specific lessons learned, difficulties encountered, and best practices used during the response and recovery stages by concentrating on a particular event, such as the flood of 2023. Future local and international catastrophe preparedness and management plans may benefit from these findings.

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AUTHOR CONTRIBUTIONS

R. Thirumurgan contributed the main content in terms of the introduction of the case study and the objectives. S. Kundhavai conducted the literature review and analysis. D. Sivakumar contributed critical thought to make the manuscript technically sound and also helped in drawing the results and interpretation of the meta-analytic review. S.B. Inayath Ahamed compiled the content, completed some of the manuscript writing, and added his contribution in terms of recent literature reviews that

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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

ABBREVIATIONS	DEFINITION
%	Percent
AI	Artificial Intelligence
cm	Centimetre

EWS	Early Warning Systems
GDP	Gross Domestic Product
GIS	Geographic Information Systems
GSDP	Gross State Domestic Product
H	Hour
IMD	India Meteorological Department
INSAT-3D	Indian National Satellite System – three-dimension
NDRF	National Disaster Response Force
NGOs	Non-Government Organizations
PSAR	Polarimetric Synthetic Aperture Radar

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REVIEW PAPER

Islamic leadership: Bibliometric analysis of global research using VOSviewer

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ABSTRACT

This study aims to analyze the structure of growing publications on Islamic leadership and its contribution to organizational effectiveness and long-term success using bibliometric analysis with VOSviewer. The sample population comprised all publications of the Scopus database from 2010 to 2023. In addition, a total of 244 publications were selected for bibliometric analysis and visualization, including original study articles, book chapters, reviews, conference papers, and other forms of literature written in English. The results showed the presence of three clusters, namely red (Indonesia, Malaysia, Egypt, and United Arab Emirates), green (United States, Iraq, Syrian Arab Republic, and Turkey), and blue (Iran, Israel, and China). These clusters represented regional cooperation in the exploration of Islamic leadership publications and their implications for organizational development. The results also showed that Islamic leadership was most commonly applied in education, psychology, community and health care, school, and government sectors. In addition, it was shown to be frequently related to trust, job performance, motivation, decision-making, job satisfaction, and empowerment. Islamic leadership placed great emphasis on motivation and job performance, as it ultimately recognized the importance of productive and purposeful work in employees' lives and society's overall well-being. Based on these results, Islamic leadership supported employees in achieving healthy work-life integration by encouraging time for family, worship of Allah (the God), and personal well-being.

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INTRODUCTION

In recent decades, there has been a significant resurgence of Islamic faith and religious observance among Muslims worldwide. This has led to increased demand for Islamic leaders who can guide and provide spiritual guidance to their communities (Egel and Fry, 2017). According to previous studies, Islamic leadership has evolved over different historical periods, from the time of Prophet Muhammad (peace be upon him) (Anthony, 2020; Armstrong, 2023; Udin and Dananjoyo, 2023) to various caliphates, empires, and contemporary societies. In addition, Islamic scholars, imams, and religious leaders have gained prominence as influencers and voices of authority within their respective communities. This prominence is primarily due to the occurrence of several ethical scandals associated with leaders, which vary greatly in nature and severity (Ciulla, 2020; Moore *et al.*, 2019; Said *et al.*, 2018). Examples of scandals include financial mismanagement, misuse of authority, embezzlement, fraud, and other forms of unethical behavior. These actions are condemned within Islamic teachings and are considered violations of the trust and responsibility placed upon leaders. Although several studies have previously offered certain leadership styles, such as transformational, ethical, authentic, servant, relational (Alvesson and Kärreman, 2016; Hoch *et al.*, 2018; Knights and O’Leary, 2005; Tumasjan *et al.*, 2011), vertical (i.e., aversive, directive, transactional and empowering leadership) (Pearce and Sims, 2002), spiritual (Akbar *et al.*, 2018; Blackaby and Blackaby, 2011; Ferguson and Milliman, 2008; Lawrenz, 2016; Maryati *et al.*, 2019; Oh and Wang, 2020), digital (Arabiun *et al.*, 2024), and global (Fry and Egel, 2021; Jones and Millar, 2010; Mendenhall *et al.*, 2017; Stahl *et al.*, 2016; Wijayanto *et al.*, 2021) to overcome ethical scandals in business and organizational failures, the outcomes have not met expectations. In line with previous reports, several Muslim-majority countries typically experience political instability, authoritarian regimes, or governance issues due to various factors. These include weak leadership, which can undermine trust in governmental or religious authorities and contribute to perceptions of a lack of effectiveness (Abbasi *et al.*, 2010; Pasha, 2011). Consequently, Islamic leadership principles can be applied to modern organizations to solve problems (Egel and Fry, 2017; Slamet *et al.*, 2020), regardless of their religious affiliation. Islamic

