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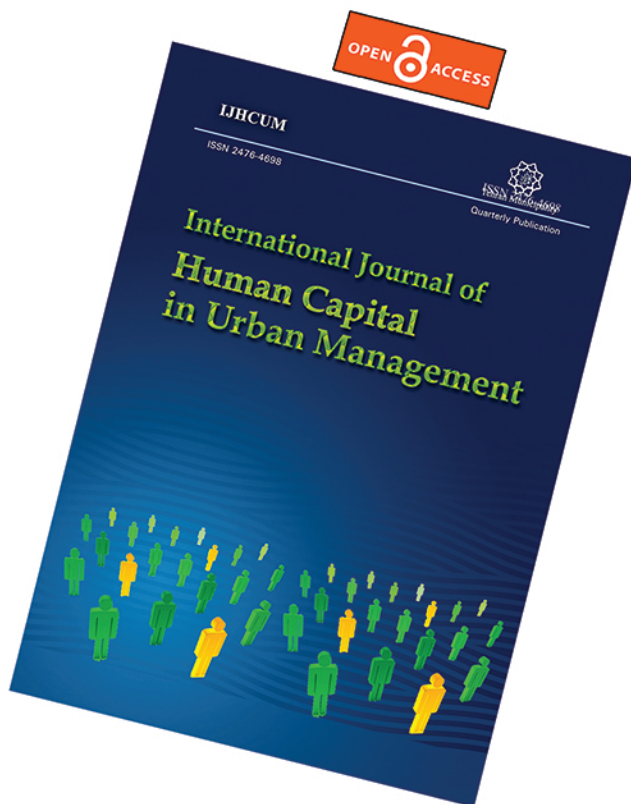
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ORIGINAL RESEARCH PAPER

## Environmental management for urban development around river valleys using a conceptual model

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### ABSTRACT

**BACKGROUND AND OBJECTIVES:** Urban river valleys are so important with regard to their benefits and functions, including air temperate, microclimate creating, landscape, fresh water supplement. Urban development over considering environmental issues, population density, constructions, solid waste or effluent discharging, especially in quantitative and qualitative river boundaries and land taking of their beds, are significant reasons to decline cities functions and ecosystems degradation. So, natural ecosystems should be restored and a thorough strategic planning is necessary for their conservations.

**METHODS:** With regards to managerial aspects involving ecological, spatial, economic, socio-cultural, and managerial- executive dimensions integrated management model has been recommended for Farahzad River Valley in Tehran city as a case study via Urban River Survey and Geographic Information System. Finally, effective and efficient strategically management plan was suggested by implementing SWOT, QSPM and Analytical Hierarchy Process.

**FINDINGS:** Amongst 12 identified strategies regulation settings, "correlation between green space and the surrounding park", and "preventing the increase of residential" and "the expansion of recreation" are prioritized as most significant strategies, scores have been calculated 5.616, 5.589, and 5.375 on QSPM matrix or 0.256, 0.192, and 0.133 by AHP method, respectively.

**CONCLUSION:** in overall, systemically, multi dimensional and holistic decision of river valleys environmental management is a magnificent example that provides essential tools to urban planners. Environmental and ecological approaches of the model are counted as a main key of succession to sustainable development achievement and its advantage to other past studies.

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## INTRODUCTION

Primary civilizations encompassing from Egypt to India and afterward Helens, Romans, Byzantine, Asia Minor, and Islamic cultures had settled along the rivers, which had urbanized numerous progressive nations in which the water is a fundamental portion of their philosophy (simsek, 2012). Rivers are counted as important ecological elements in urbans, have been a vital part in the appearance of civilizations. Not only rivers characterize circumstance for development of settlements but those also affect the imaginative quality of municipal forms and the size of cities. Rivers are known as dynamic systems and have been in interface under altering the constituents of the cities over time (Abshirini and Koch, 2016). The landscape is changing faster than its natural potential urbanization and widespread land use are considered as main agents of the change (Bratley and Ghoneim, 2018). Declining biodiversity, vegetation and habitat indicate urban development, in addition to increasing the global effects of climate change, and a significant impact on the functioning of the land system (Dewan and Yamaguchi, 2009). The world's urban population is growing, so that urban populations almost doubled between 1950 (30%) and 2014 (54%) and it is predicted that by 2050 the world's urban population Reach 66% (Hurlimann and Elizabeth, 2018). River valleys are important elements of natural ecosystems in cities that start from the upstream, pass in the urban area and end to the lowest point of the basin such as wetlands, lakes or seas (Bemanian, 2008). In fact these are the most beautiful elements and valuable natural heritage of the city that play an important role in providing environmental resources to cities and the balance between nature and human (Harvey and Gooseff, 2015). Large amounts of water is transported downstream by urban rivers and feed groundwater reservoirs along the route which have a high function in the dynamics of the morphological process (Ostrowski and Falkowski, 2020). Regardless of the slope along the valley edges, the predominant hydrological flows are maximized throughout the year (MacGregor, 2009). Rivers are rapidly changing in response to changes in the hydrological regime and drainage in the basin (McDonald et al., 2019). In the lowlands, it is more affected by climate and human activity (Ostrowski and Falkowski, 2020). River valleys also have special natural and economic values, and the management of these areas requires to recognize

their natural processes and limitations (Macklin and Lewin, 2015). Economically, river valleys are an important phenomenon for development in the city (Ostrowski and Falkowski, 2020). Urban river valleys create a natural landscape with morphological changes in depth, slope and width; these potentials attract investment in the areas and symbolize sustainable development in the city with environmental, economic and cultural effects as well as biodiversity potential on free spaces (Falkowski et al., 2017). Therefore, protection and restoration of river valleys are essential measures in the sustainable development of cities (Wang et al., 2020). Otherwise, the rehabilitation of the area is complex and requires consideration of all aspects, including environmental, socio-economic, land use for residential, industrial and recreational purposes, flood protection and environmental rehabilitation (Minh Vo et al., 2019). In recent decades, most countries have paid attention to urban river valley management and implemented many successful projects to rehabilitate it (Macklin and Lewin, 2015). According to past experiences, management criteria throughout the river valley depend on ecological characteristics (Harvey and Gooseff, 2015). Also, humans are interested in adjacent nature, so, in the cities, that managers are sensitive to the issue, so are distinguished more successful than others. In fact planners apply environmental management in their decisions and especially consider ecological properties to protect river valleys and design of surrounding lands (Mohammadian et al., 2018). In particular, environmental management is trying to improve ecological and hydrological systems in urban areas, and recently the restoration and protection of rivers is one of the main efforts of urban planning (Bernhardt et al., 2011). Other examples of these efforts are the rehabilitation and upgrading of the Los Angeles River, which is in the form of a canal, and includes 239 (Mohammadian et al., 2018). Green space projects are often carried out to improve the quality of life of residents in urban areas. These programs provide significant opportunities for urban management to benefit from public participation (Bernhardt et al., 2011). In Seoul, South Korea, they opened an 8-kilometer highway under the Chuang Chuan River, which had many environmental, economic, and cultural benefits (Wang et al., 2020). Restoration of riverside areas has been considered as an attractive

phenomenon in pollution reduction, flood management and environmental protection since 1980 (Shafaghat *et al.*, 2019). Regarding previous experiments in Iran and entire the world, such as the Zhangjiangsu Urban River in Jiangsu province of China (Yu *et al.*, 2020), the Singapore River thematic formula (Savage *et al.*, 2004), a Trinity River project in Dallas, Texas, USA (Kurwadkar *et al.*, 2020), restoration of Alangdere Urban River spaces in Gorgan province of Iran (Lotfi and Mousazadeh, 2020), and the Barcelona city restoration project in Spain (Casellas, 2009), have shown environmental, social and economic issues are most important factors in river management and combined methods are more effective and sufficient. In fact, an integrated approach involves a combination of sustainable development approaches in each section with regard to recycling, local conditions, renewable resources, water treatment and recycling, public transport, and land use (Shafaghat *et al.*, 2019). Consideration of ecological issues is important in development for management efficiency (Khandelwal *et al.*, 2017). According to experience in Sperchios River (in Phthiotis in central Greece), the SWOT analysis method (Strengths, Weaknesses, Opportunities and Threats) is known as a useful tool for environmental decision-making and planning, that processes ecological, land use, socio-economic parameters in the river area and then suggests management programs corresponding to sustainable development proposes. Weaknesses should be minimized and threats should be turned into opportunities, and uses strengths and opportunities to optimize performance (Stathopoulos *et al.*, 2013). SWOT has been conducted in south east of Anatolia, Turkey in the field of tourism development around the rivers leading to the Mediterranean Sea and also the surrounding area has been identified by using Geographic Information System (GIS) (Özüpekçe, 2019). The study of Gange River, in India and Bangladesh, has been carried out to analyze and report the river bank erosion hazard, soil stratification of river bank and morphometric parameters on the upstream of Farakka barrage using RS and GIS, in 1955, 1977, 1990, 2001, 2003, and 2005 from LANDSAT and IRS satellite images (Thakur *et al.*, 2012). GIS and RS have been implemented as a sufficient tool for mapping (Boori *et al.*, 2015). Remote sensing considers trends and future directions of river valleys and finally determines

management measures to improve ecosystem conditions (Thakur *et al.*, 2012), for instance, the study of Bug river in Poland determined the improvement of remote sensing is necessary for prevention of rational flood in lowland of river valleys especially on those places with complex geological structures (Ostrowski and Falkowski, 2020). As well as, the experiences of Dhaka River in Bangladesh and urban rivers in Malaysia have been implemented via GIS and RS as a useful tool to determine the land use cover and changes around the rivers and to measure the major factors including traffic, industrialization, and building development (Dewan and Yamaguchi, 2009). As mentioned, in order to analyze and present managerial strategies SWOT method is known as a sufficient method. In most of previous studies, SWOT has been conducted with analytical hierarchy process (AHP) model to demonstrate an urban development framework and sustainable planning. To consider the land uses, flora, and other characters of urban river areas GIS has been used; studies of Delhi in India (Rajput *et al.*, 2021), Trinity River Basin in USA (Kurwadkar *et al.*, 2020), and Sinos River in Brazil (Orteg *et al.*, 2018) are the explicit examples. AHP can contribute for choosing a better option of environmental management (Orteg *et al.*, 2018). Ecological evaluation of Trinity River basin watershed has been done by using hybridized method of AHP-SWOT-GIS; in results, the ranking of scores determines the priority for restoration as main strategy (Kurwadkar *et al.*, 2020). There are many experiments in field of river valleys which have been conducted by combined methods such as GIS-SWOT-AHP model (Wang *et al.*, 2020). The GIS-SWOT-AHP model can hardly assures the urban development strategies and it is flexible method with considering all aspects of urban planning which can be used for integrated urban management and river basin restoration (Rajput *et al.*, 2021). Since socio-cultural, economic, spatial and managerial indices of river basin are not enough indices, ecological or environmental aspects should be considered in an integrated management framework (Scott *et al.*, 2012). The urban water corridors can significantly preserve the declining natural values of the urban ecosystem (Allam and Jones, 2018), consequently, restoration of urban river valleys requires an appropriate planning model which deliberates spatial, socio-cultural, economic, managerial and ecological dimensions (Lotfi

and Mousazadeh, 2020), moreover ecological features and urban development changes, indeed a “revitalization” has different meanings in each area and it depends on all features in combination of together, so ecological indices are important factors in decision making process not formed base on this approach and also responsibilities of authorities are not certain separately (Karimi Moshaver, 2013); the river valleys were seen as deep valleys in the north of Tehran and then are shallow and old in the center of the city, in most sections converted to cement and covered canals (Laghai and Gilani, 2014). In Tehran, there are seven large valley rivers with a north-south trend (Karimi et al., 2018), which are the only remaining natural heritages on the southern slopes of the Alborz mountain ranges, and forms the water sources of old Tehran, also those are the discharge routes of surface water and possible floods (Kamanroudi Kojuri et al., 2020). The functions of river valleys of Tehran are dramatically substituted for sewerage. The urban and environmental management of the valleys should be done according to special principles and criteria (Barghjelveh and Sayad, 2011).

Because of the features such as proximity to the northern mountainous areas of Tehran, water flows, and beautiful landscapes in the urban background (Karimi et al., 2018) these are the best urban recreation areas (Kamanroudi Kojuri et al., 2020). Creating temperate climate, micro-climate, nourishing groundwater resources and supplying fresh water are important functions of urban river valleys (Karimi Moshaver, 2013). Tehran is always facing a shortage of water for drinking, irrigation and other consumptions; therefore addressing this issue in urban management is counted as a key element. Farahzad River Valley, in the north west of Tehran, has undergone a variety of changes related to urban development, in addition the variety, the intensity and speed of change is also more significant than 6 others (Bahrami et al., 2019). It rises 3410 meters height and flows in a narrow and relatively steep catchment with 3100 hectares in area (Forman Asgharzadeh et al., 2016), the flow is 0.23 m<sup>3</sup>/s per year averagely and the mean of sedimentation has been estimated 8 MCM yearly (Samadi et al., 2017). Fig. 1, shows the the study area.

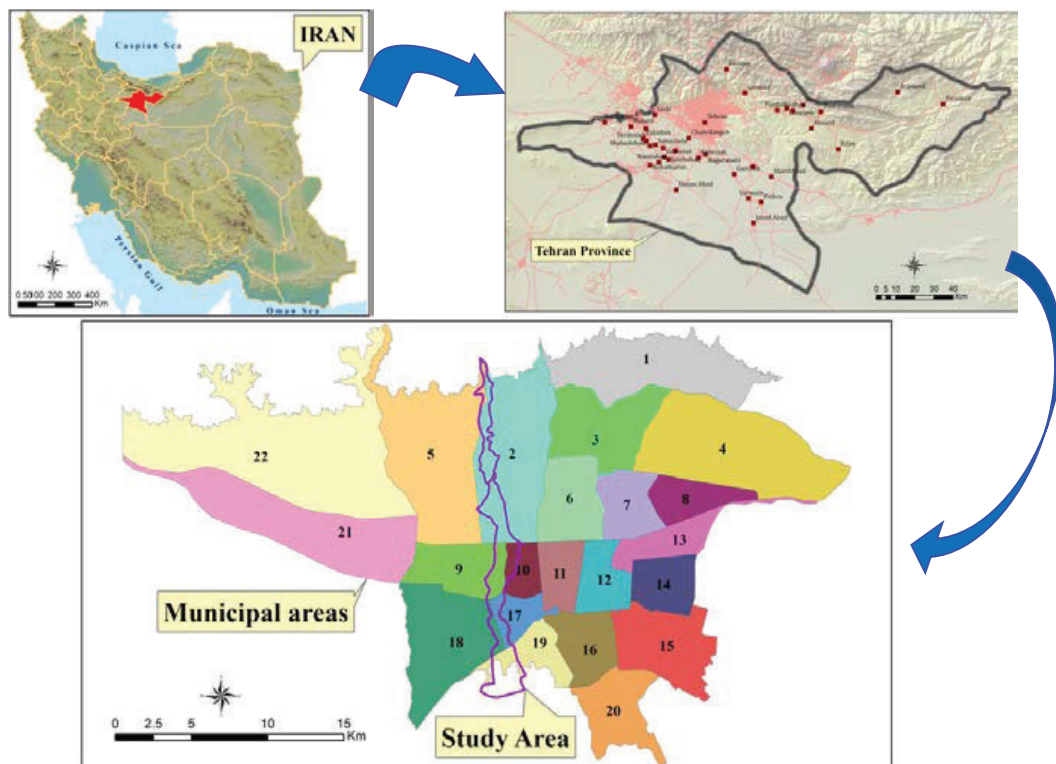


Fig. 1: Geographic location of the study area in Farahzad basin area, Tehran, Iran (Karimi et al., 2018)

Farahzad River Valley had different changes during the recent decades (Bemanian, 2008), that has converted to a sewage canal with a cement bed and its surface covered (Barghjelveh and Sayad, 2011). Taking lands for residential complexes, extending road networks and bridges (Karimi et al., 2018) led to a large scope of high level risks on Farahzad River Valley ecosystem, its structure and functions have affected in long term (Bahrami et al., 2019) as well as its environmental benefits to air, ground water, habitat supporting and biodiversity declined and erosion and sedimentation increased. Therefore, it is necessary to select a comprehensive and integrated management method to improve Farahzad River Valley which considers environmental components in the city. Thus, the study is focused on a single river valley in Tehran which is known as "Farahzad River Valley" and tried by providing a managerial strategies to improve the environmental condition of the area. The current study have been carried out in Tehran in 2018.

**MATERIALS AND METHODS**

Essentially, a very convenient framework has been defined in the conceptual model of study. Thus, every aim of incorporated management in Farahzad River Valley would be cover up on the process. So that the framework includes all categories of integrated management model comprising ecological, spatial, socio-cultural, economic and managerial indices. In order to apply the integrated management model on Farahzad River Valley and its surrounding area, some environmental management methods are used in

combined. In first stage, Urban River Surveying (URS) is used that prepares an exact process to identify all features around the river (Allam and Jones, 2018) as well as can focus on land use planning and economical activities around the river and consider relationships between environmental components and social activities (Yu et al., 2020), so that illustration of these properties GIS is an accurate tool which is used in this study and all of maps has been prepared by Arc-GIS soft ware. GIS can facilitate characterization of field information during time (Boori et al., 2015), so it is used on Farahzad River Valley to show spatial features surrounding river valleys. The required information is entered from Remote Sensing (RS) and satellite monitoring in the earth. All information of land uses and Farahzad basin has been gathered via these tools. Result of this section showed by map drawing. There were three considerable land units including upstream mountain area, middle foothill and downstream land for development management in the catchment, maps drawn by remote sensing and GIS (Ostrowski and Falkowski, 2020). Farahzad River Valley has several changes during the route, that those depend on human activities and land uses (Foman Asgharzadeh et al., 2016). For this purpose, catchment, sub-basin, slope, habitat and signs features have been considered hierarchically (Fig. 2) to identify land uses by using URS and GIS.

For second stage, has gone ahead by using management methods. In order that achievement of problem solutions and information analysis, Multi-Disciplinary Criteria Decision Making (MCDM) methods have been selected. Among of those

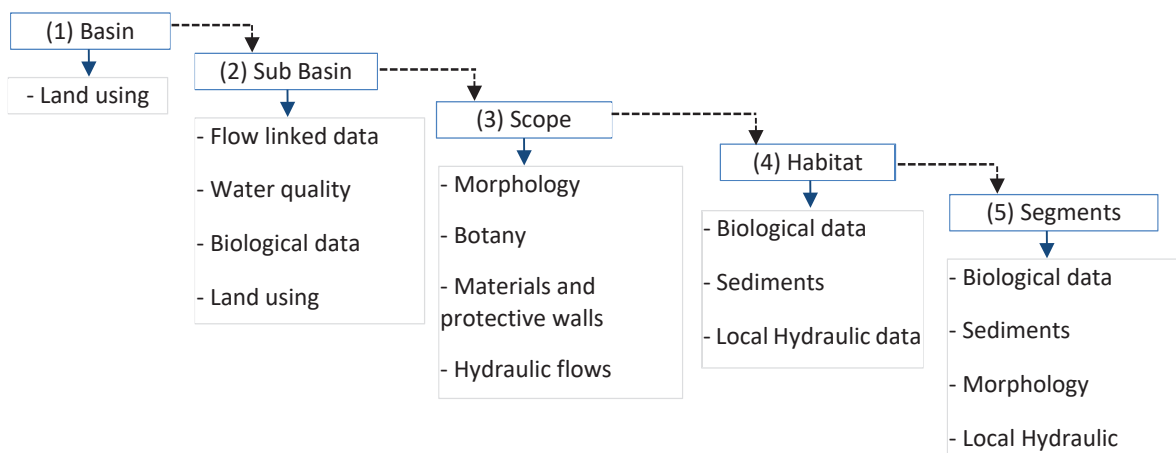


Fig. 2: Spatial hierarchical structure of basin integrated management (Linke et al., 2019)

methods, SWOT analyzing method has been used in combined AHP. The hybridized SWOT-AHP method is an integrated and flexible model which can quantify and prioritize managerial strategies (Purahmad et al., 2013). To perform this section, the strengths and weaknesses (Internal factors) and opportunities and threats (external factors) have been categorized on Internal Factors Evaluation matrix (IFE) and External Factors Evaluation matrix (EFE) respectively. Matrices would be identify dominant condition between internal or external components, it means If the average of weight scores of IFE is greater than 2.5, the environment is generally strong and either in EFE, if the mean of weights is greater than 2.5, opportunities are dominant. Then, in order to find effective and efficient ways to improve the current situation, possible and usable strategies are classified in the SWOT matrix. In fact, SWOT matrix organizes strategies in 4 categories involving aggressive strategies (SO), diversification Strategies (ST), review strategies (WO) and defensive strategies (WT) listed in SWOT matrix. In addition, Quantitative Strategic Planning Matrix (QSPM) is used which can quantify and prioritize strategies (Pazouki et al., 2017). While the SWOT method was done, a set of 21 professional experts have assisted in each step, comprising identification, quantifying and prioritizing of factors and strategies. Specialists have been selected based on their sufficient knowledge and experience in various fields of urban management, river valleys or urban surface water resources and the environment. In third section, in order to verify the scores AHP and Expert Choice (EC) software have been used, to compare pair-wisely; the combination of these methods has been known as AHP-SWOT. Saaty defined the comparison matrix with 1-9 scale, which is summarized in the following comparison matrix and Table 1. Then by using expert choice software (EC), the scale is converted to fuzzy numbers from zero to 1. In this study fuzzy numbers and graphs have been applied to illustrated ranks.

**RESULTS AND DISCUSSION**

According to the combination of preliminary data and the hierarchical study of the river valley morphology the basic environmental indicators in the Farahzad River Valley include three groups of descriptive material characteristics, habitat characteristics, plant structure and biomass. The

Table 1: Scale for pairwise comparison (Celik, 2018)

Scale	The relative importance of the two sub-elements
1	Equally important
3	Moderately important with one over another
5	Strongly important
7	Very strongly important
9	Extremely important
2, 4, 6, 8	Intermediate values

bed materials of the river in the urban part include two fixed and moving parts. Its fixed part consists of concrete, brick and bedrock and the moving part consists of silt, sand and gravel. There are several types of river bank protection that have a numerical value from zero to three based on their reliability and permeability. Leached side edges receive zero numerical value, edges with marshes, willow trees and wood plant species with a conservation value receive one, side gabions receive two (is one of the watershed management practices), and finally edges with hard material coating such as concrete blocks and bricks receive there. These numerical values can be zoned and localized in the Farahzad River Valley route and used to calculate the value of protection indicators of ecological dimension, which receives three numerical values largely in the urban area. Another indicator of primary indicators is land use that is analyzed at both basin and sub basin levels. The results of land use status in Farahzad catchment area are presented based on the latest changes in Map of Fig. 3.

This river intersected by the main communication ways and highways on the surface that crossed it through the bridges. As well as, subway light rail ways intersect the river route underground and pass it by tunnel. Therefore, the river has been exposed to risks on the intersection points. Habitat indices include river flows and are grouped on secondary and tertiary indicators, which it usually has gentle currents within the city of Tehran, because of surface water flow pattern and the predominant water flow of the river. The third level of indicators are addressed at the sub-basin level, and simulated by GIS for classifying their effects, along with the results from URS, used for land use planning in reverie environments to consequent integrated river valley management. Consideration of the current environmental settings including internal and external factors showed that in general 15 strengths and 15 weaknesses are

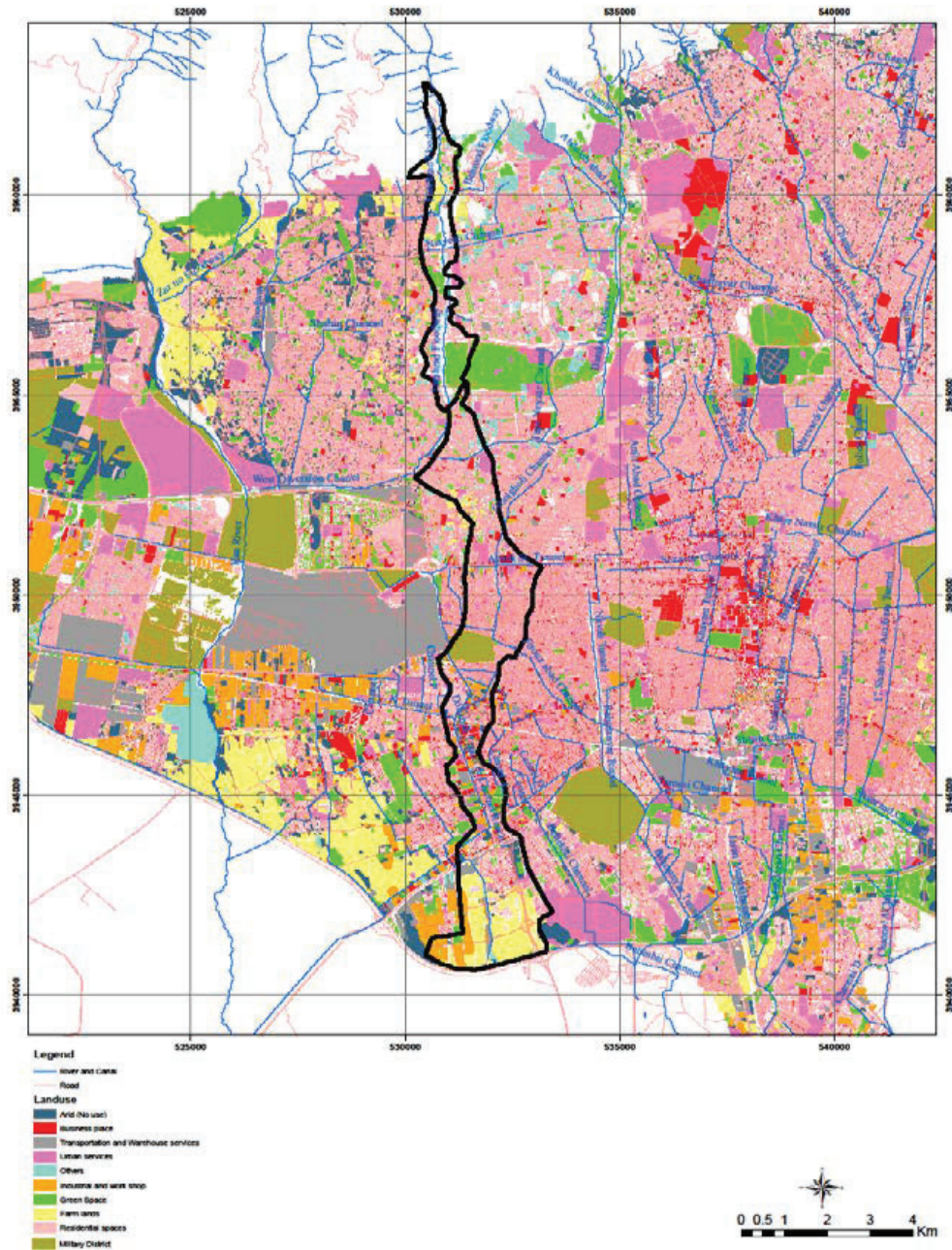


Fig. 3: Map of land use in Farahzad Basin

predictable in the Farahzad River Valley area, which categorized in Table 2. The sum of scores is 2.4, which means the environmental aspects are generally weak which indicates the dominance of environmental weaknesses over environmental strengths.

In order to prioritize internal factors (strengths

and weakness) and ensure the scores, scores are calculated through the AHP method and EC software (Fig. 4).

Overall, 14 opportunities and 15 threats have been distinguished and categorized in Table 3. The sum of score is 2.61 and indicates the dominance

*Urban river valleys management*

Table 2: IFE of Farahzad River Valley area

No.	Internal Factors	Weight	Score	Total Score
<b>Strengths</b>				
S1	The function of river canals for transferring air and climatic effects	0.056	3	0.168
S2	Green spaces around the river valley	0.018	3	0.054
S3	Regardless to the erosion of the bed and sides	0.056	3	0.168
S4	Establishment in the vicinity of the valuable rural areas	0.028	4	0.112
S5	Related to the recreation and tourism areas directly	0.025	3	0.075
S6	The connection of the river with its old bed	0.016	3	0.048
S7	Prediction of walking, cycling, city train, bus, taxi and minibus routes around the river valley	0.035	4	0.140
S8	Potential of creating different facilities	0.033	4	0.132
S9	Proximity to residential texture, natural recreational areas, scientific and educational areas	0.035	4	0.140
S10	Cultural and social area around the river	0.039	4	0.156
S11	Subjective records and public memories, rural recreational and entertainment functions, gardens, mountain hiking	0.031	3	0.093
S12	Suitable areas for the citizens to engage and attend social interactions	0.040	4	0.160
S13	Possibility of economical activities in the area	0.025	4	0.100
S14	large lands for green spaces in the middle part of valley river area	0.021	3	0.063
S15	Preparation of cadastral map of the river area	0.042	4	0.168
<b>Weakness</b>				
W1	Land taking of the river upstream by private owners and changing the morphology	0.050	1	0.050
W2	Closure of the river water metering station	0.017	1	0.017
W3	Short attention to environmental health in the upstream areas	0.023	1	0.023
W4	Destructive effects of bridges and changing of river valley morphology	0.051	1	0.051
W5	Deviation of the river from its natural path to the flood reversal	0.052	1	0.052
W6	Land transfer by various institutions, mass construction and cooperatives, construction of highways and completion of land storage in other suburbs	0.039	2	0.078
W7	Influence to river basin with land taking and constructions	0.049	1	0.049
W8	Lack of connection between immediate basin of river and historical or valuable textures	0.018	2	0.036
W9	Functional interruption and discontinuity of implemented projects along the river route	0.030	1	0.030
W10	none complete and suitable sewage network in places and lands around river valley	0.028	2	0.056
W11	Insufficient attention to the design of surrounding structures and landscaping	0.016	2	0.032
W12	Low security in some areas due to issues such as marginalization and drug dealing	0.022	2	0.044
W13	Decreased recreational and leisure activities due to increased residential functions	0.032	1	0.032
W14	Lack of income generation of river valley as a new environmental space	0.020	1	0.020
W15	Lack of integrate management and large number of organizations involved	0.053	1	0.053
Sum		1.000	-	2.4

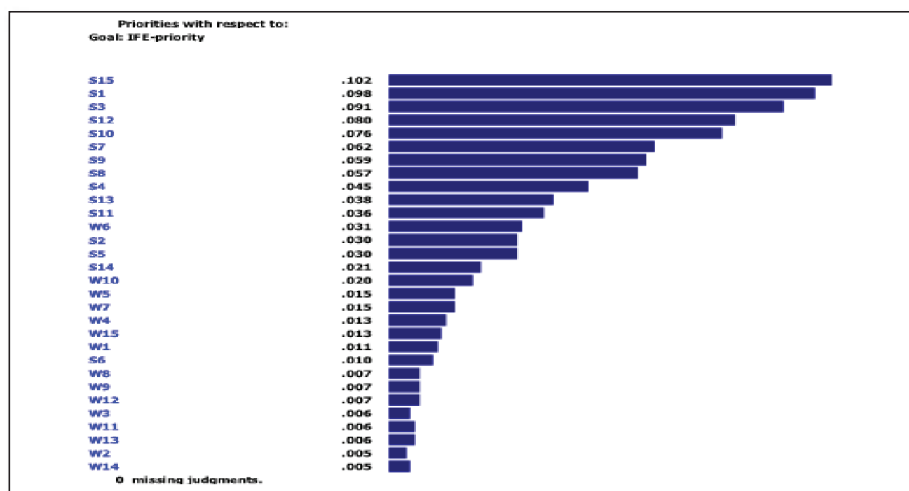


Fig. 4: Internal factors of existing environment by AHP and EC

Table 3: EFE of Farahzad River Valley area

NO.	External factors	Weight	Score	Total Score
<b>Opportunities</b>				
O1	The function of the river valley as a natural corridor upstream	0.053	4	0.212
O2	Solid waste and debris gathering by NGOs and publics in upstream to improve environmental quality (public participation)	0.018	3	0.054
O3	Possibility of creating different facilities	0.013	4	0.052
O4	Possibility of various activities in the economic field of this area	0.032	3	0.096
O5	Environmental friendly architecture by using new technologies (such as roof garden)	0.038	3	0.114
O6	Public transportation networks utilization for air pollution mitigation in the area	0.032	3	0.096
O7	The spatial composition of Farahzad River Valley and its continuity and the potential of creation a linear park	0.069	4	0.276
O8	Suitable corridor for mountaineering	0.026	3	0.078
O9	Possibility of residents participation to supply spatial social security	0.026	3	0.078
O10	Capability of supplying required conditions to play role as a recreational river valley	0.056	4	0.224
O11	Residents social cohesion in the neighborhoods adjacent to the river due to the common use of space and the desire to participate in new economic activities of education and research	0.024	3	0.072
O12	Economic efficiency due to the possibility of deploying land uses together	0.041	4	0.164
O13	Possibility of investment in recreational section and preparing public areas for citizens	0.034	3	0.102
O14	Prosperity of the surrounding areas through the tourism economy	0.038	4	0.152
<b>Threats</b>				
T1	Flooding in some sections especially bridges	0.041	2	0.082
T2	Continuation of upstream environmental pollution and waste water entrance	0.015	1	0.015
T3	Extinction of existing species in the area	0.019	2	0.038
T4	Destruction of edge natural space due to urban population and edge accommodation	0.035	2	0.070
T5	Probable disasters (earthquake, flooding and etc.)	0.042	2	0.084
T6	Disruption by land taking of river valley area in some sections	0.037	1	0.037
T7	Interruption in vital and ecological corridors by constructions	0.046	2	0.092
T8	preventing water penetrating into groundwater aquifers by concrete requirements	0.047	2	0.094
T9	Shortage of a continuous pedestrian path due to frequent intersections	0.038	2	0.076
T10	Deficiency of sewerage network organization	0.014	1	0.014
T11	Absence of attention to access to the river, which causes the loss of visual and sensory connection with the river	0.016	1	0.016
T12	Potential social problems in case of lack of social supervision	0.018	1	0.018
T13	Increasing buildings around the river by organizations, institutions and individuals	0.022	1	0.022
T14	Expanding land transfer to governmental organizations and bodies for construction	0.039	1	0.039
T15	Decentralized and non-integrated management	0.071	2	0.142
Sum		1.000	-	2.61

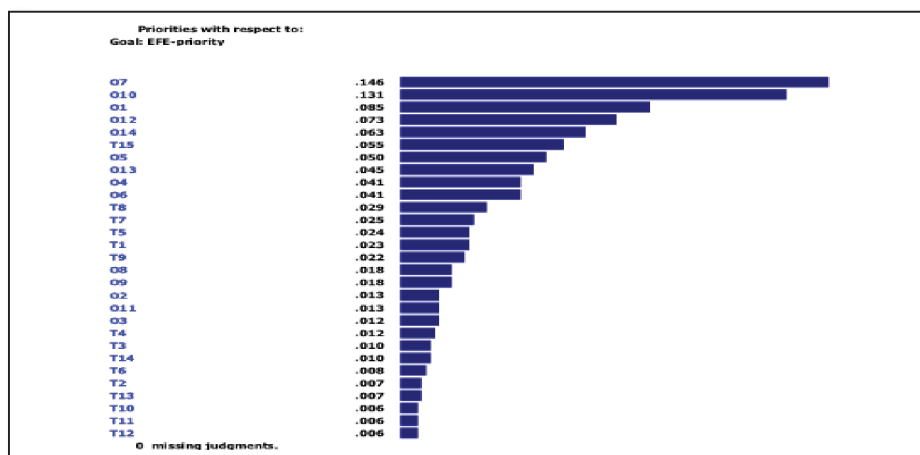


Fig. 5: External factors of existing environment factors by AHP and EC

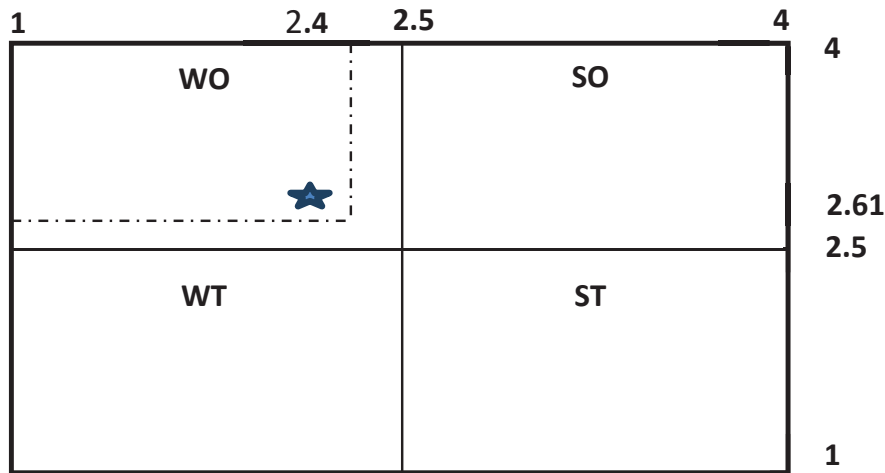


Fig. 6: Strategy classification

Table 4: Strategies prioritization by QSPM matrix in terms of total attractiveness coefficients of WO strategies

Strategies	Total attractiveness coefficients	priority
Establish integrated and comprehensive rules and regulations related to River Valley (WO11)	5.616	1
Creating a link between green spaces and other natural areas (WO3)	5.589	2
Prevention of arising residential functions around the river valley along with improving public access to the river (WO9)	5.375	3
Determination and utilization of suitable natural factors to improve environmental and landscape (WO6)	5.318	4
coordinating all decisions by establishment of permanent integrated executive and management organization (WO12)	5.269	5
Prevent the changes of use of environmentally friendly lands to other uses and consider the principles of compatibility in the design of environment (WO5)	5.103	6
Stepped design of river profile to reduce the destructive effects of floods and rehabilitate the old route of Farahzad Valley (WO4)	5.042	7
Establish communication and promote public participation in social activities and security (WO8)	4.999	8
Increasing revenue generation in the environment due to issues such as tourism boom (WO10)	4.898	9
Construction of hydrometric station to evaluate the quantity and quality of water in order to manage water resources (WO1)	4.648	10
Prioritize the completion of the sewerage system in the Farahzad River Valley area in order to reduce the inflow of sewage into the river (WO7)	4.511	11
Collection of construction waste and debris to reduce water pollution (WO2)	4.410	12

of environmental opportunities over environmental threats. Prioritization of external factors by EC and AHP scores is displayed in Fig. 5.

Results showed strategies are in conservative (WO) class (Fig. 6). This status arose from the dominance of weakness over strengthened and dominance of opportunities over threatened. Thus,

proper strategies to desirable condition achievement should improve internal weakness via environmental opportunities. Main strategies and prioritization summarized in Table 4. The result of strategies prioritization by AHP and EC has been illustrated in Fig. 7. As shown WO11 strategy (0.256) and WO3 (0.192) have a higher score than other strategies.

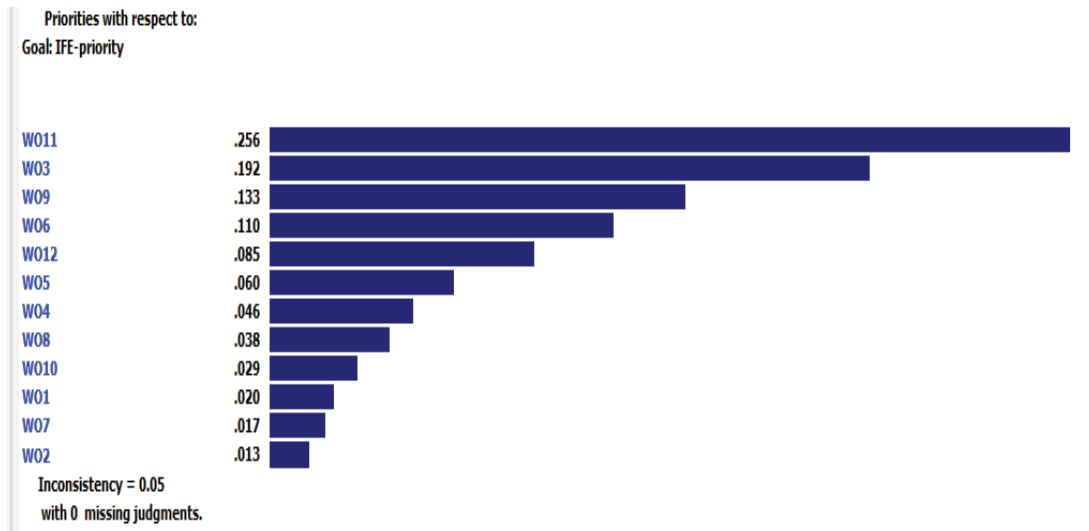


Fig. 7: WO strategies prioritization by AHP and EC for Farahzad River Valley

## CONCLUSION

In this paper, Farahzad River Valley has been considered as a largely reformed urban river, from upstream to down lands. All exposed spaces such as gardens and flora were ruined and converted to built-up areas; this study confirmed the occurred development throughout the route similar to previous studies, and has recommended strategies to solve the actual complicated concerns of the river. Hence, the most appropriate methods were selected by reviewing previous studies; by using an integrated management method tried to realize a modernized moderation measures to propose some effective and sufficient procedures to enhance river circumstances. The hybridized URS-GIS-SWOT-AHP has used, which can significantly encompass five dimensions of integrated management framework, including ecological, spatial, economic, socio-cultural, and managerial dimensions. URS is a technique is used to monitor and deliberate the dynamic phenomenon of urbanization with the aid of GIS, RS and satellite images. With regard to previous studies in the field, SWOT-AHP is a known method to determine, analyze, and conclude managerial strategies and provides appropriate information to planners for decision-making. The approaches of previous researches on Farahzad River Valley are generally towards urban development and planning for land use around the valley river. While other issues such as vegetation, floods, bed material, qualitative and quantitative

boundary of the river, its ecological resilience and interaction between ecological parameters and human-made are very important in development plan around the river valley. Indeed, Practical conceptual management model is an advantage of this study, essentially provides a framework for determining the direction of integrated river management. The suggested strategies preserve the declining natural values of the urban river ecosystem in case of Farahzad River Valley. According to the results, WO strategies are dominant strategies in this case, among the WO strategies, “establish integrated and comprehensive rules and regulations related to River valley” (W011), “creating a link between green spaces and other natural areas” (W03), and “prevention of residential functions development around the river valley along with improving public access to the river”(W09) are three first prioritized WO strategies which have been ranked via QSPM matrix and AHP. In order that revitalization of Farahzad River Valley, implementing strategies is necessary. Monitoring of land uses on certain period and consideration of changes are significant action plans of integrated environmental urban river management. Consequently, the method of this study is recommended for future studies of river valleys managements.

## AUTHOR CONTRIBUTIONS

M. Sadreazam Nouri performed the literature review, experimental design, analyzed and interpreted

the data. J. Nouri prepared the manuscript text, and manuscript edition. F. Habib revised the urban data and literature review, M. Rafian helped in the literature review and urban subject revision.

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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.

### ABBREVIATIONS

%	Percent
AHP	Analytical Hierarchy Process
DEM	Digital Elevation Map
EC	Expert Choice
EFE	External Factor Evaluation
EI	Environmental Indicators
GIS	Geographic Information System
IFE	Internal Factor Evaluation
IMMs	Integrated Management Methods
Land Sat	Satellite of Land Sat
MCDM	Multi-criteria decision Making
QSPM	Quantitative Strategic Planning Matrix
RS	Remote Sensing
	Strengths, Weaknesses, Opportunities,
SWOT	Threats (Strategic Environmental Management)
IRS	International satellite Remote Sensing
SO	Strengths and Opportunities strategies
ST	Strengths and Threats strategies
URS	Urban River Surveying

WO	Weaknesses and Opportunities strategies
WT	Weaknesses and Threats strategies

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ORIGINAL RESEARCH PAPER

Adoption of online retail banking practices as a precautionary protective behavior during the Covid-19 Pandemic

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ABSTRACT

**BACKGROUND AND OBJECTIVES:** Increase in online banking activities has been observed in the new normal of the Covid-19 pandemic. Previous studies argued that fraudsters tend to prey on unexpected events. This threat is also frightening online consumers of retail banking. Therefore, this study aimed to investigate how online retail banking users can be motivated enough to avoid online banking fraud threats while no compromise on health.

**METHODS:** The population of the study is online banking customers in Pakistan. This study obtained data from 470 respondents who used online banking services by using questionnaires through an online survey. The structure Equation Modeling approach is used to investigate the relationship among study research variables.

**FINDINGS:** Findings from a nationwide online survey confirmed the impact of the pandemic on consumer responses for online retail banking intention. Structure Equation Model results found that Perceived Vulnerability  $\beta = 0.24$ , Perceived Severity  $\beta = 0.31$ , and Response Efficacy  $\beta = 0.32$  has significant impact on precautionary behavior. Surprisingly, Self-Efficacy was not significant to consumer precautionary behavior during the new normal of COVID-19.

**CONCLUSION:** This study contributes to the literature on online banking and protection motivation theory. Results imply that bankers must invest in online banking and provide a secure environment that prioritizes the safety of the online transaction and create awareness to decrease the threat of fraud during the uncertain situation. The findings of this study particularly call for bankers, retailers' attention to online management of security systems.