leadership also emphasizes high moral standards, honesty, and integrity to create a collaborative and inclusive work environment. Several studies have shown that it encourages balance and moderation in all aspects of life, including work. In this context, leaders are expected to promote a healthy work-life balance, ensure employees’ well-being, and create a nurturing work environment to enhance productivity within organizations. Despite the importance of the concept, there are limited reports focused on Islamic leadership. Therefore, this study aims to provide a comprehensive map of Islamic leadership literature and its correlated outcomes using a Bibliometric review with VOSviewer. The results are expected to provide insights into the contribution of Islamic leadership to organizational effectiveness and long-term success.

Review of literature Islamic Society

Islamic Society refers to a social structure and community guided by the principles and values of Islam, which is a religion founded by Prophet Muhammad (peace be upon him) in the 7th century. In addition, it is characterized by adherence to Islamic teachings, which comprise various aspects of life, including spirituality, social interactions, economic, political, and personal matters (Beekun, 2012; Laluddin, 2014; Soki *et al.*, 2019). These also include a strong emphasis on monotheism (i.e., belief in the oneness of God), the Quran (i.e., the holy book of Islam), and the Hadith (i.e., the recorded actions and sayings of Prophet Muhammad) (Ali, 2010; ElKaleh and Samier, 2013; Zarpeyma and Bouzarinejad, 2022). The Quran and the authentic Hadith serve as the primary sources of guidance in Islamic Society to provide the moral and ethical framework (such as justice, honesty, humility, integrity, patience, compassion, gratitude, and empathy towards others) for Muslims, and shape their behavior and interactions with others within the community (Metcalf and Mimouni, 2011; Metcalf, 2013). Muslims are also expected to follow the Five Pillars of Islam (Husti and Mahyarni, 2019; Tittensor *et al.*, 2018) as a fundamental religious obligation to guide their lives. The Five Pillars include the declaration of faith that there is no god but Allah and Muhammad is His messenger (Shahada), the ritual prayers performed five times a day (Salat), fasting during the holy month

of Ramadan (Sawm), giving to charity for helping those in need (Zakat), and the annual pilgrimage to the holy city of Mecca in Saudi Arabia (Hajj). Muslims are further expected to conduct themselves in a manner that is consistent with these values (Haron *et al.*, 2020; Nuruddin *et al.*, 2022; Rane *et al.*, 2020) to maintain a strong connection with Allah, build a sense of community, and instill mindfulness in life. Several studies have also shown that Islamic Society emphasizes the importance of charity and helping those in need. Voluntary charitable acts, known as Sadaqah, are encouraged to seek the pleasure of Allah and to support the less fortunate members of society. In addition, it is important to note that Islamic societies can vary widely in their interpretation and application of Islamic principles and practices, and regional influences often play a role in shaping the social fabric. This social structure typically exists in diverse regions around the world, ranging from predominantly Muslim countries with a legal system based on Sharia to multicultural communities with Muslim populations adhering to Islamic principles within the framework of secular laws.

Leadership in Islamic Society

Leadership is the ability to see beyond assumed boundaries and devise solutions that only a few individuals can visualize (Bayat, 2005; Daniëls *et al.*, 2019; Hay and Hodgkinson, 2006; Hunt and Fedynich, 2019; Rafiki, 2020; Kolzow, 2014). In the context of Islamic Society, it is an important aspect guided by principles and teachings derived from the religion of Islam (i.e., the Quran, the Hadith, and the scholarly interpretations of Islamic scholars) (Ahmad and Fontaine, 2012). In addition, the Prophet Muhammad is considered the ultimate example of leadership in Islam, and his qualities and teachings guide Muslim leaders in their roles and responsibilities. Islam places great emphasis on leadership and provides guidance on how leaders should behave, make decisions, and interact with followers. Islamic leadership is also believed to derive its authority from Allah (almighty God). Leaders are often seen as representatives of God on Earth and are entrusted with the responsibility of serving and guiding the community. Muslims believe that the almighty God chooses leaders who must strive to govern and lead in line with Islamic principles. Islamic leadership has been reported to emphasize justice and fairness in all aspects of

governance by avoiding oppression, corruption, and favoritism. Several studies have also shown that it promotes high moral and ethical standards (Kessi *et al.*, 2022; Galanou and Farrag, 2015; Muali *et al.*, 2021). Leaders are expected to exhibit honesty, integrity, and trustworthiness in their personal and professional lives (Gümüşay, 2019), as well as adhere to Islamic values and teachings, setting an example for the community through conduct. Islamic leadership further emphasizes compassion, kindness, and mercy towards others. Leaders show empathy and care for the needs and concerns of the people being led. This compassionate approach helps build strong bonds with their followers. This concept also further emphasizes the principle of serving others, with leaders being expected to be humble, selfless, and dedicated to the well-being of followers. There is also a need to prioritize the needs of the community and work towards their betterment. Moreover, Islamic leadership encourages consultation and collective decision-making. The principle of Shura promotes the engagement of the community in decision-making processes (Al-Raysuni, 2011; Mohiuddin, 2016). Leaders seek counsel from experts and consult with the people being governed, considering their opinions and feedback. Finally, Islamic leadership encourages the acquisition of knowledge and wisdom. Leaders are well-informed, seek knowledge (particularly religious knowledge), and make informed decisions based on sound judgment. By incorporating these principles into business practices, these individuals align organizations with Islamic values and contribute to the overall sustainability of their businesses and communities.

The Great Man Theory (GMT) of leadership

The GMT of leadership, also known as the Trait theory, suggests that great leaders are born with innate qualities or traits that facilitate their effectiveness (Ciulla, 2020; Hoskin, 2023; Turner and Tsang, 2023). According to the GMT, individuals possess certain inherent characteristics predisposing them to become great leaders (Bans-Akutey, 2021; Northouse, 2014; Peters, 2023), and not primarily a result of acquired skills or learning. The GMT, historically, originated in the 19th century and was based on the belief that leadership is primarily determined by personal attributes, such as intelligence, charisma, assertiveness, confidence,

courage, determination, and other qualities (Ayman and Lauritsen, 2018; Bass, 2019; Northouse, 2021). Leaders further possess these inherent qualities and notions that differentiate them from others (Sinek, 2011) and are believed to be naturally present as well as challenging to develop. In addition, it implies that great leaders are rare and only a few individuals possess the necessary traits to lead effectively. The GMT emphasizes the importance of individual leaders rather than considering broader environmental or situational factors that can influence leadership effectiveness. Consequently, it has been criticized for several reasons and perspectives, including (1) the GMT overlooks the potential for leadership development through education and training. It assumes that extraordinary leadership qualities are fixed and cannot be cultivated (Buchanan, 2020), (2) the GMT tends to focus on male leaders and their perceived innate qualities (Debnath and Mishra, 2017; Garikipati and Kambhampati, 2021), thereby neglecting the contributions of women to be effective leaders, and (3) the GMT only focuses on individual traits as the sole determinant of leadership effectiveness and ignores the influence of situational factors. The substantial empirical evidence shows that effective leadership is often contingent upon the specific context and challenges faced by the organization (Madanchian et al., 2017; Reiche et al., 2017).

The Situational Theory of Leadership (STL)

The STL, also known as the Contingency Theory of leadership, is a widely recognized leadership model developed by Paul Hersey and Kenneth Blanchard in the late 1960s. The STL suggests that effective leadership is determined by the interaction between leaders' style, the readiness of the followers, and the characteristics of the specific circumstances of leading (Benmira and Agboola, 2021; Thompson and Glasø, 2018). Therefore, leaders need to assess their followers' task requirements, capabilities, and experience and adjust the used approach accordingly (Mendenhall, 2017; Zaccaro et al., 2018). The theory also highlights the importance of flexibility and the ability to match leadership behaviors to the needs of the context to achieve the best outcomes (Bass and Riggio, 2006; Thompson and Glasø, 2015). According to the STL, effective leadership requires matching leadership style to the follower's readiness