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## INTRODUCTION

People and enterprises both are facing multiple unprecedented challenges on multiple fronts due to the novel Covid-19 pandemic outbreak (Aburumman, 2020; Gunay and Kurtulmuş, 2020; Zheng and Zhang, 2020). Besides many other factors, the fear that hard cash could spread the virus encouraged the adoption of online banking for daily routine transaction activities. Consequently, an increase in online banking has been observed (Alkhowaiter, 2020; Moşteanu et al., 2020; Safari et al., 2020). However, previous studies show that with the growing demand for online banking chances of online fraud also increases. This is because fraudsters tend to prey on unexpected events (Islam et al., 2020). Thus, one must not be surprised the novel Covid-19 has an increase in online fraudulent activity. This threat is also frightening online consumers of retail banking and so for retail banks as well as other stakeholders, the need for a secure online banking environment has become a real priority. On the other hand, digital banking is always a preference for account holders. Digital technologies advancement coupled with social networking popularity facilitated the new ways of doing business activities and financial transactions smoothly and effectively (Agarwal et al., 2021). Consequently, this has also attracted fraudsters and criminals. However, fraud is a global problem with a severe negative impact on different businesses and their consumers. According to Craja et al., (2020), in the past two decades, the financial implications of fraudulent activities occurring globally are estimated to amount to up to \$7 trillion. However, low self-control and disclosing sensitive information are associated with responding to fraudulent offers. This highlights the greater need that technology user both must be informed, as well as protected from fraud through fraud prevention systems (Ali et al., 2019; Craja et al., 2020; George, 2017). During the Covid-19 outbreak, Pakistan has also experienced an increased shift of consumers towards online retail banking. In the pandemic outbreak more than 20 million financial transactions were performed in the year 2020, a total value of 900 billion PKR using online retail banking services (Arif et al., 2020). However, at the same time, the cybercrime wing of Pakistan has received many complaints of online banking fraud. This also helps to enable banks to realize changes needed in business models to provide a secure safe online banking

environment. In emerging economies, retail online banking services are still novel and least understood phenomena of research. Further, the pandemic outbreak situation has become more challenging for developing economies (Kaur and Arora, 2020). However, online banking customers have also certain own responsibilities regarding the use of online banking services safely (Reyns et al., 2019), because banks cannot control the user's devices which they prefer to use, neither their behavior towards online services. Further, previous research shows customer behavior is the major cause behind the victimization of online banking fraud (Mesch and Dodel, 2018). Therefore, threat greater awareness will help consumers to cope better and act accordingly to prevent them when recognizing a threat situation (Fenz et al., 2014). Previously researchers have mainly relied on the technology adoption frameworks to explain consumers' intentions to utilize online shopping services such as self-service, and grocery delivery (George, 2017). Besides, the application of Protection Motivation Theory (PMT) in the consumer research context is novel in the literature as PMT has been primarily studied in health-related contexts (Laato et al., 2020; Perloff and Fetzer, 1986; Ruitter et al., 2003). How online retail banking users can be motivated enough to avoid online banking fraud threats while no compromise on health is the primary motive behind this study.

### *Literature review and theoretical support*

This study is based on the PTM, in which the outcome variable is the protective measure of an individual in avoiding threats (Rogers, 1975). This study assumed that increase in online banking is a result of the precautionary behavior of the customers to avoid the Covid-19 threat. The precautionary measure is one way of avoiding threats. Which includes both technical measures and behavioral measures related to internet usage and computers, such as the use of anti-virus software and awareness of conscious care behavior (He et al., 2020). However, research is still limited in this area (Rawwash et al., 2020), and also concerning behavioral change (Craja et al., 2020). Moreover, less is known about security behavior and awareness of the end-users of financial transactions using technology particularly in the context of a pandemic outbreak situation. The threat appraisal process of PTM describes the

evaluation of certain danger levels by individuals associated with a certain event or activity (Ruiter *et al.*, 2003). This study follows the work of Liang and Xue, (2010), which describes the threat appraisal process as a combination of perceived risk, and it is influenced by perceived vulnerability and perceived severity. However, in the case of online retail banking perceived risk describes the potential loss consequently result of certain activity or service. More recently, some studies have applied the PMT model to examine factors affecting COVID-19 preventive behaviors Cyberchondria (i.e., obsessive online searching for health-related information) and information overload, which subsequently affected the threat and coping appraisals (Jungmann and Witthöft, 2020). Yet, among the appraisal variables, only perceived severity, self-efficacy, and response cost (i.e., the cost associated with recommended behavior) were discovered as significant predictors of self-isolation. Recent research studies revealed that understanding of COVID-19 had a significant impact on perceived vulnerability and severity and ultimately intention to follow prevention measures. Such inconsistency in findings warrants further investigation of the framework of the PMT in the context of the COVID-19 pandemic. Therefore the main hypothesis was derived:

*H1. Precautionary behavior will be positively related to an increase in consumer online retail banking intention*

PMT recently gained attention in research related to security information (Ifinedo, 2012), with the solid good foundation it is deemed applicable for research in the online banking domain. Earlier studies in this domain adopted PMT ranges from security information systems to spyware anti-software adoption (Fenz *et al.*, 2014), and data backing up to the prediction of protective behavior in identity theft (George, 2017). The framework of PMT has been applied to virus outbreaks and pandemics such as SARS and H1N1 and Covid-19 outbreaks (Al-Rasheed, 2020). PMT predicts that higher levels of threat appraisal and coping appraisal will lead to greater motivation to engage in protective behavior (Plotnikoff and Trinh, 2010). Studies show that threat and coping appraisals work independently of each other, and coping appraisals

tend to exhibit greater power than threat appraisals (Bamberg *et al.*, 2017). Threat appraisal describes an individual's assessment of a threat based on two factors: perceived vulnerability and perceived severity (Maddux and Rogers, 1983; Rogers, 1975). While the individual's assessment of the ability to cope with the situation is referred to as the coping appraisal. It consists of self-efficacy and response efficacy. The perceived vulnerability is as per PMT a direct predictor of protection motivation (Rogers, 1975). It is the probability of the user's evaluation that a threatening event will happen (Perloff and Fetzer, 1986). However, susceptibility or perceived risk is an important determinant of precautionary action. Some available previous research shows that people who do not victimize tend to perceive themselves as less vulnerable than those who have been victimized by negative events in life (Ruiter *et al.*, 2003). However, it can be argued that vulnerability is a necessary but not a sufficient condition for preventive action. Perceived severity is the belief and it describes event or outcome negative consequences to individual associates as a result of a particular behavior. In other words, it is the user's evaluation of the severity of threatening event consequences to them. In online banking cases, it is the perceived seriousness of the fraud consequences due to online transactions. Perceived severity in PMT is also a predictor of protection motivation:

*H2. Perceived (a) vulnerability and (b) severity will increase the precautionary behavior of online banking consumers*

Fig 1 represents the conceptual frame work of the relationships of study variables. According to PMT the coping-appraisal consists of self-efficacy, and response efficacy, however, both are associated with response costs. Self-efficacy represents the belief that an individual enacts successfully the recommended behavior. While the recommended behavior effectiveness in avoiding or removing the possible harm describes response efficacy. The coping ability amount that individual experiences are the self-efficacy and response efficacy combination minus the response costs. A user evaluates a given coping strategy in the coping appraisal process, to avert a threatening event. This study adopts the definition of (Bandura, 2010) coping appraisal

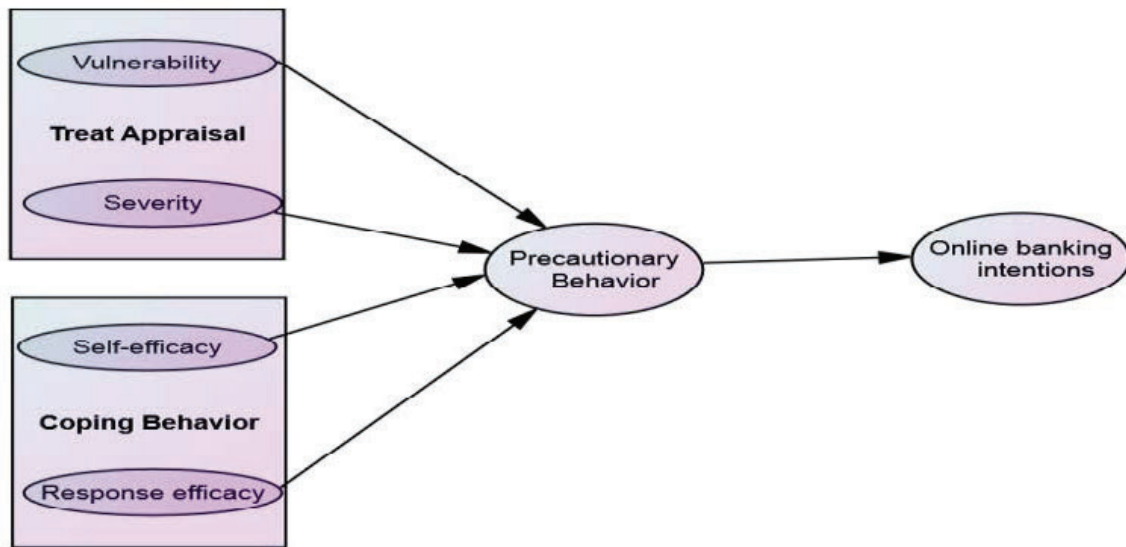


Fig. 1: Conceptual framework of the study

in information security is a user belief incapable of being too certain information protection and take some precautionary measures as compared to those individuals who show less confidence. Therefore, according to PMT:

*H3. Perceived (a) self-efficacy and (b) response efficacy will increase the precautionary behavior of online banking consumers*

This research used a quantitative method to measure the hypothesized factors (Fig 1) through online self-administrative survey. The current study has been carried out in the KPK province of Pakistan in December 2020.

## MATERIAL AND METHODS

### Data and sampling

A convenient sampling technique was used where MBA finance program students at NUML University, Pakistan were given the online survey and asked to collect responses as a part of their research assignment. The reason for MBA students was because of their ability to understand the concepts behind an online banking and related customer satisfaction. The students were given four weeks to collect the data before the survey officially closed by the end of December 2020.

### Measuring instruments

This research used a quantitative method to measure the hypothesized factors with an online self-administrative survey. Besides demographic information's such as; age, gender, education level, and work status, the survey constitute of questionnaires measuring the main six variables of the study defined as precautionary behavior" (measured with 04 items) "perceive vulnerability" (measured with 05 items), "perceive severity" (measured with 05 items), "self-efficacy" (measured with 04 items), "response efficacy" (measured with 06 items), ", and lastly, the dependent variable of the study online banking intention (measured with 05 items). The items used were formulated from previous studies to ensure the validity of the survey (Nebioglu *et al.*, 2012). A five-point Likert scale ranging from 1= strongly disagree to 5= strongly agree was utilized to quantify all independent variables. To assess the validity of the method, minor modifications were done to improve the comprehension of the survey. The modifications eliminated some items that confused the respondents, however, those items were removed without affecting the measurability of the required variables. The revised items were used in the final survey.

*Structural equation modeling*

Structural Equation Modeling (SEM) variance-based approach is applied to assess the relationships of the study variables (Henseler, 2017). Smart PLS3 was used because it helps the researcher to relate the set of multiple dependent and independent variables. Further, it is considered one of the best techniques for evaluating hypothesized relationships in a complex design.

**RESULTS AND DISCUSSION**

This study analyzed data obtained from 470 respondents who used online banking (male, female: mean age = 40.03, SD = 13.41). Respondents were employed (59.9%), self-employed (15.6%), part-timer (17.9%), and 6.6% had a different (work) status.

*Reliability and Validity Analysis*

This study follows the recommended two-step approach in literature. The scale's reliability was evaluated and tested first. Follow by the second step in which the model was evaluated to test the model's structure ability to best predict a certain outcome. Table 1 reported the obtained value for Cronbach's alpha exceeded the recommended value of 0.7. Further, Composite Reliability (CR) also exceeded the recommended value of 0.7 (Anderson and Gerbing, 1988). The Average Variance Extracted (AVE) values

also exceed the recommended value of 0.5 (Bagozzi and Yi, 1988). The Cronbach alpha and composite reliability values of the measured all constructs of the study indicate the high internal consistency of the measurement model (Table 1).

For discriminant validity, the alternative Heterotrait-Monotrait ratio of correlations (HTMT) superior to traditional approaches were applied (i.e. cross-loadings and the Fornell-Larcker criterion recommended by to assess discriminant validity). The HTMT value less than 0.85 indicated the discriminant validity has been achieved successfully for the reflective construct (Henseler et al., 2015) as can be seen in Table 2.

*Hypothesis testing*

The structural model assessment is examined by running the bootstrapping with 5000 samples (Efron, 1992). It allows the researcher to any parameter estimate of interest. This assessment is done by examining the R2 of the structural model and the predictive relevance of the model by using Q2 (Geisser, 1974). The coefficient of determination, the R2 is the proportion of variance explained by the independent variable in the dependent variable (Figueiredo et al., 2011). The R2 values are all higher than the recommended value of 0.26 Cohen (1988). Further, the results for the predictive relevance of the model (Q2) are greater than zero, as suggested

Table 1: Measurement Model

Constructs	Cronbach's Alpha	CR	AVE
Online banking	0.912	0.904	0.712
Precautionary behavior	0.930	0.910	0.827
Perceived severity	0.854	0.901	0.746
Perceived vulnerability	0.887	0.917	0.721
Response efficacy	0.924	0.901	0.725
Self-efficacy	0.920	0.912	0.764

Table 2: Heterotrait-Monotrait Ratio (HTMT)

Constructs	Online Banking	Precautionary Behavior	Perceived Severity	Perceived vulnerability	Response Efficacy	Self-Efficacy
Online Banking	-					
Precautionary Behavior	0.67	-				
Perceived Severity	0.63	0.84	-			
Perceived vulnerability	0.48	0.73	0.78	-		
Response Efficacy	0.72	0.79	0.82	0.64	-	
Self-Efficacy	0.68	0.71	0.80	0.56	0.55	-

Table 3: Hypothesis results

Hypothesis	( $\beta$ )	SE	T Statistics	P Values	Results
Precautionary Behavior ----> Online Banking	0.64	0.07	8.91	0.000	Supported
Perceived Severity ----> Precautionary Behavior	0.31	0.13	2.33	0.002	Supported
Perceived <i>vulnerability</i> ----> Precautionary Behavior	0.24	0.11	2.11	0.004	Supported
Response Efficacy ----> Precautionary Behavior	0.32	0.12	2.70	0.001	Supported
Self-Efficacy -----> Precautionary Behavior	0.08	0.12	0.64	0.053	Not-supported

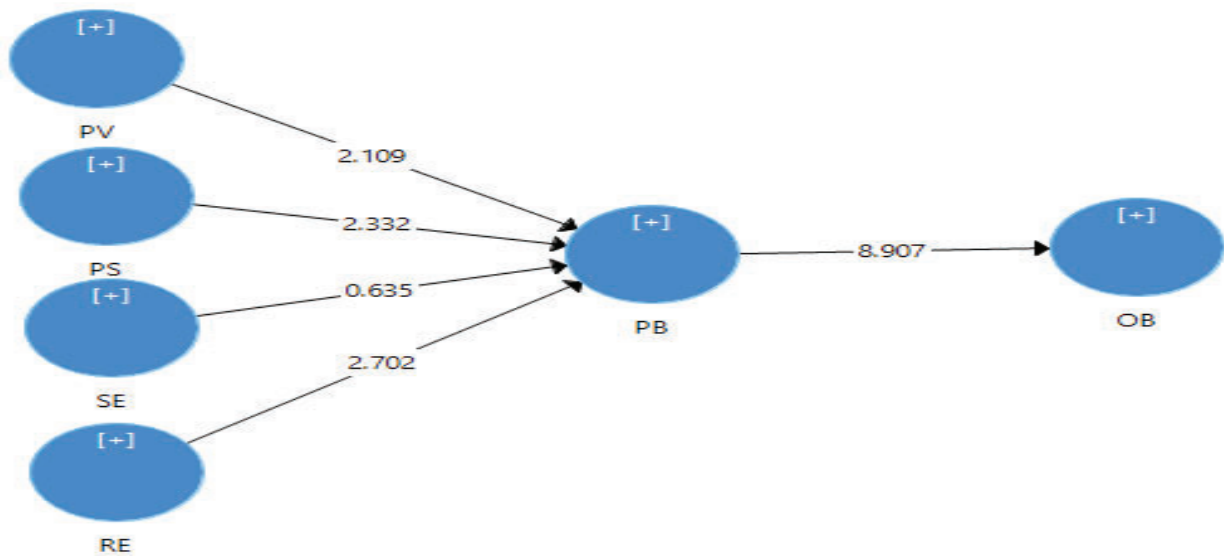


Fig. 2: Bootstrapping Result

by (Hair *et al.*, 2016). These results indicate that the model has good predictive relevance for all of the endogenous variables. The  $f^2$ , represent small, medium, and large effects, where values of 0.02, 0.15, and 0.35 respectively, while effect size values lower than 0.02 indicate that there is no effect. Therefore, the results confirm that the effect sizes of precautionary behavior on online banking are considered strong ( $f^2 = .564$ ) and that vulnerability, severity, self-efficacy, and response efficacy have an effect (2.135, 0.055, and 1.057, respectively). This indicates that perceived vulnerability had the biggest effect on the latent variable precautionary behavior. Fig. 2 and Table 3 provide the results of the hypothesis testing. The results of the inner model of the structural model verify that perceived vulnerability ( $\beta = 0.24$ ), perceived severity ( $\beta = 0.31$ ), and response efficacy ( $\beta = 0.32$ ), significantly

influence the precautionary behavior level of consumers, which are supporting hypotheses H1, 2a, 2b, and 3a respectively. However, hypothesis 3b of the study was not significant as the p-value is greater than 0.005.

The findings reveal that precautionary behavior had a significant effect on perceived severity (H2a)  $\beta = 0.31$ , and vulnerability (H2b)  $\beta = 0.24$ . This signifies how the public communication of preventive actions and their effectiveness is crucial in generating a unified response against the pandemic. Our result further confirms previous findings that coping appraisals tend to have a greater association with behavioral intentions than threat appraisals, possibly because if people already adopted protective behavior, they may no longer feel vulnerable to the threat; thus, the association between threat appraisal and intention may seem

weaker than coping appraisal. The significant influence of precautionary online behavior on the threat appraisals (e.g., severity and vulnerability) is following earlier studies, which indicated that consumer tends to perceive COVID-19 as threatening and engage in precautionary online behavior as a protection motivation (Hu *et al.*, 2020). In the coping appraisal process response efficacy (H3a)  $\beta = 0.32$  positively influenced precautionary behavior. That is, those who perceive precautionary action to be an effective protectionary measure against COVID-19 and are capable of acting are more likely to display stay-at-home intentions. Such results confirm previous research where the coping appraisals were positively correlated with other preventive behavioral intentions such as mask-wearing, hand-washing, and social distancing. Yet, given that result was not significantly related to the self-efficacy variable (H3b)  $\beta = 0.08$ , self-efficacy proved to be the essential link between political orientation and stay-at-home intention. However, this is likely due to polarized response to COVID-19 including media coverage. This finding lends support that cues from political leaders and biased media rhetoric can exert substantial influence in shaping followers' understanding of issues like COVID-19. Lastly, the increase in consumers' intentions to engage in online retail banking was positively impacted by precautionary behavior (H1) as anticipated by the main hypothesis of the study. Further, this study model confirms the findings of Painter and Qiu, (2020) geolocation analysis that political beliefs play a significant role in people's compliance behaviors with social distancing orders, which also shows a correlation with increased e-commerce shopping behavior. Overall this study suggestion based on finding is in line with the study of (Kaur and Arora, 2020) which suggest that valuable banks efforts are needed to facilitate usability and reliability of online banking services especially in designing website interface with improved security features. As banking retailers are struggling to attract customers back to their financial transactions, they must care for the safety of customers from online fraud. Consumers need reassurance to find online retail banking as a safe activity to perform (Agarwal *et al.*, 2021). Failure to do so will likely make consumers feel vulnerable and avoid retail banking. Retail bankers are also advised to streamline the

transaction process so that consumers can feel that safe and quick with minimal human contact.

## CONCLUSION

The purpose of this study was to discover the factors that contribute to individual differences in precautionary online banking intention amid COVID-19. This study finding suggests that bank retailers should emphasize the protectionary effect (e.g., safety, hygiene) of engaging in online banking. On the other hand, for awareness regarding fraud, bank retailers may highlight key sensitive information not to share through different campaigns, including the use of social media to promote safe online banking as a social marketing theme. This will also benefit online banking modes as a more reliable and convenient method of the shop online. The significant findings from the PMT model help validate the theory in the consumer research setting and open a new window of research, where PMT may be applied to other contexts of consumer behavior that involve risk and need for protection (e.g., identity theft). Doing so, this study advances the current knowledge on the PMT literature and offers deeper insights into the factors that shape the public's perception of pandemics. The results of the study can be helpful to practitioners and scholars in safe banking education, training, and awareness campaigns, thereby also empowering online retail banking users to act effectively or to avoid themselves against increasing online fraud threats. The Covid-19 pandemic caused an unprecedented shift in the behavior of consumers, there is a need to investigate online retail banking as an essential means to minimize social contact to avoid spreading of the infectious coronavirus. To that end, this study finding provides empirical evidence that consumers intend to increase the use of online retail banking services based on their motivations to protect themselves from the perils of COVID-19 as a precautionary behavior. Like any piece of research, this research study has some limitations, however, that also provide future research opportunities. Indeed, the first limitation is the sample context-specific to Pakistan. Although, the COVID-19 pandemic is a global health crisis, however, different countries implemented different strategies, and some countries have been

more successful in containing the virus than others. Therefore, a future study to compare different countries will warrant a deeper understanding of the influence of financial climates on consumer behaviors in a crisis. The second limitation arises because the intention is widely considered as a good indicator of actual behavior, the intention-behavior gap has been also well acknowledged in the literature. While the third limitation is associated with a cross-sectional methodology weakness. Because of the pandemic outbreak, the situations (e.g., policy, case number increase rate) have been changing rapidly. Yet, assessing consumer response at a single point in time cannot capture the dynamic changes. An investigation to evaluate the longitudinal changes in the impact of the COVID-19 on consumer intention to use online retail banking will help us understand the full scope of the impact over time as the level of threat changes with the situation. Just like other survey studies the last limitation of the study is the fact that this is a self-reported survey that cannot determine causal relationships between the research variables. To confirm the causal relationships future studies should investigate the relationships with an experimental design.

#### AUTHOR CONTRIBUTIONS

F. Afridi made research designs, processed the data with the help of Smart PLS3 and preformed analysis of the processed data. B. Ayaz reference data for background and conducted a literature review M. Irfan conducted data collection, prepared revised manuscript and further observation of the truth of the field data.

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#### CONFLICT OF INTEREST

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

#### ABBREVIATION

<i>AVE</i>	Average Variance Extracted
<i>CR</i>	Composite Reliability
<i>HTMT</i>	Heterotrait-Monotrait ratio of correlations
<i>OB</i>	Online banking
<i>PB</i>	Precautionary behavior
<i>PMT</i>	Protection Motivation Theory
<i>PS</i>	Perceived Severity
<i>P-value</i>	Probability value
<i>PV</i>	Perceived vulnerability
$R^2$	Coefficient of determination
<i>RE</i>	Response Efficacy
<i>SD</i>	Standard Deviation
<i>SE</i>	Self-efficacy
<i>SEM</i>	Structure equation modeling

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ORIGINAL RESEARCH PAPER

## Analysis of factors influencing human resource development for state-owned enterprises

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### ABSTRACT

**BACKGROUND AND OBJECTIVES:** This study was performed to analyze the factors influencing human resource development for state-owned enterprises.

**METHODS:** This research was an applied study concerning its objective with a descriptive-exploratory type. The study was conducted by two quantitative and qualitative approaches. The research statistical population included two groups for both approaches. In the qualitative approach, 22 experts were selected to design the model using fuzzy Delphi methods, structural-interpretive modeling. In the quantitative approach of 360 employees of state-owned enterprises companies were selected from the statistical population of 2738 people by the stratified random sampling method. Content analysis was used to analyze qualitative data and in the quantitative method used interpretive structural method, analytic network process and MICMAC.

**FINDINGS:** The result of determining the relationships revealed that organizational factors, job factors, behavioral factors, and empowerment factors affect human resource development, respectively. The findings of weighting the factors by fuzzy network analysis process indicated that empowerment factors with a weight of 0.361 among the dimensions and the knowledge management factor with a weight of 0.132 among the components have the highest importance in the development of Human Resource.

**CONCLUSION:** The variable "human resource empowerment" leads to success in human resource development, which needs to be improved quickly to bring success to the organization and improve its performance. The managers should pay attention to the high levels of the model and improve the relationships set between the factors to improve this factor. Considering the high significance of the "knowledge management" component, the managers' most important measure should be focused on improving this factor followed by continuous efforts in this context since paying attention to knowledge management has the greatest impact on the success of human resource development and requires special attention.

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## INTRODUCTION

The core of any organization's success relies on organizational assets, or indeed, Human resources (HR). HR have an important responsibility for the success or failure of the organization. Human Resource Development (HRD) involves a set of activities that support the employees' behavior change and learning opportunities. HRD activities aim to develop the employees' skills and flexibility to the current and future demands of the organization. The ultimate goal of HRD activities is to achieve high performance (Richman, 2015). HRD includes the process of developing and employing human skills through developing the organization and training and developing personnel aimed at improving the performance (Najafi et al., 2012). An organization's HR include all the people who work in the organization (Bernardin, 2010). Hence, as a part of an organization, human resource management needs to be prepared to deal with dynamic environmental change (Decenzo and Robbins, 2010; Sabokro et al., 2018; Ardakani et al., 2020). The human sector plays a key role in strategic HRD with a great impact on the strategic decisions of the organization (Ancaloana, 2013). This concept implies understanding the effects of globalization, workforce diversity, changing skills needs, conditional workforce, employees' participation as well as technological changes (Decenzo and Robbins, 2010). HRD consists of four basic components: Knowledge, attitude, skills, and behavior. No organization can survive without paying attention to HR, human aspects, and their constructive role in the development. HRD includes the process of developing and employing human skills through developing the organization and training and developing personnel aimed at improving the performance (Najafi et al., 2012). Consecutive changes in the economic, cultural, and technological environment of organizations have led them to face challenges on how to properly manage HR and improve their performance (Alvani et al., 2016). Acquiring knowledge and skills is a time-consuming process, in which, companies invest significant capital to help their employees acquire necessary competencies. Inability to determine the competence of employees to implement a strategy and failure to ensure its achievement or development at the proper level and time can dramatically weaken the company's ability to realize its goals (Kazakovs, 2014). By creating a useful work environment, HRD significantly increases the

employees' awareness, honesty, trust, and interaction at work to improve performance (Mahmood et al., 2018). Competition cannot be realized without performance management and developing the skills and competencies of employees at the same time. Therefore, there is a need to create a culture and opportunity for continuous learning of employees and the organization, to improve performance at the organizational level (Raj Adhikari, 2010). HRD as well as necessary knowledge and skills are required to overcome the highly turbulent competitive environment in industries and to succeed in such an intensely competitive environment. In fact, in such a competitive environment in the economy, smart and capable people are needed to maintain values. Therefore, there seems to be an urgent need to invest in HR. State-owned enterprises (SOE) in the area of HR face a number of development issues. These problems should be addressed first so that these SOE companies can expand their presence and activity domestically and internationally. To this end, first, SOE should have an accurate understanding of the quality of HR as organizational intelligence to provide products with appropriate quality. Second, State-Owned Enterprises, necessarily because they are SOE, have to succeed in the social and economic environment of the country, which will not happen unless through the development of HR. For example, if the training, skills, and capabilities of HR are not understood, the SOE may not succeed in providing high-quality products. Also, failure to pay attention to the beliefs of human values can lead to unsuccessful implementation in the organizational performance improvement. According to the settlement of budget report by the Supreme Audit Court (SAC) of Iran (2017), of a total of 385 SOE and production and industrial institutes, 176 SOE and institutions were profitable, 47 companies were break even, and 162 SOE and institutions were unprofitable that 375 million \$ have been dedicated from the public budget to compensate their losses. Also, according to the report of the Plan and Budget Organization of Iran (2017), low productivity and inefficiency of production factors are important factors of loss of SOE and institutions. Thus, this is the main issue that was focused on in this research. Considering the position of HR, which is the most important factor of production, so, this research was conducted to design an HRD model for SOE. Economic development in countries and providing appropriate and localized

development models have always been one of the commonly discussed topics in the area of development management in recent studies. The system of SOE is one of the foundations of Iran's economic development. The problem to be considered in SOE is the lack of sufficient attention to intangible resources such as the development of employees' thoughts to gain competitive advantages. It seems that overseeing HRD is not done seriously and senior executives do not support HR management practices in many cases. This research was performed to design and present a HRD model for SOE aimed at training thoughtful and highly skilled manpower to compete and gain competitive advantages. The current research has been carried out in Mashhad city in 2020.

#### *Theatrical background*

##### *Human Resource Development*

According to [Schlebusch and Kgati \(2016\)](#), learning is the main focus of HRD and its main goal is to achieve the goals of the organization and the individual. In this context, development takes place over time and by emphasizing the learning opportunities, development, and training to improve the individual, team, and organizational performance. According to [Mathis and Jackson \(2000\)](#), HRD is gradually turning into a tool for survival in a dynamic, competitive, and constantly changing environment. [Malone \(2004\)](#) also suggested that HRD has now turned into a significant factor, which continues to be widely used by many organizations as one of the most promising approaches for organizational success in the age of information. The goal of HRD can be seen from the perspective of activities or functions in Human resource management (HRM), which mainly involve personal development, organizational development, occupational achievement, and performance improvement that can be described as HRD-related functions. It is suggested that HRD goals are aligned with organizational strategies and goals aimed at meeting the changing and evolving social and economic needs ([Schlebusch and Kgati, 2016](#)). In an HRD review article, [Hamlin and Stewart \(2011\)](#) describe HRD performance as improvement in the individual and group performance, improvement in the organizational effectiveness and performance, the development of knowledge, skills, and competencies, and strengthening of human potential and personal growth. In line with the above definitions, the

basic elements of HRD include Organizational Development (OD), Training and Development, and Career Development (CD). While CD is almost an external organizational structure, OD and Training and Development, are HRD interventions, which are focused within the organizational framework and seek to provide and develop key skills to enhance the company's performance ([Galperin and Lituchy, 2014](#)). Some of the functions of this activity include identifying the training and development needs and selecting appropriate methods and programs for these needs, planning how to implement them, establishing communications and information management, the company's performance, productivity, organizational culture, employees' turnover, and ultimately the evaluation of their results ([Al-Mustapha and Olugbenga, 2016](#)).

##### *Human resource development theory*

In general, studies have adopted two broad theoretical models. The first models, micro-theories, are related to organism behavior and individual motivation, influence, or cognition. The second theories models include strategic choice perspectives that use human capital theories, which are resource-based contingency views derived from the company theory. Most of the available HRD studies originate from limited theories such as learning and development theory, social psychology, or mainstream economics ([Ahmed et al., 2017](#)). [Murphy and Garavan \(2016\)](#) suggest that several theoretical perspectives on HRD have been discussed in the literature, indicating that the HRD theoretical foundations have been largely focused on the nature of models, principles, and theories. Researchers such as [Gilley and England, 1989](#); [McLagan, 1989](#); [Swanson et al., 2009](#) focus on the theory of human resource psychology and state that HRD refers to a process, which enables personnel to experience and learn over a period of time aimed at changing the individual's behaviors. In system theory, HRD has been discussed as organizing activities or learning in the organization to improve the performance and growth of workers to improve the work, personnel, and the organization ([McLagan, 1989](#)). Similarly, some researchers have relied on the economic theory and suggest that HRD refers to the process of developing and disseminating expertise to personnel aimed at improving the performance and process of

Table 1. A summary of the literature review

References	Title	Results
Hajilou <i>et al.</i> (2018)	Designing an ethical-based model of HRD in government organizations	Human capital development has been studied in three dimensions of empowerment, talent management, and knowledge management to achieve the optimal combination.
Fallah (2018)	Identifying and explaining the coming results of human resource empowerment with the knowledge management approach	Based on the results, the mediating variable of knowledge management plays a crucial role in the organization to empower employees by creating synergy between two categories of cultural factors and capacity building.
Pakdel <i>et al.</i> (2018)	Designing a national HRD model with a system dynamics approach	The results of this study indicate that the national HRD system has the main subsystems of training and providing manpower and labor market. These two subsystems are subject to the policies made by the human resource management subsystem and economic growth and development.
Askari Masouleh (2017)	The integrated model of HRD in government organizations of the Islamic Republic of Iran based on the Islamic-Iranian model of progress	Managerial factors; national and extra-organizational factors; individual factors; factors of service compensation and performance appraisal system; employees' commitment and career path progress factors; planning and employee's guidance factors; factors of employees' independence in performing tasks; factors of hardware and software conditions of the work environment; training and knowledge management in the organization factors; employees' empowerment factors; factors of organizational culture, values, and behavior; religion-oriented factors, organizational justice, and perfectionism factors, and content and indigenous factors of the development model
Jalali <i>et al.</i> (2017)	Identifying and modeling the factors affecting the empowerment of managers	The research results indicate 7 variables in the form of a structural model as follows: 1. Management effectiveness, 2. Knowledge and skills, 3. Risk acceptance, 4. Access to information, 5. Participation in decision-making, 6. Organizational culture, and 7. Faith.
Rad <i>et al.</i> (2017)	Identifying the effective factors on human resource empowerment of the headquarters of Ardabil University of Medical Sciences	Analysis of findings demonstrated that all three studied variables (individual factors, group factors, and organizational factors) play a decisive role in explaining the dependent variable (psychological empowerment).
Taghvaie and Daneshfard (2015)	The infrastructure model of human resource management tailored to telecommuting in Iranian government organizations	According to the results, all hypotheses were confirmed and a positive and significant relationship was found between culture, technology, and strategy.
Aghdasi and Nowrouzadeh (2013)	Analysis of effective factors on human resource empowerment	The research findings demonstrated that participatory management, clear goals, providing information, access to resources, reward system, group formation, delegation authority, performance appraisal, modeling, supporting, motivating, independence, and organizational structure are respectively the most effective factors on the empowerment of HR of the headquarters of the Ministry of Science, Research and Technology.
Ahmadvand and Yavari Bafghi (2008)	HRD model in the Law Enforcement Force of the Islamic Republic of Iran	According to the results, the following factors are respectively important for the development of HR in the Law Enforcement Force of the Iran: Evaluation and leveling of HR, commissioning of training, the continuation of education and training, job rotation, and the individual's opinion

Continued Table 1. A summary of the literature review

References	Title	Results
Mahmood <i>et al.</i> (2018)	The relationship between spiritual intelligence and human resource development	The results revealed that IQ affects EQ in HRD and EQ also affects SQ, and in total, three dimensions lead to the development of HR.
Nguyen and Hadikusumo (2017)	The effects of HRD on the success of engineering projects	They considered the components of HRD as individual development, education and development, career development, team development, and the development of the organization.
Ensour <i>et al.</i> (2016)	The impact of factors affecting the strategic position of HRD in Jordanian Universities	Revealed by the results, all the proposed variables (functional, organizational, and personal factors) had a significant contribution in predicting the dependent variable (HRD strategic position).
Sparkman (2015)	Factors and conditions of national HRD in Brazil	Political, economic, social, and educational conditions lead to the development of HR.
Uchechukwu and Uche (2015)	HRD analysis as a critical factor effective on organizational productivity	The attitudes of senior managers and other employees as components of HRD affect productivity.
Kazakovs (2014)	Analysis of factors affecting the choice of solutions for human resource development	Twelve influential factors were identified in this study, including the need for development, efficiency of development solutions, time, development methods, cognitive style, and place of residence, price, travel cost, indirect costs, position development priorities, and skills development priorities.
Hunko (2013)	Factors effective in the formation of HR	External factors, including the average wage in the industry and the average wage in the region, and micro-factors, including staff policy, life cycle stage, level of engineering and technology, and characteristics of the production process play a role in human resource development.
Burdbar Khan and Nisar Sheikh (2012)	HRD model based on motivation and Islam	Organizations need to place further emphasize the values of ethical and normative goals that may affect the reduction of satisfaction.
Kumpikaite and Sakalas (2011)	Evaluation model of HRD systems	The variables of the model were the organization's approach to human resource development, job organization, training, professional development, and their adaptation and evaluation, determining development needs, and rewarding.
Bae and Rowle (2004)	Macro and micro approaches to HRD in South Korean industry	The dimensions were as follows: 1. Political practices, 2. Government structure, 3. Education and development system, 4. Industrial/company structure (the type of industry, employment, job/domain design, authority structure, professional structure/change, and management), 5. Financial markets and institutions, 6. Industrial relations (employers' organizations, labor unions).

teamwork and performance at the individual level. HRD seeks to improve these issues through training and development, organizational development, performance improvement, organizational learning, professional management, leadership, and development, etc. (Swanson *et al.*, 2009).

#### State-owned Enterprises

SOE refer to institutions that more than 50% of their shares are owned and held by the government,

government agencies, or institutions. SOE are subject to Iranian accounting standards, commercial law, Iran's public accounts law, and the provisions of the law of the five-year plan and the laws of the annual budget in terms of laws and regulations governing them. Pursuant to Article 44 of Iran's public accounts law (Islamic Parliament Research Center, 2005), SOE are required to deposit the government dividends in the treasury account by the end of the legal deadline stated in the mentioned article.

Table 2. The dimensions and factors effective on HRD

Strategic Planning	Mankin, 2001; Gosney and Hughes 2016; Šiugždinienė, 2009; Sablok et al., 2017; Kieopairee, 2008,	
Management Development	Sablok et al., 2017,	
Job Planning	Sablok et al., 2017; Otoo and Mishra, 2018; Galperin and Lituchy 2014	
Technology	Wedchayanon, 2016 ; Kieopairee, 2008	
Budget	Kieopairee, 2008	
Management Support	Wedchayanon, 2016	
Organization structure	Mankin, 2001; Wedchayanon, 2016	
Organizational Culture	Mankin, 2001 ; Galperin and Lituchy 2014; Gosney and Hughes 2016	
Human Resource Management	Mankin, 2001	
Government policies	Bondarouk et al., 2010; Hatcher, 2009; Mankin, 2001.	
Knowledge Management	Hajilou et al. 2018	
Performance evaluation	Otoo and Mishra, 2018	
Information Technology	Banton, 2019; Wang, 2018	
Leadership	Nguyen and Hadikusumo, 2017	
Human Resource Development	Individual Development	Nguyen and Hadikusumo, 2017
	Organizational Development	Sablok et al., 2017; Hughes, 2019 ; Nguyen and Hadikusumo, 2017 ; Otoo and Mishra, 2018; Galperin and Lituchy, 2014 ; Mankin, 2001
	Team Development	Sablok et al., 2017; Hughes, 2019; )Nguyen and Hadikusumo, 2017; Otoo and Mishra, 2018; Galperin and Lituchy 2014; Gosney and Hughes 2016; Mankin, 2001
		Nguyen and Hadikusumo, 2017 ;Mankin, 2001

*Literature review*

The dimensions of HRD were identified due to the theoretical literature and given in Table 2, which form the basic conceptual model of the research.

According to Table 2, the conceptual and basic model of HRD is as illustrated in Fig. 1

**MATERIALS AND METHODS**

This study is considered an applied research from the perspective of goal since it evaluates the development of applied knowledge in the area of HRD in SOE. The research data consists of qualitative and quantitative data. Give that a questionnaire was provided to the experts besides interviewing with them, this research can be seen as a quantitative-qualitative concerning the data type. Since the study was focused on designing a HRD model for SOE, thus, it can be considered an exploratory research of content analysis type. The study population consisted of experts, including managers and employees with at least 10 years of experience, with higher related education and experience as a human resource manager in SOE. Since the present study was conducted quantitatively and qualitatively, therefore, the statistical sample was selected in two parts. In the qualitative part of the research, the research statistical sample consisted of experts in the area of HR and managers and experts in the field of HR planning and management of SOE in the city of

Mashhad. The purposive sampling by the snowball method was used in this research due to the type of employed method. The proper number of samples for the grounded data method is between 10 and 25 subjects based on the suggestion by Strauss and Corbin. The increase in this number depends on the theoretical saturation phase. In this study, 15 experts were used for semi-structured interviews who were accountable. The characteristics of these experts were as follows: Higher and related education fields, work experience of at least 10 years or more, history of human resource management in industry, knowledge and full mastery of the subject, sufficient motivation, cooperation with the researcher, and availability. The content analysis approach was utilized to analyze the qualitative method. There are seven steps in qualitative content analysis approaches as follows (Bagh Mirani et al., 2017):

1. Designing the questions that should be answered;
2. Selecting the desired sample (theoretical background) that should be analyzed;
3. Specifying the content analysis approach;
4. Designing the coding process (deductive and inductive);
5. Implementing the coding process;
6. Determining the validity and reliability;
7. Analyzing the results obtaining from the coding process.

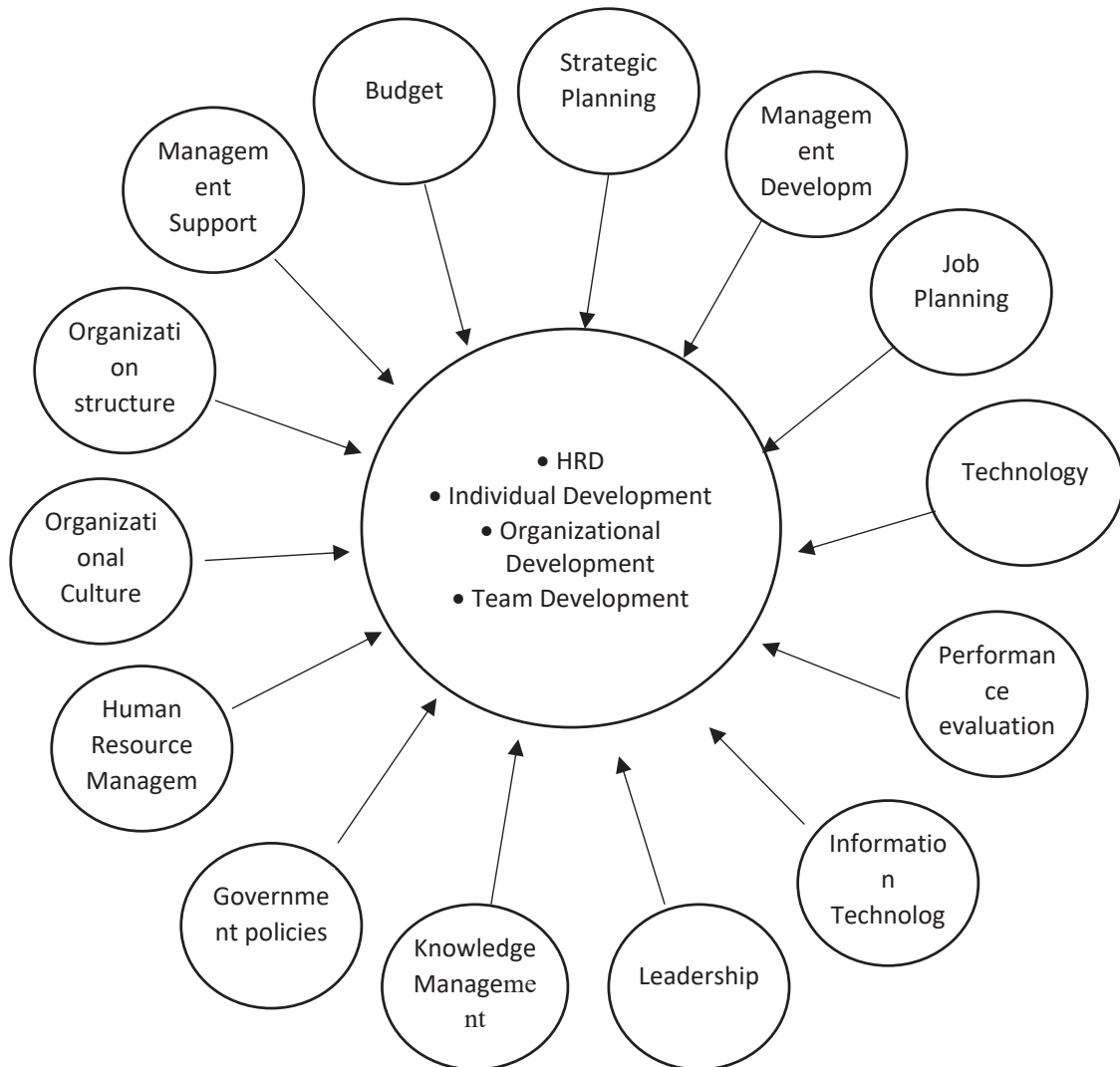


Fig. 1. The conceptual and basic model of HRD

In the quantitative part, the verbal propositions were screened with experts' opinions and fuzzy Delphi method, so, the initial conceptual model was designed. Then, interpretive-structural modeling method has been used to determine the relationships between the identified components and their leveling. Also, analytic network process (ANP) has been used to determine the weight and importance of the dimensions and criteria of human resource development. Finally, the MICMAC technique was used to detect and analyze the conductivity and dependence of the components.