level. First, leadership style includes *task-oriented or directive leadership* (i.e., leaders have a strong focus on setting goals, defining tasks, and providing clear instructions to followers by giving specific guidance and monitoring progress), and *relationship-oriented or supportive leadership* (i.e., leaders emphasize building relationships, providing support, and promoting a positive work environment by showing concern for followers' well-being, listening to their needs, and fostering open communication). Second, followers' readiness includes *low readiness* (i.e., followers have low competence to perform tasks independently), *some readiness* (i.e., followers have limited competence but are willing to learn and improve by the direction from the leader), *moderate readiness* (i.e., followers have the necessary competence but may lack the confidence to take full responsibility), and *high readiness* (i.e., followers have high competence and confidence in performing best outcomes). In addition, there are four main leadership styles according to the STL: (1) directing or telling: in situations where the task is highly structured and followers have low readiness, leaders are expected to provide specific instructions and closely supervise their followers; (2) coaching or selling: when the task is still structured but followers have moderate readiness, leaders provide guidance and engage followers in the decision-making process to develop their skills and confidence; (3) delegating or observing: when the task is unstructured and followers have high readiness, leaders delegate authority and responsibility to their followers, allowing them to make decisions and take ownership of their work; and (4) supporting or participating: in situations where the task is less structured but followers have a high level of readiness, leaders encourage participation, listen to the ideas and suggestions of followers, and provide support and resources as needed.

METHODOLOGY

This study presented a Bibliometric analysis of the literature on Islamic leadership using the VOSviewer software. The global studies and literature on Islamic leadership published between 2010 to 2023 were accessed in the Scopus database. In addition, "Leadership" and "Islam" were used as keywords in the title to find publications that matched the closest to fulfilling the criteria. A total of 1,134 documents

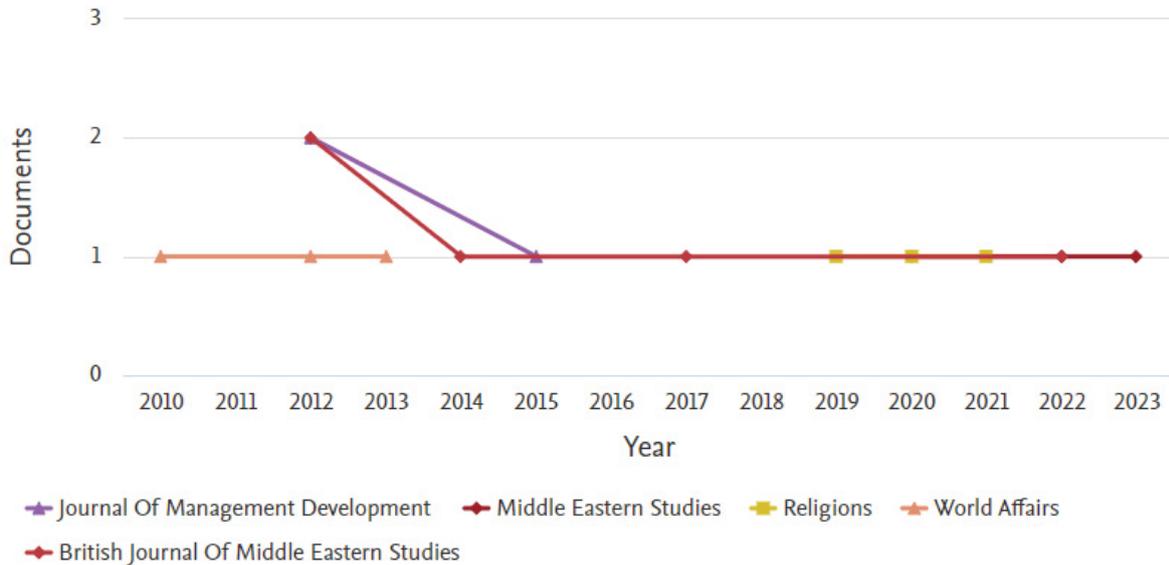


Fig. 1: Documents per year by source in the Scopus database (2010–2023)