## RESULTS AND DISCUSSION

### *Identifying categories by content analysis method*

In this section, each interview was analyzed after completion. Accordingly, the concepts and categories identified and determined during open and axial coding were considered in subsequent interviews. Also, the data of each interview were analyzed based on the three stages of open coding, axial coding, and the main category. The data were separated from each other in the first stage and open codes were extracted from them. Then, similarities and differences in the data were examined, and accordingly, the gaps in

areas that need more questions were specified. In the axial coding stage, the codes separated in the previous stage were connected in a new combination based on their relationships with other codes to form the concepts. The main category was considered in the third stage, in which, the codes of the axial coding stage of the concepts, which had been separated in the previous stage, were connected together in a new combination under the main category based on their relationships with other concepts. Then, the analysis was completed with the new data, followed by the appearance of the initial theoretical framework. Finally, the theory emerged from the heart of the data. In open coding, the main concepts obtained during the process were referred to. These concepts were broken down into small pieces in axial coding and described and explained as much as possible. In selective coding, these concepts were presented at a more general and more abstract level to demonstrate the basic principles of the work. Finally, a model was provided, which is indeed a theorem to describe the development of HR in SOE. This theorem narrates how the HRD system is designed, its components and relationships with other subsystems and internal and external systems. Accordingly, the categories extracted from the research concepts are listed in Table 3.

The research variables are illustrated in Fig. 2 according to the categories extracted from the research concepts.

*Determining the hierarchy by Interpretive Structural Modeling (ISM)*

The problem-solving was made in the present study with the ISM method (Lin et al., 2019) as

follows:

Step 1: Determining the variables used in the model

Step 2: Obtaining the Structural Self-Interaction Matrix (SSIM)

Then, the opinions of 22 experts who were fully aware of the research topic were used and the results of their comments were summarized in the Table 4.

Step 3: Obtaining the access control matrix

The access matrix was obtained by determining the relations as zeros and ones from the matrix obtained in the previous stage through 2 steps:

In the first step, initially is considered a single numerical scale and compare the numbers of the previous step table with it. If the corresponding number in the table is larger than the scale, is used the number one in the new table, and otherwise, used zero, as stated in Eq. 1

$$M = \begin{cases} a_{ij} = 1 & \text{if } a_{ij} \geq m \\ a_{ij} = 0 & \text{if } a_{ij} < m \end{cases} \quad (1)$$

Therefore, the component access matrix will be obtained by summing with the unit matrix as shown in Table 5.

In the second step, the matrix obtained in the first step is added to the unit matrix, as stated in Eq. 2

$$RM = M + I \quad (2)$$

Step 4: Adjusting the access matrix

Once the initial access matrix was obtained, its internal consistency needs to be established. Various methods have been proposed to make the

Table 3. The categories extracted from the research concepts

Main category	Concepts	Main category	Concepts
Organizational factors	Strategic planning	Occupational factors	HRD
	Budgeting		Career rotation
	Organizational structure		Job enrichment
	Information Technology		Career path
Empowerment	Communications	Behavioral factors	Career progression path management
	Education		Management and leadership
	Knowledge management		Motivation
	Talent management		Organizational culture
HRD	Performance appraisal		Creativity and innovation
	Individual development		
	Organizational development		
	Team development		

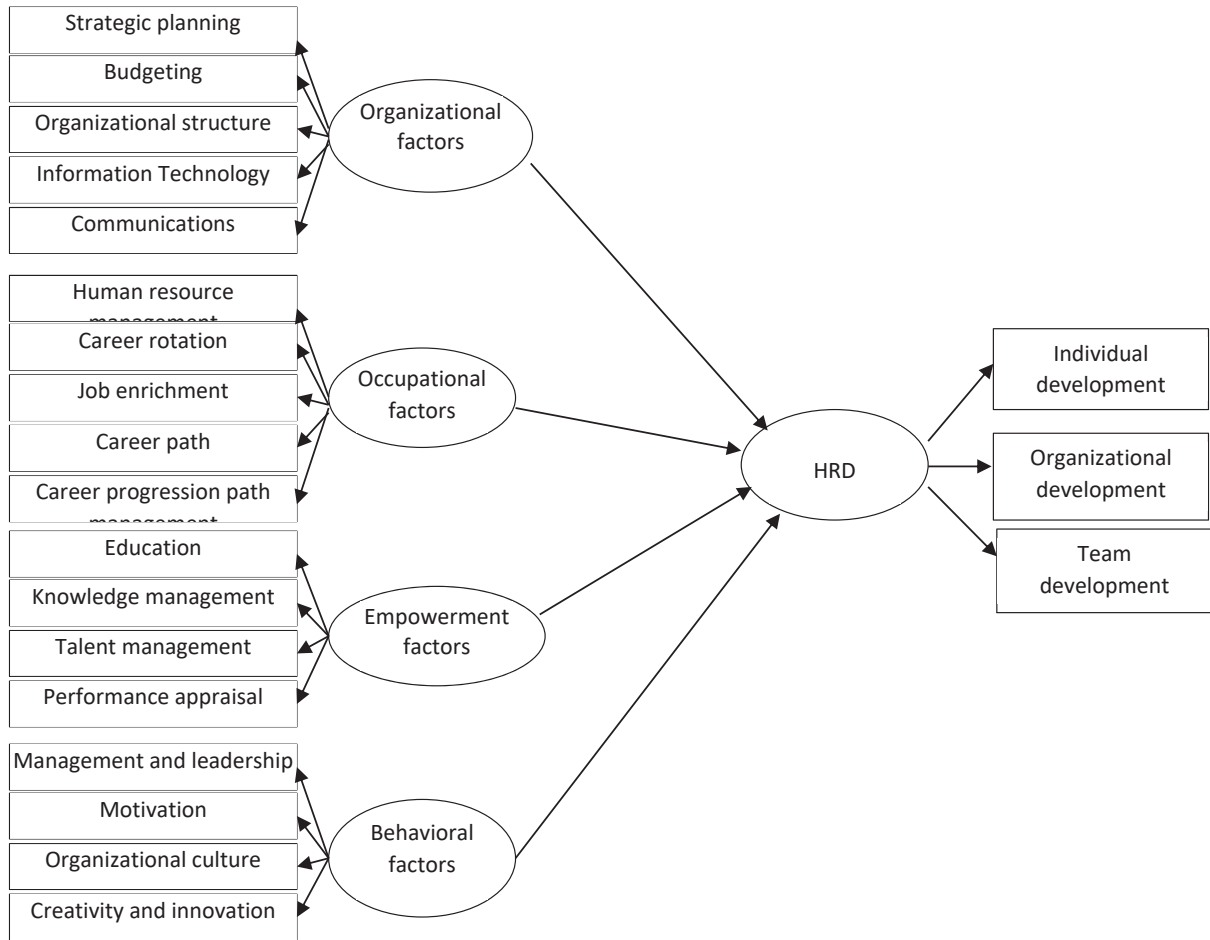


Fig. 2. The variables of the HRD model in SOE

Table 4. The SSIM matrix

Factors		1	2	3	4	5
Organizational factors	1	0	69	74	85	72
Occupational factors	2	45	0	73	69	86
Empowerment factors	3	57	55	0	60	81
Behavioral factors	4	61	82	86	0	79
Human resource development	5	63	59	49	56	0

Table 5. Access matrix

Factors		1	2	3	4	5
Organizational factors	1	1	1	1	1	1
Occupational factors	2	0	1	1	1	1
Empowerment factors	3	0	0	1	0	1
Behavioral factors	4	0	1	1	1	1
Human resource development	5	0	0	0	0	1

Table 6. The access matrix after adjustment

Factors		1	2	3	4	5
Organizational factors	1	1	1	1	1	1
Occupational factors	2	0	1	1	1	1
Empowerment factors	3	0	0	1	0	1
Behavioral factors	4	0	1	1	1	1
Human resource development	5	0	0	0	0	1

Table 7. Determining the levels of HRD components for SOE

Components		D (Direction)	R (Dependence)	D-R	Level	Result
Human resource development	5	1	5	-4	1	Dependent
Empowerment factors	3	2	4	-2	2	Dependent
Occupational factors	2	4	3	1	3	Connected
Behavioral factors	4	4	3	1	3	Connected
Organizational factors	1	5	1	4	4	Independent

matrix consistent; however, Boolean rule is used in this study. According to this rule,  $1 * 1 = 1$ . The calculations made and the consistency matrix formed for the components are shown in Table 6. According to the result, the access matrix was consistent.

Step 5: Determining the level and priority of variables

This process is done using the access matrix. After determining the access and prerequisite sets for each variable, common elements in the access and prerequisite sets are identified for each variable. In this study, the sum of rows and columns of the compatibility matrix based on the theory of Karimi et al. (2017) are used to determine the level instead of doing the achievable set calculations, the predecessor set, and common elements. The calculations are given in Table 7. Thus, the factors are classified into 5 levels based on the results of Table 7.

Step 6: Drawing the model

After determining the relationships and the levels of the components, they can be drawn as a model. To do so, initially, the components were adjusted in descending order according to their levels. In this research, the factors were on 4 levels. Fig. 3 shows the design of the interpretive-structural model for the partitioning of HRD components for SOE.

The component of “organizational factors” is at the highest level of the model (fourth level). These factors act as the foundation stone of the model, which affects the development of

HR. The improvement of HRD begins from this component and is directed to other components. The component of “organizational factors” also affects other components of its level. There are two “occupational” and “behavioral” components at the second level. These two components influence their next level besides their internal relationship between themselves. The “human resource empowerment” component is at the second level, which affects the first level component of “human resource development”. Therefore, the component of “human resource development” is at the first level, which is the result of other components of human resource development.

*Directing-Dependency Analysis (MICMAC)*

The MICMAC analysis aims to identify and analyze the power of directing and dependence of the components. The components are divided into four categories in this analysis based on their directing power and dependence rate. The information on directing power and dependency is provided in Table 7. The directing power and dependency of HRD components for SOE companies are illustrated in Fig. 4

1. The first category includes self-governing components, which have poor directing power and dependence. These variables are relatively unconnected to the system and have low or weak relations with the system. There are no variables

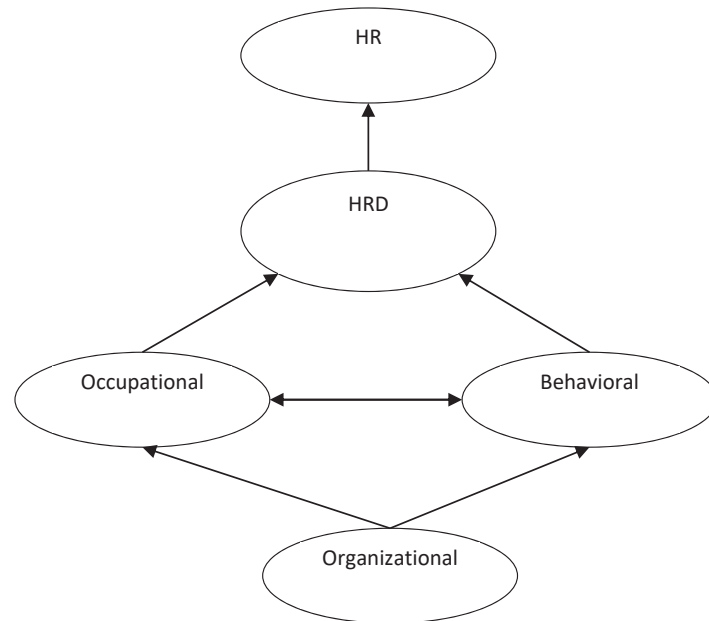


Fig. 3. The interpretive-structural model of HRD components model for SOE

		Cluster IV Driving Variable			Cluster III Linkage Variable	
Driving power	5	Organizational				
	4			Occupational- Behavioral		
	3					
	2				Empowerment	
	1					Development
		1	2	3	4	5
		Cluster I Autonomus Variable			Cluster II Dependent Variable	
		Dependence power				

Fig. 4. The analysis of directing–dependence power of HRD components for SOE

in this area, which indicates the correlation and relationship between factors.

2. The dependent components are the second category with low directing power but strong dependence. Two components of “human resource empowerment” and “human resource development” fall in this category. This variable mainly leads to success in HRD that many variables are involved in creating it, while they hardly can provide the context for other components by themselves.

3. The third category includes connected

components with high directing power and high dependence. These components are non-static since any changes in them can affect the system. Finally, the system feedback can change these components again. The “occupational” and “behavioral” components fall into this category in this research.

4. The fourth category includes independent components with strong directing power but weak dependence. These components act as the cornerstone of the model and they should be emphasized in the first place to initiate the system

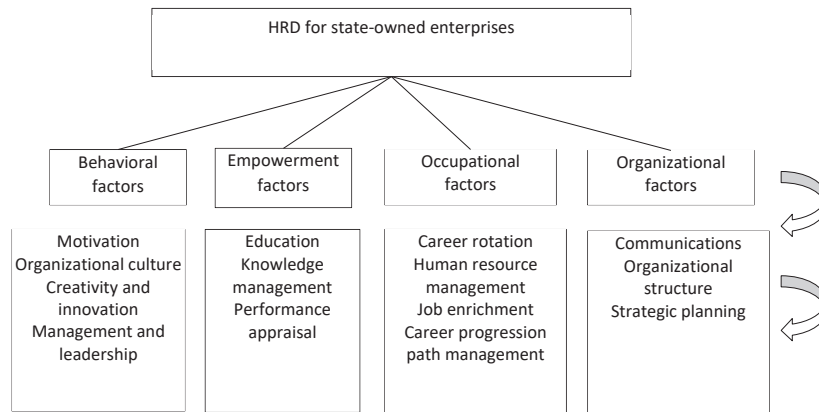


Fig. 5. A model with the research network structure for HRD for SOE

Table 8. The weight and importance of the dimensions and criteria of HRD for SOE

Weight and rank of dimensions	Criteria	Code	Weight and relative rank of criteria	Weight and final rank of criteria
Organizational factors C <sub>1</sub>	Communications  Organizational structure  Strategic Planning	C <sub>11</sub>	0.3471	0.0412 11
		C <sub>12</sub>	0.3255	0.0386 14
		C <sub>13</sub>	0.3274	0.0389 13
		C <sub>21</sub>	0.4451	0.0528 8
Occupational factors C <sub>2</sub>	Career rotation  HRM  Job enrichment  Career progression path management	C <sub>22</sub>	0.3358	0.0399 12
		C <sub>23</sub>	0.2579	0.0501 10
		C <sub>24</sub>	0.2646	0.0514 9
		C <sub>31</sub>	0.6029	0.1171 2
Empowerment factors C <sub>3</sub>	Education  Knowledge management  Performance appraisal	C <sub>32</sub>	0.6808	0.1322 1
		C <sub>33</sub>	0.5772	0.1121 3
		C <sub>51</sub>	0.2034	0.0735 6
Behavioral factors C <sub>5</sub>	Motivation  Organizational culture  Creativity and innovation Management and leadership	C <sub>52</sub>	0.285	0.103 4
		C <sub>53</sub>	0.2116	0.0765 5
		C <sub>54</sub>	0.2017	0.0729 7

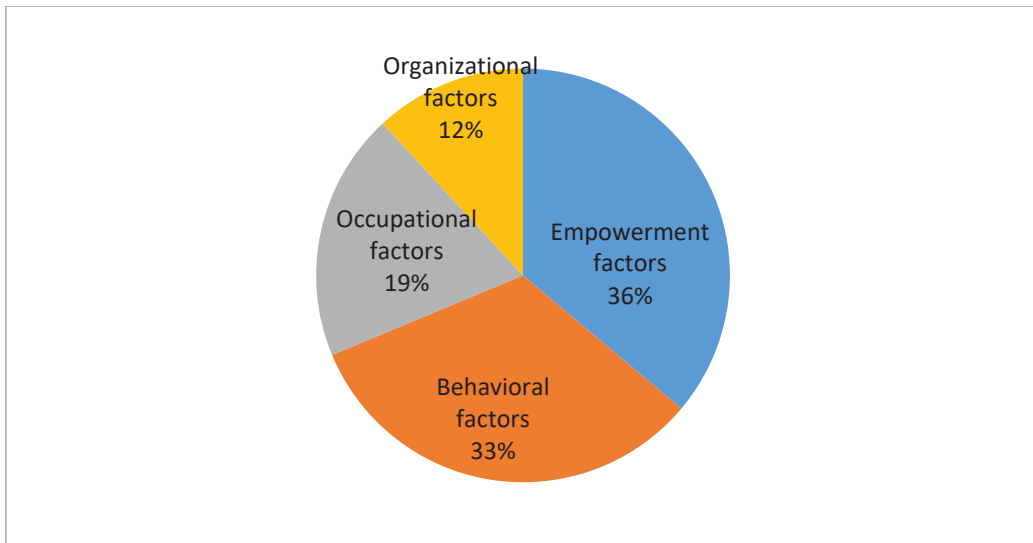


Fig. 6. The relative priority diagram of HRD dimensions for SOE

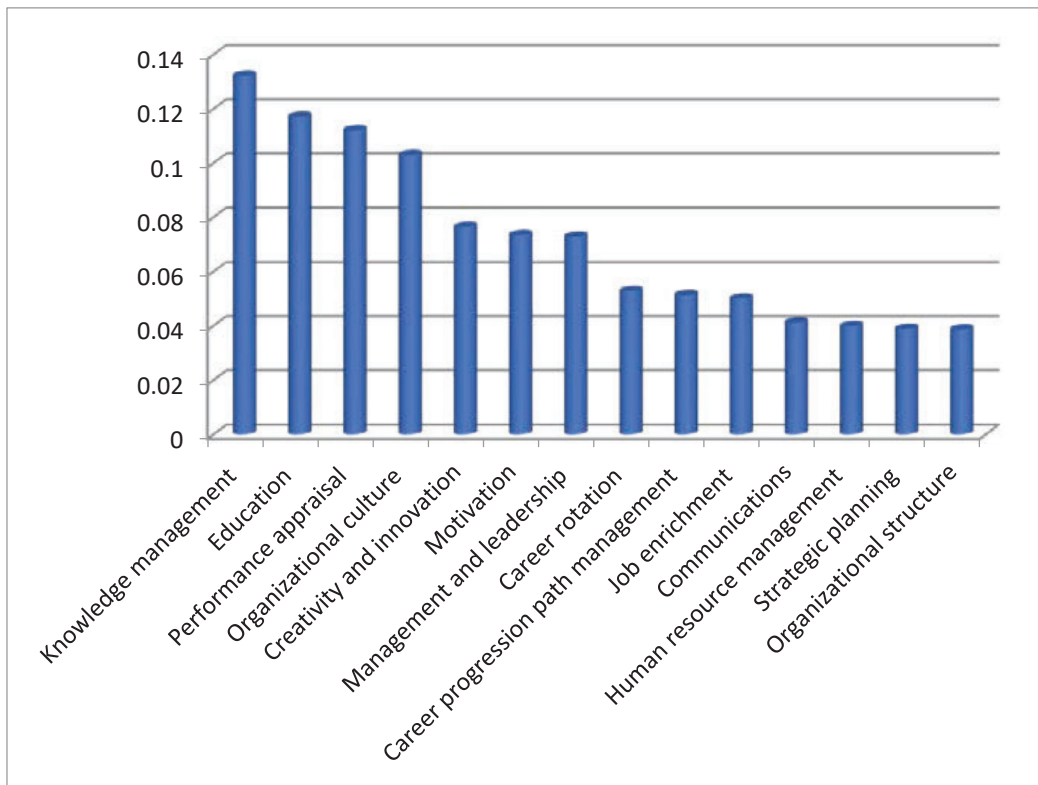


Fig. 7. The final priority chart of HRD criteria for SOE

function. The component of “organizational factors” is in this category in the present study.

#### *The results from the Analytic Network Process (ANP)*

In this research, based on the general relationship matrix, fuzzy ANP is solved. In this section, first, the general relationship matrix is normalized and the fuzzy unbalanced super matrix is obtained. The balanced (symmetric) super matrix was then resulted from multiplying the general relations of dimensions by the criteria. A balanced super matrix is a super matrix used for the final weight, which is obtained by normalizing the unbalanced super matrix where its sum appears as a row of number 1. The graph with the network structure of the research is shown in Fig. 5

Finally, the weight of the dimensions and criteria were determined and achieved by obtaining the bounded super matrix, which is shown in Table 8.

As shown in Table 8, the highest weight is related to the “empowerment factors” of the workforce with the weight of 0.361. “Knowledge management” has gained the first priority among the criteria. The criteria of “education”, “performance appraisal”, “organizational culture”, “creativity and innovation”, and finally “motivation” gained the second, third, fourth, fifth, and sixth priorities, respectively, among the 14 criteria, accounting for almost 61% of the total weight of the criteria. This reflects the great importance of these criteria.

Fig. 6 shows the priority diagram of dimensions and Fig. 7 shows the final priority diagram of the criteria by the F.ANP method

#### **CONCLUSION**

Management and HRD, which are seen as the largest asset of an organization, can help maximize the efficiency of the organization and lead the organization toward success in the community. The core of any organization’s success relies on organizational assets or HR. HR bear an important responsibility for the success or failure of the organization. HRD is a set of activities that support behavior change and learning opportunities for employees. The significance of HRD has been widely accepted in the world today. Emphasis on the importance of HRD is indirectly related to the profitability of organizations. Organizations should benefit from core competencies to achieve a sustainable competitive advantage based on their strategy. This study was performed to design

and present a HRD model for SOE organizations aimed at training thoughtful and highly skilled manpower to compete and gain competitive advantages. The research findings were obtained in two parts: Qualitative and quantitative. In the qualitative section, the dimensions, components, and indicators of the research were identified and categorized through interviews with experts. The research components were then screened by obtaining the opinions of 22 experts by the Fuzzy-Delphi method. In this regard, the experts commented on the removal, merging, addition, or aggregation of components. Finally, after analyzing the data by the fuzzy Delphi method, they ultimately reached a consensus on a HRD model for SOE organizations with 5 dimensions, including 17 components and 65 indicators. The dimensions included organizational factors, occupational factors, empowerment factors, behavioral factors, and human resource development. Therefore, the following suggestions are presented according to the above results and analyses:

- Managers can use the relationships and hierarchical levels specified in the ISM and SEM models to plan necessary actions aimed at improving human resource development. Accordingly, the variable “human resource empowerment” leads to success in human resource development, which needs to be improved immediately to bring success to the organization and improve its performance. To improve this factor, managers need to pay attention to the high levels of the model and improve the relationship determined between the factors. In general, managers can improve HRD according to the criteria of the factors identified. Some suggestions are given in the following to do so.

- The “knowledge management” component is the most important one in the HRD model according to the results of the importance of the components affecting human resource development. Therefore, the first suggestion and the first step of managers should be focused on improving this factor and they need to make continuous efforts in this area. For, paying attention to knowledge management has the greatest impact on the success of human resource development, and thus, it needs special attention. The following measures are recommended to improve this component:

1. The knowledge management system should be established based on the culture and structure of

companies.

2. Education and knowledge should be promoted through culture-making. For example, knowledge sharing can be supported and encouraged.

3. Information-sharing in the system should be highly focused on through special planning. For example, the knowledge employees should be supported. Also, synergistic social networks, committees, and professional associations of employees need to be established in companies to interact and share knowledge and experiences.

4. The knowledge should be developed in companies. For example, research and development units and areas of knowledge and research need to be created in companies. Also, the risk-taking capacity of the organization should be increased in carrying out innovative projects resulting from knowledge, creativity and innovation, new ideas and solutions.

The "education" component is at the second level of importance. Thus, it is suggested:

1. Educational need assessment should be done carefully and with planning. Environmental changes and the needs of the organization in the future should be considered in educational need assessment.

2. The training of staff should be planned. The hours required for training, training areas, place of training, how to convey training through physical or electronic presence should be considered in planning the training.

3. The training should be practical and specialized. The need of each person for the required expertise should be identified to hold the training tailored to their needs.

4. The training should be done continuously.

5. The coaching in the system should be focused on by trying to institutionalize such type of training since people acquire better skills along with experts.

The "performance appraisal" component is at the third level of importance in human resource development. Thus, it is suggested:

1. The performance appraisal system needs to be designed and implemented based on an appropriate method.

2. The behaviors and practices should be evaluated based on appropriate criteria. To this end, an appropriate performance appraisal system should be first designed to define and identify appropriate criteria.

3. The performance should be continuously

monitored and evaluated with appropriate indicators.

4. The performance feedback should be assessed in the system to identify and plan for each person's strengths and weaknesses.

The "organizational culture" component gained a fourth level of importance. The following are recommended to improve this component:

1. The culture of value-orientation should be created in companies so that the individuals come to the understanding that companies value them and consider them as a means to achieve goals, and thus, their development.

2. The participatory culture should be considered by participating individuals in decision-making as well as presenting new ideas and solving problems.

3. Work culture should be created. The work and the people who do the work should matter. A culture should be made that success in doing things better will lead to the success of people in meeting economic and social needs.

#### *Limitations*

There are limitations to any research, because science basically has a partial approach. The present study, since its audience is human, has been associated with the collection of information and the use of available resources or its own barriers and limitations. In addition, the results of the present study can be generalized to SOEs, and if necessary, generalization to other organizations of such nature should be done with caution and sufficient knowledge. Also, this research has been done cross-sectionally. Because of this, it makes it difficult to draw conclusions about causality.

#### **AUTHOR CONTRIBUTIONS**

A. Zamanimoghadam performed the literature review, experimental design, analyzed and interpreted the data, prepared the manuscript text, and manuscript edition. A. Heravi, A. Hashemi, Y. Vakil Alroaia and S.A. Sajadi performed data collection and correction, writing original draft preparation, writing reviewing and editing references 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.

### ABBREVIATIONS

$\alpha$	Level of significance
ANP	Analytical network process
CD	Career development
HR	Human resources
HRD	Human resource development
HRM	Human resource management
ISM	Interpretive structural modeling
OD	Organizational development
SAC	Supreme audit court
SOE	State-owned enterprises
SSIM	Structural Self-Interaction Matrix

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ORIGINAL RESEARCH PAPER

## Management and safety practices in utilization of agro-food waste among urban agro-producer households

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### ABSTRACT

**BACKGROUND AND OBJECTIVES:** Whereas management of waste in urban areas across the globe is essentially a public service, there is dearth of knowledge on waste management efforts at the household level in developing countries. The study aimed to avail crucial information on the largely informal management of agro-food waste that is practiced in low- and lower middle-income countries. Insights of safety measures adopted in the utilization of agro-food waste among urban agro-producers were explored empirically.

**METHODS:** An electronically-structured questionnaire was administered on a sample of 456 urban agro-producer households for data collection. Descriptive as well as Multivariate Probit models were employed for analysis.

**FINDINGS:** The results indicated significant disparities in management options and safety risk management practices between the participating and non-participating livestock and mixed producers. Waste reduction (86%), utilization (86%), segregation (63%) and composting (58%) were the most preferred waste management practices. Waste disposal (18%) and mixing with salt/dry feeds (24%) were lowly preferred methods. Whereas the regression models showed disparities in the contextual factors influencing management options and safety risk measures, the knowledge variables (waste sorting and urban agriculture knowledge) had greater influence across these agro-food waste aspects. This implies that implementation of education programs in agro-food waste management and safety risk management practices among urban agro-producer households by urban authorities would enhance sustainable food safety in urban food supply chains.

**CONCLUSION:** The findings could inform self-management efforts of agro-food waste in small-urban agribusinesses thus increasing economic benefits and improving environmental wellbeing.

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## INTRODUCTION

Environmental and health-related risks make management of waste an issue of global concern (Wilson *et al.*, 2015; Ferronato and Torreta, 2019). Perhaps in order to make its management efficient, waste is generally handled as a public service component (Beigl *et al.*, 2008; Abrate *et al.*, 2014). However, this has not translated to admirable results in some countries. In provision of waste collection services, urban authorities are often non-streamlined and corruption may influence the provision of services (Breukelman *et al.*, 2019; Gumisiriza and Kugonza, 2020). In most countries, waste management service in urban areas is a monopoly run by those who are in power (Abrate *et al.*, 2014; Abrate *et al.*, 2018) thus affected by accountability, corruption and inefficiency. In cases where city authorities are unable to address waste issues in a feasible way, they contract private service providers; public-private partnership. However, these contracts may be riddled by “under-the-table dealings” which bear more weight, eventually compromising waste management. Some countries even go a step further to privatize waste collection services to ensure accountability and quality of services (Kaza *et al.*, 2018). Waste management in developing countries is regarded as inefficient, narrow and may involve improper disposal of waste (Kassaye, 2018) with weak capacity systems. According to Henry *et al.* (2006) and Zohoori and Ghani (2017), urban centers of developing countries face the same municipal solid waste problems; illegal dumping, limited services, non-structured neighborhoods and poor waste infrastructure. An estimated 52 and 74 percent of waste in urban and rural areas of low-income countries remain uncollected compared to lower- and upper middle-income countries whose urban and rural uncollected waste range between 15-29 and 55-67 percent respectively. High-income economies’ urban and rural uncollected waste is even lower at zero and two percent respectively (Kaza *et al.*, 2018). As noted by Kassaye (2018), waste is generated from our ways of life especially in quest for satisfaction of development needs and wants through supply chain activities. In response, understanding the processes that lead to rise of waste and adopting requisite management practices is fundamental. From a public perspective, the wheels of transition from viewing waste as a problem to considering and tapping its value

are turning rather slowly in developing countries. Some urban authorities across the world have put in place appropriate mechanisms for recovery, reuse and recycling waste into other forms such as energy and compost (World Energy Council, 2016; Dubbeling *et al.*, 2016) in furtherance of the right to clean and healthy environment and economic empowerment for the population. However, according to Kaza *et al.* (2018), in low- and lower-middle income countries, public waste collection services do not reach the whole population. In response, households often make own arrangements to manage the waste they generate. The waste management efforts embraced at micro-level may have a significant impact on the overall waste management in urban areas by spinning and steering the wheels of waste perception transition. As a result, a resource management approach in dealing with waste has been increasingly adopted especially at the household level. Although not risk-free, initiatives such as composting and utilization of waste in urban agriculture have often been preferred. Urban agriculture as an alternative avenue for managing organic waste departs from the traditional methods such as dumping and landfilling. This illustrates a transition of waste from a burden to value; revealing the worth of resources concealed in waste (Menyuka *et al.*, 2020).

### *Waste management options*

In Bahir Dar City, Ethiopia, Wegedie (2018) established that households’ waste management practices included burning, burying and or dumping generated waste within their compounds. Dumping waste in undesignated places such as roadsides, river banks, and or vacant lands was also common. Some household adopted these practices notwithstanding that they received local authority services but were either considered undependable or inefficient. Notably, some households utilized waste for composting and as animal feed. Similarly, Brown (2015) indicated that in Tanzania, households managed waste through improper disposal (throwing along roads and drainage channels), designated place within their compounds, taking to public landfill, and/or handing to waste collectors. In Ghana, Adu-boahen *et al.* (2014) findings on waste management practices study indicated that burning was the most prominent choice although recycling and burying were practiced to a lesser extent. Waste management

practices in Kenya were found to be similar to those in Ethiopia, Ghana and Tanzania, where dumping was dominant though reuse, recycling and burning were practiced (Nthambi, 2013). Afroz *et al.* (2011) and Nigussie *et al.* (2015) brought in a perspective of selling agro-food waste as a management practice. Further, Jouhara *et al.* (2017) in the assessment of municipal waste management for home use showed that households could benefit from adopting segregation, composting, anaerobic digestion, combustion and sterilization management practices. Mu'azu *et al.* (2018) in their study summarized waste management practices to include reduction at source, feeding the needy, use as animal feeds, energy recovery, anaerobic digestion, composting, incineration and landfilling. The study indicated that in Saudi Arabia, although incineration and landfilling could be considered as waste management strategies, they represented the least preferable avenues since they were least beneficial. Source reduction was argued to be the most desirable option since it fulfils a religious obligation of judicious resource utilization and the value of food is not lost in the process unlike all the other practices. From a different angle, Kassaye (2018) categorized waste management approaches as conventional practices (top-down approach). In this case, public participation is not key. Command and control practices where the public is expected to follow bylaws and public-private partnership under medium- or long-term arrangement of sharing or transferring responsibilities. Kassaye (2018) arguments were more of local authority approaches but are key in the direction in which households may choose to manage their waste especially as groups, for instance in gated neighborhoods. In this regard, Knussen *et al.* (2004) indicated that past behavior was crucial in waste handling. In a study on household solid waste management in Tanzania, Brown (2015) findings showed that knowledge on local authority waste management regulations was a key driver in the choice of waste management practices. From another perspective, Kim *et al.* (2000) cited the role of women in food waste management in Korean society. Zakianis and Djaja (2017); Hellwig *et al.* (2019) and Loan *et al.* (2019) findings indicated the importance of knowledge in waste management. However, even though most of the households knew the related health dangers, majority (four-fifths) practiced illegal waste disposal. Surprisingly, almost

a fifth of the sampled households had no knowledge of the solid waste management services that the local authority offered. However, Ali and Song (2016) indicated that knowledge does not necessarily contribute to concern in waste management. Similarly, Alemayehu *et al.* (2017) cited rampant unauthorized dumping of waste in Ethiopia. Almost three-quarters of households practiced improper waste disposal. Guerrero *et al.* (2013) argued that provision of waste management information to residents may translate to improved waste recycling. Equally, Ezebilo and Animasaun (2011) and Kassaye (2018) reiterates the problem of inefficiency in waste collection by local authorities and the likely resultant emergence of private waste collectors and illegal dumping in Ethiopia and Nigeria. Mamady (2016) identified dumpsite, private and local authority collectors as the major waste management practices in Guinea which were either good or poor. The findings indicated that gender, education level, marital status, residential neighborhood, household earnings and access to permitted dumpsite (distance) were significant factors in choice of good and poor management practices. Furthermore, Gutiérrez-macías *et al.*, (2015); Bakshi *et al.* (2016); Truong *et al.* (2019) associated the low cost appeal for agro-food waste with its choice as an input. Comparably, the Malaysian waste management by local authorities was characterized by poor management though controlled, resulting to inadequate application of pollution mitigation measures. In a choice experiment for hypothetical assessment of waste disposal technology options (control, landfill and incineration), Pek and Jamal (2011) estimated the non-market prices of waste management options with anxiety, air pollution, land utilization and water quality (river) attributes. Varying choice sets of the technology attributes were used in labelling of disposal technologies. The findings showed that implicit prices were higher for technology specific options and distance from the current and proposed waste management facility were significant in determination of waste management fee. The approach of dichotomizing all management practices into good or poor aspect led to limitation of information whereas choice experimentation may have caused fatigue due to the size of choice set. This may have translated to low validity of information generated.

### Safety risk management practices

Literature shows that waste management practices can help to mitigate the likely negative effects of waste or possibly amplify them (Mamady, 2016). It was also evident that in utilization of waste resulting from human activities, it would be critical to consider the safety risk arising and therefore adopt appropriate risk mitigation measures. For instance, though becoming popular in some developing countries (Jouhara *et al.*, 2017), waste segregation practices at source have been minimal in most developing countries' waste management systems (Ferronato and Torreta, 2019; Kassaye, 2018). However, where practiced it is either not encouraged or is done poorly (Mu'azu *et al.*, 2018). This is a major oversight on the likely economic benefits from reusable and recyclable materials as highlighted by Wegedie (2018) and may become a potential safety risk source. When the environmental quality and health (human, livestock, soil and plants) is threatened, safety risk issues arise. In recognition of the risks associated with use of waste in urban agriculture, Drechsel *et al.* (2015) suggested health-based objectives such as health-outcome, water-quality, and performance and specified technology application target measures to manage associated risks. Moreover, in considering the ease of implementation of the foresaid strategies especially in developing countries, Drechsel *et al.* (2015) recommended use of basic strategies at farmer level. These included at least some level of wastewater treatment and drip irrigation preference to cut down pathogen load in waste application, and washing produce after harvest. Overnight storage of produce after harvest, disinfection, peeling and cooking were also cited as cost friendly on-farm interventions. Mamady (2016) conducted analysis of safety behavior (hygiene, proper disposal and child care) in waste management. Gender, age and education of the head as well as income and residential location of the household were significant in explaining household safety risk management behavior although Ashenmiller (2006) and Basev (2016) indicated mixed findings in regard to income effect in waste management. Likewise, past studies have expressed agro-food waste safety risk concerns especially in their utilization in farming activities. Salemdeeb *et al.* (2017) cited that European Union guidelines permits preferential use of food waste as animal feeds. However, use of most food waste as

animal feeds is illegal owing to potential disease risk but nevertheless the practice is growing. Contrastingly, in East Asia, heat is used to treat food waste to meet feed safety standards. Similarly, Rivin *et al.* (2014) and Bakshi *et al.* (2016) noted that size and high moisture content is a safety risk for using waste as animal feed but chopping, drying, ensiling, mineral and common salt mixing can be employed as risk management practices. Salemdeeb *et al.* (2017) further indicated that wet and dry pig feed technologies used in South Korea as well as anaerobic digestion and composting could be readily used in boosting safety of agro-food waste utilization. According to Zu Ermgassen *et al.* (2016), food waste processing as pig feed could translate to reduced land under pork production and safety risk of greenhouse emissions yet providing a low-cost animal feed. In 'Food waste to animal feed,' Westendorf (2000) outlined food waste that has been used as animal feed such as maize remains, wheat middling, distiller's residue, hotel waste and generally garbage. He further indicated that there were risk concerns associated with using food waste as feed. In pig feeding, producers employed safety risk management practices on food waste such as cooking, mixing garbage with grains and forage. Likewise, Haapapuro *et al.* (1997) indicated that there were likely health risks associated with using food waste on both livestock and humans. Drechsel *et al.* (2015) stresses the need for nutrient recovery in organic waste utilization in urban agriculture and in the process managing the likely safety risk of waste. Alike, Sabiiti (2011) delved on utilization of agricultural waste in urban Uganda for improving the organic matter and fertility of soil as well as animal feed as a way of managing the likely risk arising. Sánchez-bascones *et al.* (2008) and Gamroth (2012) identified livestock waste as a composting catalyst in crop residue. Waste segregation, composting and energy generation from agro-food waste were identified as critical in safety risk management (Saravanan *et al.*, 2013; Mamady, 2016; Jouhara *et al.*, 2017; Kassaye, 2018; Mu'azu *et al.*, 2018; Wegedie, 2018; Ferronato and Torreta, 2019). Whereas addressing safety risk issues in the utilization of agro-food waste may contribute to improved food safety in the urban food supply chain, the assessment of choice of safety risk management practices is remarkably scarce in literature. In Nairobi, Kenya, over 2,400 tons of waste are generated daily. About 30-40 percent of the waste

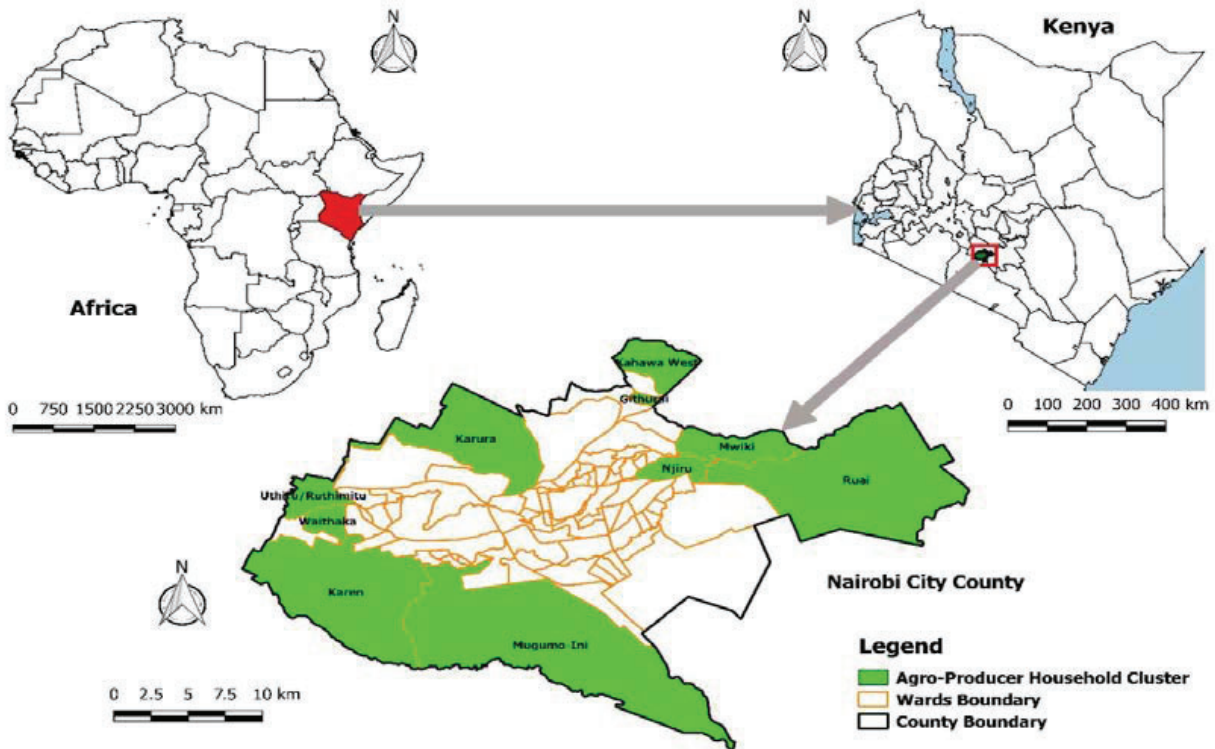


Fig. 1: Geographic location of the study area, Nairobi City County in Kenya

is not collected since only about 50 percent of urban population are served with waste collection services (NEMA, 2015; Kaza *et al.*, 2018). An estimated 68 percent of waste generated is domestic while food waste constitutes 57 percent (Ondiba, 2016). In taking advantage of the existing national feed and waste management policy gaps, some of the waste is recovered (NEMA, 2015). There is evidence of informal agro-food waste management efforts at the household level, although it is limited (Karanja *et al.*, 2010; FAO, 2012). As an alternative to conventional agricultural inputs, enhanced management of agro-food waste forms a support system for small-urban farm businesses. Therefore, the study sought to assess 1) contextual factors influencing choice of agro-food waste management options for waste generated within urban agro-producer households who had agricultural output market orientation and 2) safety risk management practices devised among urban agro-producer households for agro-food waste generated within the households and that which is acquired from elsewhere. The findings of the study would be of interest to urban center managers and

governments in formulation of a requisite framework for safe use of agro-food waste. It is also expected to invoke interest in agro-food waste commercialization by small-urban farm businesses. On overall, the study is expected to contribute to the research and development in agro-food waste management through improved data, models, and concepts in relation to safety risk practices. For this study, agro-food waste refers to agricultural and food waste. The agro-food waste typologies considered for this study included food, livestock and crop waste generated by households, restaurants, markets and processors as well as waste recovered from dumpsites in urban areas. The current study was carried out in Nairobi City County in 2020.

## MATERIALS AND METHODS

### Study area

The study was conducted in Nairobi City County (Fig. 1), the administrative capital of Kenya. The choice of the study area was informed by the city authority's effort towards streamlining urban agriculture through Nairobi City County Urban Agriculture Promotion

and Regulation Act, 2014 (RoK, 2014). The area is an important center for agricultural trade (local, imports and exports), processing, distribution and consumption thereby contributing to the amount of agro-food waste generated. In addition, over 20 percent of households in the City are involved in agriculture (Lee-smith, 2010). Land under urban agriculture is estimated to be 13.9 percent of the Nairobi City County surface area (RoK, 2018). Having the highest population of over 4,397,073 people (KNBS, 2019) compared to other major Kenya's urban areas, the area was projected to portray a higher diversity of agro-food waste management practices.

#### *Sampling and survey instrument*

The study sample involved a cross-sectional survey of urban agro-producer households who (a) had been involved in one or more agricultural enterprises, (b) produced agricultural products and sold some or all of it during the three months preceding the survey and (c) freely consented to participate in the survey. Agro-producer refers to a household producing agricultural products (and selling a portion of the produced products) in Nairobi City County. Small-urban farm businesses run by households were the respondents per se. The selection of respondent households was through a multi-stage sampling procedure. The first stage involved clustering the study area to 85 clusters as per the existing administrative wards. Purposive sampling of ten clusters based on past and present agricultural activities in the areas was used in the second stage. Although a smaller sample size of 356 had been estimated, a sample of 456 was used in order to establish meaningful association of parameters and sample size as cautioned by Wolf et al. (2013). Since the population of agro-producers in the respective wards was unknown during the survey, the total sample size of 456 for the study was distributed equally among the selected clusters; approximately 46 households. However, requisite adjustments were done later centered on the agricultural situation that was found in the specific wards. In the third stage, the cluster specific sample was selected through systematic random sampling in areas where a list of agro-producers was available. Lists of potential respondents were developed through pre-identification by field facilitators who were engaged during the study. In addition, the last stage involved

referral sampling in clusters where a list of potential respondents was not available. The requisite ethical approvals were granted by National Commission for Science, Technology and Innovation (NACOSTI) vide License No. NACOSTI/P/20/4406 before commencing the survey. An electronic-structured questionnaire designed in the Kobo Humanitarian platform under KoBoToolbox was implemented in the KoBoCollect mobile application in offline-online mode. Prior to data collection, requisite training of research assistants on how to execute the research questionnaire was conducted for two days using the KoBo mobile app and printed out questionnaire. This was followed by two days of pilot survey in order to test the research assistant's familiarity with the questionnaire, likely gaps, flow and adequacy of the instrument. Upon conclusion of the pre-testing phase, the principal investigator and the research assistants' shared experiences during the execution of the questionnaire. These views were assessed and where found compelling, they were incorporated into the questionnaire. The research assistants that portrayed difficulties during the pilot study were dropped while the rest were involved in the survey. The research assistants were required to inform potential respondents on their rights regarding their involvement in the study and subsequently consent to participate was obtained. The data collected were downloaded from KoBoToolbox in Microsoft Excel and exported to Stata 15 for cleaning and analysis.