on the topic of Islamic leadership were found in the Scopus database between 2010 and 2023, including 761 (67.1%) original study articles, 271 (23.9%) books and book chapters, 55 (4.9%) review articles, 30 (2.7%) conference papers, and 17 (1.5%) other forms of publications, such as editorials and notes. Almost all the publications (1,076, 94.9%) were written in English, followed by 23 (2.1%) Russian publications, 1,106 (93.5%) papers were final versions of publications, and 28 (2.5%) were articles in the press. After limiting to the final keywords “Leadership” and “Islam”, 244 documents were identified for further analysis. Among 244 documents, 222 (90.9%) were published in journal versions, 16 (6.6%) in the form of books, 5 (2.1%) in book series, and 1 paper in a conference proceeding. This study further used VOSviewer software for analyzing the final collected data. VOSviewer was a versatile tool for directly visualizing and analyzing Bibliometric networks (Bukar *et al.*, 2023; Ding and Yang, 2022; Oyewola and Dada, 2022; Xie *et al.*, 2020; Yu *et al.*, 2020). In addition, it acknowledged and allowed researchers to explore scientific literature databases, create visual representations of bibliographic data, and identify patterns as well as relationships among publications, authors, and keywords (Huang *et al.*, 2022; Markscheffel and Schröter, 2021; Sood *et al.*, 2021). VOSviewer could also be used to conduct

various types of analyses, such as co-authorship, co-citation, and keyword analysis (Jacobsen *et al.*, 2022; McAllister *et al.*, 2022); van Eck and Waltman, 2010; Zhang *et al.*, 2024).

RESULTS AND DISCUSSION

VOSviewer was used to address the study objectives, with the discussions and implications summarising the mapping of bibliographic data via VOSviewer.

Fig. 1 shows the top 5 journals in the sample that frequently published articles on Islamic leadership across different domains. *British Journal of Middle Eastern Studies* from a reputable publisher (i.e., Taylor & Francis) had published 5 (2.05%) articles, followed by *the Journal of Management Development* from Emerald Publishing (3, 1.23% articles), *Journal of Religion and Health* from Springer Nature (3, 1.23% articles), *World Affairs* from Sage (3, 1.23% articles), and *Religions* from Multidisciplinary Digital Publishing Institute (3, 1.23% articles).

Fig. 2 classified the terms of the three clusters, namely red (i.e., Indonesia, Malaysia, Egypt, and United Arab Emirates), green (i.e., United States, Iraq, Syrian Arab Republic, and Turkey), and blue (i.e., Iran, Israel, and China). These three themes represented the cooperation among regions to focus on the study of Islamic leadership and its associate’s