#### *Analytical framework*

Influenced by literature, experience and intuition, the identified agro-food waste management practices that were likely to be practiced by urban agro-producers were waste reduction, utilizing, giving out or selling, and disposing. In managing agro-food waste through utilization, it was projected that small-urban farm businesses were likely to encounter safety risks which were likely to affect soil, air, water, crops, animals and humans. These risk perceptions necessitated sorting or segregation, cleaning (using water), heat treatment (cooking/boiling/steaming and or drying), composting, mixing (with dry feeds and or salt) and specific sourcing (sourcing only from self-vetted outlets) of agro-food waste as safety risk management measures in utilization. In literature, a common practice in choice of waste management practices has been the assumption

of mutually exclusiveness of waste management alternatives where Multinomial Logit (MNL) has been applied (Launio *et al.*, 2014; Nthambi, 2013; Molem and Enjema, 2017). However, given the numerous alternatives available for agro-food waste management and safety risk management, urban households could adopt several options concurrently, an indication that the assumption of mutual exclusiveness is misleading. MNL is suited for studies where the individual under observation can only make a single choice amongst various options at their disposal; it assumes exclusivity in choices (Bel and Paap, 2014). In real-life situations such as in waste management, an individual can make simultaneous choices which are correlated and therefore not mutually exclusive. Equally, the Multinomial Probit is challenged in that it requires a structural-error covariance matrix that is arbitrary up to a fixed element and therefore constrained beyond normalization (Bruno and Dessy, 2014). As an alternative, Multivariate Probit (MVP) model has been argued to be advantageous in that it enables a joint estimation of several associated binary outcomes. It employs a simultaneous approach rather than sequential approach in the determination of the influence in a set of independent variables on each of the different agro-food waste management options/practice choices by a household. Unlike MNL and univariate Probit, MVP allows for correlations between unobserved stochastic components and outcome (management choices) relationships. In addition, MVP enables derivation of marginal probabilities directly (Young *et al.*, 2006). Therefore, the study was based on the theory of choice (Launio *et al.*, 2014) using MVP.

**Management options**

Informed by the above insights, if a household *i* choose *k*, it is a representation of a choice set of agro-food waste management options/practices. The choice set could be made up of several management alternatives. Considering each agro-producer household can choose one or more management option/practice, then  $k = (Y_1, Y_2, Y_3, \dots, Y_n)$  depending on the choice set constitution. From this, the net benefit for the *i*<sup>th</sup> household was as depicted in Eq. 1.

$$Y_{ik}^* = U_k^* - U_0 > 0 \tag{1}$$

Where  $Y_{ik}^*$  a latent variable and U is utility.

Based on McFadden (1986) notion that choices can be altered by socio-economic and demographic variables, then the latent variable which is a product of management alternatives can be explained by the household characteristics as well as the disturbance that occurs in the estimation of resulting benefit. In essence, the covariance symmetric matrix gives rise to the MVP model (Tarekegn *et al.*, 2017). The system is based on the indicator function using Eq. 2 in which the unobserved choices are in a binary outcome (adopted = 1 or otherwise = 0) form for each of the management option/practice choices;

$$Y_i = \begin{cases} 1 & \text{if } Y_{ik}^* > 0 \\ 0 & \text{otherwise} \end{cases} \quad K = Y_1, Y_2, Y_3, Y_4 \tag{2}$$

Where,  $Y_i$  is the management option and K is options/practices choice set. Eq. 3 is a system of *j* equations which can be expressed as (Dessie *et al.*, 2018);

$$Y_{ik}^* = X_i' \beta_k + \varepsilon_i \tag{3}$$

Therefore, the anticipated agro-food waste general management options (choice set) were coded as waste reduction ( $Y_1$ ), utilize ( $Y_2$ ) give out or sell ( $Y_3$ ) and or dispose ( $Y_4$ ). The MVP model for the choice of agro-food waste management options are portrayed by Eq. 4, Eq. 5, 6 and 7.

Where  $\beta_k$  is a range of parameters to be estimated,  $X_i'$  are contextual and Extended Theory of Planned Behaviour construct variables, and  $\varepsilon_i$  is the disturbance term. Given Eq. 3, the choice of individual household agro-food waste management options/practices can be presented as;

Waste reduction  $Y_{1i}^* = X_{1i}' \beta_1 + \varepsilon_{1i} \tag{4}$

Utilise  $Y_{2i}^* = X_{2i}' \beta_2 + \varepsilon_{2i} \tag{5}$

Give out or sell  $Y_{3i}^* = X_{3i}' \beta_3 + \varepsilon_{3i} \tag{6}$

Dispose  $Y_{4i}^* = X_{4i}' \beta_4 + \varepsilon_{4i} \tag{7}$

Where  $X_i'$  is 1 x k vector of independent

variable that influences the choice of management options/practises,  $\beta_k$  being  $k \times 1$  vector of unknown parameters to be estimated, and  $\varepsilon_i$  is the error term with a multivariate normal distribution  $[MVN \sim (0, \Omega)]$  with a mean of zero and respective variance-covariance matrix  $V$  using Eq. 8. The values of  $V$  are one on the leading diagonal and correlations that is  $p_{11}, p_{22}, \dots, p_{66} = 1$  (Rodríguez-Entrena and Arriaza, 2013; Tarekgn *et al.*, 2017; Dessie *et al.*, 2018).

$$\Omega = \begin{bmatrix} p_{11} & p_{12} & p_{13} & p_{14} \\ p_{21} & p_{22} & p_{23} & p_{24} \\ p_{31} & p_{32} & p_{33} & p_{34} \\ p_{41} & p_{42} & p_{43} & p_{44} \end{bmatrix} \quad (8)$$

Where,  $p$  is probability.

#### Safety risk management practices

In response to the risk perceptions that agro-producer households have towards waste, requisite safety risk management practices are adopted. Therefore, a household  $i$  is likely to choose one or more safety risk management measures which are projected to include sorting ( $Y_1$ ), cleaning ( $Y_2$ ), heating ( $Y_3$ ), composting ( $Y_4$ ), mixing ( $Y_5$ ) and or specific sourcing ( $Y_6$ ). The choices are assumed to be simultaneous. Similar to the choice of agro-food waste management options, MVP was applied to assess the choice of safety risk management practices. As such the theoretical expressions for management options were similar to those of safety risk practices with a slight difference on the number of equations and the variance-covariance matrix. These are specified as Eqs. 9, 10, 11, 12, 13, 14 and 15.

$$\text{Segregation / sorting} \quad Y_{1i}^* = X_{1i}'\beta_1 + \varepsilon_{1i} \quad (9)$$

$$\text{Cleaning} \quad Y_{2i}^* = X_{2i}'\beta_2 + \varepsilon_{2i} \quad (10)$$

$$\text{Heating} \quad Y_{3i}^* = X_{3i}'\beta_3 + \varepsilon_{3i} \quad (11)$$

$$\text{Composting} \quad Y_{4i}^* = X_{4i}'\beta_4 + \varepsilon_{4i} \quad (12)$$

$$\text{Mixing} \quad Y_{5i}^* = X_{5i}'\beta_5 + \varepsilon_{5i} \quad (13)$$

$$\text{Specific sourcing} \quad Y_{6i}^* = X_{6i}'\beta_6 + \varepsilon_{6i} \quad (14)$$

$$\Omega = \begin{bmatrix} p_{11} & p_{12} & p_{13} & p_{14} & p_{15} & p_{16} \\ p_{21} & p_{22} & p_{23} & p_{24} & p_{25} & p_{26} \\ p_{31} & p_{32} & p_{33} & p_{34} & p_{35} & p_{36} \\ p_{41} & p_{42} & p_{43} & p_{44} & p_{45} & p_{46} \\ p_{51} & p_{52} & p_{53} & p_{54} & p_{55} & p_{56} \\ p_{61} & p_{62} & p_{63} & p_{64} & p_{65} & p_{66} \end{bmatrix} \quad (15)$$

## RESULTS AND DISCUSSION

The data analysis of study involved pre-estimation and post-estimation tests that aimed at boosting the reliability and validity of the results. Multicollinearity and cross-correlation tests were conducted. Likewise, post estimation tests that included Wald chi-square and Likelihood ratio tests were conducted as shown in Tables 3 and 4.

#### Descriptive analysis

The descriptive results compared the percentage choice of adoption and non-adoption of waste management practices as well as participation and non-participation in crop, livestock and mixed farming systems as presented in Table 2. The chi-square ( $\chi^2$ ) results showed that utilization of agro-food waste between crop production participants and non-participants were significantly different at  $p \leq 0.05$ .

Participants and non-participants in livestock production had significant differences in the choice of waste reduction, utilization and disposing at  $p \leq 0.01$ . The percentage of choice of agro-food waste management options among livestock producers were consistently higher for participants compared to non-participants except for disposing where non-participants' choice for the practice was higher. Similarly, choice of waste management options between participants and non-participants in mixed production showed consistent significant differences except for waste reduction option. Mixed producers had higher level of participation in waste reduction, utilizing and giving out than non-mixed producers. Proportion wise, this implies that urban agro-producers were more likely to adopt waste reduction, utilization and giving/selling agro-food waste upon generation than disposing but preferred waste reduction and utilization. The findings concurred with Mu'azu *et al.* (2018) that waste reduction at source was the most desirable and effective food waste management practice. The results displayed in Table 2 indicate that segregation and composting of waste were the most preferred safety risk management measures. Comparatively, heat treatment and mixing

Table 1: Description of variables used for the study

Variables	Measurement
Dependent variables	
Management options and safety risk management practices	Adopters=1; Non-adopters=0
Socioeconomic variables	
Sex of household head	Female=1; male=0
Age of household head	Number of years
Education level of the household head	Number of schooling years
Education level of woman of household	Number of schooling years
Household size	Number of persons in a household
Persons aged ≤5 years in a household	Number of persons in a household
Employment status of household head	Employed=1; otherwise=0
Woman of household employment	Employed=1; otherwise=0
Regular servant	Yes=1; no=0
Total garden size	Meter squared
Home ownership status	Own=1; do not =0
Urban agricultural knowledge	Ordinal scale (1-5)
Waste sorting knowledge	Ordinal scale (1-5)
Livestock production	Yes=1; no=0
Crop production	Number of crop enterprises
Monthly per capita agricultural income	Amount (KES)
Monthly per capita disposable income	Amount (KES)
Institutional variables	
Access to agricultural extension services	Access=1; no access=0
Access public waste collection services	Access=1; no access=0
Monthly private waste collectors charges	Amount (KES)
Waste variables	
Quantity of agro-food waste generated	Quantity (kg)
Experience in using agro-food waste	Number of years
Risk variables	
Safety risk training	Trained=1; not trained=0
Experience in implementing safety risk measures	Number of years
Behavioural Variables	
Behavioural intentions	Ordinal scale (1-5)
Past behaviour	Ordinal scale (1-5)

agro-food waste with salt or dry feeds were the least adopted safety risk practices although cleaning and specific sourcing had low scores as well. This may imply that segregation and composting were the most effective in dealing with safety risk issues arising from agro-food waste utilization. The results also revealed that the level of adoption of safety risk management measures was consistently higher among participating than non-participating livestock and mixed producers with exception of specific sourcing where non-participating livestock and mixed producers had a higher adoption rate. The difference in adoption of safety risk management strategies between participating and non-participating livestock and mixed producers were all significantly different (Table 2).

#### *Choice of agro-food waste management options among urban agro-producer households*

The MVP model for agro-food waste management options showed that the Wald test statistics (Wald  $\chi^2$  (84) = 261.25, Prob>  $\chi^2=0.00$ ) were significant at  $p \leq 0.01$ , implying that its subset of coefficients were jointly significant. This also implied that the model's explanatory power of the factors used provided a satisfactory fitting. Equally, the MVP model was significant since the management options lacked independence. The Likelihood ratio test (LR  $\chi^2$  (6) = 69.910, Prob>  $\chi^2=0.00$ ) implies that the agro-food waste management options were not mutually exclusive, an indication that the agro-producers chose them simultaneously. As such separate estimation of agro-food waste management options in urban

Table2.: Percentage choice of agro-food waste management options and safety risk management practices

Variable	Crop farming			Livestock farming			Mixed farming			$\chi^2$ value
	All producers	Participant	Non-participant	$\chi^2$ value	Participant	Non-participant	$\chi^2$ value	Participant	Non-participant	
General management options										
Reduce	86.40	86.37	100	0.16	88.73	79.09	6.60**	88.44	81.62	3.78
Do not reduce	13.60	13.63	0		11.27	20.91		11.56	18.38	
Utilize	85.53	85.71	0	5.92*	93.35	60.91	70.97**	93.44	66.91	54.25**
Do not utilize	14.47	14.29	100		6.65	39.09		6.56	33.09	
Give out/sell	26.75	26.59	100	2.74	28.90	20	3.38	29.69	19.85	4.71*
Do not give out/sell	73.25	73.41	0		71.10	80		70.31	80.15	
Dispose	17.54	17.58	0	0.21	8.09	47.27	88.57**	8.44	38.97	61.51**
Do not dispose	82.46	82.42	100		91.91	52.73		91.56	61.03	
Safety risk management practices										
Segregate	62.72	62.64	100	0.60	67.05	49.09	11.52**	66.88	52.94	7.92**
Do not segregate	37.28	37.36	0		32.95	50.91		33.13	47.06	
Clean	24.12	23.96	100	3.15	27.75	12.73	10.29**	27.19	16.91	5.51*
Do not clean	75.88	76.04	0		72.25	87.27		72.81	83.09	
Heat treat	21.71	21.76	0	0.28	25.72	9.09	13.58**	25.31	13.24	8.19**
Do not heat treat	78.29	78.24	100		74.28	90.91		74.69	86.76	
Compost	57.89	58.02	0	1.38	61.27	47.27	6.71**	63.13	45.59	12.04**
Do not compost	42.11	41.98	100		38.73	52.73		36.88	54.41	
Mix/salt/dry feed	23.90	23.96	0	0.31	30.35	3.64	32.74**	30	9.56	21.92**
Do not mix	76.10	76.04	100		69.65	96.36		70	90.44	
Specific source	32.68	32.75	0	0.49	29.19	43.64	7.92**	27.50	44.85	13.06**
No specific sourcing	67.32	67.25	100		70.81	56.36		72.50	55.15	

\*significance at 5% and \*\*significance at 1%

Table 3: Choice of agro-food waste management options among urban agro-producer households

Variables	Waste reduction	Utilize	Giving out/sell	Dispose
	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)
Sex of head	0.4767(0.2322)*	0.1018(0.2260)	-0.0213(0.1673)	-0.1161(0.1939)
Age of head	-0.0148(0.0084)	0.0054(0.0083)	0.0019(0.0063)	-0.0061(0.0070)
Education of head	0.0168(0.0233)	-0.0303(0.0243)	0.0033(0.0184)	0.0040(0.0216)
Employment of head	0.5076(0.2666)	0.3802(0.2481)	0.0375(0.1818)	-0.0922(0.1958)
Household woman employment	-0.6924(0.2573)**	0.0756(0.2782)	0.1066(0.2103)	0.3666(0.2237)
Household size	0.0346(0.0492)	-0.0357(0.0508)	0.0644(0.0382)	0.0322(0.0391)
≤5 years	-0.0433(0.1297)	-0.0895(0.1410)	-0.0221(0.1053)	-0.0443(0.1186)
Agriculture knowledge	0.2625(0.1143)*	0.0995(0.1269)	0.1244(0.0855)	0.0673(0.0927)
Regular servant	-0.2141(0.2402)	0.4795(0.2802)	0.0573(0.1792)	0.0955(0.2150)
Waste separation knowledge	0.2889(0.0894)**	0.4531(0.0949)**	-0.1478(0.0682)*	-0.2254(0.0775)**
Home ownership	0.5152(0.2897)	-0.4431(0.3058)	0.4527(0.2817)	-0.0710(0.2288)
Garden size	0.0315(0.0807)	0.1007(0.0750)	-0.0983(0.0653)	-0.0209(0.0651)
Livestock	0.0356(0.0970)	0.5867(0.1349)**	-0.0463(0.0726)	-0.2470(0.0952)**
Crops	0.0369(0.0339)	0.0041(0.0351)	0.0002(0.0239)	0.0331(0.0269)
Lnurban agriculture income	0.0452(0.0773)	-0.1645(0.0802)*	-0.0130(0.0629)	0.0208(0.0637)
Ln disposable income	0.1362(0.1288)	-0.0340(0.1304)	-0.1312(0.1025)	0.1009(0.1146)
Access to public waste collection	0.4889(0.4420)	-0.0620(0.3353)	0.2168(0.2678)	0.5696(0.2483)*
Ln monthly private collection fees	0.6131(0.3744)	0.3889(0.3806)	-0.4327(0.3071)	0.1878(0.3139)
Quantity of waste generated	-0.0242(0.0740)	0.1253(0.0700)	0.2209(0.0562)**	-0.3227(0.0688)**
Behavioural intention	-0.4170(0.1455)**	0.0670(0.1305)	-0.2237(0.1030)*	0.0346(0.1110)
Past behaviour	0.2622(0.1938)	-0.3571(0.1729)*	0.7554(0.1435)**	0.0920(0.1613)
Constant	-4.9228(2.6069)	-0.7489(2.5276)	0.3354(1.9872)	-0.7997(2.1582)

N=456; Log likelihood=-543.416; Wald  $\chi^2$  (84)=261.25, Prob>  $\chi^2$ =0.00; LR  $\chi^2$  (6)=69.910, Prob>  $\chi^2$ =0.00

\*significance at 5% and \*\*significance at 1%

households would have been biased (Tarekegn *et al.*, 2017; Dessie *et al.*, 2018). Therefore, the null hypothesis that  $\rho$  (rho) values = 0 was rejected. This confirms the appropriateness of the MVP model for the study. The MVP model results (Table 3) revealed that there were disparities of contextual factors that determined the choice of agro-food waste management options among urban agro-producer households. Household women in employment were less likely to implement reduction of agro-food waste efforts at source thus more waste generation in a household. This may imply that employed women had inadequate time to oversee agro-food waste reduction at their households. Although focussing on consumer households, Kim *et al.* (2000) had similar findings in regard to younger employed women who were associated with frequently eating out and higher food waste. Women headed households were more likely to adopt waste reduction practices, implying that women were perceived to have important influence in agro-food waste reduction. This notion could be associated with the role of women as custodians of food related resources in households across many societies of the world. The

findings coincided with those of Kim *et al.* (2000) who associated food waste management with women who were said to have critical influence in its reduction. Further, Secondi *et al.* (2015) established that women were likely to waste more food than men. Contrary, Barr (2007) revealed that women were associated with higher likelihood of reducing waste. Household heads with more knowledge on waste sorting and urban agriculture were more likely to opt for waste reduction as a management option. Higher urban agricultural knowledge may be associated with higher understanding of what it entails to bring food on the table. Additionally, higher knowledge may be associated with a higher understanding of agro-food waste effects as such opting for waste reduction.

SIANI (2017) associated increase in knowledge with reduction in food waste across Sweden which was being fostered through raising awareness and collaborations. The findings concurred with Brown (2015) that knowledge is critical in waste management. The behavioural intention towards utilization of waste had an inverse effect in adopting waste reduction. This imply that urban agro-producer households' intentions to utilize agro-food waste was

likely to increase waste generated thus hampering the waste reduction efforts. Probably this is because of eventual loss of value; waste's value is lesser than the actual product value. These findings concurred with Russell *et al.* (2017) of a negative relationship between intention and food wasting behaviour where respondents who exhibited negative emotions when they thought about food waste ended up wasting comparably more food. The MVP results further revealed significant influence of waste sorting knowledge on waste reduction, utilization, giving out/selling, and disposing. More knowledge in waste sorting in households was likely to increase waste reduction and utilization but reduced the likelihood of giving out/selling and disposing. In other words, agro-producer households that practiced waste sorting were more likely to utilize agro-food waste they generated than giving out, selling or even disposing. Additionally, having high level of waste sorting knowledge enabled households to segregate agro-food waste more effectively. As a result, households were able to map out their agro-food quantities and typologies wasting trend thereby likely to devise ways of managing it better. However, these findings contradict those of Ali and Siong (2016) where higher knowledge does not translate to concern or the urge to implement waste management practices such as reduction. The contradiction could have been influenced by the attitude of the Shah Alam City residents on waste management, which was generally negative. Livestock producing households were likely to utilize waste generated in their households. Probably, these materials were used to feed on their animals in an effort to manage agro-food waste. This implies that agro-food waste supplement conventional feeds in livestock production enterprises. The findings coincided with those of Wegedie (2018) where cattle feeding was an important avenue in agro-food waste management. Increased income from urban agriculture among urban agro-producer households was more likely to reduce agro-food waste utilization. The choice may be in favour of alternative agricultural inputs especially when agro-food waste was associated with filth and likely risks of its utilization. The results were supported by Ashenmiller (2006) that low-income households were likely to recycle waste especially motivated by monetary benefits. The findings were reasonable considering urban agro-producer

households participated in urban agriculture and utilized waste for income and minimizing the cost of production associated, respectively. However, Basev (2016) findings revealed that students from high-income households were more likely to recycle waste compared to their low-income counterparts. Past behaviour of an urban agro-producer household in utilization of agro-food waste was a likely hindrance in its adoption as a waste management option. Past perceived challenges associated with agro-food waste utilization may have had a stake in forming present behaviour. Therefore, where minimal or no utilization of agro-food waste had been practiced in the past it would have likely contributed to lesser utilization of agro-food waste. The results coincided with Knussen *et al.* (2004) findings that positive past behaviour in recycling waste had strong influence on the present waste handling behaviour. Monthly per capita quantity of agro-food waste generated from a household was associated positively with giving out or selling, implying that the higher the waste generated the higher the likelihood it was to be either given out or sold. This indicates that low amounts of waste did not warrant consideration of others as an avenue for its management but, increased quantities of generated waste encouraged market transactions. Probably, the results may be associated with low value of small quantities of agro-food waste compared to large quantities that have higher value. The findings concur with observations made during the survey that a few households gave out waste generated to their neighbours and in return they received agricultural products especially milk; payment in kind. Afroz *et al.* (2011) and Nigussie *et al.* (2015) associated waste generation (crop residue and animal waste; organic waste) in households with its sale. This enabled household to raise some income. Commercial utilization behavioural intention had a negative influence on the choice of the giving out. The relationship implied that intended use of agro-food waste discouraged the adoption of selling/giving out option. These findings seemed reasonable since agro-producer households used generated waste to supplement conventional inputs and as such inclined towards utilizing it in their gardens compared to giving it out/selling. On the contrary, past behaviour's positive influence on giving/selling meant that households opted to give out/sell waste upon generation based on past behaviour. This

Table 4: Choice of safety risk management practices in utilization of agro-food waste among urban agro-producer households

Variables	Segregation	Cleaning	Heating	Composting	Mixing	Specific sourcing
	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)
Sex of head	-0.0025(0.1798)	0.1859(0.1571)	0.0845(0.1645)	-0.1566(0.1396)	-0.0471(0.1756)	0.1716(0.1456)
Age of head	0.0053(0.0068)	0.0061(0.0061)	0.0003(0.0062)	0.0083(0.0053)	-0.0018(0.0067)	0.0009(0.0055)
Household size	0.0014(0.0346)	-0.0120(0.0286)	-0.0173(0.0318)	-0.0024(0.0254)	-0.0432(0.0342)	0.0052(0.0259)
Employment of head	0.3440(0.1881)	-0.2928(0.1841)	-0.0781(0.1870)	0.1141(0.1593)	-0.0730(0.1996)	-0.2312(0.1653)
Household woman employment	0.2900(0.2219)	-0.2604(0.2143)	-0.2010(0.2266)	0.2424(0.1858)	-0.0818(0.2420)	-0.0035(0.1924)
Home ownership	0.0851(0.2426)	0.5423(0.2662)*	-0.0900(0.2247)	0.2697(0.1966)	0.0799(0.2844)	-0.3262(0.1983)
Agriculture knowledge	0.2197(0.0811)**	0.2460(0.0795)**	0.2980(0.0849)**	-0.0087(0.0674)	0.1703(0.0832)*	-0.0801(0.0703)
Extension access	0.7828(0.2034)**	0.2414(0.1606)	-0.0523(0.1743)	-0.1775(0.1499)	-0.2055(0.1788)	-0.5059(0.1607)**
Waste separation knowledge	0.6843(0.0767)**	0.1358(0.0672)*	0.1624(0.0680)*	-0.1812(0.0586)**	0.3374(0.0777)**	-0.1279(0.0593)*
Livestock production	-0.0195(0.2026)	0.3480(0.2022)	0.6757(0.1736)**	0.4445(0.1609)*	1.0328(0.2788)**	-0.2536(0.1647)
Experience using waste	-0.0012(0.0034)	0.0001(0.0033)	0.0016(0.0032)	-0.0010(0.0023)	0.0028(0.0030)	0.0005(0.0024)
Livestock agriculture income	0.0032(0.0146)	0.0075(0.0131)	0.0346(0.0139)*	0.0048(0.0118)	0.0109(0.0144)	0.0080(0.0122)
Safety risk training	-0.3382(0.2310)	0.3321(0.2010)	-0.2147(0.2171)	0.3632(0.1938)	0.2564(0.2237)	0.4178(0.1910)*
Experience in safety measures	0.0098(0.0060)	0.0148(0.0065)*	0.0174(0.0053)**	-0.0057(0.0050)	0.0227(0.0054)**	0.0033(0.0050)
Behavioural intention	0.4194(0.1154)**	-0.0598(0.1003)	0.0525(0.1086)	0.0984(0.0875)	0.3644(0.1121)**	0.0925(0.0905)
Past behaviour	0.0658(0.1454)	0.0920(0.1249)	0.0226(0.1362)	0.1879(0.1168)	0.2109(0.1411)	0.5149(0.1210)**
Constant	-1.7247(0.6462)	-2.9937(0.6054)	-3.0343(0.6427)	-0.9837(0.5025)	-2.5921(0.6689)	-0.3418(0.5102)

N=456; Log likelihood = -1296.92; Wald  $\chi^2$  (96) = 410.67, Prob >  $\chi^2$  = 0.0000; LR  $\chi^2$  (15) = 63.7853 Prob >  $\chi^2$  = 0.0000

\*significance at 5% and \*\*significance at 1%

implies that the more positive the past behaviour in utilizing waste, the higher the likelihood for the agro-producers to give out/sell the waste generated. Probably, this indicates that experience gained in utilizing agro-food waste led to increased waste market transactions. Therefore, intentions limited the adoption of the giving out/selling option but past behaviour enhanced it. Agro-producer households were more likely to dispose waste generated if they had a higher access to the public waste service. This may also indicate that most agro-producers were forced to self-manage agro-food waste they generated since they had limited or no access to urban authorities' waste collection services. As such, enhanced public waste collection was likely to reduce the intensity of agro-food waste use in urban agriculture. Livestock production had a negative association with disposal of waste as a management option. This implies that a household was less likely to dispose waste if it practiced livestock production. This is an indication that agro-food waste generated in a household is considered an important feed resource in livestock enterprise due to its perceived low cost and availability. These findings were supported by [Gutierrez-macias et al. \(2015\)](#); [Bakshi et al. \(2016\)](#) and [Truong et al. \(2019\)](#) that agro-food waste can be a key feed component for livestock. However, [Westendorf \(2000\)](#) and [Saleem et al. \(2017\)](#) cautioned the use of waste as feeds due to likely pest and disease risks. The quantity of agro-food waste generated had negative influence in adopting disposal management among households, implying that the higher the quantity of agro-food waste generated from a household, the lesser the likelihood of its disposal. Perhaps this is because large quantities of agro-food waste generated in a household attracts a higher economic benefit resulting to its economic usability.

#### *Choice of safety risk management practices in utilization of agro-food waste among urban agro-producer households*

The MVP model ([Table 4](#)) for agro-food waste safety risk management practices was significant as indicated by the Wald test statistics (Wald  $\chi^2$  (96) = 410.67; Prob >  $\chi^2$  = 0.0000). The test statistics implies that the model subset of coefficients were jointly significant and its explanatory power of the adopted factors provided satisfactory fitting. This also implies that the model was significant since

the choice decisions of agro-food waste safety risk management practices were interdependent. The likelihood ratio test (LR  $\chi^2$  (15) = 63.7853; Prob >  $\chi^2$  = 0.0000) indicated strong significance in the choice of management practices and supported presence of the joint correlations thus the  $\rho$  (rho) values were greater than zero ([Tarekegn et al., 2017](#); [Dessie et al., 2018](#)). This implies that the null hypothesis that the  $\rho$  (rho) values = 0 was rejected. The test statistics supported the suitability of the MVP model in assessing the choice of safety risk management practices. The MVP results for the choice of safety risk management practices among urban agro-producer households are presented in [Table 4](#). Higher urban agriculture knowledge was associated with greater adoption of agro-food waste segregation, cleaning, heating and mixing practices. The association may imply that higher urban agriculture knowledge indicated increased awareness on agricultural perspectives thus contributing to improved understanding in implementing safety risk management practices. Higher knowledge may also imply a greater ability to interpret and utilize agricultural information in choosing and implementing agricultural practices that would enable them to effectively manage agro-food waste. Since the adoption of the management practices was simultaneous, the influence of urban agricultural knowledge on various safety risk management practices may imply that the practices were supplemental to each other. The findings corresponded to those of [Hellwig et al. \(2019\)](#) that knowledge contributes to waste sorting management behaviour.

The increase in waste separation knowledge was likely to sway agro-producer households to enhance adoption of segregation, cleaning, heating and mixing but contribute to decline in composting and specific sourcing. Increased knowledge in waste separation may be an indicator of agro-producers' ability to understand the effects of agro-food waste utilization. As a result, agro-producers with higher knowledge in waste separation were likely to choose relatively more effective safety risk measures. Waste segregation knowledge seemed to be the prerequisite for performing segregation, cleaning, heating and mixing management practices. This improved the ease of implementing and effectiveness of these safety risk management practices. Similarly, [Zakianis and Djaja \(2017\)](#) findings associated low

household waste management knowledge with lesser sorting behaviour in Indonesia. On the other hand, higher waste separation knowledge reduced adoption of composting and specific sourcing. This aspect implies that segregated waste was less likely to be composted; an indication that agro-food waste that was set aside for composting was not likely to be sorted. Similarly, increased waste separation knowhow reduced the choosy behaviour in acquisition of agro-food waste. This implies that agro-producers who had higher waste separation knowledge were not worried about the source of agro-food waste acquired since they could easily manage it through efficient waste sorting. Contrary, [Loan et al. \(2019\)](#) findings indicated that knowledge and compost training had positive significant influence on composting participation which compares well with this study's significance of waste separation knowledge. Increased access to agricultural extension services among agro-producer households enhanced adoption of segregation and specific sourcing management strategies in utilization of agro-food waste. Higher access to extension services implies higher diffusion of agricultural knowledge thus empowering agro-producers in managing risks associated with agro-food waste. By limiting the sources of waste, agro-producers may have minimized the likely sources of risk. This implies that through extension advice, agents may encourage limiting of agro-food waste sourcing to contain likely pathogens and disease factors. [Guerrero et al. \(2013\)](#) were of the view that when citizens receive information on waste recycling benefits and how to implement sorting, it translated to higher likelihood of adopting recycling behaviour. Livestock production in urban households influenced higher adoption of heating as a safety risk management practice. This implies that use of heat was likely to kill and/or minimize the microbes posed by agro-food waste utilization in livestock production. Agro-producer narrations during the survey indicated that heat treatment practice was specially used by agro-producers who were involved in pig production where agro-food waste was boiled or steamed to soften as well as disinfect it. However, other livestock producers especially those involved in dairy production dried agro-food waste (brewer's residue, vegetable and food waste) under direct sunlight to reduce its odour and moisture content

before feeding it to animals. The heat treatment practices were adopted to eliminate likely transmission of pathogens and zoonotic diseases (Anthrax, Brucellosis, Rift Valley Fever, Tuberculosis, Salmonellosis among others) to livestock (especially pigs) and then to humans. According to [Westendorf et al. \(1996\)](#) and [Haapapuro et al. \(1997\)](#), any agro-food waste that has or had contact with meat or meat products is mostly associated with the likely disease transmissions. [Beyihayo et al. \(2015\)](#) advised on the necessity for boiling and drying waste for pigs to kill pathogens and reduce anti-nutritional factors. Agro-producers were more likely to adopt composting if they were involved in livestock production. The findings coincide with observations made during the field survey where agro-producers heaped animal and crop waste in alternate layers to compost. The indications were that animal waste accelerated the process of composting crop waste. As such agro-producers were able to produce higher quantities of compost manure within shorter periods. [Sanchez-bascones et al. \(2008\)](#) and [Gamroth \(2012\)](#) concurred with the findings in that animal waste speeds up the composting process thus improving waste management rapidly. Livestock production increased the likelihood of adopting the mixing of salt and or dry feeds with agro-food waste practice than non-livestock producers. Some agro-producers indicated that salt was used to minimize pest and microbial effects emanating from waste. For instance, salt was used to kill and eliminate snails and the slimy mucus that they left on waste and fodder. Apart from minimizing agro-food waste risks, farmers' narrations during the survey revealed that they sprinkled salt and dry commercial feeds on waste to entice animals into consuming their feed portions. The findings were similar to [Rivin et al. \(2014\)](#) and [Bakshi et al. \(2016\)](#) recommendations in mixing dry feeds and common salt in utilization of agro-food waste to manage moisture and contaminants respectively. The findings concurred with [Saravanan et al. \(2013\)](#); [Mamady, \(2016\)](#); [Jouhara et al., \(2017\)](#); [Kassaye, \(2018\)](#); [Mu'azu et al., \(2018\)](#); [Wegedie, \(2018\)](#); and [Ferronato and Torreta, \(2019\)](#) that waste management contributes to safety risk mitigation. Adoption of cleaning, heating and mixing practices were likely to rise with increased experience in implementing safety risk measures while utilizing agro-food waste. Accumulated

experience in utilizing agro-food waste may be an indicator of amassed knowledge thus ability to identify the most effective safety risk management measures. As such increased knowhow among the agro-producers contributed to their empowerment in safety related decision making. Similar findings were reported by Kritzinger (2017) whose study candidly explored the role of experience in safety assessment. Higher commercialization intentions among agro-producers in using agro-food waste were likely to boost the adoption of waste sorting at the household level. This implies that projected demand for agro-food waste for urban agriculture was a driver for waste separation thus increasing its usability. The segregation approach may be meant to minimize the likely risk on urban agriculture investment. In concurrence, Yu et al. (2018) indicated that behavioural intentions were critical in forming the waste sorting behaviour among residents of Hangzhou, China. Higher commercial utilization intentions were also associated with increased adoption of mixing practice. This implies that mixing would be adopted to suppress pests and pathogens as well as moisture levels thus increasing commercial viability of small-urban farm businesses. Increased home ownership among urban agro-producer households was likely to boost the choice of cleaning as a safety risk management measure. Home ownership status was an indicator of availability of space for conducting cleaning of agro-food waste. This may imply that since agro-food waste is associated with filth (Crane, 2000), ownership of a private space- in terms of a home-gave waste users a platform to clean it which reduced the likelihood of causing nuisance on others. This may also imply that non-home owners would rarely implement a similar exercise on a landowner's compound. Amount of monthly per capita agricultural income of a household was associated with enhanced choice of heating of agro-food waste. This implies that the higher the agricultural income, the higher the likelihood of adopting the heating practice. Considering that some aspects of heating such as use of fuel may contribute to increased cost of production in agricultural enterprises, higher agricultural income would enable agro-producer households to meet such costs. This also imply that agro-producers were likely to be more protective of their agricultural

investments by adopting safety management practices that they consider effective as agricultural income increases. Since heating was associated with livestock production, this implies that it is an appealing practice in addressing their susceptible nature to pests and pathogens. Past behaviour of agro-producers in utilization of waste was associated with lesser adoption of specific sourcing as a safety risk management practice. This may indicate that agro-producers' past behaviour was not favourable in forming agro-food waste commercial utilization inclination thus were not vigilant in sourcing of waste. This may imply that aspects of safety risks managed through specific sourcing of agro-food waste were likely to threaten agricultural investments due to past behaviour influence.

## CONCLUSION

The study aimed at exploring the choice of agro-food waste management options and drivers of the safety risk management practices devised among urban agro-producer households. Requisite methods of analysis were employed to reveal the differences, similarities, associations and implications of agro-food waste management. Findings from the study indicated that management options and safety risk management practices varied between the participating and non-participating crop, livestock and mixed categories of producers but were more pronounced among the livestock and mixed production groups. The adoption of utilization and disposal options as well as segregation, cleaning, heat treatment, composting, mixing of waste with salt and feeds, and specific sourcing management practices were significantly different among participating and non-participating households in both livestock and mixed production systems. Reduction and utilization of agro-food waste were the most preferred management options at 86% adoption while segregation (63%) and composting (58%) were the preferred safety risk management practises. These results implied that these management aspects could be enhanced as avenues for promoting sustainable agro-food waste management in urban areas. The results further revealed that contextual factors for choice of agro-food waste management options differed but waste sorting knowledge of agro-producer households was largely a common factor. Similarly, variations in the

determinants of choice of safety risk management practices were recorded but urban agriculture and waste sorting knowhow had a cross-cutting effect. This implied that knowledge and awareness were critical aspects in agro-food waste management and its safe use. As such awareness education programs may introduce a paradigm shift on how waste is managed and utilized by small-urban farm business practicing households. A further implication is that although waste management is generally a public service, self-management may be a fairly effective avenue in the pursuit of the right to “clean and healthy environment” for the population. In absence of a substantive National Feed Policy and the failure to implement the existing waste management laws, agro-producers will continue to take advantage of the lapse thus continued safety threat to the resultant food. As such enhanced self-management of agro-food waste would propel safety issues in urban agriculture at the household level.

#### LIMITATIONS AND SUGGESTIONS FOR FURTHER STUDY

Whereas risk management measures employed by agro-producer households were explored, risk perceptions influencing these choices were not concretely identified and assessed. As such risk perceptions aspect of agro-food waste utilization would avail critical knowledge into the limelight.

#### AUTHOR CONTRIBUTIONS

C. Karani performed the literature review, research design, analyzed and interpreted the data, prepared the manuscript text and edited it. E. Gido and H. Bett were the academic supervisors for this study.

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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.

#### ABBREVIATIONS

CESAAM	Centre of Excellence for Sustainable Agriculture and Agribusiness Management
<i>Eq</i>	Equation
FAO	Food and Agriculture Organization of the United Nations
KES	Kenya shillings
KNBS	Kenya National Bureau of Statistics
<i>LR</i>	Likelihood Ratio
<i>MNL</i>	Multinomial Logit
<i>MVN</i>	Multivariate Normal Distribution
<i>MVP</i>	Multivariate Probit
NEMA	National Environment Management Authority
<i>N</i>	Sample Size
NACOSTI	National Commission for Science, Technology and Innovation
<i>p</i>	Probability
ROK	Republic of Kenya
<i>SE</i>	Standard Error
SIANI	Swedish Agricultural Network Initiative
$\chi^2$	Chi-square

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ORIGINAL RESEARCH PAPER

## Investigating the factors affecting landscape adaptation with the heritage of the oil industry to achieve urban sustainability

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### ABSTRACT

**BACKGROUND AND OBJECTIVES:** Abadan oil industry in Iran is very significant due to its various valuable layers as a part of national memory and identity. Therefore, to protect and reuse this industrial heritage, the adaptive reuse strategy by means of the landscape is considered. The purpose of this study is to achieve urban sustainability through a landscape adaptable to the oil industry heritage.

**METHODS:** This research is descriptive-correlational and has been done through a survey. The statistical population of this research consists of pundits and experts of Abadan's oil industry and the sample size is 88 people. In the analytical section, while using documentary studies, a questionnaire with 21 closed questions was used for data collection. After collecting the data, its validity and reliability were measured and confirmed.

**FINDINGS:** In this study, the relations between nine environmental, historical, economic, social, cultural, policy, technology, physical, and infrastructure factors were measured as the factors affecting the landscape adaptable to the oil industry heritage.

**CONCLUSION:** The results showed that the completion and facilitation of policies lead to the creation and strengthening of opportunities for cultural and social interactions in the industrial landscape. Also, the impact of physical factors on infrastructure, economic, and environmental leads to strengthening economic factors and infrastructure reuse in urban development. Findings indicated that the impact of environmental factors on economics and policy by using landscape leads to success in the mentioned fields.

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## INTRODUCTION

In recent years, researchers have considered industrial heritage as a source and an integral part of collective identity in assessing, documenting, and developing the remnants of industrial society to emphasize the need for consideration of post-industrial landscapes in urban planning, (Loures, 2008). However, Industrial heritage landscapes, still face inadequate assessment of the material, cultural, and industry stereotypes, whose design does not meet aesthetic, environmental, and functional requirements and criteria (Alanen and Melnick, 2000). The protection and recreation of industrial heritage have high significance given to its value and importance. Today, world landscape architects such as Hogg, Latz, etc., are facing new professional projects concerning ecology, in which they took the adaptive reuse approach for post-industrial landscapes. In such projects, the principles of design and planning are formed in a comprehensive and integrated system based on human-ecological interactions. Adaptive and flexible interventions are designed to interact with sudden and intermittent environmental changes; developments that are natural, but not definitively predictable and controllable (Farahmand, 2011). Abadan oil industry is one of the most important historical bases, as well as the economic center of the oil industry and a strategic region in Iran. Besides, to create a nostalgic feeling in a modern space (in the 70s), it also has many capacities due to the consequences of landscapes such as tolerance (St. Carapet Church -1958), and peaceful coexistence of different nationalities (Myanmar Rangooniha Mosque-1921) besides, remembering the collective history memories recorded in the hearts and minds of the people, it is the narrator of a century of economy and history of oil. On the other hand, due to the experience of World War II (using the "Akwan" crane - 1939, The first giant crane that played an important role in World War II, carrying thousands tons of cargo, including armored vehicles, locomotives, and train cars and other public goods.) and the imposed war between Iran and Iraq, it has a lot of potentials and creates a nostalgic feeling (of '70s). However, because of functional impairments, technological obsolescence, or infrastructural changes, it is necessary to adaptively reuse the landscape to preserve the historical-cultural landscape, economic prosperity, solving environmental problems, and

ultimately urban sustainability.

The hypotheses of this research are as follows:

- The physical factor affects the infrastructure factor as a necessity of landscape adaptation to industrial heritage as the governing context.
- The physical factor affects the environmental factor as a necessity of landscape adaptation to industrial heritage as the main category.
- The physical factor affects the economic factor as a necessity of landscape adaptation to industrial heritage as an intervening condition.
- Environmental factor affects the economic factor as the main category of landscape adaptability to industrial heritage as an intervening condition.
- Environmental factor influences policy factor as the main category of landscape adaptability to industrial heritage as a strategy.
- Infrastructure factor influences policy factor as a precursor of landscape adaptation to industrial heritage as a strategy.
- Policy factor affects the social factor as a strategy of landscape adaptation to industrial heritage as a consequence.
- Policy factor affects the cultural factor as a strategy of landscape adaptation to industrial heritage as a consequence.
- Environmental factor influences the infrastructure factor as the main category of landscape adaptation to industrial heritage as the governing context.
- Environmental factor affects the economic factor as the main category of landscape adaptation to industrial heritage as facilitator/ barrier conditions.

Due to the vacuum of the adaptive landscape native model with the heritage of the oil industry, first by using the grounded theory method, the causes, contexts, intervening factors and consequences related to the adaptability of heritage with landscape were identified, and then the comprehensive model of adaptive landscape with industrial heritage was presented that can provide the basis for further studies, both quantitatively and qualitatively. the foundation data theory method is one of the methods that plays a key role as a bridge between the past and future paradigms. It was used in the qualitative part of the research. Because in the data foundation theory method, an indigenous model can be designed that is completely in accordance to the heritage conditions

of Abadan oil industry and can be implemented. It is also possible to test the adaptive landscape model with the heritage of Abadan oil industry from the oil industry experts view by using the structural equation model. In this research, a small part is considered. This research seeks to find an answer to this question: What are the relations between the factors affecting landscape adaptation with the oil industry heritage?

This study is conducted in Abadan, Khuzestan, Iran in 2020.

#### Theoretical framework

All over the world, they have intervened in the Brownfields (Loures, 2020) to reduce the adverse effects of these developments, and the landscape architects' approach in these interventions has been to reconcile human with the context of their creation and nature (Graham *et al.*, 2000). In this regard, adaptive reuse has been presented as a sustainable development strategy (Yung and Chan, 2012), which aims to focus on redevelopment in cities and tries to reduce the undesirable urban dispersion (Cantell, 2005). Sugden (2017) considers industrial heritage buildings as part of the cultural capital of society. Mısırlısoy and Günçe (2016); Wong (2017) found industrial heritage to be very important in terms of transmitting cultural identity from one period to another. Also, according to Cho and Shin (2014) recognizing the social values of obsolete spaces and using them helps to adaptively reuse the preservation

of industrial heritage and turn them into assets, which are an example of "place identity" and a source of pride for communities (Xie, 2015). On the other hand, the landscape as a factor in attracting tourists leads to the empowerment and growth of tourism (Halewood and Hannam, 2001), absorbing more companies and tourists by strengthening the territorial identity (Xie, 2015), and also leads to the creative economy (Hoyle *et al.*, 1988), and government participation in investment for economic growth and development (Yung and Chan, 2012). Adaptive reuse of industrial buildings employing landscape leads to reduced energy consumption in heating and cooling (Langston *et al.*, 2008), lowering greenhouse gas emissions (Kirkwood, 2013; Moschella *et al.*, 2013), as well as the use of green spaces in body development leading to the formation of constructive social interactions, the improvement of cultural life (Yung and Chan, 2012) and the integration between industrial heritage through the green network along with the identity and historical dimension and adaptation to different cultural and social layers (Khan Sefid, 2008). Therefore, strengthening the aesthetic dimensions by creating combined landscapes is the result of strengthening the visual elements of the landscape by interrelationships of values in cultural, economic, and biological dimensions (Amir and Gidalizon, 1990; Sowińska-ierwierkosz, 2016). It should be noted that the purification and treatment of soil and wastewater (Douglas, 2002) from chemicals and petroleum

Table 1: Theoretical framework

Wong (2017)	Preservation of industrial heritage in terms of transferring cultural identity from one period to another
Xie (2015)	Recognizing the social values of obsolete spaces and reusing them as an example of "place identity"
Halewood and Hannam (2001)	Empowerment and tourism growth through the use of perspective in adaptability
Hoyle <i>et al.</i> (1988)	Strengthening territorial identity leads to a creative economy through adaptability
Yung and Chan (2012)	Government participation in investment for economic growth and development through the adaptability of industrial heritage
Langston <i>et al.</i> (2008)	Reduction of energy consumption in heating and cooling due to adaptive reuse of landscape industrial buildings
Kirkwood (2013)	Reduction of greenhouse gas emissions through adaptive reuse of landscape industrial buildings
Khan Sefid, (2008)	Compatibility of different cultural and social layers through the integration of industrial heritage with the green network with identity and historical dimension
Sowińska-ierwierkosz (2016)	Strengthening the aesthetic dimensions by creating combined landscapes is the result of strengthening the visual elements of the landscape with the interrelationships of values in the cultural, economic and biological dimensions.
Liduíno <i>et al.</i> (2018)	In the reuse of industrial heritage, innovative technologies are used to adapt and re-coordinate the site.
Clark (2006)	Use of innovative technologies for adaptation and re-coordination of industrial heritage

products left over from industrial heritage are also done by phytoremediation (Hoyle *et al.*, 1988; Liduino *et al.*, 2018). On the other hand, the use of innovative technologies to adapt and re-coordinate the site (Clark, 2006) and the valuation and aesthetics are done by creative and innovative industries (UNESCO *et al.*, 2012) in the adaptation of industrial heritage. Table 1 summarizes the theoretical framework of this research.

#### The study Area

##### Abadan Oil Industry

Abadan city in Khuzestan province with an area of 65.1 square kilometers and a population of 300,000 is located in the southwest of Ahvaz. This industrial city is one of the most important and largest cities built in the twentieth century in Iran (Figs. 1 and 2). During the Second World War with the occupation of Iran (1941), the Abadan refinery became the largest refinery in the world and the decisive point of the war (Kaabi Falahiye, 2015). In 1978, a strike was held

due to the cooperation of Abadan oil refinery staff with the Islamic Revolution of Iran, and the Abadan refinery was closed. After the beginning of the war in Iraq from 1980 to 1988, it was unable to operate due to its proximity to the Iraqi border and the bombing and suffered extensive damage. Today, although most of the refineries and factories are operating, some parts of the Abadan oil industry have failed due to the introduction of new technology, water shortages, and sometimes depreciation and infrastructure changes (Fig. 2).

#### MATERIALS AND METHODS

This applied research is descriptive-correlational. The research has been done by survey. The statistical population of this study consists of pundits and experts in the Abadan oil industry. To determine the sample size, the Cochran formula was used and the sample size was 88. Since the literature review indicates the weakness of the existing theories in explaining the landscape model adapted to the

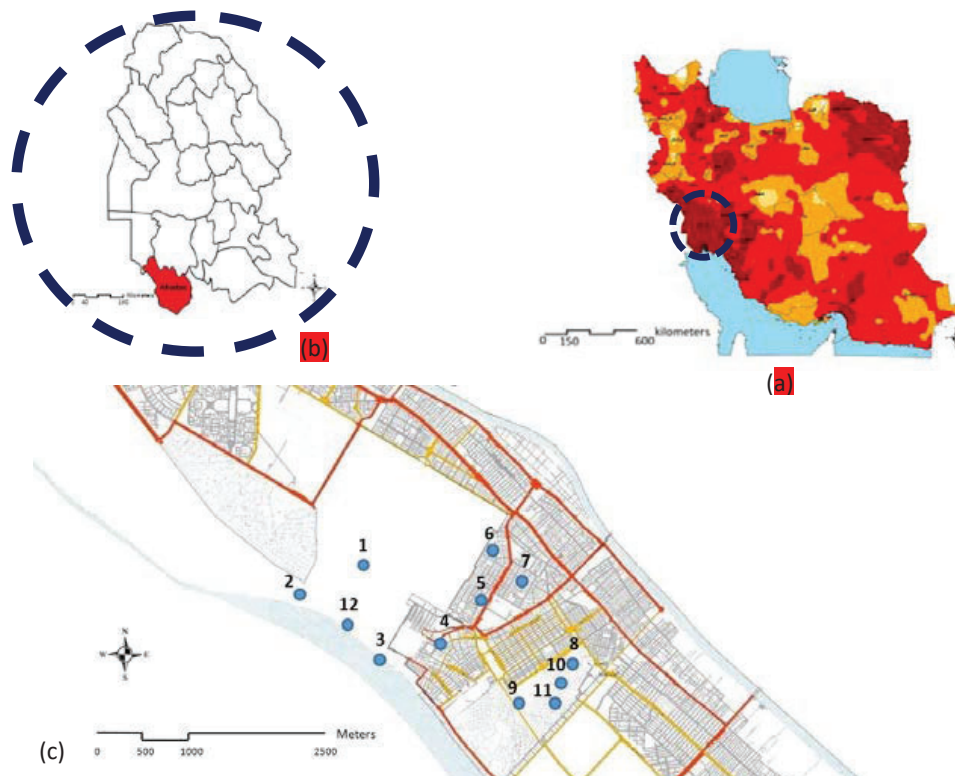


Fig.1: The study area: a) Iran map with the specified area of Khuzestan, b) Khuzestan map with the specified area of Abadan, c) Aerial map and location of Abadan industrial heritage (General department of roads and urban development of Khuzestan Province, 2020)



1: Oil Refinery · Photo Date 1973



2: Annex open-air Club and Cinema, 1931



3: Akwan crane 1937, obsolete



4: Gas Station 1926 turned into a museum



5: Vocational School, 1933 Turned into a museum



6: Ziba bathroom · 1934, closed



7: Children's Park, 1949 Closed



8: North Bovardeh Water Reservoir, Obsolete



9: The Petroleum University, 1939, Still working



10: Bovardeh neighborhood-2floors– at the same time with the start of Abadan Oil Company and Refinery



11: Bovardeh neighborhood-Villa – at the same time with the start of Abadan Oil Company and Refinery



12: Abadan wharf, 1912, obsolete

Fig. 2: The oil industry effects in Abadan city (1 to 12), (Iran Petroleum Museum and Documents, 2020)

industrial heritage, the grounded theory method was used to identify and extract the components, as well as designing the model. The grounded theory method is based on the construction and presentation of theory. During this method, the data were collected through interviews with experts and then divided into three stages of open, axial, and selective coding, and finally, a paradigm model was presented based on 8 main categories and 23 subcategories. In this study, a conceptual model derived from the qualitative phase was tested and the relations between factors were explained. A questionnaire was used to assess the identified factors of landscape adaptability to industrial heritage. The scoring method of this instrument was based on a seven-point Likert scale. The results of statistical analysis were presented in two sections: descriptive findings and inferential findings. In the descriptive section, demographic variables and main variables were described using statistical indicators of central

tendency and variability. In the inferential section, the relationships between variables were analyzed by the Pearson correlation test, validity and reliability of the questionnaire were tested by confirmatory factor analysis test and structural equation modeling test was used for the conceptual model test by the partial least squares method. Data were analyzed using SPSS 25 and Smart PLS version 3 statistical software.

## RESULTS AND DISCUSSION

### *Descriptive findings*

#### *Statistical Society*

The statistical population of this study consists of experts in the Abadan oil industry and the sample size is 88. 73% of the participants were men and 27% were women. The frequency of respondents' fields of study includes architecture 32%, civil engineering 19%, computer 28%, and other fields 43%. Table 2 shows the frequency of executive positions of individuals.

The Kolmogorov - Smirnov test was used to evaluate the normal data distribution. The significance level of the Kolmogorov-Smirnov test for all variables in this study was more than 0.05, which indicates the natural distribution of the variables. Also, the study of the means shows that the average of all components is in the range of 5 to 6, which is relatively high. The study of the means shows that the lowest average is related to the environmental dimension with an average of 5.46 and the highest average is related to the economic dimension with an average of 6 and the social dimension with an average of 5.96. Table 3 shows the descriptive indices and variables normality test.

*Checking the validity of research variables*

Confirmatory factor analysis was used to evaluate the validity of the researcher variables. In Table 4, the measurement model is standardized in the form of coefficients and is extracted with combined reliability,

Cronbach's alpha, and mean-variance. Also, the historical variable has only one question and its results are not reported in the table. The results showed that according to the number of factor loads that are more than 0.50 and are at a significant level less than 0.05 ( $p < 0.05$ ) (all t-values are greater than 1.96), the construct validity of all questions is confirmed. All questions have a factor load greater than 0.50, which confirms the validity of all questions of research variables. The value of combined reliability is obtained from a minimum of 0.73 for the social variable with a maximum of 0.97 for the infrastructure variable, in which the value of combined reliability is greater than 0.70. These reliability values are confirmed and indicate that the reliability of the research variables scale is statistically confirmed. The Cronbach's alpha values of the components are obtained from a minimum of 0.61 for the economy to a maximum of 0.95 for the infrastructure, indicating that the reliability of the internal synchronization method is

Table 2: Description of the respondents' executive position

Position	Number	Percent	The Cumulative Percentage
Working in the oil industry	57	65	65
Abadan Citizen	6	7	72
Professional designer	4	4	76
Faculty member	15	17	93
Researcher	6	7	100
Total	88	100	

Table 3: Descriptive indicators and normality test of the studied variables

Variable	Average	The Standard Deviation	Significance of Kolmogorov-Smirnov	Skewness	Kurtosis
Physical	5.86	0.96	0.064	-1.82	1.38
Environmental	5.46	1.29	0.168	-0.991	0.430
Infrastructure	5.82	1.19	0.072	-1.49	1.54
Economic	6.00	0.99	0.061	-1.75	1.58
Historical	5.48	1.52	0.089	-1.29	0.705
Technology	5.75	1.06	0.133	-0.846	-0.019
Policy	5.81	1.01	0.116	-0.831	-0.298
Social	5.96	0.91	0.094	-1.04	1.58
Cultural	5.65	0.94	0.154	-0.697	0.486

also confirmed. Because the variables have a small number of questions and the questionnaire was also made by the researcher, Cronbach's alpha above

0.60 was determined as the criterion. The extracted mean-variance that measures the convergent validity is obtained from a minimum of 0.59 for

Table 4: The results of confirmatory factor analysis: Evaluation of validity and reliability of research variables

Variable	Question number	Standardized coefficient (factor load)	Mean-variance extracted (AVE)	Combined reliability	Cronbach's alpha
Cultural	2	0.80	0.70	0.82	0.63
	3	0.87			
Social	4	0.91	0.59	0.73	0.62
	5	0.59			
Economic	6	0.80	0.68	0.81	0.61
	7	0.85			
	8	0.71			
Environmental	9	0.92	0.71	0.88	0.79
	10	0.88			
	11	0.83			
Physical	12	0.83	0.68	0.87	0.77
	13	0.82			
Technology	14	0.92	0.81	0.89	0.76
	15	0.88			
	16	0.85			
Policy	17	0.82	0.62	0.86	0.79
	18	0.74			
	19	0.73			
Infrastructure	20	0.97	0.95	0.97	0.95
	21	0.98			

Note: All factor loads are significant at 95% confidence level: (p <0.05) and (t >1.96)

Table 5: Correlation matrix of latent variables and divergent validity

Variables	Physical	Environmental	Infrastructure	Economic	Historical	Technology	Policy	Social	Cultural	Ave root
1. Physical	<u>1</u>									0.82
2. Environmental	0.68***	<u>1</u>								0.84
3. Infrastructure	0.50**	0.34**	<u>1</u>							0.97
4. Economic	0.61***	0.59***	0.50***	<u>1</u>						0.82
5. Historical	0.19*	0.40***	0.32**	0.30**	<u>1</u>					-
6. Technology	0.63***	0.65***	0.46***	0.40***	0.36**	<u>1</u>				0.9
7. Policy	0.68***	0.66***	0.72***	0.58***	0.39***	0.61***	<u>1</u>			0.78
8. Social	0.51***	0.52***	0.34**	0.57***	0.37***	0.55***	0.48***	<u>1</u>		0.76
9. Cultural	0.24*	0.32**	0.29**	0.32**	0.63***	0.42***	0.34**	0.59***	<u>1</u>	0.83

Note: 0.05 ≥ p = \* and 0.01 ≥ p = \*\* and 0.001 ≥ p = \*\*\*

the social variable with a maximum of 0.95 for the infrastructure variable. The obtained values show that the convergent validity of the social variable is a moderate value and the convergent validity of the infrastructure is a desirable value.

The correlation of latent variables is shown in Table 5. If in the correlation matrix of latent variables, the root means square of variance extracted for each structure is greater than the correlation of that structure with other structures, the divergent validity of the model is confirmed. Divergent validity is a fitness criterion of the measurement models in the partial least squares method. According to the results, the correlation of each structure with itself is more than its correlation with other structures.

Finally, based on the obtained results, the reliability, convergent validity, and divergent validity of the research are confirmed and it is determined that the fitness of the research measurement model is appropriate.

*The main research model test*

The conceptual model of the research was

tested using the structural equation modeling technique by the partial least squares (PLS) method (The partial least squares approach is used when the statistical population and the number of items are small or the variables are hidden in two or more levels, which of course was not the last case in this study). The software employed is Smart PLS. In the following, the research model has presented in the form of standard coefficients and the significance state. Fig. 3 shows the original model in the standard coefficient mode. Fig. 4 shows the model in the state of T value or significance. If the T value is greater than 1.96, it means that the statistical relationship is confirmed at a confidence level of at least 95%. Examination of T values shows that eight relations are confirmed and four relations are rejected.

*The model fitness Check*

Table 6 presents the three main indicators of model fitness. The Goodness of Fit (GOF) index in the PLS model is a practical solution to solve the problem of checking the overall fitness of the model and acts

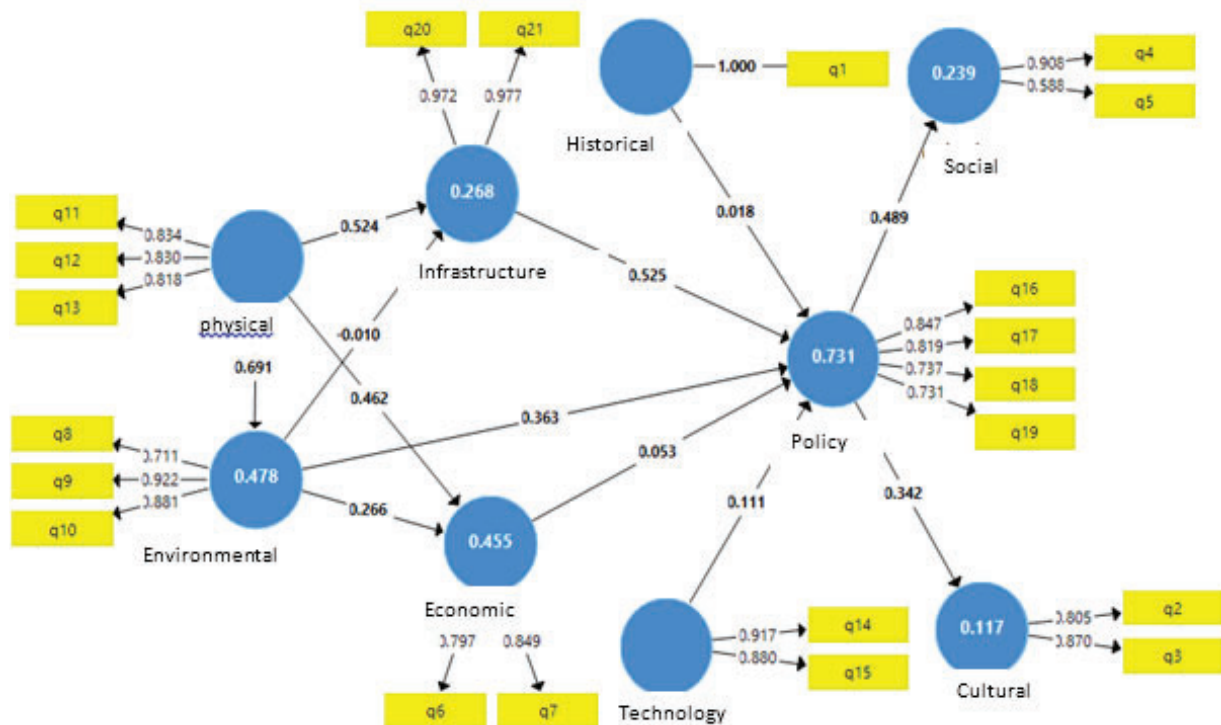


Fig. 3: Research model in the state of standardized path coefficients

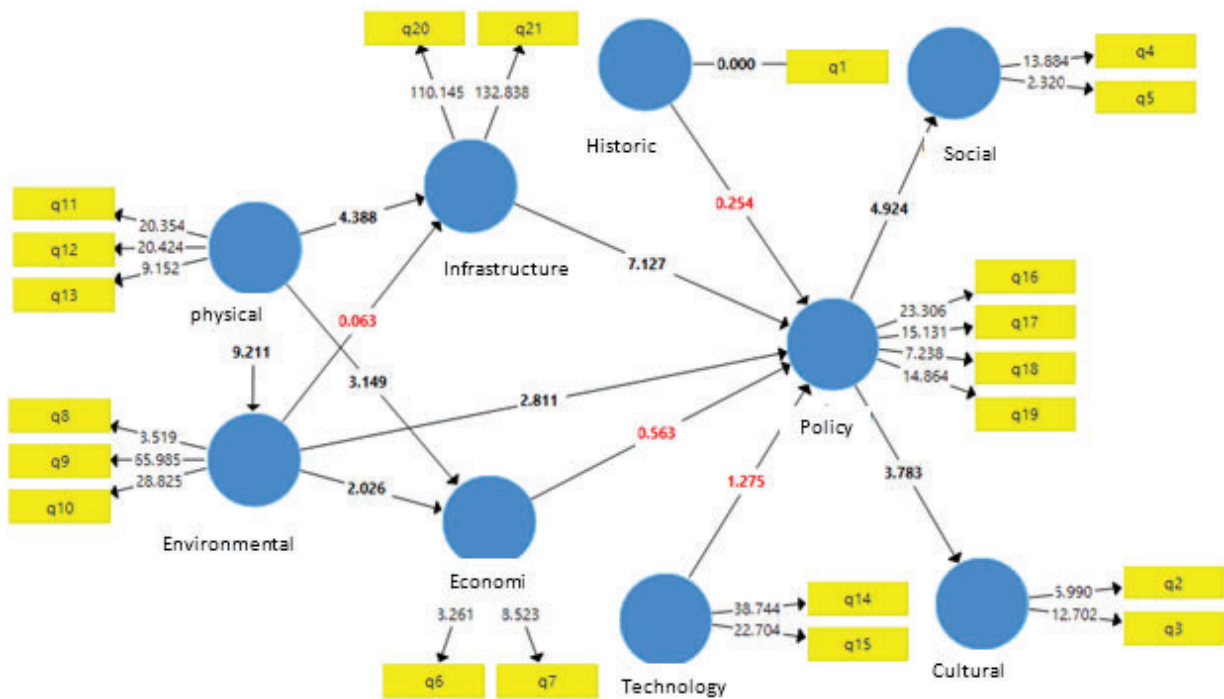


Fig. 4: Research model in a significant state (T-value)

Table 6: Indicators of research model fitness

Dependent or mediating variable	Coefficient of determination index R <sup>2</sup>	Redundancy Credit Index Q <sup>2</sup>	General Fitness Index GOF
Policy	0.73	0.40	0.49

as the fitness indices in covariance-based methods and can be used to check the validity or quality of the PLS model in general.

According to the results, the determination coefficient for the policy dependent variable is equal to 0.73, which is a good value and shows that this number of affective variables has been able to explain the acceptable amount of changes in the dependent variables. Based on this, the model-independent variables were able to explain 73% of the variance of the policy dependent variable. The value of the Q2 index (CV-Redundancy) for the policy is equal to 0.40, which is positive and above 0.15, so it can be inferred that this index confirms the fitness of the models. The value of the GOF index which measures the overall fitness of the research model is 0.49 which is a good value. It can be said that the GOF index is

good because it is higher than the standard value. In general, the examination of the fitness indices shows that the model fitness is acceptable and the model is approved. In other words, the data could be firm support for the model and the model gave an acceptable result in the research sample.

*Model relations test*

Table 7 reports the results of the research model relations test. In Table 6, the value of the standardized path coefficient, the T value, and the significant level (P-value) are reported. Examination of relations and the conceptual model shows that out of 12 relations and paths in the model, 8 relations have been confirmed (p < 0.05).

In this study, the model test indicates the effect of the physical factor on the infrastructure factor with

Table 7: Structural model coefficient test: standardized coefficients, T value, and significance level

Impacts	Standardized coefficient	T-value	P-value	Result
Physical relation to infrastructure	0.52	4.39	<0.001	Confirmed
Physical relation to environment	0.69	9.21	<0.001	Confirmed
Physical relation to economic	0.46	3.15	<0.001	Confirmed
Environmental relation to infrastructure	-0.01	0.06	0.950	Rejected
Environmental relation to economic	0.27	2.03	<0.001	Confirmed
Infrastructure relation to policy	0.52	7.13	<0.001	Confirmed
Environmental relation to policy	0.36	2.81	<0.001	Confirmed
Economic relation to policy	0.05	0.56	0.574	Rejected
Historical relation to Policy	0.02	0.25	0.800	Rejected
Technology relation to Policy	0.11	1.27	0.203	Rejected
Policy relation to Social	0.49	4.92	<0.001	Confirmed
Policy relation to cultural	0.34	3.78	<0.001	Confirmed

an intensity of 0.52. Since infrastructure equipment is one of the basic requirements of society and plays an important role in urban development and sustainability, facilitating access is one of the most important development infrastructures. On the other hand, the body and space constitute service facilities and are necessary for urban sustainability. The results of [Douet \(2020\)](#); [Watson and Bentley \(2007\)](#); [Colquhoun \(1995\)](#) studies also confirm the effect of the physical factor on the infrastructure factor. It is suggested to change the old buildings use with new ones, e.g. construct a cultural and artistic campus in an industrial building. Expand public open spaces and improve the transportation network security. Build a pedestrian promenade for visitors to walk on the factory’s old production path for the site’s industrial archeology. The strong impact of the physical factor of the environmental factor with a relation intensity of 0.69 indicates the important role of adaptive reuse of industrial heritage buildings in reducing greenhouse gas emissions and energy consumption and an environmentally and sustainability friendly process in the urban landscape. [Yung and Chan \(2012\)](#); [Colquhoun \(1995\)](#); [Douglas \(2002\)](#) also achieved similar results in their studies. In this regard, it is suggested that adaptive reuse of industrial heritage bodies should be done through the landscape to reduce environmental pollution and strengthen the environment quality. It also reduces energy consumption by reusing existing

materials in harmony with the industrial heritage environment. Also, the physical factor with a relation intensity of 0.46 has a moderate effect on the economic factor. In a way that the adaptive reuse of the industrial heritage body through landscape leads to the empowerment and growth of tourism and makes a creative economy, which has a significant impact on the economic level. The research results of [Vardopoulos \(2019\)](#); [Bullen \(2007\)](#); [Yung and Chan \(2012\)](#); [Xie \(2015\)](#) are consistent with these findings. The proposed solutions in this field include the use of existing capacities in the industrial heritage space to create environmentally controlled agriculture, as well as the dynamic environment for local entrepreneurs, artisans, and the community plus attracting tourists by beautifying the industrial heritage body through the landscape. The effect of environmental factor on economic factor with the relation intensity equal to 0.27 indicates that cleaning and improving environmental quality in the reuse of industrial heritage through the landscape is one of the factors affecting tourist attraction. Also, due to the existing capacities, saving energy consumption, and increasing productivity, it leads to a favorable environment for the use of national and regional investors and companies. Results of [Vardopoulos \(2019\)](#); [Halewood and Hannam \(2001\)](#) studies agree with this finding. It is suggested that expand open and green spaces for the economic prosperity of a region, increase the value of

lands, and build a recreational space to attract tourists. Also, urban agriculture should be used in industrial heritage spaces to attract investors and meet society's needs. The positive and significant effect of the infrastructure factor with the relation intensity equal to 0.52 on the policy factor shows the average effect of the infrastructure factor on the policy factor. Since the maintenance and creation of infrastructure play an important role in urban development and sustainability, therefore, policy-making in the field of infrastructure with the public participation and private sectors is very vital and necessary for countries. This finding is consistent with the results of [Watson and Bentele \(2007\)](#); [Colquhoun \(1995\)](#); [Tang and Ho \(2015\)](#) studies. It is suggested that the private and public sectors provide services and improve infrastructure, also, cooperation and coordination should be done between stakeholders to improve the obligations and laws regarding the domestic reform policies and security (mental and environmental). The average effect of environmental factor on policy factor with a relation intensity equal to 0.36 indicates favorable environmental effects due to the industrial heritage adaptation to the landscape, but due to a lack of environmental legislation in policy, there are challenges between industrial heritage adaptability and regulatory and enforcement requirements. By addressing these challenges and shortcomings and paying attention to the environment and climate, a profound impact can be made on the adaptive reuse of industrial heritage success. The results of [Romeo et al., \(2015\)](#); [Ifko \(2016\)](#); [Coratza et al., \(2018\)](#); also confirm the impact of the environmental factor on the policy factor. It is proposed to consider the expansion, creation, and promotion of laws related to landscape and environment in the development of industrial heritage toward urban sustainability. Also, cooperation and coordination should be established between stakeholders to improve the environmental obligations and laws regarding the preservation of tangible and intangible industrial heritage. The effect of a policy factor on social factor with the relation intensity is equal to 0.49. Policy-making for the benefit of stakeholders in the adaptive reuse of industrial heritage through the landscape by creating new spaces leads to strengthening social participation. On the other hand, it brings together collective and individual memories and creates an

emotional bond between stakeholders and industrial heritage. [Chavez et al., \(2017\)](#); [Hinnerichsen \(2011\)](#); [Sutestad and Mosler \(2016\)](#) also achieved these results in their studies. In this regard, it is proposed to develop a comprehensive plan for the development of service and welfare uses, given the existing capacities in the industrial heritage to promote public participation and meet society's needs. Potential places should also be created for public participation (social communication and attention to aesthetic dimensions). The policy factor with a relation intensity equal to 0.34 on the cultural factor indicates that policymaking toward preserving the cultural factor leads to the connection, development, and strengthening the reconstruction of historical memory and place attachment dimensions. Also, paying attention to the cultural context is effective in maintaining the semantic importance and creating a coherent relationship. By employing landscape, it strengthens and presents capacities, identity, sustainable development, and reconstruction of local culture. This finding is consistent with the results of [Vardopoulos \(2019\)](#); [Wong \(2017\)](#); [Sugden \(2017\)](#) studies. In this regard, efforts should be made to turn industrial heritage into a national attraction and to hold annual celebrations close to the industrial heritage, Since the intensity of the relations between environmental, infrastructure, economic, historical, and technology factors on the policy factor has been less than 0.05, they are ineffective and rejected. In this regard, efforts should be made to turn industrial heritage into a national attraction and to hold annual celebrations in industrial heritage. Close to them, because the intensity of the relationship between the above-mentioned factors on the policy factor is less than 0.05, they are ineffective and rejected.

## CONCLUSION

This study aims to investigate the factors affecting landscape adaptation with the heritage of the oil industry to achieve urban sustainability. The oil industry, with its historical, technological, cultural, and physical layers, is the main factor in the body of Iran's economy and has significant consequences for Iran, especially Khuzestan. In this regard, to achieve urban sustainability by means of an adaptable landscape with the industrial heritage, new strategies should be adopted and

various factors should be reviewed. Destruction of industrial heritage leads to energy loss, damage to the environment, destruction of socio-cultural, economic, and indigenous values. Adaptive use of the Abadan oil industry heritage by means of landscape results in increasing the life of industrial heritage and thus reducing transportation, materials, energy, and pollution, which in turn leads to environmental sustainability. Applying the adaptive landscape with the Abadan oil industry heritage also has economic benefits, which can be referred to as energy efficiency and increasing the building price. Also, the participation of government investment in economic growth provides the development of local businesses by creating jobs, and ideal conditions for prosperity and solving the economic problems of the region. The Abadan oil industry heritage due to its historical and cultural features as tourist attractions can be the main element in the growth and development of tourism. On one hand, maintaining and exploiting its capacities leads to more income and employment in addition to attracting companies, more tourists, and social participation, and ultimately, leads to economic prosperity at the national and regional levels and sustainability. On the other hand, adaptive use of landscape and industrial heritage leads to the strengthening of traditions, indigenous values, identity, continuity of social life as a result of socio-cultural sustainability. The results of this study show that the completion and facilitation of policies also lead to more opportunities for cultural and social interactions in the industrial landscape. So this approach is innovative and much research has been done on the dimensions and characteristics affecting industrial heritage, but none of them had a structural approach regarding the landscape adaptable to the industrial heritage.

#### AUTHOR CONTRIBUTIONS

H. Faramarzi wrote the literature review, analyzed and interpreted the data, and prepared the manuscript. M. Khakzand helped in research methodology as well as data analysis and interpretation.

M.H. Talebian assisted in the collection and review of literature related to the oil industry heritage and preparation of the manuscript. M. Masoudinejad aided in data analysis and preparation of the manuscript.

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#### CONFLICT OF INTEREST

The authors announce that there is no 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.

#### ABBREVIATION

<i>GOF</i>	Goodness of Fit
<i>PLS</i>	Partial least squares
<i>SPSS</i>	Statistical Package for the Social Sciences

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CASE STUDY

Effect of activities conducted near lakes by comparing contaminant levels, trophic status, and a possible bioremediation method

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ABSTRACT

**BACKGROUND AND OBJECTIVES:** The lakes in the state of Minnesota (MN) have undergone accelerated changes with the passing of time, where cattle ranching, agriculture, the increase of industrial jobs and urban area development have changed their condition from pristine to critical. To evaluate this problem, secondary data obtained from the public domain of three lakes from a county used for a long period for agriculture and cattle (Carver County) and three lakes from a county where the land has been used more for housing and industrial economy (Hennepin County). The aim of the study was to use the information to evaluate the trophic status, and compare the results of the lakes of rural areas versus lakes in urban areas in order to create a possible mitigation plan to improve the condition of the area.

**METHODS:** Trophic status was determined to evaluate the water quality of each lake. ANOVA analysis was employed to analyze the data set obtained from the public domain in the official webpage of the Minnesota Pollution Control Agency.

**FINDINGS:** Data results for total phosphorus, Secchi Disk and Chlorophyll-a, showed that all lakes are under eutrophic-hypereutrophic status with Trophic State Index (TSI) results between 59 to 80. Hennepin County had two of the three lakes evaluated in hypereutrophic states when compared with Carver County lakes. Carver County has only one lake out of the three evaluated under hypereutrophic conditions. Statistical analysis showed that  $p < \alpha$ . The results demonstrated that lakes near areas used mainly for urban/industrial purposes are more contaminated than lakes near areas used for agriculture/livestock.

**CONCLUSION:** The restoration of wetlands that are near the lakes is proposed as a possible bioremediation method to improve water quality. Alternatively, an artificial wetland could be implemented in the lakes that do not have this natural system. Placing a Subsurface Flow System (SFS) artificial wetland in parallel trenches, which bypasses the lake and/or into the mouth of the river, would allow the sedimentation process to occur in these spaces. In addition, the use of Phosphor-Accumulator Organisms (PAO) and specialized aquatic plants, such as *Hydrodictyon reticulatum*, *Elodea canadensis*, *Eichhornia crassipes*, *Eleocharis plantaginea*, *Pistia stratiotes* and *Hydrilla verticillate* will trap contaminants and aid in their removal.

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## INTRODUCTION

The state of Minnesota (MN), also known as the “land of 10,000 lakes”, has seen accelerated changes to its environment with the passing of time. Changes in cattle ranching and agriculture, along with the increase of industrial jobs and urban areas, have altered the conditions of the bodies of water in this state from pristine to critical. According to the Minnesota Public Radio (MPR) news station, approximately two-thirds of Minnesota’s watersheds were tested, and it was determined that 40% of all Minnesota’s watersheds, rivers and lakes have been damaged by agricultural runoff, bacteria, mercury, and other pollutants (Gunderson, 2016). The most delicate part of the problem is that this list continues to grow. Minnesota has worked hard to regulate working conditions to take care of not only the bodies of water, but also of the organisms that benefit from them. Regulatory policies that have been implemented in the last 15 years have promoted the reduction of total phosphorus discharged, but not enough to avoid eutrophication of some bodies of water. Creating controls for pollutants, such as nitrogenous compounds, have been on the rise since 2000 (Engelkin and Kovacevic, 2018), although can be extremely costly for the state. Most of the polluted bodies of water lie between central and south-southeast Minnesota, in areas where construction, pharmaceutical, agriculture, and livestock industries are most prominent. Runoff not only damages the quality of water available for consumption, but also directly impacts the species that inhabit these bodies of water. An increase in nutrients will lead to an increase in algae growth in lakes, thereby decreasing the amount of oxygen available to aquatic species and bringing some of these lakes close to eutrophication parameters. Aquatic plants die due to the cycle of freezing and thawing that comes with seasonal temperature changes, creating a sedimentation problem that reduces their water-holding capacity. The state has more than 3,000 lakes, watersheds, streams and other aquatic areas, including parts of the Mississippi River, that appear on the Minnesota Pollution Control Agency (MPCA) 303 (d) list of impaired waters and have been classified as a “category 5” due to their inability to meet various quality standards. A “category 5” classification is used by the United States Environmental Protection Agency (US EPA) where the

listed bodies of water do not, or have the future potential to not, meet quality standards, and the Total Maximum Daily Load (TMDL) must be determined and evaluated (United State Environmental Protection Agency (US EPA), 2020). Many of the lakes, basins, streams, and areas of the Mississippi River are on the list as their current condition affects aquatic life, recreation, and consumption. In addition to high levels of nutrients, contaminants such as chloride, deionized ammonium, and chlorpyrifos, and problems with fish such as accumulation of mercury, Polychlorinated Biphenyl (PCB), and Perfluoro Octane Sulfonate (PFOS), have been found in these bodies of water. Furthermore, turbidity problems, *Escherichia coli* (*E. coli*) and mercury have all been present in the water columns (Minnesota Pollution Control Agency (MPCA), 2021). Sources of organic nutrients include animal pens, sewage treatment plants, and various industries such as construction, pharmaceuticals, and corn plantations, to name a few (Chiras, 2010a). Two of the biggest contributors to water pollution include runoff due to the clearing of vegetation for new construction and snow melting from seasonal temperature changes (Minnesota Pollution Control Agency (MPCA), 2008). Excess of organic material reduces the amount of oxygen in these bodies of water because the living bacteria use it to break down waste, thereby contaminating the water with methane and hydrogen sulfide, which are formed as secondary products in the process, and eventually causing some of the aquatic organisms to perish (Chiras, 2010a). According to Chiras (2010a), “the [water] system can only recover if the source of organic nutrients ceases”. In the case of inorganic nutrients, these are produced by a wide variety of sources and generate a large amount of Phosphorus (P) and Nitrogen (N) pollutants. These compounds tend to promote the growth of algae and aquatic plants and function as a limiting factor. An increase in phosphorus is proportional to an increase in algae within the affected water body. Anaerobic bacteria use these inorganic nutrients and degrade them, and the same putrefaction process occurs (Chiras, 2010a). As a result, both aquatic and human lives are impacted. In the past, the Minnesota Department of Health has warned people to avoid blue-green algae in lakes, streams, and ponds because they can cause illness in humans and animals when exposed. “The

symptom of eutrophication is rapid growth and accumulations of phytoplankton, leading to discoloration of affected waters. These events are termed blooms. Blooms are a prime agent of water quality deterioration, including foul odors and tastes, deoxygenation of bottom waters (hypoxia and anoxia), toxicity, fish kills, and food web alterations. Toxins produced by blooms can adversely affect animal (including human) health in waters used for recreational and drinking purposes" (Dyble, Fulton, Moisaner and Paerl, 2001). The biggest contributor to algal blooms is the polluted runoff from farms and agriculture, which is high in phosphate content that is then carried out to surrounding areas (Marohn, 2018). According to MPR in the article from 15<sup>th</sup> of May 2018, the US EPA has given health advice for two cyanobacterial toxins in drinking water; however, there are currently no legal limits being enforced (Marohn, 2018). There are organizations that demand that more regulations be made in such a way that fertilizer and manure runoff from farms does not continue to reach water bodies. Phosphate pollutants also seem to have a deleterious effect on human health, as well as on bodies of water. According to the EPA, water samples are evaluated against a quality standard of 3 milligrams per liter (mg/L) of phosphate, which is equivalent to one part per million (ppm) of phosphorus (P) (United States Environmental Protection Agency (US EPA), 2012). In waters with low oxygenation, phosphorus can react with water and form what is known as phosphine, an extremely toxic gas, which can bioaccumulate in the body of fish and eventually reach human consumption (Hui Hoon, 2012). On the other hand, an increase in the concentration of phosphorus in water bodies' results in the proliferation of algae, which eventually leads to its eutrophication (United States Environmental Protection Agency (US EPA), 2012). The results conclude that the pollution problem increases further towards the south-southeast region of Minnesota where the predominant industries of these rural areas are agriculture and livestock, the hypothesis of this study expresses that there is a greater probability of eutrophic pollution in lakes near rural areas than in lakes near urban areas. The problem of eutrophication of lakes, streams, and rivers has been increasing along with the increase in population and the activities that sustain human life. The natural eutrophication of water bodies no longer occurs

gradually over time, but rather is accelerated by the culture of border ethics (Chiras, 2010b). Sadly, this brings us to the main problem: lakes, streams and rivers suffer from cultural eutrophication. Globalization has forced humans to increase the residential, industrial, harvesting, and livestock areas in order to keep up with the supply and demand requirements of the consumer model of today. The deterioration in the bodies of water has increased so much that it has changed the way in which the system flows, making life around it unsustainable. Cultural eutrophication and the deterioration in the bodies of water directly impacts aquatic plants, fish, and other species that live, feed, or recreate on it. Many of the pollutants can be evaluated provided that the point source is known; however, urban growth, the manipulation of these areas (such as the removal of wetlands, shrubs and other plants that prevent soil erosion), and the inappropriate use of resources have made it so that many of the pollutants found cannot be attributed to a point source. "Non-point sources can come from farms, pastures, crops, forests or urban areas, the source is diffuse, and an owner cannot be assigned" (Chiras, 2010a). These "affects the chemical composition of lake waters by controlling the time available for biogeochemical and photochemical processes to operate, the extent of accumulation, loss of dissolved and particulate materials and the duration of biogeochemical interactions with the lake sediments and littoral zone. In lakes that experience anoxic bottom water conditions and nutrient release from the sediments, a prolonged residence time caused by reduced precipitation and inflows can result in increased phosphorus accumulation (internal phosphorus loading) and eutrophication" (Bhateria and Jain, 2016). Another problem that must be taken into consideration regarding the eutrophication of a water body is sedimentation. This sediment, being suspended in water, reduces the penetration of light, which deteriorates the growth process of aquatic plants, and eventually causes them to die. In turn, this excess of dead material lowers oxygen levels, suffocates fish eggs and disrupts the food chain (Chiras, 2010a) whilst decreasing the capacity of the body of water. According to a 2011 report by Easter and Perry, Minnesota has "about 105,000 miles of streams, distributed among 81 major watersheds, and about 9.3 acres of wetlands. The National

### *Trophic status of lakes and possible recommendations*

Hydrographic Data Set (NHDS) places the number of lakes at 12,200; of these, 800 are greater than 500 acres, 4,000 are between 100 and 500 acres, and the remainder are between 10 and 100 acres” (Easter and Perry, 2011). The state has 5 main rivers of which three start in the state of Minnesota: the Mississippi River, the Red River, and the Rainy River. In order to properly assess this problem and accept or reject the study hypothesis, the following goals must be carried out:

1) Evaluate and analyze the secondary data obtained at the MPCA public domain for the test concentrations of Secchi Disk, total phosphorus, and Chlorophyll-a in six Minnesota lakes for the period 2008-2016 and determine the potential risk through the degree of eutrophication;

2) Compare the results of the lakes belonging to Carver County with the results of Hennepin County in order to determine if the activities carried out by agriculture and livestock generate more nutrient problems in the lakes than those generated in lakes near urbanized areas (construction activities, industries and other businesses);

3) Recommend bioremediation strategies according to the results obtained for Secchi, total phosphorus and Chlorophyll-a for the six lakes of Minnesota, in order to minimize the trophic problem, taking in consideration findings of studies performed in lakes with similar predicament and adjusting the authors’ recommendation to the lakes of MN.