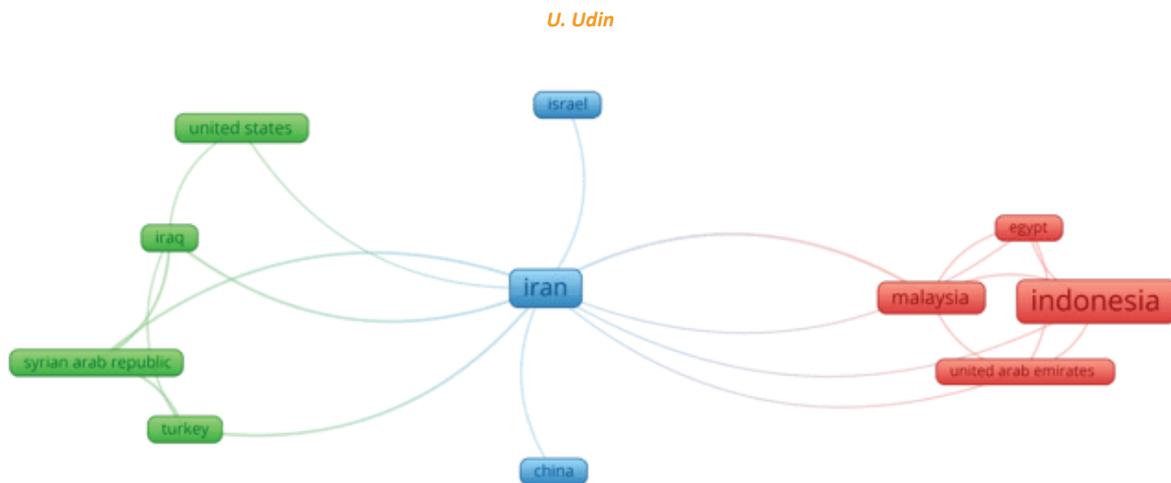


Fig. 2: Cooperation among contributing regions

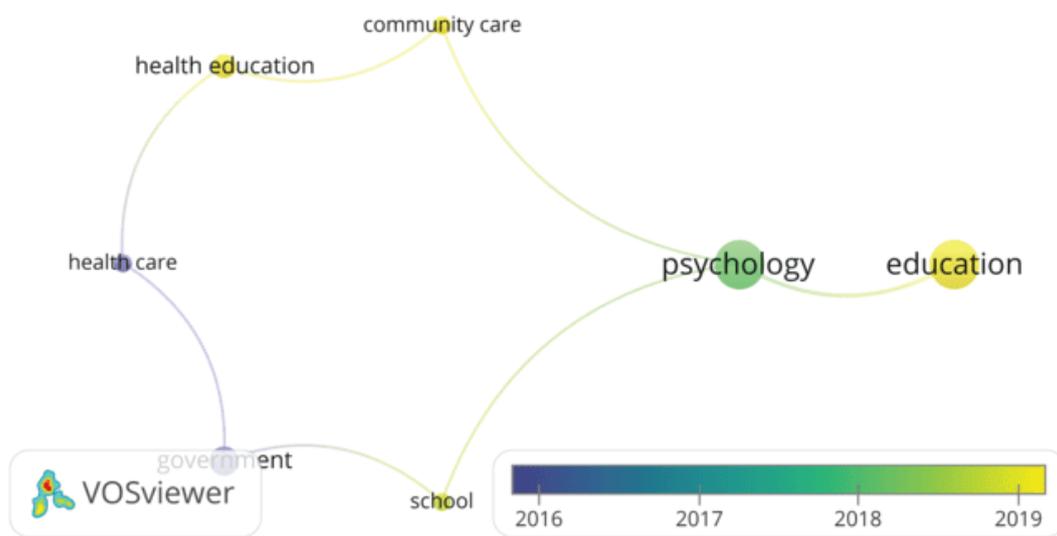


Fig. 3: The main terms are established based on the field

impact on organizational development. In addition, the 5 most prolific authors and co-authorship ultimately contributed to the paper focused on Islamic leadership. These included Purwanto, A. from Pelita Harapan University, Indonesia who generated 7 papers, followed by Mufid, A. with 6 papers from Sekolah Tinggi Agama Islam Khozinatul Ulum Blora – Indonesia, Faris, N. with 3 papers from the University of South Australia, Fahlevi, M. with 3 papers from Bina Nusantara University – Indonesia, and Wekke, I.S. with 2 papers from Sekolah Tinggi Agama Islam Negeri (STAIN) Sorong, Indonesia.

Based on Fig. 3, Islamic leadership was most commonly applied in education, psychology, community and health care, school, and government

sectors. For example, Saudi Arabia was a country that practiced Islamic leadership principles to operate the country’s social interactions and economic, political, and personal matters. Islamic law guided the governance, judiciary, and social policies to support the growth of the country. In addition, the implementation of Islamic leadership in Saudi Arabia reflected a balance between traditional values and modernization efforts.

Fig. 4 shows that Islamic leadership emphasizes trust as a fundamental aspect of leadership in enhancing job performance (Astuti *et al.*, 2020; Hamzah and Basri, 2021). In Islamic teachings, trust was seen as a critical component of any relationship, including the leader-follower relationship to foster a