The lakes to be evaluated are supplied by the Mississippi River (Dutch Lake, Wassermann Lake, Turbid Lake and Minnetonka Lake), the South Fork Crow River which also discharges into the Mississippi River (North Whaletail Lake) and the Lower Minnesota River (Lake Hydes). Currently, there are several lakes and parts of the “South Fork Crow” river that do not meet the quality standards for it, thus jeopardizing the use of this body of water for aquatic recreation, drinking and swimming. Longitudinal data collected on June 13, 2013 along the South Fork Crow River shows a general trend of phosphorus values increasing along the South Fork Crow River from upstream to downstream (Minnesota Pollution Control Agency (MPCA), 2017b). This in turn directly affects the Mississippi River as the “South Fork Crow” discharges its polluted waters directly into this river. The same problem was observed with the Minnesota River. “Water quality issues found in this

watershed include high suspended sediment loads, high levels of nutrients, and the potential for high DO flux. One reach in the sub watershed had a previous impairment for turbidity that was corroborated with updated TSS information” (Minnesota Pollution Control Agency (MPCA), 2017c), directly affecting the Mississippi River. This excess of nutrients has created a bigger problem since the lakes supplied water from the Mississippi River are also suffering from problems of blue-green algae. It should be noted that most of the land in the area is used for agriculture. Some states have lost up to 90% of their original wetlands, with agriculture being the activity with the greatest impact in these systems (United States Department of Agriculture-Natural Resources Conservation Service/National Resources Inventory (USDA-NRCS/NRI), 2014). Wetlands are transitional areas between aquatic and terrestrial systems (Bigio, 2020). The lack of wetlands prevents water retention in the landscape and leads to increased runoff and discharges related to times when storms occur that can destabilize currents and increase sediments in the water. Similarly, in urban and suburban environments, impervious surfaces send large volumes of water to storm drains and nearby bodies of water (Minnesota Pollution Control Agency (MPCA), 2018), which are non-point sources of pollution. The Mississippi River is the fourth longest river in the world, flowing 2,350 miles from Lake Itasca in Minnesota to the Gulf of Mexico, passing not only through valleys, cliffs, grasslands, and forests (Minnesota Pollution Control Agency (MPCA), 2017a) but also through industrial areas, residential areas, and areas of livestock and agriculture. Since the river is born in Itasca Lake in northern Minnesota, the water has been pristine. As the water continues to descend, the purpose of the land around the river changes to areas for crops, livestock, residential and industrial. The tributaries, as explained previously for “South Fork Crow” River which flows through heavily cultivated areas, bring in pollutants such as sediment, nutrients, and bacteria in addition to those already brought in by the Mississippi River. When these water discharges reach the Minnesota capital, the water no longer meets quality standards, having a cumulative impact that makes it difficult to use the waters of the metropolitan area on several occasions (Minnesota Pollution Control Agency (MPCA), 2017b). This problem of inflows comes from the pollutants dragged by the

river, plus the contaminants in the runoff, cause the lakes in question to be in, or close to, a state of eutrophication. To address the areas more effectively, the environmental protection agency (EPA) has zoned resources according to similar characteristics, and the agency has a Roman numeral classification scheme for different hierarchical levels of ecoregions, ranging from general regions to more detailed ones. An ecoregion is an ecological region that is intended to provide a spatial framework for ecosystem assessment, research, inventory, monitoring, and management (Easter and Perry, 2011). The state of Minnesota is classified at a level III. This level contains 105 ecoregions on the continent and the border of the United States has 84 ecoregions (Omernik and Griffith, 2014). Of these, the state of Minnesota has 7 ecoregions: Northern Minnesota Wetlands, Red Lake Valley, Northern Lakes and Forests, Northern Glacial Plains, Western Plains Corn Belt, Driftless Areas, and the North Central Hardwood Forest area. The lakes to be assessed are contained within region 5 and division 51. That means they belong to the north central hardwood forest area. This ecoregion contains many lakes, and the water clarity and nutrient levels they are presumed to be within moderate parameters. The land surrounding many of these lakes has been developed for housing and recreation, and the metropolitan area is densely populated and dominates the eastern part of this region. The water quality problems faced by many of the water bodies in this area are associated with contaminated runoff from paved surfaces and treated lawns (United States Environmental Protection Agency (US EPA), 2003). Urban stormwater and snowmelt pollution contribute significantly to the deterioration of surface waters quality (Müller, *et al.*, 2020). In the case like Carver County, the contamination problem also comes from the crops and livestock in the area. The state has a duty to assess the lakes initially to find out what type of pollutants and calculate the trophic level. For this, they take samples and evaluate the data for the summer season (June 1 to September 30) in the lakes for total phosphorus, Secchi disk and Chlorophyll-a, although in some cases different periods of sampling and other types of tests are generated that are also indicative of if the body of water is in good condition or that it is detrimental. Regulation §7050.0222 sub-part 4a-B, the state has multiple rules to prevent a body of water from reaching eutrophic levels for point source

pollutants. For the lakes in question, the pollution is presumed to be mostly from a non-point source. The state has classified them as 2B, and according to Minnesota statute, they are suitable for aquatic recreation of all kinds, including bathing, for which the waters can be usable, these are not protected as drinking water, but they are as a reserve, which allows the state to create specific standards to ensure the integrity of the body. For deep lakes belonging to the “North Central Hardwood” ecoregion, the water quality is measure with the following parameters:

- Total Phosphorus (TP): <40 µg/L
- Chlorophyll-a (Chl-a): <14 µg/L
- Transparency per-Secchi disc: Not less than ( $\geq$ ) 1.4 m

In some cases, they evaluate the values of nitrates/nitrogen, dissolved oxygen, and suspended solids to calculate the survival ratio of the fish and their food source (MPCA *et al.*, 2018). In the event that the lake is in the eutrophication process and has excessive algae growth, according to sub-part 5aB, the magnitude, duration and frequency are evaluated (Minnesota Administrative Rules (MAR), 2017a) to work on a method that decreases the nutrients of which these are fed. In statute §114D.26, the state provides strategies to restore and protect the state's watersheds. The state expects that for the year 2020, the evaluation of 80% of the lakes of Minnesota is completed, where this evaluation includes a physical, chemical, and biological evaluation; and describes which basins, streams, rivers and lakes are at delicate levels of quality. In this evaluation, it is decided whether the body of water should be within the TMDL study, and which are the stressors identified as a contaminant. With this information, the organization begins to work on an improvement plan and strategy (Minnesota Administrative Rules (MAR), 2019). On November 2020, the state reported that for the assessment performed on the ecoregions of Northern Forests, Eastern Temperate Forest, and the Great Plains, 44% and 24 % of the lakes were in eutrophic and hypereutrophic condition, respectively (Minnesota Pollution Control Agency (MPCA), 2017). The current study has been carried out in Minnesota in the year 2020 and updated during the year 2021.

## **MATERIALS AND METHODS**

### *Investigation design and data collection*

The most polluted area of lakes is in the central

south-southeast area of the state. Therefore, two counties were chosen within the area of interest: Carver and Hennepin. The lakes that were evaluated had as characteristic that they are known as deep lakes since they are more than 15 feet deep. Hennepin County was selected as a county that is more urbanized, it is close to the metropolis, there are different industries (pharmaceuticals, medical device company, grocery industries, among others), and there are many new constructions. The runoff was mainly from the removal of land from the construction of new developments, from the particulate of the streets in general and/or businesses in the area. Carver County borders the southwest area of Hennepin County and was chosen as a county governed mostly by agriculture and the livestock industry. Runoff comes mostly from washing areas where there are livestock and from chemicals added to plantations. Some of these pollutants percolate through the ground and others reach the lakes when during the rainy season, or throughout the snowmelt season.

#### *Study timeframe*

In Minnesota, the water analysis for the lakes had not been constant and/or they were governed by specific rules for each place, so finding lakes that were evaluated under the same parameters in the area of interest, during the same period and classified as a deep lake in the state, was challenging. The Minnesota Pollution Control Agency (MPCA) tested water samples for lakes throughout the year, but most samples were taken during the June through September period. As explained above, the state measured the eutrophication level through tests for total phosphorus, Secchi Disk, and Chlorophyll-a. The analysis of all these parameters has not been constant. Therefore, the period evaluated spanned approximately seven (7) years (years 2008, 2010 to 2011 and 2013 to 2016) during the summer season (June to September, with the exception of 2010 that is from July to September) and averaging the values per month to have the same amount of data. This data was in the public domain on the official website of the Minnesota Pollution Control Agency and was used as secondary data for this study.

#### *Sample Description*

The lakes assessed are deep lakes, within the

“North Central Hardwood” forest ecoregion, and mostly within a large-scale surface area (over 100 acres, except for Turbid Lake). The sampling areas have been classified by the state with a numerical code so that data can be collected in the same area later, and the results were reported on the information webpage for each lake. This secondary data, taken from the official webpage by February-March of 2020, were used in this study and evaluated to verify the status of the lake. According to the law §7050.0222 of the state of Minnesota, a lake was in good condition, if the following parameters were met (Minnesota Administrative Rules (MAR), 2017a):

- Total Phosphorus (TP) : <40 µg/L
- Chlorophyll-a (Chl-a) : <14 µg/L
- Transparency per Secchi disc: Not less than (≥) 1.4 m

The information station used for each lake was the following:

- a. Dutch Lake: 27-0181-00-201 for Hennepin County
- b. North Whaletail Lake: 27-0184-01-203 for Hennepin County
- c. Minnetonka-Halstead Bay Lake: 27-0133-09-201 for Hennepin County
- d. Wassermann Lake: 10-0048-00-201 for Carver County
- e. Hydes Lake: 10-0088-00-201 for Carver County
- f. Turbid Lake: 10-0051-00-201 for Carver County

The lakes in Carver County, even though urban areas are developing in this area, were mostly used for agriculture and livestock in the past; the lakes belonging to Hennepin County are in a more urbanized and industrial area.

#### *Experimental design*

No testing was performed to the lakes for this study. The data used was from analytical tests performed by analysts hired by the Minnesota Pollution Control Agency (MPCA) and results were documented in the public domain (Secondary data). Therefore, these results were used to calculate the trophic state of each lake and to perform the comparison between counties using statistical analysis.

#### *Statistical analysis*

To verify the trophic status of each lake, and to

be able to compare whether lakes in rural areas are more prone to contamination than lakes belonging to urbanized areas, the data evaluated was from the Minnesota Pollution Control Agency. The data from June to September was used within the period from 2008 to 2016 and the experimental method was a quantitative. Since the number of samples were not the same for all lakes analyzed, the values were averaged per month. Trophic status was calculated per year and evaluated how the activities carried out near the areas of interest had affected the lakes.

After evaluating the trophic level, the data was evaluated using the bilateral hypothesis, where:

$H_0$ : Pollution in Lakes of Rural Area = Pollution in Lakes of Urbanized Area (when  $p > 0.05$ )

$H_1$ : Pollution in Lakes of Rural Area  $\neq$  Pollution in Lakes of Urbanized Area (when  $p \leq 0.05$ )

Using the data from the three lakes per county, the data was processed using the ANOVA test and the

results were evaluated to see if the null hypothesis was correct or if, on the contrary, the alternate hypothesis was correct. The usage of Histograms and Pareto's method was also used for the evaluation.

## RESULTS AND DISCUSSION

### General Evaluation

For total phosphorous results (Fig. 1), three of the six lakes showed a pattern of increasing in nutrients parameters through the years: Minnetonka Halstead Bay Lake, Wassermann Lake and Dutch Lake, which had the highest amount in total phosphorus during the 2015 year. After an evaluation of the Secchi Disk data (Fig. 2), it showed that the visibility in Minnetonka Halstead-Bay Lake had decrease, indicating the lowest result by the year of 2010. A similar pattern was observed for Dutch Lake and Wassermann Lake. For Chlorophyll-a (Fig. 3), the results were decreasing by year 2010 and then started to increase with the

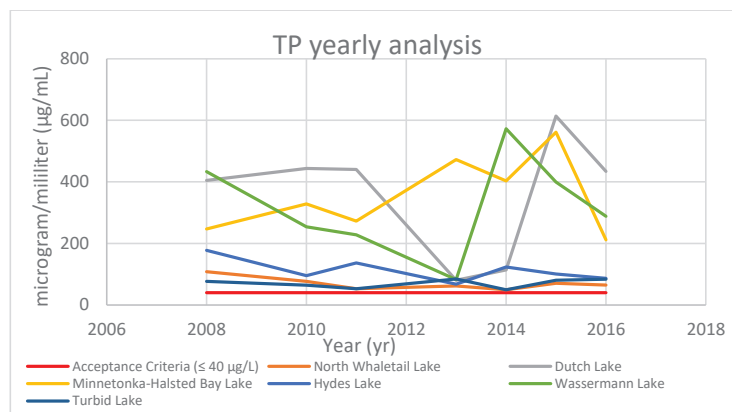


Fig. 1: Total Phosphorus Evaluation for all lakes through the study period: 2008-2016

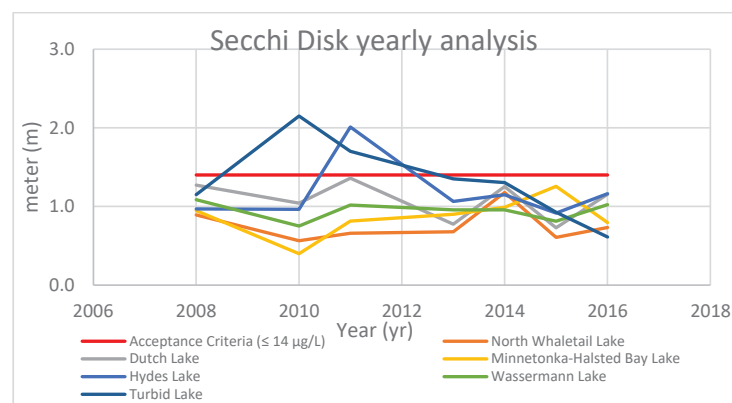


Fig. 2: Secchi Disk Evaluation for all lakes through the study period: 2008-2016

### Trophic status of lakes and possible recommendations

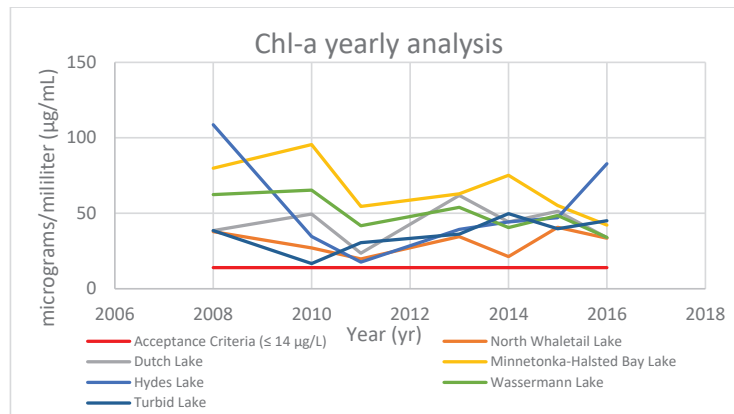


Fig. 3: Chlorophyll-a Evaluation for all lakes through the study period: 2008-2016

highest results during the 2016 year for Hydes Lake. The remaining lakes showed a similar pattern; Dutch Lake and Wassermann Lake had an increase by 2013 and Minnetonka Halstead-Bay Lake had an increase by the year of 2014.

#### *Trophic status evaluation*

Results were evaluated for trophic status and are discussed in Table 1. The results obtained showed that for Hennepin County, North Whaletail Lake had a 65 result of trophic level, Dutch Lake showed a 72 result of trophic level, and Minnetonka-Halsted Bay Lake a 74 result of trophic level. For Carver County, Hydes Lake showed a 66 result of trophic level, Wassermann Lake showed a 72 trophic level, and Turbid Lake showed a 63 trophic level. A comparison of the results against the trophic status parameter (Carlson and Simpson, 1996) was performed and the results showed that two of the three lakes evaluated for Hennepin County was under hypereutrophic conditions. Conversely for Carver County, two of the three lakes evaluated were under eutrophic condition. These results are the initial indication that the null hypothesis should not be accepted, and confirms that for the data analyzed, the activities performed in urban areas affect more of the lake's water quality than the activities carried out in rural areas. A possible root cause is that the state has identified the agriculture and livestock as a punctual source and has a program with guidelines to maintain the integrity of water near the areas. Since 2015, the state governor Mark Dayton had a proposal to improve water quality by implementing a buffer initiative, where he wanted to "establish 50-foot-wide

buffer strips between nearly every state waterway and farmland, from which fertilizer and other agricultural runoff had become one of the leading causes of the state's deteriorating water quality" (Bierschbach, 2015). This buffer seems to work better for rural areas than for urban areas. Conversely, regarding the controls the state has for construction sites and other industries, the buffer initiative is not enough to control the contamination, and for the time period analyzed, these activities had a deteriorating effect in the water quality for urban areas. Literature cases for bodies of water in quasi-similar to similar conditions (less cold than the study area or depth) had lakes with similar trophic conditions as they found in this study for both counties. Lakes such as Carey Lake in MN and Caohai Lake in China, evaluated different aquatic plants and sediment modifications to eliminate these contaminants. Both studies are a good proposal to improve the conditions of the lakes.

A statistical analysis was performed by using ANOVA two factor with replica, to compare properly both counties' data. Results obtained (Table 2), showed a  $p < 0.05$  and values obtained for F are higher than F critical, demonstrating that there is a difference between the two counties that had been compared and therefore, the second indication that the null hypothesis should be rejected.

There are differences between the conditions of the lakes between the areas of study, but the original statement presumed that rural areas are more polluted than urbanized areas. For Hennepin County, Minnetonka Halstead-Bay and Dutch lakes are under hypereutrophic conditions, and North Whaletail Lake

Table 1: Average results for Total Phosphorus, Secchi Disk and Chlorophyll-a and trophic state for Hennepin and Carver Counties Lakes

County	Lake	Month	TP	Secchi	Chl-a	TP	Secchi	Chl-a	Mean	Lake status
			AVERAGE Results			Trophic status				
Hennepin	North Whaletail Lake	Jun	65	0.9	24	64	61	62	63	eutrophic
		Jul	77	0.8	33	67	64	65	65	
		Aug	68	0.7	36	65	66	66	65	
		Sep	64	0.7	30	64	65	64	64	
		Grand AVG	69	0.8	31	65	64	64	64	
	Dutch Lake	Jun	235	1.6	28	83	53	63	66	hypereutrophic
		Jul	322	0.8	51	87	64	69	73	
		Aug	378	0.7	53	90	65	70	75	
		Sep	482	1.3	38	93	56	66	72	
		Grand AVG	354	1.1	42	89	59	67	72	
	Minnetonka-Halstead Bay Lake	Jun	189	2.2	19	80	49	60	63	hypereutrophic
		Jul	367	0.7	57	89	66	70	75	
		Aug	573	0.5	83	96	70	74	80	
		Sep	278	0.4	95	85	72	75	78	
		Grand AVG	352	0.9	64	89	61	71	74	
Hydes Lake	Jun	67	2.1	27	65	49	63	59	eutrophic	
	Jul	126	1	73	74	61	73	69		
	Aug	136	0.8	82	75	63	74	71		
	Sep	117	1	30	73	60	64	66		
	Grand AVG	112	1.2	53	72	57	70	66		
Wassermann Lake	Jun	153	2	23	77	50	61	63	hypereutrophic	
	Jul	301	0.8	50	86	63	69	73		
	Aug	401	0.6	67	91	68	72	77		
	Sep	422	0.6	52	91	67	69	76		
	Grand AVG	319	1	48	87	60	69	72		
Turbid Lake	Jun	65	1.9	27	64	51	63	59	eutrophic	
	Jul	79	1.1	52	67	58	69	65		
	Aug	64	1	33	64	60	65	63		
	Sep	74	1.2	36	66	58	66	63		
	Grand AVG	70	1.3	37	65	56	66	63		

Table 2: ANOVA: Two factor with Replica comparison results for Hennepin and Carver counties

SUMMARY	Hennepin County			Carver County			Total
Chl-a	North Whaletail	Dutch Lake	Minnetonka-Halsted Bay	Hydes Lake	Wassermann Lake	Lake Turbid	
Count	27	27	27	27	27	27	162
Sum	830.7083	1161.187	1764.983	1462.15	1320.45	1007.3	7546.778
Average	30.76698	43.00691	65.36975	54.1537	48.90555556	37.30741	46.58505
Variance	117.3097	478.561	1165.12	3979.845	381.2701496	507.8676	1198.908
Secchi							
Count	27	27	27	27	27	27	162
Sum	20.65833	29.29167	23.98833	31.95417	25.6419755	34.61	166.1445
Average	0.765123	1.084877	0.888457	1.183488	0.949702796	1.281852	1.025583
Variance	0.062634	0.375264	0.570721	0.409198	0.349839154	0.597814	0.413282
TP							
Count	27	27	27	27	27	27	162
Sum	1861.417	9680.117	9659.817	3055.833	8778.633333	1906	34941.82
Average	68.94136	358.5228	357.771	113.179	325.1345679	70.59259	215.6902
Variance	490.8636	48007.79	56371.2	2432.812	43937.99987	735.7892	42262.71
Total							
Count	81	81	81	81	81	81	
Sum	2712.783	10870.6	11448.79	4549.938	10124.72531	2947.91	
Average	33.49115	134.2049	141.3431	56.17207	124.9966088	36.39395	
Variance	985.7835	41528.52	43114.4	4202.94	35069.90796	1215.477	
ANOVA							
Source of Variation	SS	df	MS	F	P-value	F crit	
Sample	4144669	2	2072335	235.1826	2.00684E-71	3.01499	
Columns	1052693	5	210538.6	23.89335	2.00588E-21	2.233275	
Interaction	1820865	10	182086.5	20.66441	8.14019E-32	1.850937	
Within	4123829	468	8811.599				
Total	11142056	485					

Therefore, if  $F > F_{crit}$  and  $p$  values is  $< \alpha$ , then  $H_0$  is rejected ( $\alpha=0.05$ ).

is under eutrophic conditions. The difference between the trophic status results progresses from 49 to 96 result, and for all the lakes the trophic values start increasing from June to August and begins to decrease in September. For Carver County, Wassermann Lake is in hypereutrophic condition and Hydes and Turbid lakes are under eutrophic conditions. The difference between the trophic status results progresses from 49 to 91, and for all the lakes the trophic values start increasing from June to August and begin to decrease in September. Histogram and Pareto analysis was performed for each parameter and county. Relating to Chlorophyll-a results at Hennepin County (Fig. 4), second-class interval (23, 39] contains most of the

results with an approximate of 28% of the values, and a cumulative percent of about 51%. Results conforming to the specification ( $\leq 14 \mu\text{g/L}$ ) are contained in the first-class interval and are less than 22%, since this interval also contains results above acceptance value. Therefore, approximately 78% of the results in the period of study are in eutrophic-hypereutrophic status. For Carver County, (Fig. 5) shows the same pattern as Hennepin County but the class interval values contain results higher than the results from Hennepin County. The interval goes from (35, 69] and contain 43% of the results with a cumulative of 85%. Less than 42% of the results conform to specification, and about 58% does not

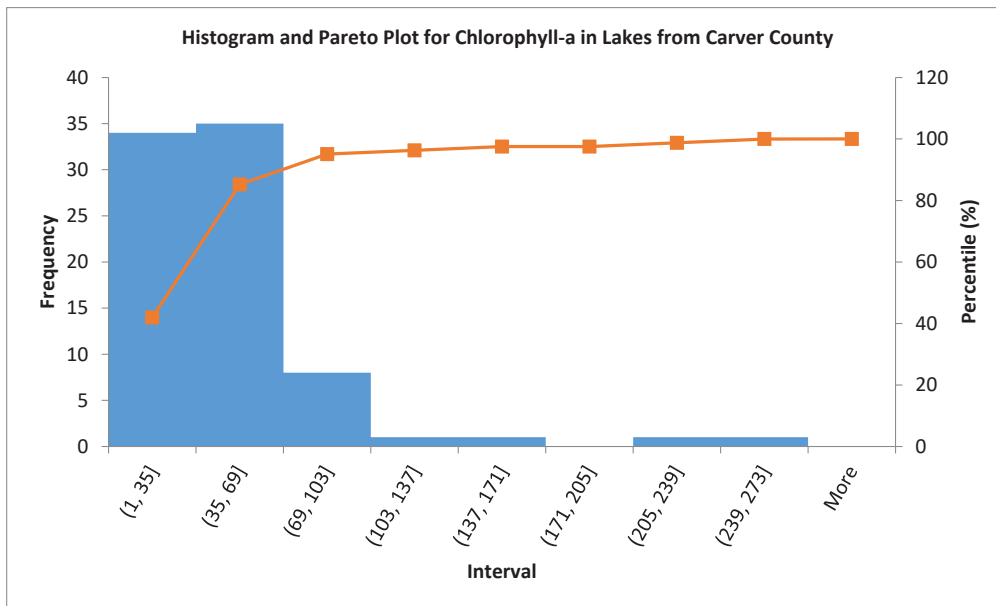


Fig. 4: Histogram and Pareto Plot for Chlorophyll-a in Lakes from Carver County (n=81)

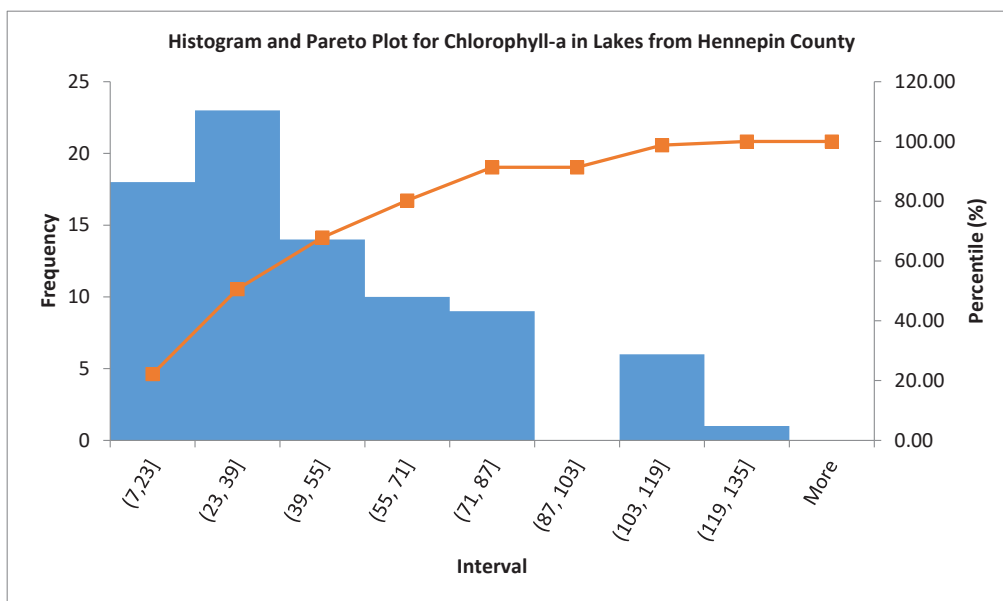


Fig. 5: Histogram and Pareto Plot for Chlorophyll-a in Lakes from Hennepin County (n=81)

conform to the specification and are in eutrophic-hypereutrophic status. Regarding Secchi Disk results at Hennepin County (Fig. 6), first-class interval (0.4, 0.8] contains most of the results with an approximate of 54%, and all the results contained in the interval do not conform to the specification ( $\geq 1.4$  m). In fact, 78% of the cumulative results do not conform to the

specification and are in eutrophic-hypereutrophic status. For this county, only 15% of the results for SD conform to the specification. Carver County shows the same pattern as Hennepin County, but the number of results is less (Fig. 7). The first-class interval goes from (0.4, 0.8] and contain 40% of the results. Less than 12% of the results conform to specification and

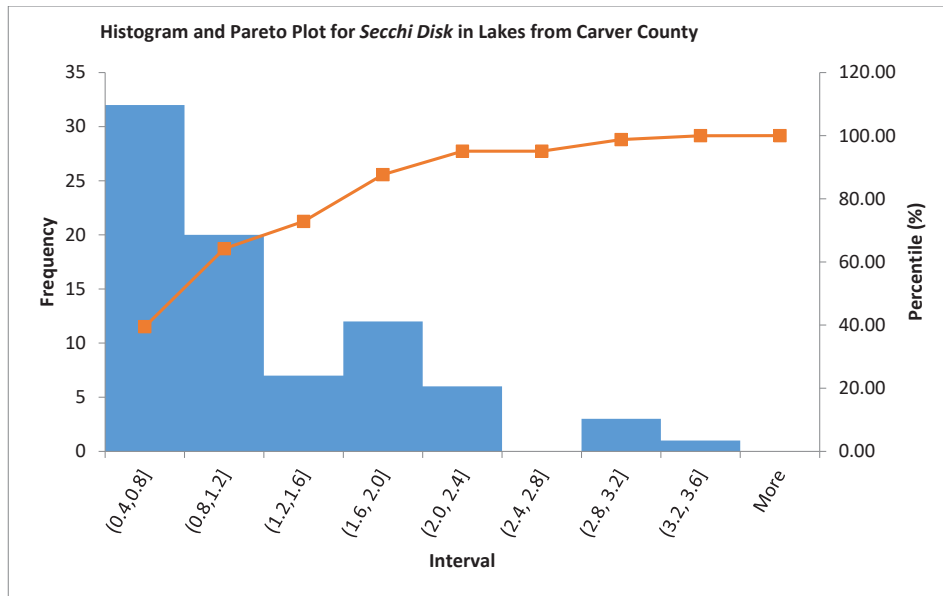


Fig. 6: Histogram and Pareto Plot for Secchi Disk in Lakes from Carver County (n=81)

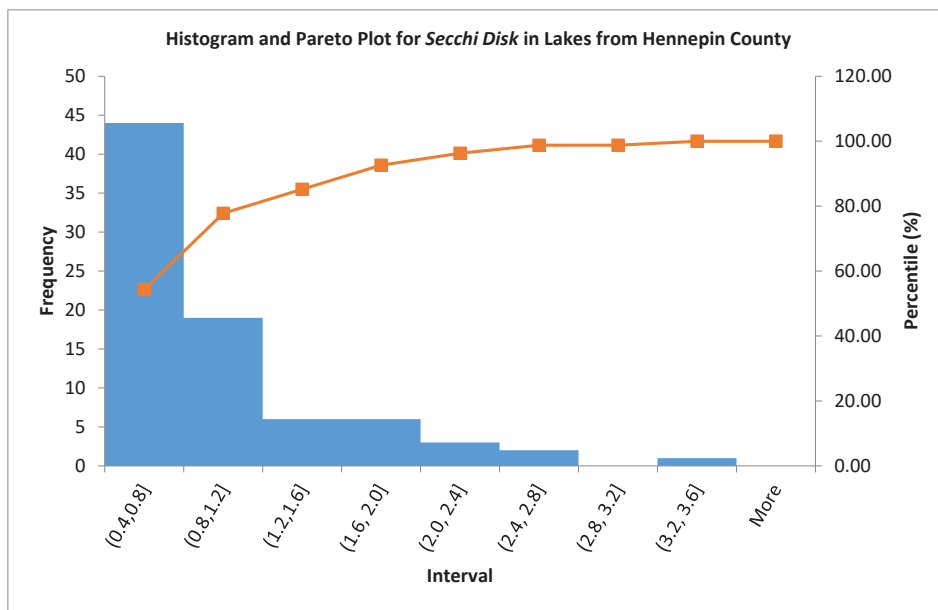


Fig. 7: Histogram and Pareto Plot for Secchi Disk in Lakes from Hennepin County (n=81)

about 88% do not conform to the specification and are in eutrophic-hypereutrophic status. For Total Phosphorus results in Hennepin County (Fig. 8), first-class interval (43,159] contains most of the results with an approximate of 51% and no results contained in the interval conform to the specification ( $\leq 40 \mu\text{g/L}$ ). In fact, 100% of the results do not conform to

the specification and are in eutrophic-hypereutrophic status. For Carver County (Fig. 9), the results show the same pattern as Hennepin County, but the class interval values contain results lower than the results from Hennepin County. The interval goes from (21, 134] and contain 67% of the results. Less than 67% of the results conform to specification and about

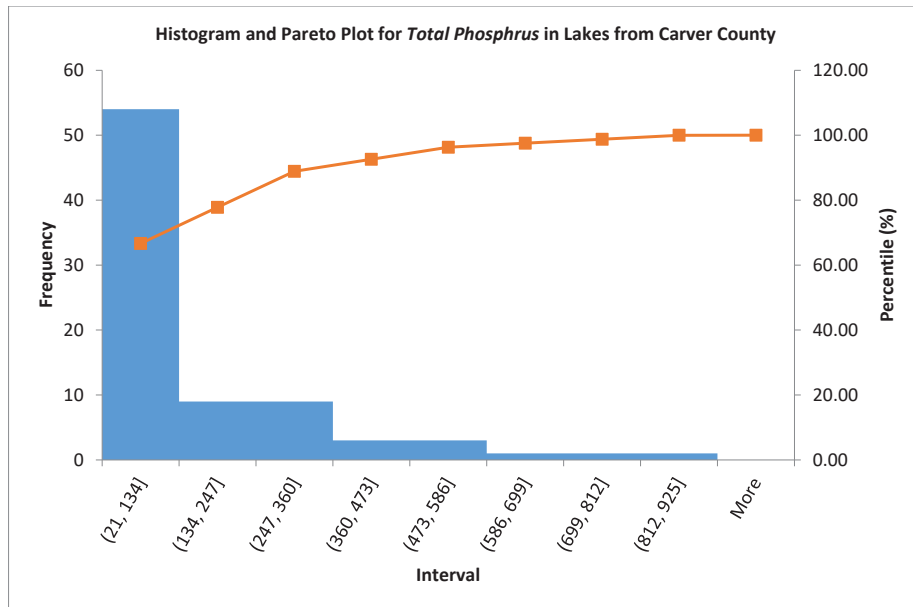


Fig. 8: Histogram and Pareto Plot for Total Phosphorus in Lakes from Carver County (n=81)

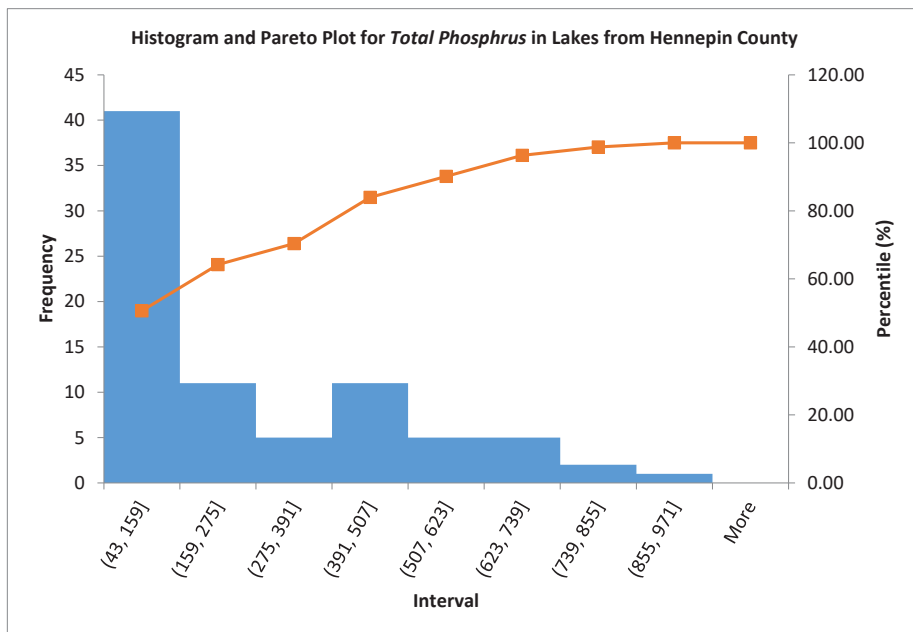


Fig. 9: Histogram and Pareto Plot for Total Phosphorus in Lakes from Hennepin County (n=81)

33% do not conform to the specification and are in eutrophic-hypereutrophic status.

*Literature Comparison*

Similar cases were evaluated in lakes that are

close to or at a similar temperature to the lakes of Minnesota or in lakes with similar eutrophication problems. Bioremediation plans have been started, where the work consists of the creation of artificial wetlands that promote denitrification and

phosphorus removal using different sedimentation and plants, which effectively removes them from the body of water. A similar case in Taihu Lake Bay in China has soil erosion problems, causing high increase in nutrients and turbidity, and is severely in eutrophic status. These problems are due to a “significant urbanization over the last 20 years, deforestation, soil erosion and poorly regulated horticultural and agricultural activities resulted in a heavy inflow of nutrients into the lake from catchment areas” (He, Lin and Ma, 2016). Other authors suggest the usage of integrated systems where ecological modifications are performed using “locally available natural resources in ecologically balanced systems” (Shutes, 2001). Literature cases for water bodies in quasi-similar to similar conditions (less cold than the study area or depth), had lakes with similar trophic conditions as the found in this study for both counties. As explained previously, lakes in eutrophic conditions such as Carey Lake in MN and Caohai Lake in China, evaluated different aquatic plants such as *Eichhornia crassipes* removing almost a 100% of TP (Zhang et al, 2019), and sediment modifications such as the zinc modification performed by Huang group (Huang et al, 2019), to eliminate these contaminants, and should be considered as a possible bioremediation method to improve the water quality of the studied lakes by restoring the wetlands near these lakes, or implementing these changes by creating an artificial wetland in these areas.

## CONCLUSION

According to the results obtained during this study, the following conclusions were made:

1. There was enough evidence to reject the null hypothesis since the F-statistical value obtained is higher than F-critical, and the p-value obtained is lower than alpha ( $\alpha=0.05$ ). There was a difference in the water quality between the counties, but not as expected. The original statement specified that the lakes near areas mostly used for agriculture or livestock should have worse water quality than urbanized areas. The results obtained showed that for the lakes studied, the urban areas have more contamination than the lakes in rural areas, but still both areas have eutrophic-hypereutrophic conditions. During the past decade, the state resulted data that indicated an increase in nutrients and are

shown in the annual graphs for total phosphorus, Secchi Disk and Chlorophyll-a, Figs. 5 to 10. It is also observed that the state's resulted data had a decrease in the contaminant early in the decade and suddenly the contaminants started an increasing during the following years. This evidence that anthropogenic activities from a non-point source are the most probable cause for the rise in contaminants. The state adopted a buffer project to lessen the effect of the contaminants inserted in the lakes, rivers, watershed, and streams by runoffs. As explained previously, the urban growth and the manipulation of the areas (such as the removal of wetlands, shrubs and other plants that prevent soil erosion) and the inappropriate use of the resource, have shown that many of the pollutants found cannot be attributed to a point source, making this a huge problem. This is the case for Hennepin County. Carver County, even though is developing in urban and commercial areas, still has most of the lands used for agriculture or livestock. Therefore, the state already identified these as a point-source and has created different strategies to mitigate the impact of these activities in the lakes (such as a program with guidelines to maintain the integrity of water near the areas);

- 2) Trophic status objective was completed, and the results showed that the lakes under the study are in eutrophic-hypereutrophic conditions. In fact, lakes evaluated under this study, demonstrated that Hennepin County had worse conditions for the lakes than Carver County. The possible root cause redounds to anthropogenic activities affecting the lakes at different levels. Phosphorus (in its variation) in the lake water, limits Chlorophyll-a and therefore in excess (usually also in the presence of nitrogen and its variations), proliferate growth of aquatic plants, algae and cyanobacteria in the lakes that eventually, with the changes in temperatures due the seasons, will affect the transparency of the lakes;

- 3) After evaluating the results, it can be concluded that the buffer parameters implemented by the state are either not sufficient or need more time to be evaluated for the significance of implementing this method into the water quality. Therefore, the restoration or the implementation of a variation of an artificial wetland is recommended. Also, an evaluation of the soil and plants used in the buffer zones should be re-evaluated.

### Recommendations and limitations

Because of the limitations of this study, creating a complete environmental treatment program is not an appropriate method for this study, but general recommendations for the future to improve water quality are discussed. As a first recommendation, the original buffer zones should be evaluated. The timeframe studied is closed to the implementation of this system but still, the lakes are in eutrophic-hypereutrophic conditions. Therefore, an evaluation of specialized types of plants, soils, and/or bacteria needs to be performed to control the contaminants impacting the water bodies. As an option to improve the water quality of the lakes in Minnesota, a restoration of lakes with wetlands or an artificial wetland project can be implemented and paired with the original buffer plan the state has already implemented. Since the study demonstrated that urban areas suffer from more non-point source contamination than the rural areas, the plan can be focused on the improvement of water quality in this type of area. After evaluating the results obtained, the implementation of an integrated method using a Subsurface Flow System (SFS) is highly recommended because this method can have an effectiveness of 80% the removal of organic material and suspended solids, but nutrient removal efficiency is normally below 60% (Shutes, 2001). The SFS system uses a "layer of soil or gravel as a substrate for plant growth. The water flows go through the substrate and the roots of the plants by gravity and horizontally. During the passage of wastewater through the root system of plants, organic matter decomposes biologically, nitrogen can be denitrified, and phosphorus and heavy metals are fixed in the soil" (Fernández-González, n.d.). Since Minnesota lakes have higher results for PO contaminants, the addition of "Phospho-accumulating organisms" (PAO's) will be useful to help in the conversion of these contaminants in the Phosphorous (P) form, and then be trapped in the plants from the artificial wetland, such as the proposed below (Minnesota Pollution Control Agency (MPCA), 2011). Shutes (2011) has an example of an artificial wetland specifically created for urban surface runoff treatment where the following procedure was followed. The following modifications can be incorporated in the subsurface flow system (SFS) artificial wetland:

1) An area with modified soil can be used to

remove properly P and N. Soils like  $ZnSO_4$  were used by other authors obtaining good results removing orthophosphates and controlling algal blooms (Huang et al, 2019);

2) Studies suggested the usage of *Eichhornia crassipes* and *Pistia stratiotes* due to its effectiveness removing between 93% to 96% of TP (Irfan, Sayantan, Shardendu and Sharma, 2012 and Bartodziej, Blood and Pilgrim, 2017);

3) Other phosphorus remover plants that can be used such as *Hydrilla verticillate*, *Hydrodictyon reticulatum* *Eleocharis plantaginea*, and *Elodea canadensis* (Bartodziej, Blood and Pilgrim, 2017; Irfan, Sayantan, Shardendu and Sharma, 2012 and Zhang, 2019);

4) Additional plant that can be used as nitrogen removers are *Myriophyllum spicatum*, *Zostera marina*, *Egeria densa*, *Lemna obscura*, *Phragmites australis*, and *Typha* (Irfan, Sayantan, Shardendu and Sharma, 2012).

According to Huang et al. (2012), the construction of an artificial wetland that has optimal anaerobic and anoxic conditions for denitrification and nutrient removal, when focusing on Minnesota cases, can be used as an option to bioremediate the problem. As explained by Guadalupe and Llagas, the creation of an SFS has three crucial parts: the physical, biological, and chemical removal process (Guadalupe and Llagas, 2006):

1) The physical process is one in which the flow of water is slow for an effective removal of solids since they are trapped in the plants and the bioturbation and gas evolution process begins.

2) In the biological process, nutrients are absorbed by plants, algae, and shrubs. When plants go to the dying process, the leachate process occurs where water soluble contaminants are suspended in the soil. The material that the microorganisms do not absorb and decompose, eventually turns into peat, storing these contaminants.

3) The chemical process occurs through absorption, where an exchange of cations occurs in the soil: either clay or organic material. Other processes that occur are precipitation by metal sulfides and volatilization of compounds.

### Limitations

The monitoring program was not constant and limited the data available for the study. Therefore,

the span of seven years was evaluated: 2008, 2010 to 2011 and 2013 to 2016 through the period of June to September (except for 2010 that June was removed due to missing data for one lake under evaluation). Since multiple lakes have site specific parameters, it was difficult to find bodies of water evaluated under the same parameters. This fact limited the quantity of lakes to be analyzed per county. Therefore, the results obtained under this study are specifically for the lakes analyzed and during the specified timeframe. To have more accurate information of the status of each county, the timeframe needs to be extended to conclude if the efforts made by the state are helping the water quality of the lakes, and if additional remediation plan needs to be implemented.

#### AUTHOR CONTRIBUTIONS

N. Guerrero Del Castillo performed the literature review, experimental design, analyzed and interpreted the data, prepared the thesis document, and the thesis committee of Ana G. Méndez University: J. Musa, K. Malavé and C. Morales mentored, gave recommendations and review the final thesis report.

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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.

#### ABBREVIATIONS (NOMENCLATURE)

<i>Chl-a</i>	<i>Chlorophyll-a</i>
CWA	Clean Water Act
DW	Dry weight
ENRD	Environmental and Natural Resources Department

FFS	Free Flow system (artificial wetland system)
$H_0$	Null hypothesis
$H_1$	Alternate hypothesis
$\mu\text{g/L}$	Microgram Per Liter
MAR	Minnesota Administrative Rules
MDNR	Minnesota Department of Natural Resources
$\text{mg} \times \text{g}^{-1}$	Milligrams Per Gram
$\text{mg/L}$	Milligrams Per Liter
MPR	Minnesota Public Radio
MPCA	Minnesota Pollution Control Agency
MN	Minnesota
N	Nitrogen
NHDS	The National Hydrographic Data Set
NOx	Nitrate pollutants
USDA-NRCS/NRI	United States Department of Agriculture-Natural Resources Conservation Service/National Resources Inventory
OS	Oxidized Sediment
PAO	Phospho-accumulating organisms
P	Phosphorus
PCB	Polychlorinated biphenyl
PFOS	Perfluoro octane sulfonate
$\text{P/m}^2/\text{day}$	Phosphorus in a square meter per day
ppm	Part per million
PO	Phosphate pollutants
RS	Raw Sediment
S-CTAB	Centrimonium bromide Sediment
SD	<i>Secchi Disk</i>
SFS	Subsurface flow system (artificial wetland system)
S-Zn	Zinc Sulfate Sediment
TMDL	Total maximum daily load
TP	Total phosphorous
TSI	Trophic State Index
US EPA	United States Environmental Protection Agency
WQA	Water Quality Association

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REVIEW PAPER

The urban innovation system modeling: using Meta- synthesis method

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ABSTRACT

**BACKGROUND AND OBJECTIVES:** According to the path of economic growth theories, especially the introduction of endogenous growth theories to address the shortcomings of extrinsic theories, the economic systems in order to achieve long-term economic growth goals need to drive stimuli and improve endogenous components that originate, crystallize, and evolve within these systems. Some endogenous growth models have stated that one country could be more successful than another if it devoted more resources to innovation. So today, the study of how to create innovation in various economic systems has become a challenging issue in the world's economic circles.

**METHODS:** Using the Meta- synthesis method, 19645 sources were collected between 1997 and March 2020 related to the urban innovation system, and after 7 steps and classification of resources, finally, 10 sources were selected and based on the coding method, the ten mentioned sources were coded. The estimated kappa coefficient indicates the reliability of the selected codes.

**FINDINGS:** The paradigm model of the urban innovation system was extracted based on the performed codes. This model can be used as a pivotal model in future studies.

**CONCLUSION:** An innovation system that can be implemented and applied in urban geography overcomes many urban, regional, and even national problems. Since this study examines the theory of Urban Innovation System, it can be expected that the results of this study can bring a positive step to determine the specifications and measures needed to create, sustain, and expand urban innovation systems.