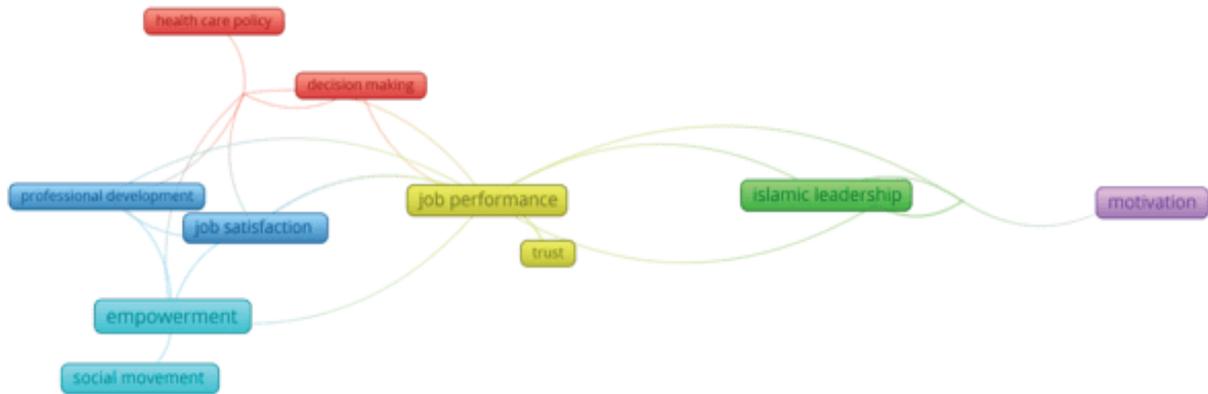


Fig. 4: The term co-occurrence network on Islamic leadership

positive work environment within an organization. Islamic leadership also strongly emphasizes the leader's trustworthiness to show integrity, honesty, and consistency in their actions and decisions. By establishing themselves as trustworthy, these individuals could create an environment where employees feel secure and confident in their intentions, leading to improved job performance. Islamic leadership also encourages leaders to empower their employees and provide the necessary support for enhancing their roles (Meiyani and Putra, 2019; Supriyanto, 2019; Zaim *et al.*, 2024). By empowering employees, leaders showed trust in their abilities to improve job performance as employees were more likely to take ownership of work and strive for excellence. Islamic leaders further upheld high standards of honesty and integrity in business dealings to build trust with stakeholders and contribute to the well-being of the community. Islamic leadership promoted a holistic approach that considered employees' spiritual, ethical, and social aspects (Adawiyah and Pramuka, 2017; Faseruk and Hossain, 2017). In addition, it emphasized the importance of aligning work with a higher purpose and connecting to the service of Allah and the betterment of society. This perspective incorporated a sense of meaning and purpose in employees' work, which could significantly enhance their motivation and engagement to work. Islamic leadership promoted fairness and justice in dealing with employees. Leaders treated their employees with equity, ensuring that rewards, opportunities, and punishments were distributed fairly. When employees perceived fairness and justice in their leader's

actions, trust was established, leading to enhanced job satisfaction, job performance, and organizational success (Tajpour and Razavi, 2023). The concept also emphasizes the importance of recognizing and appreciating workers' efforts and contributions (Ahmad and Ogunsola, 2011; Noermijati *et al.*, 2019; Zaim *et al.*, 2021). Leaders expressed higher levels of gratitude (Ahmad and Fontaine, 2011; Mohammad, 2015) and acknowledged the achievements of their employees (Aini, 2020; Jamil, 2015). This recognition not only boosted self-esteem but also enhanced their motivation and dedication to perform effectively. Moreover, Islamic leadership promotes collaboration and consultation in decision-making processes. Leaders highly engaged their employees in decision-making and sought their input. By engaging employees in the decision-making process, leaders showed respect for their expertise and perspectives. This inclusive approach of leaders enhanced higher levels of employee job satisfaction, leading to high performance.

CONCLUSION

In conclusion, the results showed that Islamic leadership was frequently related to trust, job performance, motivation, decision-making, job satisfaction, and empowerment. Islamic leadership also placed great emphasis on motivation and job performance, as it ultimately recognized the importance of productive and purposeful work in employees' lives and society's overall well-being. In addition, it supported employees in achieving healthy work-life integration by encouraging time for family, worship of Allah (God), and personal well-being. This

approach helped employees maintain motivation, thereby enhancing overall job performance. The practical implications of the study are that Islamic leadership emphasizes ethical conduct and decision-making based on Islamic principles to prioritize the needs of employees and strive to serve. Leaders were humble, empathetic, and compassionate towards employees, seeking to understand their concerns and actively supporting their well-being. This is aimed at fostering a sense of motivation, leading to increased job satisfaction and better performance. This study restricted the data collection and analysis to articles available in the Scopus scientific database, and it was acknowledged as a limitation. Although Scopus has become a comprehensive abstract and citation database covering a wide range of academic disciplines (Baier-Fuentes *et al.*, 2019; Dias *et al.*, 2019; Udin, 2023), it could still have biases in terms of geographical representation. The Scopus scientific database could result in a skewed perspective, particularly when the study topic was region-specific. Therefore, future studies could expand potentially valuable information available in other popular scientific databases to ensure comprehensive coverage of the literature, such as Web of Science, PubMed, JSTOR, IEEE Xplore, and Google Scholar. The addition of other languages, such as Arabic, Bahasa Indonesia, Bengali, or Urdu offers numerous advantages, including access to diverse perspectives, global reach, and policy implications. Embracing multilingualism enriched the study landscape and contributed to a more inclusive, interconnected, and culturally responsive academic community.

AUTHOR CONTRIBUTIONS

U. Udin has performed the writing of the original draft, investigation, methodology, and supervision.

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CONFLICT OF INTEREST

The author declared 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

GMT	Great Man Theory
STL	Situational Theory of Leadership

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