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## INTRODUCTION

### *Innovation in Endogenous Economic Growth Theories*

In this strict competition era, all actors in economics must focus on their strengths for continuous growth, which would presumably lead to economic development (Soyer et al., 2020). Therefore, some economists have tried to explain knowledge, innovation, and new technologies as endogenous growth factors by providing endogenous growth patterns. In this regard, the separation of human capital from other production factors in the form of coded knowledge is one of the important issues that shows research and development activities are more important than before. In some other studies, differentiation between human capital, knowledge, and technology leads to long-term growth affecting the per capita production. In the early 1980s, Romer (1986) and Lucas (1988) stimulated the interest of macroeconomists in economic growth by emphasizing the economics of thought and human capital after Solow studies (1956) and focusing on the accumulation of physical capital. Using new advances in incomplete competition theory, Romer (1990) introduced the technology economy to macroeconomists (Oketch, 2006). Following these theoretical advances, empirical studies began by some economists, such as Barro (1990), to quantify and test growth theories. According to Solow model (1956), the technology is assumed to be exogenous, which goes forward regardless of other issues. But in the mid-1980s, Romer (1986) established the link between economic growth and the economics thought, and the pattern of endogenous growth was taken seriously at the economic level (Pala, 2019). The endogenous growth pattern seeks to explain technology as an endogenous factor influencing production and economic growth. These models introduced the effect of technology through different ways and factors such as human capital, improving production quality, and expanding various products in the growth model. The endogenous growth pattern presented by Lucas has been expanded by introducing the human capital factor in the neoclassical growth model. In their model of improving production quality, Aghion and Howitt (1992; 2005) and Aghion et al., (1998) explained the use of new technologies that would allow producers to leave the scene with old technology using the Schumpeter perspective (1934). Grossman, and Helpman (1993) introduced

endogenous growth patterns with the advent of new technology, which they said led to research and development. This in turn leads to the production of knowledge and innovation that could ultimately pave the way for economic growth (Fagerberg et al., 2010). On the other hand, there is the view that with increasing economic growth, more facilities and financial resources will be provided to entrepreneurs, and this in turn can expand innovations. In fact, there may be a circular flow between innovation and economic growth. Innovation increases economic growth, and economic growth itself can lead to increased innovation (Galindo and Mendez, 2014).

### *Innovation*

“From a terminological point of view, innovation means the process of acquiring a creative idea and turning it into a useful product, service, or operating method. In other words, innovation is a thought, idea, or application in a product, service, or method” (Henderson and Clark, 1990). In fact, innovation is the development and implementation of new processes or procedures that are inherently different from what they are. The position of innovation is a well-known position in economics and especially in the theories of economic growth. A significant part of economic growth is explained by the factor of innovation. In traditional economics, the relative economic power of countries and regions was explained by factors such as the existence of diverse amounts of natural resources and the abundance of cheap labor (Pyka and Prettner, 2017). Over the past decades, economic, regional management, and economic geography scholars have gained more evidence that increasing productivity is the key factor to achieving high levels of income, employment, and productivity growth that could be achieved by the innovation (Dziallas and Blinda, 2019). This finding led to extensive research efforts to understand how innovation works and how innovators and policymakers can increase innovation. On the one hand, stimulating the innovation capacity of enterprises and industries is an opportunity to improve living standards, and on the other hand, ignoring innovation will lead not only to economic recession, but also to economic collapse. As Schumpeter (1934) warned as “the father of innovation studies”, innovation is a double-edged sword. Innovators are creating a temporary monopoly on new products that allow them to

have high profits and employment over a period of time. But at the same time, existing products and techniques are obsolete due to new innovations, and this leads to the destruction of the forward movement of the creative process, which can lead from wealth to poverty in a very short time. Thus, "innovation is the engine of economic development, and for its growth and development, the necessary infrastructure must be created and strengthened in different countries, especially in developing countries" (Imon, 2006). As noted, although most entrepreneurs and policymakers are now aware of the importance of innovation, many researchers are still trying to better understand the innovation mechanism production and its supportive policies (OECD, 2008). Therefore, innovation is considered as one of the most basic requirements for the path of economic growth and development, which requires the maximum use of existing capacities, the creation of new capabilities and the conversion of potential capacities to actual capacities with emphasis on all types of capital, especially human and social capital that provide suitable conditions for the movement of the cycle of innovative activities (Perry, 2011).

#### *The importance of innovation*

In fact, the key to economic growth is human capital and emphasizes the role of innovation as an input factor of production. Numerous studies have attempted to explain innovation by combining models of economic growth, most of which agree that increasing the quantity and quality of innovative activities increases a country's economic growth rate. Among them, the studies of Fagerberg and Verspagen (2002); Metcalfe (2002); Demirel and Mazzucato (2007); Hasan and Tucci (2010); Sener and Saridogan (2011); Bartiuk (2014), Dmitriev *et al.*, (2016); Ashford and Hall (2018); Berneir and Plouffe (2019); Hu and Jaffe (2007) can be mentioned. However, some of these studies suggest that innovations can only improve a country's economic growth if the necessary conditions are provided for their implementation in the country (Lebel, 2008; Chen and Puttitanun, 2005). Innovation, as the engine of economic growth and national welfare, takes place within an innovation system that includes the activities and interactions of a set of members, including firms, individuals, universities, government-sponsored researchers and non-governmental organizations, and the socio-

economic environment (Pece *et al.*, 2015). For this reason, designing an innovation system is very important to provide a favorable atmosphere in which economic agents innovate and create technology (Rauhut and Hatti, 2017). The most important aspects of urbanization are industrial capacities, trade and handicrafts, interaction with the surrounding agricultural areas, a community that accepts and includes immigrants, an efficient and effective judicial system, schools and studies, and physical location with access to a good transportation system. It is possible to trade with other cities and countries. Therefore, only cities can provide the necessary environment to increase revenue and power (Lee *et al.*, 2017; McQueen, 2008; Oleinik and Zakharova, 2019). Cities are vessels of creativity and have always been the cycles of movement, concentration and direction of human creative energy. Most of the literature that has been written about innovative cities has not only focused on the role of innovation in urban growth and formation, but also emphasizes that by removing restrictions and barriers (physical, social, cultural, etc.) from cities, Innovation will become the driving force of economic growth and development of cities, regions and countries (Chen *et al.*, 2020; Caratelli *et al.*, 2019). Economic growth requires the accumulation and utilization of different types of capital, especially human capital and skilled labor. Cities are one of the most important population points, which are the factors affecting economic growth due to the existence of numerous educational and research centers and the accumulation of skilled labor (Bakhri and Fauzi, 2019; Zhang *et al.*, 2019; Zait, 2017; Chen and Choi, 2004; Carillo, 2004; Edvinsson, 2006).

#### *The Importance of Cities*

Throughout history, cities have played an important role in the social and economic development of countries. Cities are effective and efficient elements for the growth of the national economy, as well as the production of resources needed for public and private investment in infrastructure, education, and health, improving living conditions and reducing poverty (Marceau, 2014; Wei *et al.*, 2020). The capacities and capabilities of creativity and problem solving in cities are unique, as most cities are described as the cradle of creativity and as an innovative environment (Brezzi and Veneri, 2015). Cities are the boiling springs of

new ideas and innovative experiments and the center of the opportunities and threats flow (Athey *et al.*, 2007). Therefore, it is expected that the establishment of an appropriate UIS, given the specific conditions in each city, will make it possible to turn challenges into opportunities.

#### *Cities: The Geography of Innovation*

Based on the previous discussion, it can be concluded that the place of production and birth of innovative ideas should be a rich environment in all types of capital (Lever, 2002; Schragger, 2007). Cities are potentially innovative in terms of community and the accumulation of physical, financial, human and social capital (Song and Kim, 2020). In fact, cities are a gift of a dual nature to human societies (Maradana *et al.*, 2017). Providing favorable conditions for development in all areas will lead to the growth of urban living standards, improve productivity, and increase per capita income. Yet, on the other hand, in many developing countries, experience has shown that cities have a lot of social and economic issues. In some cases, in these countries, cities do not generate economic growth for the countries, but are an obstacle to development. Many major cities in these countries are the proven evidence for serious economic losses in urbanization. Policymakers in these countries may argue that in order to boost the national economy, it is necessary to limit urban growth, although the practicality of such policies will always be controversial (Berezin *et al.*, 2019, Aranha *et al.*, 2017). However, it can be said that the benefits of big cities outweigh their disadvantages. Even in the cities of developing countries, according to Scott (2006), in all cases, the long-term benefits of urban growth outweigh the costs. In the City Economics, O'Flaherty (2005) suggests that urban problems arise from the same factors that lead to the successful functioning of cities, such as skiing on water and expecting it not to get wet. Despite the losses and other problems caused by urban growth, big cities act like the growth machine of the national economy and, in recent years, the world economy. Large cities in the capitalist economy are places for high productivity and efficiency (Pinto Ferreira *et al.*, 2015). They have achieved astonishing growth through the growth of trade, industrialization, modernization, and now globalization. The importance of cities in national development as well as in global development has

been emphasized in many academic works. Life without cities will be very poor, not only for urban dwellers, but also for all those goods and services that are produced in cities, as well as people with high income. Because they have migrated to cities to achieve a higher life quality. Cities have always been at the forefront of national wealth creation (Chung, 2008). Very difficult experiments become commonplace through cities. Cities are the mother of innovations and inventions, and valuable interactions are made possible by the presence of a thoughtful mass and diversity. Cities are densely populated environments where people adapt, and their ability to leap toward progress is tested. Cities over the centuries have grown slowly to fulfill this role (Savitch and Kantor, 2002).

#### *Urban Innovation System (UIS)*

Cities cannot function separately and independently, but each city is part of an interconnected complex network of cities. This intertwined network in the context of globalization, as part of the global human subsystem and urban space (Navarro Yanez, 2013; Herrera- Medina *et al.*, 2013). Meanwhile, the increasing spatial expansion of cities, constructions, increasing the cars, creating permanent urban traffic and environmental pollution, etc. create this undeniable necessity in the third millennium, that is the creation of a UIS to make a permanent suitable communication with urban problems and solving them in a timely position (Taylor *et al.*, 2014; Chamchong and Boossabong, 2020). UIS deals with unique social aspects that exist in the urban environment by upwards or downwards. "An innovation system on such a small scale is considered not only because of economic factors, but also because of all the range of social challenges. Therefore, the present time is a 'critical time' to lay the groundwork for future success" (Markatou and Alexandrou, 2015). Fig. 1 shows the characteristics that appear to have the greatest effect on the performance of a UIS.

- ✓ Actors: UIS requires a specific combination of actors depending on the step of development and profile of the system.
- ✓ Networks: In addition to the composition of the actors and their individual characteristics, the innovation capacity of a UIS also depends on the interactions and connections between the actors.

Different types of networks can be distinguished from formal, institutional, and commercial networks to informal and populist networks.

- ✓ Platforms: Many networks appear automatically when playing between actors. Successful UIS have platforms that host networking and care for permanent innovation and network reconstruction (Francin, 2015).
- ✓ Space environment: This includes the city location and access where the innovation system is located, as well as the range and quality of amenities that make this place attractive for skilled workers, entrepreneurs, and businesses (Florida, 2005).
- ✓ Institutional environment: This regulates the rules of the game, and defines business cultures and attitudes towards cooperation and entrepreneurship, and therefore has a great impact on the innovation process.
- ✓ Externalities: The path of development and innovation capacity is a UIS influenced by external factors such as the market and technological opportunities that arise at different times during the system development process (Van Winden et al., 2014).

UNCTAD (2018) in its report shows the relationship between the performance of innovation, enterprises, government, civil society and universities. Each of these components and their functions leads to the creation of human capital, market demand and conditions, finance and the entrepreneurial ecosystem, policy and regulatory framework, technology infrastructure, governance and institutional issues, and the connection to innovation. International political cooperation, natural resources,

poverty, migration and other social challenges, as well as emerging technologies, influence the performance of innovation. Jukneviene (2019) examines the relationship between innovation and institutional structures and stated that innovation capacity in any country is subject to political decisions in that country. The current study has been carried out in Kermanshah in 2020.

## MATERIALS AND METHODS

### Survey design and data collection

#### Grounded Theory (GT)

Grounded theory refers to discovering a theory in social science research based on systematic data collection to reach a step of the subject matter understanding that enables us to compare the theory we have built with real data with existing theories. Grounded theory aims to identify and understand people's experiences of events in a particular context. In this method, using data, a theory is developed that explains a process or phenomenon (Glaser et al., 1968). When we need a theory to explain a process, achieving it requires the use of a strategy that involves constructing a theory. Especially when existing theories are not able to explain such a process well, with the help of grounded theory, it is possible to formulate a theory about the occurrence of this process, the problem or the observed individuals. Grounded theory is an inductive exploratory research method that allows researchers in a variety of subject areas to develop their own theory rather than relying on the existing theories. This theory is formulated systematically based on the real data. It is used in cases where our knowledge is limited in intended fields.

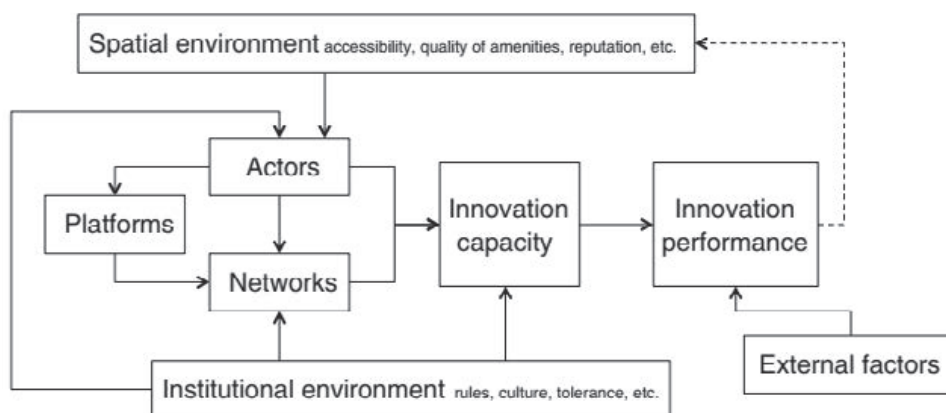


Fig.1: Performance and innovation capacity in the UIS (Van Winden et al., 2014)

Therefore, this paper has a qualitative method, and collects and analyzes data from the grounded theory (Bazargan, 2010). Given that no research has been conducted so far on the UIS that focuses exclusively on step-by-step elements and their stratification, this study, using the grounded theory method and similar studies, first establishes a general framework of UIS and, then, by using systematic study of texts (meta-synthesis method) and related tools in that field.

*Grounded Theory and Coding Method*

There has been some discussion in the literature about what characteristics a grounded theory study must have to be legitimately referred to as ‘grounded theory’ (Morse et al, 2009). The fundamental components of a grounded theory study are set out in Table 1. These components may appear in different combinations in the qualitative studies; a grounded theory study should have all of these.

*Systematic Study of Texts*

Meta-synthesis is a qualitative research method that provides an interpretive combination of qualitative findings, so that the result of the combination is more than the total findings of the resources used (Mays and Pope, 2000). The ultimate goal is to develop a theory, summarize, and generalize it at a high level to

provide more access to qualitative findings for their practical application (Sandelowski et al., 2008). This resource is most useful in meta-synthesis studies. The steps in this method include setting up the research question, systematic literature search, searching and selecting appropriate texts, extracting paper details, analyzing and combining qualitative findings, quality control, and presenting findings (Xu, 2008). In order to determine transcendental validity, the Critical Appraisal Skills Programme (CASP) vital assessment tool provides a comprehensive list of questions that can be used to determine the validity, applicability, and appropriateness of the study (Glynn, 2006). The remainder of this paper is organized as follows. The next section provides the results including the results of meta-analysis, the grounded theory, and the end section concludes the paper.

**RESULTS AND DISCUSSION**

*Meta-synthesis*

*Step 1: Setting up the research question*

The first step is to determine “what” to study. In this paper, the main question in order to conceptualize this structure is that what the components of the UIS are.

*Step 2: Systematic literature search*

Table 1. Fundamental components of a Grounded Theory study

Component	Stage	Description
Openness	Throughout the study	Grounded theory methodology emphasizes inductive analysis. Induction moves from the particular to the general: it develops new theories or hypotheses from many observations. This means that grounded theory studies tend to take a very open approach to the process being studied. The emphasis of a grounded theory study may evolve as it becomes apparent to the researchers what is important to the study participants.
Analyzing immediately	Analysis and data collection	In a grounded theory study, the researchers do not wait until the data are collected before commencing analysis. In a grounded theory study, analysis must commence as soon as possible, and continue in parallel with data collection.
Coding and comparing	Analysis	Data analysis relies on coding - a process of breaking data down into much smaller components and labelling those components - and comparing - comparing data with data, case with case, event with event, code with code, to understand and explain variation in the data. Codes are eventually combined and related to one another - at this stage they are more abstract, and are referred to as categories or concepts.
Memo-writing (sometimes also drawing diagrams)	Analysis	The analyst writes many memos throughout the project. Memos can be about events, cases, categories, or relationships between categories. Memos are used to stimulate and record the analysts' developing thinking, including the <i>comparisons</i> made.
Production of a substantive theory	Analysis and interpretation	The results of a grounded theory study are expressed as a substantive theory, that is, as a set of concepts that are related to one another in a cohesive whole. As in most science, this theory is considered to be fallible, dependent on context and never completely final.

(Sbaraini et al., 2011)

Table 2: The key terms of UIS

	Word
1	Innovation system
2	Innovation function
3	Urban innovation
4	UIS
5	Sectorial innovation system
6	Regional innovation system
7	National innovation system

Various terms were used from 1997 to March 2020 to search for papers to answer the question at Scopus, Science Direct, and Springer. These terms can be seen in Table 1:

In the first step, the introduced databases were searched using the key terms of Table 2, and all papers were collected based on the relationship between the papers and their titles. 19,645 sources were found, among which 6,192 were book chapters and 13,453 were papers. In addition, 17 sources were Persian and the rest were English.

*Step 3: Searching and selecting appropriate texts*

In this step, the sources found in the previous step

are browsed step by step according to acceptance or non-acceptance of articles. Acceptance criteria include articles published in journals and books in Persian and English on the subject of the innovation systems and, in particular, the UIS from 1997 to March 2020 by qualitative or qualitative–quantitative research methods. At this step, the articles are carefully reviewed in several steps to determine which ones are appropriate for the research questions. Therefore, during these steps, articles that do not relate to the questions are omitted to ultimately detect the most relevant articles to extract the accurate answers to the questions. The review process includes skimming the articles’ titles, abstracts, and content which are reviewed at each step according to the acceptance criteria. In this study, the steps of the review process are as follows:

1- The field of work of the obtained findings was examined, and some of the findings were left out due to the lack of a systematic scientific structure. At this step, 889 abstracts (excluding articles), 1,707 lexical explanations, 287 newsletters, 921 book reviews, 231 conference introductions, 813 authors, 670 debates, and 3,256 other unrelated items were discarded. And

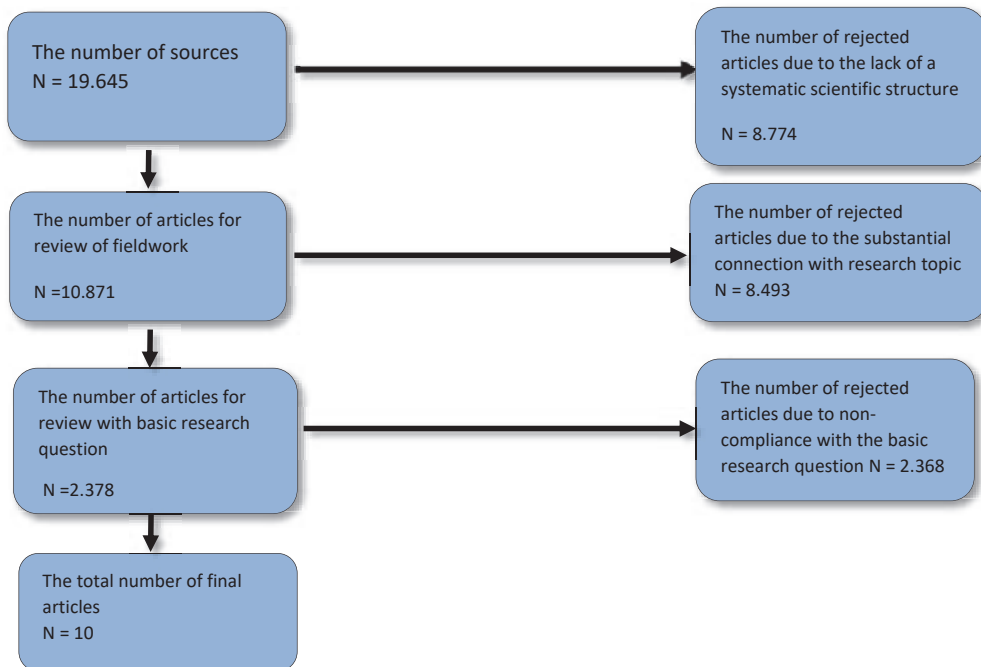


Fig. 2: A diagram of the meta-synthesis steps for the main research question

10,871 sources entered the second phase for further investigation.

2- According to the main research question regarding the UIS, articles in non-related fields were removed. Thus, 8,493 cases were removed, and 2,378 cases remained.

3- Among each two articles with the same authors and duplicate findings, one was omitted, and the more complete article remained. In addition, the abstracts of all articles were studied, and 2,368 articles whose findings were unrelated to the main research question were deleted. Eventually, ten sources remained to go to the next step.

4- The remaining articles were reviewed in terms of content quality. Quality was measured with criteria such as research objectives, method logic, research design, sampling method, data collection, reflectivity or relationship between researcher and participants, ethical considerations, accuracy of data analysis, clear expression of findings, and value research. When using this tool, articles were read, and a score of one to five was assigned to each article for having the above features. Based on CASP's 5-point scale, we introduce the following scoring system, and categorize articles based on their

quality. Very high (4-5), high (3-4), medium (2-3), poor (1-2), very poor (0-1). In this study, 10 articles and books were accepted in the evaluation process, among which four articles received average scores, 3 articles received high scores, and 3 articles received very high scores (Singh, 2013).

*Step 4: extracting article details*

Throughout the meta-synthesis, we continuously review the selected and finalized sources several times in order to obtain separate in-content findings, in which the original studies are performed. In the present study, resource details are categorized as follows: the reference for each article is recorded (author's name or surname, the year the article was published), the main factors influencing or constituting the UIS that the source refers to it, and key methodological details such as: the research purpose, methods, procedures, and measuring tools (Leary and Walker, 2018).

*Step 5: analyzing and combining qualitative findings*

The meta-synthesis method aims to create an integrated new interpretation of the findings. Meta-synthesis method has been adopted to clarify

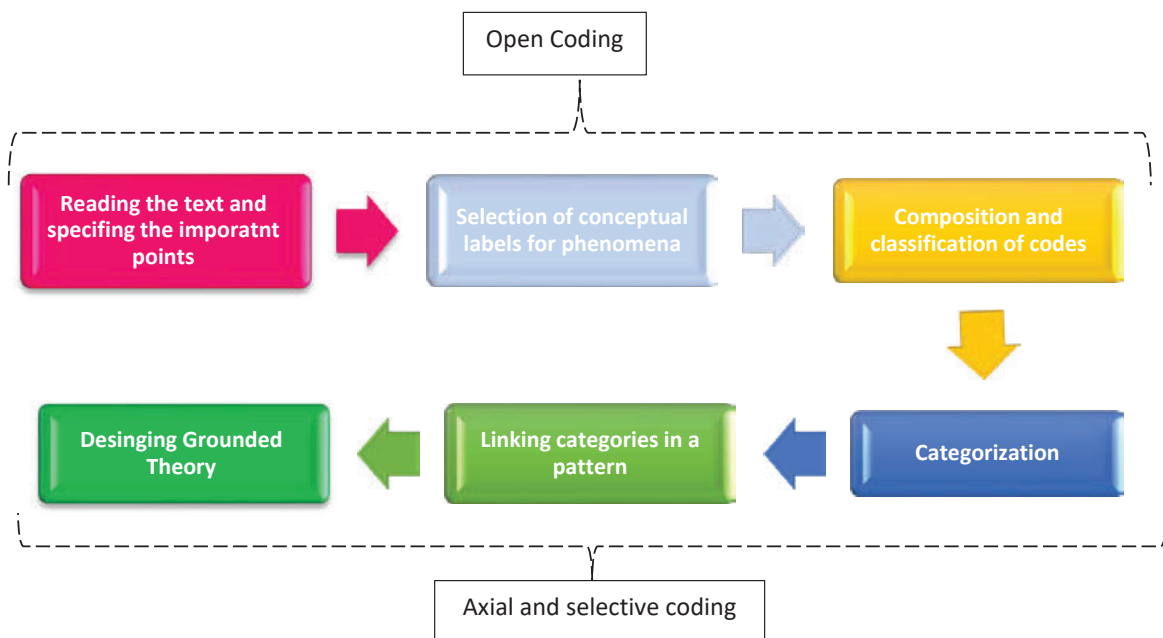


Fig. 3: The analysis process

the concepts, patterns, and results in refining existing modes of knowledge and the emergence of operational models and theories. During the analysis, topics are explored that have emerged among the existing studies, which is called “thematic study” (Smit *et al.*, 2020). After identifying the topics, a thematic classification is formed, and similar and relevant classifications are placed in a topic that best describes it. Fundamental topics are presented to create explanations, models, and theories or hypotheses (Sandelowski *et al.*, 2008). In the present study, first all of the factors extracted from the sources are considered as code, and then by considering the meaning of each of these codes, they are categorized in a similar concept (dimension) in order to form research concepts. We need coding tools to categorize concepts and categories and to theorize. For this purpose, three methods of open, axial and selective coding are used. Beginning with line-by-line open coding of data and comparing incidents to each other in the data, the researcher codes the data in every way possible and asks a set of questions of the data: ‘What is this data a study of?’, ‘What category does this incident indicate?’, ‘What is actually happening in the data?’, ‘What is the main concern being faced by the participants?’, and ‘What accounts for the continual resolving of this concern?’ (Glaser, 2005; Siau and Long, 2005). These questions sustain the researcher’s theoretical sensitivity, transcend descriptive details, and encourage a focus on patterns among incidents that yield codes. Line-by-line coding forces the researcher to verify and saturate categories, minimizes missing an important category, and ensures relevance by generating codes with emergent fit to the substantive area under study. The result is a rich, dense theory with the feeling that nothing has been left out. The first step of coding is using the open coding method, to modeling the urban innovation system according to the conditions and requirements of the model (Abili *et al.*, 2021).

The steps of open coding are:

A- Analysis and coding: At this stage, the researcher must pay attention to the coding of all events. Many codes may be extracted from a single text; but when the data is reviewed regularly, the final codes are specified.

B- Discovering categories: In this stage, concepts are classified based on their relationship to similar topics, which is called categorization.

C- Description of categories according to their characteristics: In order to clarify the categories.

Axial coding is the second stage of analysis in grounded theorizing. The purpose of this step is to determine the relationship between the categories created in the open coding step. In axial coding, the researcher identifies a central or axial phenomenon, describes the causal conditions, identifies the intervening and context conditions, and determines the consequences and outcomes of strategies for this phenomenon (Khan and Krishnan, 2021; Adler and Lalonde, 2019).

Selective coding is the most important stage of theorizing in which the researcher expresses the relationship between categories and modifies the categories that need to be improved and revised. In fact, the researcher tries to build a new theory by establishing connections between categories and based on these relationships (Holton, 2010).

The steps of the coding method according to Fig. 3 for the 10 selected articles have been followed by the meta- synthesis method, which can be seen in Table 4.

*Step 6: quality control*

In the meta-synthesis, the following procedures are considered to maintain quality:

1. Throughout the research, an attempt is made to provide clear and concise explanations for the available options for the realization of the necessary steps;
2. All facilities are used to access the acquired sources;

Table 3: Kappa coefficient estimation Symmetric measures

		Value	Asymptotic standardized Error <sup>a</sup>	Approximate T <sup>b</sup>	Approximate significance
Measure of agreement	Kappa	0.730	0.175	4.274	0.000
N of valid cases		10			

a) Not assuming the null hypothesis.  
 b) Using the asymptotic standard error assuming the null hypothesis.

Table 4: Components for the realization of UIS

Category	Concepts	Codes
Innovation	Technology Patent Research	Technological innovation (Chai – Lee, 2017; Putra and Knaap, 2018; Nguyen and Moehrle, 2019; Van Winden et al., 2014), sustainable city (Chai–Lee, 2017), smart city (Chai–Lee, 2017; Marakatou and Alexandrou, 2015), institutional innovation (Chai–Lee, 2017), research institutes (Warnke et al., 2016), innovation supply (Johnson, 2008), innovative competition (Johnson, 2008), creative class (Johnson, 2008), open innovation (Genuchten et al., 2019), sustainable urban life (Genuchten et al., 2019), community-based innovation (Genuchten et al., 2019), government-based innovation (Genuchten et al., 2019), Public interest in innovation (Genuchten et al., 2019), Patent (Nguyen and Moehrle, 2019; Van Winden et al., 2014), startup city (Marakatou and Alexandrou, 2015), urban planning (Marakatou and Alexandrou, 2015), research and development activities (Van Winden et al., 2014), tacit knowledge (Van Winden et al., 2014), offshore (Van Winden et al., 2014), scientific publications (Van Winden et al., 2014), innovation hub (Van Winden et al., 2014)
	Knowledge	
Economic	Production	Economic growth and development programs (Chai – Lee, 2017; Johnson, 2008), public goods (Chai–Lee, 2017), consumption patterns (Chai–Lee, 2017), production productivity (Chai–Lee, 2017), final demand (Warnke et al., 2016), intermediate demand (Warnke et al., 2016), high-tech products (Warnke et al., 2016; Van Winden et al., 2014), SME (Small and Medium-sized Enterprises) (Warnke et al., 2016), banking and venture capital funds (Warnke et al., 2016; Van Winden et al., 2014), taxation systems (Warnke et al., 2016), business tendency (Warnke et al., 2016), production factors mobility (Warnke et al., 2016), mother industry (Warnke et al., 2016; Van Winden et al., 2014), web information exchange (Caragliu and Del Bo, 2018; Putra and Knaap, 2018), urban transport (Caragliu and Del Bo, 2018), e-government (Caragliu and Del Bo, 2018; Putra and Knaap, 2018), virtual markets (Putra and Knaap, 2018), urban employment (Ratanawaraha, 2012), per capita urban income (Ratanawaraha, 2012), urban trade (Ratanawaraha, 2012; Van Winden et al., 2014), financial investment (Ratanawaraha, 2012; Marakatou and Alexandrou, 2015; Van Winden et al., 2014), intellectual capital (Ratanawaraha, 2012), industrial networks and clusters (Ratanawaraha, 2012; Van Winden et al., 2014), competitive advantage (Van Winden et al., 2014), economic reforms caused by the crisis (Van Winden et al., 2014), history of economic growth and development (Van Winden et al., 2014), business space (Van Winden et al., 2014)
	Income	
	Competition	
	Market	
Social	Culture	Innovative culture (Chai–Lee, 2017; Putra and Knaap, 2018; Genuchten et al., 2019; Van Winden et al., 2014; Marakatou and Alexandrou, 2015), health system (Chai – Lee, 2017; Ratanawaraha, 2012), education programs (Chai–Lee, 2017; Putra and Knaap, 2018; Genuchten et al., 2019; Van Winden et al., 2014; Marakatou and Alexandrou, 2015; Johnson, 2008; Warnke et al., 2016), standards and norms (Warnke et al., 2016), social and human capital (Caragliu and Del Bo, 2018; Van Winden et al., 2014; Johnson, 2008), art activities (Putra and Knaap, 2018), urban physical space (Ratanawaraha, 2012), urban entertainment (Ratanawaraha, 2012), knowledge tools (Ratanawaraha, 2012), informal institutions (Ratanawaraha, 2012; Van Winden et al., 2014), demography (Johnson, 2008; Van Winden et al., 2014; Marakatou and Alexandrou, 2015), cultural diversity (Genuchten et al., 2019; Johnson, 2008; Van Winden et al., 2014), social tolerance (Johnson, 2008; Van Winden et al., 2014), urban brand (Marakatou and Alexandrou, 2015; Van Winden et al., 2014), life style (Van Winden et al., 2014)
	Education Systems	
	Institutions	
	Norms	
Environmental	Physical Urban Space	Waste management (Chai – Lee, 2017; Nguyen and Moehrle, 2019), energy management (Chai – Lee, 2017; Ratanawaraha, 2012), urban green space (Caragliu and Del Bob, 2018), water quality (Ratanawaraha, 2012; Nguyen and Moehrle, 2019), food security (Ratanawaraha, 2012), urban order (Johnson, 2008), urban viability (Genuchten et al., 2019; Nguyen and Moehrle, 2019), climate change (Nguyen and Moehrle, 2019), geographical location (Marakatou and Alexandrou, 2015; Van Winden et al., 2014), accessibility (Van Winden et al., 2014)
	Livability	
Political	Governance	Public participation (Chai–Lee, 2017), government policy (Chai–Lee, 2017; Marakatou and Alexandrou, 2015), allocation of resources (Chai–Lee, 2017), governance (Warnke et al., 2016; Caragliu and Del Bo, 2018), political capital (Ratanawaraha, 2012; Van Winden et al., 2014; Johnson, 2008), legal system – rule of law – judicial system – military equipment (Van Winden et al., 2014)

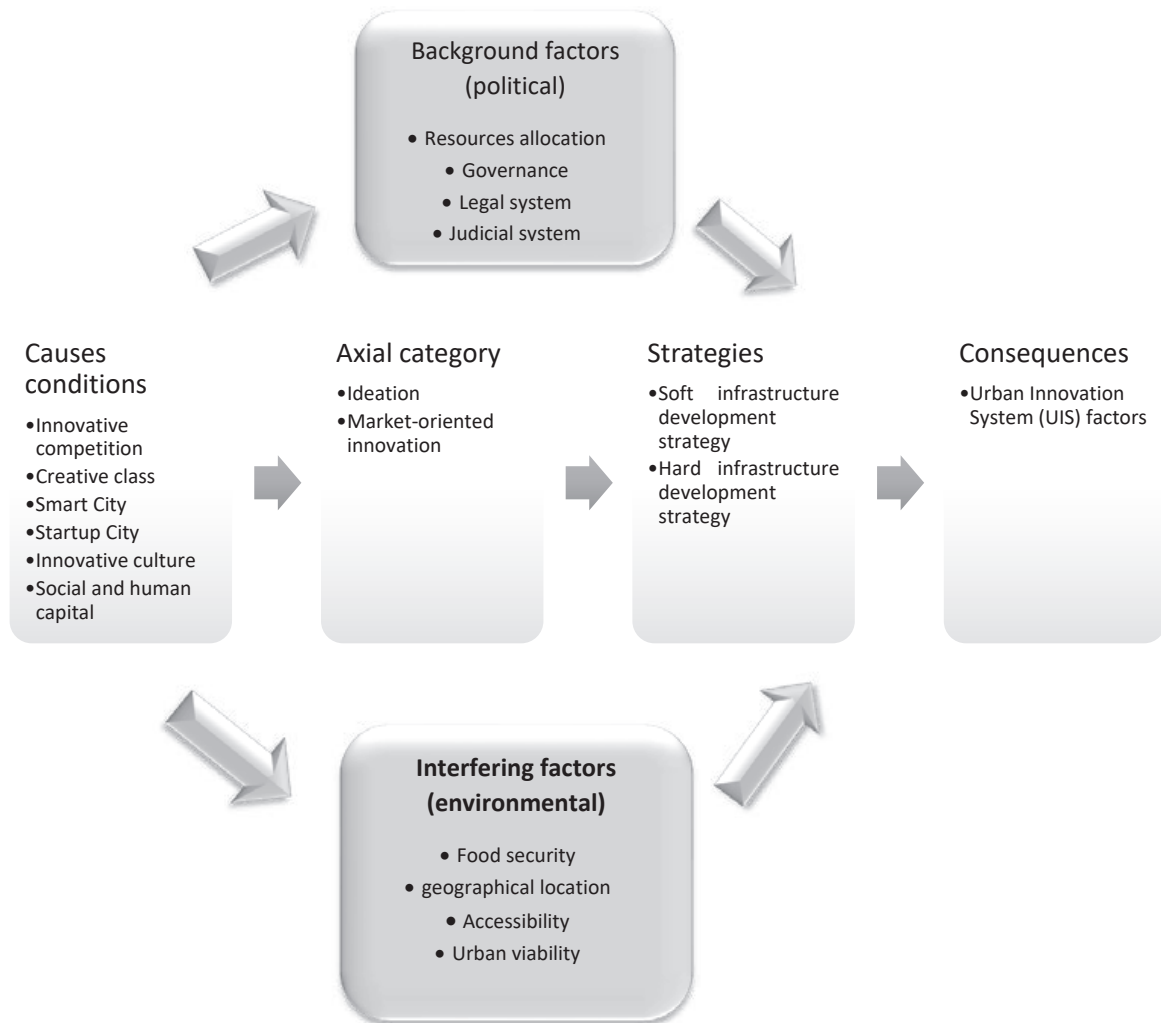


Fig. 4: The paradigm model of UIS

3. To combine the main studies, CASP tool is used to evaluate the meta-studies performed. Kappa coefficient has also been used in this study to maintain the quality of the study (Sattar et al., 2021).

The Kappa coefficient is used to determine reliability. Kappa coefficient is a statistic that is used to measure inter – rater reliability (and also intra-rater reliability) for qualitative (categorical) items (McHugh, 2012). It is generally thought to be a more robust measure than simple percent agreement calculation, as Kappa coefficient takes into account the possibility of the agreement occurring by chance. Researchers have suggested that it is conceptually simpler to evaluate disagreement between items

(Sim and Wright, 2005). In this study, a total of five codes were extracted. The extracted codes were provided to one of the experts for review and possible additional feedback. The results of the coding show that the Kapa coefficient calculated by SPSS software was 0.730, which is higher than the acceptable value (0.6) (Gwet, 2014; Zhang and Xiao, 2020). Since the numerical value obtained for the Kappa index is less than 0.05, the assumption of the independence of the extraction codes is rejected and the dependence of the extraction codes is confirmed. Therefore, it can be claimed that the codes of the tools used to extract the codes were sufficiently reliable (Mohagher et al., 2011).

#### *Step 7: findings present*

In this study, the constituent components for the UIS were questioned and what was extracted from the text of the selected sources was considered as the code. In general, five codes (innovation, economic, social, environmental, and political) were defined, each of which has two general aspects in terms of soft infrastructure and hard infrastructure (Finfgeld-Connett, 2010). In each code, the concepts that are used as examples in each of the classified sources were also identified.

#### *Paradigm Model of UIS*

According to the studies, in general, five sets of variables can be identified in the UIS: innovation, economic, social, political, and environmental variables. Each of these code instances has two main dimensions called soft infrastructure and hard infrastructure, both of which are mutually effective and interactive. In addition, the variables identified in the above five sets have interrelationships. Therefore, the paradigmatic model of UIS is a dynamic system of four economic, social, political, and environmental concepts, which ultimately leads to the production of a combined index of innovation concepts in the field of urban geography. Based on the classification, a set of codes and concepts have emerged that are interrelated. So to discover how to interact those codes and concepts, we need to receive the opinions of UIS experts, which are discussed in the second section. Fig. 3 shows the paradigmatic model of UIS.

#### **CONCLUSION**

Cities, due to their extraordinary potentials in idea generation, the beginning of new activities in all fields, are always the center of the first sparks of change in the fields of art, economy, culture, society, etc., and the most important changes is innovations. Thus, cities are the birthplace of innovation and the continuous flow of the innovation production cycle. The today world is in transition from the industrial age to the creative age. In addition to meeting basic needs, modern man seeks to meet other needs such as the need for imagination, mastery, vitality, innovation and curiosity. Innovation is a fundamental principle for being human and a vital resource for the individual, society and the life of economics. Innovative and vibrant societies with

human potential, foster individual growth, shine in cultural and technological advances, generate jobs and wealth, and embrace the diversity of lifestyles and cultures. It can be said that today, innovation has become a very important element in urban marketing policies around the world. The emergence of this issue in the simplest possible form constitutes a distinct stage in the development of capitalism, according to which the main force of the economy is no longer technological and organizational tools, but man. Therefore, understanding the complex systems in cities increases a large part of our current knowledge about the urban geographical area, and the urban innovation system is one of these systems. Designing an urban innovation system model, as a research priority, has little history among academic and research studies, so to model an urban innovation system, cannot use a fundamental theory like other humanities studies that revolved around the fundamental theory and generalized new topics. Therefore, there is a need to develop a new theory and theorizing. For this purpose, one of the methods used to explain new theories is grounded theory. The purpose of this study is to provide a paradigmatic model of the urban innovation system that can be developed and generalized in the future as a basic theory in urban innovation systems. To construct a grounded theory, all studies that have a slight resemblance to the subject under study should be carefully studied so that not all aspects of urban innovation system modeling are overlooked. It should be noted that so far no study has been conducted to model the urban innovation system using the grounded theory method. The method of the study is to use the Meta-Synthesis method in order to construct a paradigmatic model in the context of grounded theory. To enumerate the elements of the paradigm model, one of the common methods is to use the coding method, especially the open coding method. The estimated kappa coefficient indicates the reliability of the selected codes. This study reviews and compiles a set of valid studies on the paradigmatic factors in the formation of the urban innovation system. Using the Meta-synthesis method, 19645 sources were collected between 1997 and March 2020 related to the urban innovation system, and after 7 steps and classification of resources, finally, 10 sources were selected and based on the coding method,

the ten mentioned sources were coded. Based on the time allotted for the project, the results are uniquely novel. Finally, the paradigm model of the urban innovation system was extracted based on the performed codes. This model can be used as a pivotal model in future studies.

#### **AUTHOR CONTRIBUTIONS**

H. Samari performed the literature review, model design, analyzed and interpreted the data, prepared the manuscript text, and manuscript edition. S. Delangizan performed the literature review and compiled the data. K. Soheili helped in 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.

#### **ABBREVIATIONS**

<i>CASP</i>	Critical Appraisal Skills Programme
<i>OECD</i>	Organization for Economic Cooperation and Development
<i>SME</i>	Small and Medium-sized Enterprises

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CASE STUDY

## The effect of electronic banking services usage on clients electronic loyalty

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### ABSTRACT

**BACKGROUND AND OBJECTIVES:** This research targets at investigating and identifying the factors affecting electronic loyalty (E-loyalty) of electronic banking services (E-banking services) in Jordanian bank sector from clients' point of view. The scale of eTailQ was appointed to accomplish the research objectives. The procedures of current research were conducted under COVID-19 pandemic conditions such data collection, access the sample and different aspects. The model of current research was adopted based on three stages which are aiming at measuring the level of influence of independent determinants; that are subject norms, value perception, web design, reliability, customer support security; through mediation determinants; that are Electronic-satisfaction (E-satisfaction) and Electronic-trust (E-trust); on the E-loyalty of E-banking services usage.

**METHODS:** The population of the current research was the Jordanian clients who use the E-banking services, the sample size was 403 client. Structural Equation Model was declared to be a methodology of research to acquire the research outcomes

**FINDINGS:** Depending on the obtained outcomes, Reliability, Customer support, Value Perception, and Subject Norms have a positive effect on E-satisfaction with the .484, -.166, .281, and .249 scores respectively. Moreover, Web design, Reliability, Customer support, and Security/privacy a positive effect on E-trust with 199, .719, -.017, and .463 scores, respectively. The results also indicated that E-satisfaction and E-trust have a positive effect on E-loyalty with the .441 and .515 scores, respectively.

**CONCLUSION:** The focal result of present study is that scale of eTailQ is an optimal measurement for determining the factors that impact the clients E-loyalty of E-banking services usage in Jordanian banks. The present study is encouraged the related specialists to conduct many investigations attached to E-banking services and the development process of E-loyalty.

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## INTRODUCTION

### *Background*

The nature concept of “loyalty” has practically been established to bring considerable prosperity in any type of organization through growing in the profitability in different methods (Reichheld and Schefter, 2000). To get more insight about loyalty revenue for companies, (Reichheld and Sasser, 1990) in a worthy study, it has emphasized that reaching 5 percent of customers can fetch 85 percent of profitability for the organization in the market. Logically, keeping customers loyal can give a share in increased the revenue of the organization much more than transitory customers. Accordingly, the profitability could be achieved by reiterating the purchase process of the same products and bringing many unprecedented customers by describing the products of the organization. Retailers have a comprehensive view of loyal customers and their anticipations that leads to having their satisfaction (Reichheld and Sasser, 1990; Zeithaml *et al.* 1996). Moving into online fashion, the E- loyalty has been taken its place that declares as “feelings or attitudes that prompt a positive memory and thus make a customer to re-visit a website for information, communication or entertainment purposes, or to re-purchase a particular product or services from an online business” (Anderson and Srinivasan ,2003). Similar to the offline mechanism, the e-loyalty paradigm have an authentic role in e-business processes (Reichheld and Schefter, 2000). Reichheld and Schefter (2000) indicated that the clients in an online pattern resort to combine their purchased products from a single major supplier, and this purchase process comes to be daily behavior for them. In the same fashion, Balabanis *et al.* (2006) pointed out that the clients in the online pattern have more loyalty than the clients in the offline pattern as they do not prefer to turnover suppliers, where the website and online tools could offer many options of purchases.

### *Problem statement*

Generally, many models have been examined in the literature engaged with e-service quality for elucidating determinants affecting the e-loyalty development context such as E-SERVQUAL (Zeithaml *et al.*, 2002), E-S-QUAL/E-RecS-QUAL (Parasuraman 2005; Yang and Tsai, 2007), and

eTailQ (Wolfinbarger and Gilly, 2003). Accordingly, two results have come up from these measured frameworks: the first result is that a big deal of previous researches concentrated on the e-service quality with an absence of value perception variable; where the second result is that there is a scarcity for measuring and validating the eTailQ framework even the eTailQ model has been measured by a single research (Kim, *et al.*, 2009). Due to less cost and the high quality of information transmission, the online pattern considers as an optimal alternative to accomplish banking operations; whereas the online pattern provides comprehensive information that allows clients to make a comparison with others. Specifically, E-banking processes have been occupied solid affirmation in a few years. Akhisar *et al.* (2015) point out that the bank’s performances could be negatively affected when the percentage of clients adopting e-banking services is less expected. In the same fashion, Yang *et al.* (2018) suggest that a client-oriented business strategy should be instituted, which targets to maximize the loyalty of clients level for their e-banking services. Otherwise, several types of research emphasized that developed countries are still disinclined to embark on adopting E-banking services due to different reasons such: influence social, cultural constraints, and economic issues (Al-Qeisi, 2009; AbuShanab and Pearson, 2007; Dajani, 2011; Nasri and Charfeddine, 2012; Riffai *et al.*, 2012; Mansour *et al.*, 2016). Accordingly, it is paramount to make an effort for conducting studies connected to factors that impact e-banking services usage in Jordan. According to Rawash *et al.* (2019), their worth work suggested that the bank’s sector requires to widen the effort to make some procedures for explaining the characteristics of E-banking services and their benefits. The research also asserted to identify the client’s challenges to rely on E-banking services to perform their financial processes. It further recommended that the banks in Jordan should always seek to adopt the newest technology to improve the old e-banking services and launch new services for clients. Finally, the study counseled the bank’s sector in Jordan to rapidly respond to client’s complaints and matters related to E-banking services. Due to the COVID-19 pandemic, the level of E-banking services usage is significantly increasing in Jordan banks without accessing the branches building of banks. Thus,

determining the factors affecting E-loyalty of Jordanian E-banking services usage is taken attention to conduct this study during unexpected current conditions. According to the aforementioned, there is an encouragement to conduct more researches to gauge and validate eTailQ framework in several contexts. Entailing eTailQ framework, this research comes to measure the impact of the e-banking services usage on e-loyalty from clients' perspective in Jordan. This study will have nine dimensions which are value perception, customer support, reliability, security/privacy, web design, e-satisfaction, e-trust, and e-loyalty.

#### *Contributions*

The primary initiative of the current study is to reconnoiter the connection between E-banking services and E-loyalty from the client's perspective in Jordanian banks. Besides, the current study crystallizes in explaining the dimensions of E-banking services over client e-trust and e-satisfaction that lead to client loyalty. The objective of the current study is to highlight on sophisticating of E-banking services with concentrating the clients. Empirically, the potential outcomes of the current study would present assistance for contributors, scholars, and practitioners for exploring the construct and content of E-banking services in Jordanian banks in the future. Subsequently, there are objectives as follows:

1. To test the status of e-banking services in Jordanian Banks.
2. Widen the eTailQ framework to encompass the value perception and subjective norms as adding dimensions, and empirically examine the developed model.
3. Inspect the impacts of every sub-dimension of the eTailQ framework in E-banking services in Jordanian banks inclusive of newly added dimensions as predecessors of E-trust and e-satisfaction, and then examine the e-loyalty in the banks sector context.

#### *Literature review*

##### *E-banking services*

E-banking has been presenting as a new banking system (Ota, 2010). E-banking is a particular kind of banking service to supply its patrons who harness an electronic climate such as website, mobile

forces, and applications. Through the E-banking style, the main target is to transform the entire banking processes from traditional legacy pattern to online pattern, these processes are for receiving or depositing money, signature verification services, organized inventory, and other considerations. Moreover, the E-banking paradigm and technology have been aiming to superfast employing E-channels for offering banking products to target clients during the 1990 period (Salehi and Alipour, 2010). E-banking defines as a newfangled approach for bank patrons to perform their services and activities in an online pattern such as ease bills paid, having authority for domination of their money, taking benefits of the several services. Practically, the conclusive purpose of organizing the E-banking technology is to diminish the number of bank branches and to accomplish banking services connected to banking customers with trending to possibility cancel all of these geographical locations of branches. E-banking provides clients of the bank appropriate access to administer their financial issues with a minimum rate of harassment. Depending on the annual report of the banking Center of Jordan in 2019, the number of Islamic banks are 3, the number of commercial banks is 13, and the number of foreign banks is 10. For meeting clients' demands, the banks of Jordan have begun to offer their services through electronic mode that provides lower expensive and effortless to customers (Siam, 2006). The presented E-banking services in banks of Jordan are; SMS, M-bank, Bank Call Centre, and online bank.

##### *Research model and its hypothesis*

The model of this study entails the eTailQ framework by adding some factors to achieve the research objectives (Wolfenbarger and Gilly, 2003). The eTailQ framework classifies into four basic factors which are namely; reliability, customer support, security/privacy, and web-design. The eTailQ variables have been rarely indicating for impacting the E-loyalty through the mediation of E-satisfaction and E-trust. The following sections demonstrate the developed model of the current study by adding modified variables to the eTailQ framework, as follow:

##### *Common eTailQ factors as Antecedents of E-Satisfaction and E-Trust*

Web-design is an idiom which indicates to show

the power of corporation in the online pattern for performing business processes and also takes the attention of some determinants such as usability, ease of use, aesthetic design, interactivity, layout, navigation, checkout, search strength, and quality of information. Several contributors and scholars have theorized that web-design factor has a significant impact on E- satisfaction and E-trust (Alkhouli and Samer2017; Cristobal *et al.*, 2007; Wolfinbarger and Gilly; 2003). Reliability is an idiom that indicates to corporation's capability for guaranteed delivering products to the customer's in the promised stipulation and time. (Cristobal *et al.*, 2007). Several contributors and scholars have theorized that the reliability factor has a significant impact on E-satisfaction (Coulter and Coulter, 2002; Hwang and Kim, 2007) and E-trust (Coulter and Coulter, 2002). Customer support is a term which appears the corporation capability to respond to the client's requests and complaints and commit the level of the corporation preparedness to seriously solve and deal with its client's requirements (Negash *et al.*, 2003). Several contributors and scholars have theorized that the Customer support factor has a significant impact on E-satisfaction (KVan La, 2005) and E-trust (Hwang and Kim, 2007).

According to the aforementioned theories, the current research will draw the following hypotheses:

- H1:** *web-design will positively effect on E-satisfaction of E-banking services customers in Jordan.*
- H2:** *web-design will positively effect on E-trust of E-banking services customers in Jordan.*
- H3:** *reliability will positively effect on E- satisfaction of E-banking services customers in Jordan.*
- H4:** *reliability will positively effect on E- Trust of E-banking services customers in Jordan.*
- H5:** *Customer support will positively effect on E-satisfaction of E-banking services customers in Jordan.*
- H6:** *Customer support will positively effect on E- Trust of E-banking services customers in Jordan.*

#### *Security/Privacy as Antecedents of E-Trust*

Security/Privacy is an idiom that concentrates on the confidentiality of the client's information in their corporation. Security/Privacy factor considers as a major matter which influences

on undesirable behaviors such as unauthorized access, the dispensation of personal information, and disingenuous use of financial data (Cristobal *et al.*, 2007). Several contributors and scholars have theorized that the Security/Privacy factor has a significant impact on E-Trust (Wolfinbarger and Gilly, 2003). According to the aforementioned theory, the current research will draw the following hypothesis:

- H7:** *Security/Privacy will positively effect on E- trust of E-banking services customers in Jordan.*

#### *Value Perception and subject Norms as Antecedents of E-Satisfaction*

Value Perception is an idiom that indicates to the advantages of firm offers for its clients when they pay for goods or services. To best of knowledge, only one research has been theorized that the Value Perception factor has a significant impact on E- satisfaction (Honglei *et al.*, 2014). Subject Norms is pointed out as citizen perception which indicates to a set or citizen to boost or refuse the given practice or attitude (Fishbein and Ajzen, 1977). Subjective norm interacts with the forces of a surrounded environment which compel the citizen towards acceptance or rejection of behavior. Subjective norm has beheld as a critical variable which effects on client purchase propensity (Ryan and Bonfield, 1975). According to Venkatesh and Davis (2000), social forces drive citizen to accomplish a practice even in case citizen does not have a tendency for accomplishing the practice. Moreover, subjective norm also aims at gauging the social impact on citizen tendency and behavior which come from the motivation and expectancies of family and friends. Practitioners and contributors have been theorized that the subject norms factor has a significant impact on E-satisfaction Alnaser *et al.* (2017). According to the aforementioned theories, the current research will draw the following hypotheses:

- H8:** *Value Perception will positively effect on E-satisfaction of E-banking services customers in Jordan.*
- H9:** *Subject Norms will positively effect on E-satisfaction of E-banking services customers in Jordan.*

*E-Satisfaction and E-trust as Antecedents E-loyalty*

Keyr *et al.* (2009) introduced a definition of e-loyalty that is tangible inclinations to execute some actions on the website such as visiting, reutilizing, and performing purchase products continuously. Anderson *et al.* (2003) have interpreted e-loyalty as a positive demeanor and customer adherence toward an electronic business causing to cyclic shopping demeanor (Leung *et al.*, 2011). In term of E-satisfaction, The satisfaction has been debated in the e-loyalty context as E-satisfaction which has been considered as a central indicator in consolidating loyalty in the online and traditional mode. The anticipations sophisticated as an outcome of announcements and community opinions about products are pivotal to have the satisfaction of clients within and after the purchase process (Van La, 2005). The tincture of the relationship between satisfaction and loyalty in the online pattern (e-satisfaction and e-loyalty) has been coming from the classical loyalty researches which indicate that a high level of customer satisfaction will be achieved a high level of customer loyalty to the organization (Jones and Sasser, 1995). Several contributors and scholars have theorized that the E-satisfaction factor has a significant impact on E-loyalty (Garepasha *et al.*,

2020; Alkhouli and Samer, 2017; Amin, 2016; Honglei *et al.*, 2014; Rahman and Ramli, 2016; Sathyavany and Shivany ,2019; Vadivelu *et al.*, 2017). In terms of E-trust, E-trust can points out as a client’s certainty and belief which client’s anticipations of E-business could be achieved, that harnessed to expound the growth process of E-loyalty linking with the theory of expectation confirmation (Valvi and West, 2013). The nature concept of trust is that organizations should create powerful relationships with clients with a high scale of confidence. Trust in both mode offline or online is a paramount matter, due to its ability to have success and uninterrupted relationship. Several contributors and scholars have theorized that the E-trust factor has a significant impact on E- loyalty (Garepasha *et al.*, 2020; Amin, 2016; Honglei *et al.*, 2014; Rahman and Ramli, 2016; Papadopoulou *et al.*, 2001).

According to the aforementioned theories, the current research will draw the following hypotheses:

**H10:** *E-satisfaction will positively effect on E- Loyalty of E-banking services customers in Jordan.*

**H11:** *E-trust will positively effect on E- Loyalty of E-banking services customers in Jordan.*



Fig. 1: The Conceptual Model of E-Banking Services

Fig. 1 shows the conceptual framework of the current study with an illustration the study hypothesis. The current study has been carried out in Jordan in 2020.

## MATERIALS AND METHODS

### *Range of Research*

Due to the capacity for employing a numeral approach and statistical techniques, the selected methodology of current research is a quantitative style for acquiring the research purposes and objectives. Structural Equation Model (SEM) is harnessed for several purposes such as measuring the impact of each variable, analyzing the gathering data, performing the data analysis and obtaining the study results. Moreover, the SEM method demands a robust research design by emphasizing a passable sample size, continuously and normally distributed observed factors, and no missing data (Hair *et al.*, 2014).

### *Instruments Measurement of Research*

Items categorizations of current research instrument were labeled corresponding with a five-point Likert scale where 1 value represents by "strongly disagree" and 5 value represents by "strongly agree". The high-level score points out the high-level scale of impacting the E-loyalty of E-banking services usage. According to Wolfenbarger and Gilly (2003) and antecedent supported measurements, this study was based on the eTailQ framework for adapting the instrument. The questionnaire of this study is included two domains which are A and B. Domain A of the questionnaire consists of the characterizations of sample demographic such as gender, age, monthly income, education, income, occupation, and frequency of usage of E-banking services. Domain B encompasses of items of the construct which are 30 within the conceptual framework of E-loyalty of E-banking services usage. The constructs of this study are classified into three layers which are independent, mediation and dependent layer. The independent layer is encompassed of six dimensions: the first dimension is Website design which was come to be adapted from Chang *et al.* (2008), the second dimension is reliability which was come to be adapted from Coulter and Coulter (2002), the third dimension is customer support

which was come to be adapted from (Hwang and Kim, 2007; Negash *et al.* (2003), the fourth dimension is security/privacy which was come to be adapted from Kim *et al.* (2009), the fifth dimension is value perception which was come to be adapted from Yang *et al.* (2004) and the last dimension in this layer is Subject norms which was come to be adapted from Ramayah and Razak (2008). The mediation layer consists of two dimensions which are E-satisfaction and E-trust; the items of e-satisfaction and e-trust have been come to be adapted from previous studies (Jin *et al.*, 2008; Chang and Chen, 2008). The independent layer is included just one dimension which is e-loyalty that was come to be adapted from (Jin *et al.*, 2008; Chang and Chen, 2008).

### *Sample Plan and Size of Research*

The real tincture of the sampling concept is to represent the whole population of the study through fetching data and representing the basic characteristics from a part of the targeted population as possible. For having the sample size and the collecting data style of research, the current research was harnessed the convenience sampling mode. This mechanism has many features such as its ability to access the subjects of current research easily, its capacity for easy handle and less expensive for data collection processes. Due to the customers who use the E-banking services in Jordan was unknown, the minimum sample that could be used in this study is (384). Thus, the initial size of the current research was launched with (600) clients who utilize E-banking services in Jordanian banks. The clients agreed to delightedly share their opinions in this research.

### *Data Collection and Time Frame*

Given that the language of the population of this study is Arabic, the items of current research instruments were developed and adapted in the English language. The current research was embarked to translate the instrument items into the Arabic language, this process was performed by inviting two experts in the translation field (English to Arabic). Next, a scholar specializing in the Arabic language is invited to improve the instrument items after moving the instrument into Arabic. The gathered data were from the clients who utilize the E-banking services in Jordanian banks. In terms of

data gathering procedures, a pilot study was fulfilled with 10 systematic clients of E-banking services in Jordan who were interested to contribute to the current research. The recommended feedback from this procedure assisted to make corrections in construct items such as: reshaping the obscure and unclear figures. After redesigning the instrument items in the final version, Due to the spread of coronavirus and to decrease the close contact with the respondents to the questionnaire, an online questionnaire was used (Basarir-Ozel *et al.*, 2017). The link of online survey was delivered to clients during many approaches such as E-mail, WhatsApp and possible electronic channels, the previous processes were accomplished to guarantee the client's privacy response to the survey without misusing their answers. This was executed to diminish the possibility of a threat of common method bias (Podsakoff *et al.*, 2003). The design of the online survey is prepared with asserting that all items of an instrument will be answered; thus, the data set of this research do not comprise missing data. The data gathered process was begun in July 2020 and it took 2 months to be finalized. The link of questionnaires was sent to 600 clients, the number

of returned questionnaires was 403 which were used for analysis purposes.

**RESULTS AND DISCUSSION**

*Results*

Table 1 represents the demographic variables of the current research sample which includes the frequency and percentage for each variable.

The construct was undergone to Confirmatory Factor Analysis (CFA) for achieving some purposes such as improving dimensionality, enhancing convergent and supporting discriminant validity. The overall model was reasonable to carry on in the current research analysis as can be manifested in Table 2 and Fig. 2. The model after subjected to CFA was applied to measure the probability impendences of Common Method Variance (CMV), the results supplied that CMV impendences do not be existed.

One item from Reliability construct was omitted due to some processes in CFA. Table 3 shows the constructs reliability values of each construct and their Standard Deviation values (STD). Accordingly, the normality and skewness of the current study responses were evaluated, thus; the values were matched with the accepted values scale to conduct

Table1: Demographic characteristics (N=403)

Demographic characteristic		FREQ	(%)
Gender	Male	234	58.1
	Female	169	41.9
Age	20 or Less than	8	2
	21-30 years	54	13.4
	31-40 years	184	45.7
	41 & above	157	39.0
Monthly Income	500JD or Less than	182	45.2
	501-1000 JD	179	44.4
	1001-1500 JD	25	6.2
	1501 JD & above	17	4.2
Education	High school or less	12	3.0
	Diploma	29	7.2
	Bachelor	214	53.1
	Master	104	25.8
Occupation	PhD	44	10.9
	Trade sector	30	7.4
	Public sector	322	79.9
Bank Type	Private sector	51	12.7
	Islamic	239	59.3
	Commercial	133	33.0
Frequency of usage of E - banking services	Foreign	31	7.7
	Never	40	9.9
	Once per month	88	21.8
	Twice per month	101	25.1
	Three times per month	174	43.2

Effect of electronic banking and client loyalty

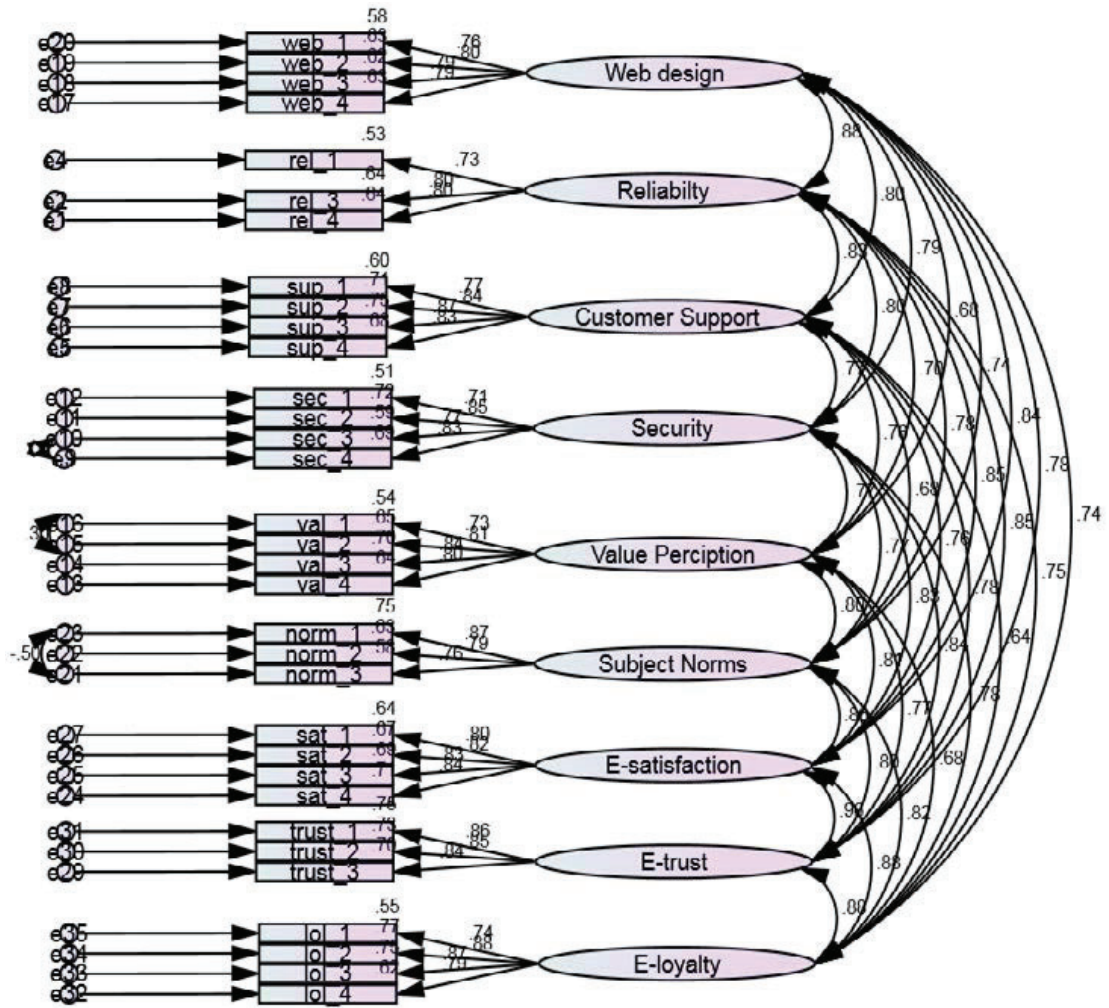


Fig. 2: Overall Confirmatory Factor Analysis Model for Research construct

Table 2: fix model of Research construct

Goodness-of-fit- indices	Values	Recommended value
Chi-square (X <sup>2</sup> )= 1208.843,Df = 456, P<0.00		
GFI	0.849	Values comes to be closed to 1 signalize a very good fit (Jöreskog and Sörbom, 1984).
NFI	0.894	Values close to 1 signalize a very good fit (Bentler and Bonett, 1980).
CFI	0.931	Values comes to be closed to 1 signalize a very good fit (McDonald and Marsh, 1990).
TLI	0.920	Values comes to be closed to 1 signalize a very good fit (Tucker and Lewis ,1973).
RMSEA	0.064	Values < .08 indicating good fit (Browne and Cudeck, 1989).
CMIN/DF	2.651	Values >1 and < 5 were accepted (Marsh and Hocevar, 1985; Tanaka and Huba, 1985).

Note: the abrivation of GFI is Goodness of Fit Indices, DF is Degree of Freedom ,NFI is Normed Fit Index , CFI is Comparative Fit Index, TLI is Tucker-Lewis Index, RMSEA is Root Mean Square Error and CMIN/DF is Relative Chi-square

Table 3: Reliability of construct

Factor	Cronbach's alpha	STD	CR	AVE
Subject Norms	0.82	2.37	0.849	0.653
Value Perception	0.88	3.70	0.873	0.633
Web design	0.87	3.20	0.866	0.617
Reliability	0.80	3.01	0.820	0.603
Customer Support	0.90	3.50	0.896	0.684
Security/Privacy	0.88	3.40	0.869	0.625
E-Satisfaction	0.89	3.20	0.893	0.677
E-Trust	0.87	3.23	0.888	0.725
E-Loyalty	0.89	3.17	0.892	0.674

KMO Measure of Sampling Adequacy= 0.964, Bartlett's Test of Sphericity=11567.838, df= 595, p = .000.

Table 4: Validity discrnmnt

	E-Trust	Reliability	Web design	Subject Norms	E-Satisfaction	E-Loyalty	Customer Support	Security/Privacy	Value Perception
E-Trust	<b>0.851</b>								
Reliability	0.850	<b>0.776</b>							
Web design	0.781	0.883	<b>0.786</b>						
Subject Norms	0.800	0.777	0.741	<b>0.808</b>					
E-Satisfaction	0.961	0.853	0.839	0.858	<b>0.823</b>				
E-Loyalty	0.878	0.747	0.743	0.818	0.879	<b>0.821</b>			
Customer Support	0.779	0.831	0.803	0.682	0.763	0.641	<b>0.827</b>		
Security/Privacy	0.840	0.800	0.789	0.768	0.828	0.780	0.773	<b>0.791</b>	
Value Perception	0.775	0.702	0.681	0.800	0.808	0.683	0.760	0.771	<b>0.796</b>

the next step of the analysis.

The Cut-off point of CR is 0.7 where AVE is equal to 0.5 as proposed by Hair *et al.* (2006). Based on the current outcomes, the model convergent is accomplished. Thus, convergent and discriminant validity of the constructions of the current research are clearly consummated; as can be seen in (Table 4).

The Pearson correlation matrix was calculated for the variables of current study. As can be noticeable in Table 5 web-design is positively linked to E-satisfaction and E-trust of E-banking services customers in Jordan (r= 0.887, p <.01), (r= 0.850, p <.01) respectively. Moreover, the Pearson correlation results presents that reliability is positively attached to E-satisfaction and E-Trust of E-banking services customers in Jordan (r= 0.912, p <.01), (r= 0.905, p <.01) respectively. The results also

show that Customer support is significantly related to E-satisfaction and E-Trust of E-banking services customers in Jordan (r= 0.816, p <.01), (r= 0.826, p <.01) respectively. Security/Privacy is positively related to E-trust of E-banking services customers in Jordan (r= 0.899, p <.01). Value Perception is also positively and significantly attached to E-satisfaction of E-banking services customers in Jordan (r= 0.862, p <.01). Subject Norms is positively linked to E-satisfaction of E-banking services customers in Jordan (r= 0.902, p <.01). Finally, the results also show that E-satisfaction and E-trust are positively and significantly engaged to E-Loyalty of E-banking services customers in Jordan (r= 0.925, p <.01), (r= 0.923, p <.01) respectively. As evident in Table 5 the Net use in demographic variables has a positive and strong correlation with E-loyalty

Table 5: Means, Standard Deviations (SD), and Correlations of Study Variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
E-Loyalty	1															
E-Trust	.923**	1														
E-Satisfaction	.925**	.983**	1													
Subject Norms	.870**	.855**	.902**	1												
Web design	.803**	.850**	.887**	.803**	1											
Value Perception	.750**	.836**	.862**	.860**	.756**	1										
Security/Privacy	.844**	.899**	.892**	.834**	.861**	.843**	1									
Customer Support	.697**	.828**	.816**	.737**	.864**	.822**	.840**	1								
Reliability	.816**	.905**	.912**	.838**	.945**	.784**	.877**	.894**	1							
Gender	.018	.077	.073	.054	.116*	.115*	.104*	.178**	.132**	1						
Age	.000	-.049	-.047	-.043	-.004	-.107*	-.044	-.060	-.025	-.003	1					
Education	.064	.075	.067	.023	.094	.039	.065	.076	.086	-.013	.273**	1				
Job	-.055	-.083	-.067	-.054	-.021	-.077	-.066	-.048	-.048	.115*	-.064	.049	1			
Salary	.178**	.173**	.171**	.154**	.149**	.155**	.160**	.159**	.144**	-.062	.275**	.526**	.068	1		
Bank_type	-.010	.043	.036	.051	.011	.089	.053	.113*	.047	.033	-.058	.052	-.037	.201**	1	
Net_use	.441**	.367**	.383**	.370**	.404**	.272**	.352**	.299**	.385**	-.037	.201**	.232**	-.018	.262**	.008	1
Mean	4.02	3.69	3.92	3.77	4.02	3.53	3.76	3.79	3.62	1.42	3.22	3.34	2.05	1.69	1.48	3.01
Std. Deviation	0.78	0.73	0.76	0.74	0.78	0.82	0.77	0.84	0.69	0.49	0.75	0.88	0.45	0.77	0.64	1.02

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

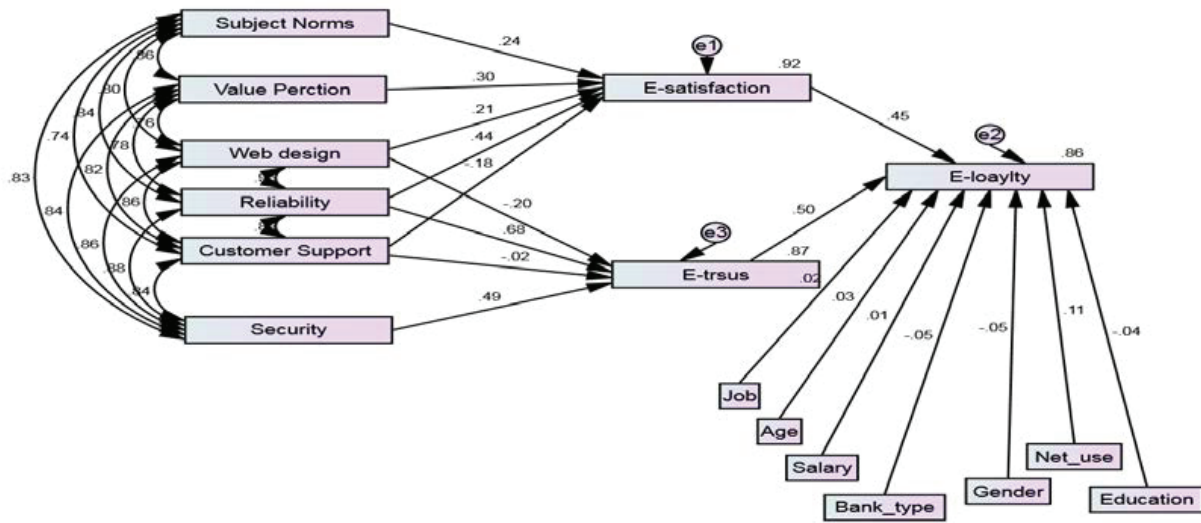


Fig. 3: Structural Equation Model of research construct

Table 6: Maximum Likelihood Estimates

Independent Variables	dependent Variables	Coefficient Estimates(Beta)	Standard Error	T-statistics	P
Web design	E-satisfaction	.199	.044	4.562	***
Web design	E-trust	-.183	.052	-3.481	***
Reliability	E-satisfaction	.484	.061	7.877	***
Reliability	E-trust	.719	.068	10.584	***
Customer support	E-satisfaction	-.166	.036	-4.614	***
Customer support	E-trust	-.017	.036	-.480	.631
Security/privacy	E-trust	.463	.037	12.435	***
Value Perception	E-satisfaction	.281	.033	8.485	***
Subject Norms	E-satisfaction	.249	.038	6.628	***
E-satisfaction	E-loyalty	.441	.035	12.595	***
E-trust	E-loyalty	.515	.036	14.187	***

Notes: \*Significant at the p < 0.05 level (two-tailed); \*\*significant at the p < 0.01 level (two-tailed)

( $r = 0.441, p < .01$ ). Coming up to test hypothesis step, SEM was executed to examine the research hypothesizes. Fig. 3 is obtained by SEM that shows the illustrated variance and the level of intensity of the relationship.

Rely on Coefficient Estimates, Standard Error, T-statistics and P value measurements, Table 6 manifests the outcomes of the research hypothesizes.

Firstly, the results of the first hypothesis of research signaled that web-design has a positive effect on the E-satisfaction of E-banking services customers in Jordan ( $\beta = .199, p = .000$ ) and web-design explicates  $R^2_{(E-satisfaction)} = 21\%$  of the variance (H1 is accepted). The results of the second

hypothesis of research signaled that web-design has a positive effect on E-trust of E-banking services customers in Jordan ( $\beta = -.183, p = .000$ ) and web-design explicates  $R^2_{(E-trust)} = -20\%$  of the variance (H2 is accepted). Moreover, the results of the third hypothesis of research signaled that reliability has a positive effect on E-satisfaction of E-banking services customers in Jordan ( $\beta = .484, p = .000$ ) and reliability explicates  $R^2_{(E-satisfaction)} = 44\%$  of the variance (H3 is accepted). The results of the fourth hypothesis of research signaled that reliability has a positive effect on E-trust of E-banking services customers in Jordan ( $\beta = .719, p = .000$ ) and reliability explicates  $R^2_{(E-trust)} = 68\%$  of the variance (H4 is accepted). In addition, the results of the fifth

hypothesis of research signaled that Customer support has a positive effect on E- satisfaction of E-banking services customers in Jordan ( $\beta = -.166$ ,  $p = .000$ ) and Customer support explicates  $R^2_{(E-satisfaction)} = -18\%$  of the variance (H5 is accepted). The results of the sixth hypothesis of research signaled that Customer support dose not have a positive effect on E- Trust of E-banking services customers in Jordan ( $\beta = -.017$ ,  $p = .631$ ) which means (H6 is not accepted). Furthermore, the results of the seventh hypothesis of research signaled that Security/Privacy has a positive effect on E- Trust of E-banking services customers in Jordan ( $\beta = .463$ ,  $p = .000$ ) Security/ Privacy explicates  $R^2_{(E-trust)} = 49\%$  of the variance (H7 is accepted). The results of the eighth hypothesis of research signaled that Value Perception has a positive effect on E- satisfaction of E-banking services customers in Jordan ( $\beta = .281$ ,  $p = .000$ ) and Value Perception explicates  $R^2_{(E-satisfaction)} = 30\%$  of the variance (H8 is accepted). The results of the ninth hypothesis of research signaled that Subject Norms has a positive effect on E- satisfaction of E-banking services customers in Jordan Jordan ( $\beta = .249$ ,  $p = .000$ ) and Subject Norms explicates  $R^2_{(E-satisfaction)} = 24\%$  of the variance (H9 is accepted). Finally, the results of the tenth hypothesis of research signaled that E-satisfaction has a positive effect on E- Loyalty of E-banking services customers in Jordan Jordan ( $\beta = .441$ ,  $p = .000$ ) and E-satisfaction explicates  $R^2_{(E-loyalty)} = 45\%$  of the variance (H10 is accepted). The results of the eleventh hypothesis of research signaled that E-trust has a positive effect on E- Loyalty of E-banking services customers in Jordan ( $\beta = .515$ ,  $p = .000$ ) and E-satisfaction explicates  $R^2_{(E-loyalty)} = 50\%$  of the variance (H11 is accepted). According to the study results, it is uncovered that the Net use has a positive moderation effect on E-loyalty ( $\beta = .079$ ,  $p = .000$ ) and Net use explicates  $R^2_{(E-loyalty)} = 11\%$  of the variance.

### Discussion

Count on outcomes of the current research, E-satisfaction determines by subject norms, value perception, web design and reliability, while E-trust determines by web design, reliability, customer support, and security. E-loyalty influences by E-satisfaction and E-trust depending on their antecedents. Thus, the outcomes of current study adressed and verified the question of study which

is “What is the relationship between the eTailQ varaibles and customers E-loyalty of E-banking services usage under COVID-19 condtions?”. The results also confirmed the query “What is the impact of E-satisfaction on customers E-loyalty of E-banking services usage under COVID-19 condtions?”. The results also adressed the follwing query “What is the impact of E-trust on customers E-loyalty of E-banking services usage under COVID-19 condtions?”.

According to the outcomes of the present research, the banks of Jordan could concentrate on facilitating the E-banking services for clients to find information and meet the client’s requirements in E-banking services channels as mentioned in the firstand second hypothesis (Alkhouli and Samer, 2017; Cristobal *et al.*, 2007; Zeithaml *et al.*, 2002; Wolfinbarger and Gilly, 2003). The results disclosed that the banks of Jordan could inform the clients of E-banking services about the security level on their transactions and acquaint about the procedures for keeping their information as declared in the third hypothesis (Coulter and Coulter, 2002; Hwang and Kim, 2007). Moreover, the outcomes of present research exposed that the banks of Jordan could improve the technical infrastructure of E-banking services and its channels to serve the clients perfectly as stated in hypothesis four (Coulter and Coulter, 2002). As declared in the fifth hypothesis, the banks of Jordan could focus more on supporting their clients (Hwang and Kim, 2007). Besides, the present study outcomes uncovered that the banks of Jordan could increase the level of responsibility to interact with clients for solving their problems and reduce the response time waiting to react the client’s matters as declared in the sixth hypothesis (Hwang and Kim, 2007). Next, the outcomes discovered that the banks of Jordan could increase the level of client’s security to safeguard their information from attackers and improve the used security mechanisms continuously as mentioned in the seventh hypothesis (Wolfinbarger and Gilly, 2003). According to eighth hypothesis outcomes, Banks of Jordan are advised to encourage the clients of E-banking services use by presenting offers (Li *et al.*, 2014). Depending on the results of the ninth hypothesis, Banks are advised to have an overview about citizen’s environment and know about their behaviors (Alnaser *et al.*, 2017). Rely on the tenth hypothesis results, banks of Jordan could Update

the current E-banking services and present new services with care about client's requirements and banks are advised to fetch the feedback of E-banking services clients to continuously improve the presented services (Garepasha *et al.*, 2020; Alkhoul and Samer, 2017; Amin, 2016; Honglei *et al.*, 2014; Rahman and Ramli, 2016; Sathyavany and Shivany, 2019; Vadivelu *et al.*, 2017). Finally, depending on the eleventh hypothesis results, banks of Jordan could increase the technical level of E-banking services properly and banks are advised to boost the quality of E-banking services for keeping their place in the competition (Garepasha *et al.*, 2020; Amin, 2016; Honglei *et al.*, 2014; Rahman and Ramli, 2016; Papadopoulou *et al.*, 2001).

#### *Implications*

The implications of the current research focus on the realizing of the banks requirement to estimate a spacious of factors when evolving their E-banking services for clients. Moreover, the high extreme implication of current research is to seek from the banks to improve and create the E-banking services perfectly. Through this context, the banks will have an ability to enhance the E-banking services which will influence customer satisfaction and loyalty. For scholars, practitioners and contributors, the focal implications of the current research represent in employing the eTailQ framework in the E-banking services context. In addition, the idiom of E-banking services has been debated for a little period; accordingly, we do not have a unanimous about E-banking services factors. The current research has indicated that the E-loyalty of E-banking services usage could be formed from web-design, reliability, customer support, security/privacy, value perception, subject norms, E-satisfaction, E-trust but the customer support factor did not provide a positive influence on the E-loyalty through E-trust which means customer support factor is required for more fulfillment. Moreover, the banks of Jordan could focus on increasing the E-banking services quality and enhance its content to be more helpful for bank clients.

#### **CONCLUSION**

Rely on current research analysis, the current research is subjected to the scale of eTailQ which is an efficacious framework to demonstrate

the development process of e-loyalty, that has more shored the target of eTailQ framework that encourages the client to perform the banking activities through E-banking services and to depend on E-banking services in E-buy, E-shopping and various activities. Client E-loyalty of E-banking services usage considers as a complicated phenomenon that is formed by an enormous of factors comprising the level of customer support technically, proper infrastructure, the level of security and the ease of usage. The level of understanding the previous factors could encourage the banks to build and innovate E-banking services system which basically associates with client demands and increase the scale of client's E-satisfaction and E-trust. In this way, the E-banking services system could supply the bank with E-satisfaction and E-trust of clients which could be achieved by using E-banking services for a long-time by clients. The high scales of E-loyalty of E-banking services usage will increase the revenue and profit of banks and remain to keep the high level of competitive advantage. Even though having E-banking services system which provides client E-loyalty is a positive significant promise for the banks, the current research could facilitate the capacity of the bank to produce an E-banking services system which authorizes for constructing client E-loyalty. However, in current study it has been uncovered that E-satisfaction and E-trust with their antecedents had a positive and strong relationship with E-loyalty of E-banking services usage in Jordanian banks under the pandemic of COVID-19.

#### *Recommendations and Limitations*

The future trends of researches could focus on different deterrents affecting the E-loyalty of E-banking services usage such as the culture of developing country about E-banking services and bank reputation. Diversity of culture considers a part of different domains which pull the scholars, practitioners and contributors consideration. Subsequently, there is an unassuming number of study in the E-banking services domain which measure the cultural diversity. The current research relies on the scale of eTailQ to determine the factors that impact E-loyalty of E-banking services usage, it is recommended that conduct much research in the E-banking services area in Jordan with different

conceptual models to have a comprehensive overview about the potential determinants. The present research has some limitations, the sample size of the current research was not sufficient to represent the study objectives, convenience sampling that used in current research may not present a high level of accurate outcomes.

#### AUTHOR CONTRIBUTIONS

H. Alhanatleh performed conceptualization, methodology, software, literature review, manuscript preparation, data correction, writing original draft preparation, writing reviewing and editing references.

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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.

#### ABBREVIATIONS (NOMENCLATURE)

<i>AVE</i>	Average Variance Extracted
<i>CFI</i>	Comparative Fit Index
<i>CMIN/DF</i>	Relative Chi-square
<i>CMV</i>	Common Method Variance
<i>CR</i>	Compiste Reliability
<i>DF</i>	degree of freedom
<i>E</i>	Electronic
<i>GFI</i>	Goodness-Of-Fit Indices
<i>NFI</i>	Normed Fit Index
<i>NFI</i>	Normed Fit Index
<i>RMSE</i>	Root Mean Square Error

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CASE STUDY

The effect of environment and behavior synomorph based on the type of activity selected in urban space

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ABSTRACT

**BACKGROUND AND OBJECTIVES:** Urban space is like a living thing that affects the behavior of participants and is also influenced by their behavior, whether it affects the body or the meaning of the space. The importance of this issue has laid the foundation of environmental psychology, so that it has attracted the attention of designers and urban planners to the application of the basic components of this branch of psychology in the design of urban spaces and public open environments. The purpose of this study is to investigate the effect of environment and behavior synomorph on the type of activity of users. The case study was Enghelab Street as an urban space has a historical background and a trans-regional functional scale was located in center of Tehran is suitable for examining patterns of environmental psychology, types of activities and their behaviors, as well as suggestions from field studies conducted.

**METHODS:** This research is a descriptive-analytical research based on the basic-applied purpose. In data collection, quantitative-qualitative method was performed using exploratory studies and questionnaire analysis with SPSS software and analysis (version 22.0).

**FINDINGS:** The growing number of participants respectively, make use of this space for compulsory, social, and optional activities. According to the required activities such as roundtrip time from work, most periods are between 7 to 11 a.m. after 6 to 9 p.m. The results obtained from the implementation of the Kruskal-Wallis test on the data show that the use of sample space for doing purpose compulsory, optional, and social activities is of equal importance in the sense that designing urban space following behavior and need is equally important among the users of space who choose with different purposes of social, optional, and compulsory activities. In more detail the differences in the indicators were in the intimacy component (Sig: 0.024).

**CONCLUSION:** These findings may provide that it is not important in what propose person use the place, the quality of urban place should be presented in the design of all public spaces of the city.

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## INTRODUCTION

With the spread of urbanization and urbanism in today's world, the expansion of economic and physical structures of cities, the dimensions of their psychological effects on citizens expand, urban spaces play an essential role as a place to reduce psychological pressures on citizens, increase the quality of urban life in various dimensions and expand social interactions. Urban spaces are just environments in different objects but with similar functions that incorporate the psychological consequences of urban life problems (Krampen, 2013). Streets as urban spaces are where people spend most of their daily time can be one of the strongest and most effective environments that can play a significant role in controlling individual and collective behaviors of citizens (Gifford, 2014). Designing the body of urban space as a place in which many everyday events of space take place is very important in shaping and directing the behaviors of urban society (Stavrides, 2016). Therefore, it can be concluded that the design of flexible spaces, under the hierarchy of human needs that every citizen unconsciously or consciously seeks to meet, is an integral part of the city. The purpose of this study is to investigate the effect of environment and behavior synomorph on the type of activity of users. Therefore, based on the literature review, it seems necessary to explain the criteria required to design an urban space under citizenship perspectives and enrich their needs. What criteria should be observed to design a lively and dynamic environment that can meet the different needs of society and what indicators should be paid special attention to or avoided? In previous studies in various fields of social and environmental psychology, theorists have pointed to different patterns in the design of environments appropriate to human perception and behavior, which can be a roadmap for the final goal of this study (Lewin, 1944; Barker, 1989; Rogers, 1989). Now, the main question of the research is whether the type of selected activity based on the reason for its presence affects the importance of environmental and behavior synomorph in urban space? To answer this question, the need to pay attention to environmental psychology in synomorph between the body of the environment and human behavior based on his/her needs is important. Today, many urban spaces are not designed to meet the needs of users and the environment cannot meet the needs of its audience.

In the long run, functional burnout will occur in these spaces and they will lose their function as different activity destinations. This study, with special attention to human needs and factors that shape human behavior based on these needs, can play an effective role as a guide for designing or redesigning similar spaces. Table 1 presents the history of research in the field of perception, behavior, and synomorph of environment and behavior over different periods. Looking at the two-way effects of the environment on behavior and vice versa has been discussed in line with design theories. Attention to different senses and their role in perception is not only important but the view that the senses are not limited to the five main senses and in today's researches other senses such as the sense of revelation are effective in perceiving an urban space, makes it to pay attention to the category of perception and subsequent behaviors in space in designing the space.

### *Theoretical Foundations*

#### *Urban space and its features*

Space in its material sense alone does not present any particular feature, but as soon as a human group begins activity in a place, the symbolic meaning of space emerges. From now on, space becomes a bedrock for the occurrence of human behaviors (Habibi, 2020). The urban space is vast and includes aspects of space including artificial and natural elements. They are places where most acts and communications occur in them between citizens and create the main platform for functional and ceremonial activities of citizens (Andalib, 2010). Public areas are the most important part of cities and urban environments (Karndacharuk *et al.*, 2014). In such areas, most contact, communication, and interaction between humans occur. These areas include all parts of the urban context to which people have physical and visual access (Heidari *et al.*, 2013). Classification of urban spaces according to the totality of theories proposed in this field, including entrance, nodes, paths, water edges, and stairs that are common to most of the features expected by users of these spaces, and their differences are more evident in the physical aspect of these spaces. Here, the path, which is a strong element and effective urban space that citizens have the most connection and the amount of use of this space in daily life, has been researched and its characteristics are classified based on the

Table 1: Selected literature in the field of perception and behavior

Theorists	Research	Emphasis
Javanmardi et al. (2020)	The results of research show that the components of identity and desirable visual quality have the greatest impact on attracting users to the city entrance spaces. Moreover, the visual quality of landscapes and the surrounding views are directly related to space presence and space. The influence of this component is greater than the effect of other components such as privacy and spatial layout	- Physical factors - Environmental perception - Behavior patterns
Lee et al. (2018)	In a study entitled "Perceptions of walkability and determinants of Walking Behavior among Urban seniors in Toronto, Canada", the authors investigated the effect of people's perception of using the sidewalk to travel, especially for the elderly, using a questioning technique. Finally, researchers have pointed to the direct relationship between objective and mental components along the way and have examined indicators such as color, materials, readability, etc. in terms of components affecting perception. The general result of the study is the effectiveness of perceptual criteria in promoting walking in the sample community	- Physical factors - Psychological dimensions of current activities
lang (2018)	Lang in the book "Creation of Architectural Theory: The Role of Behavioral Sciences in the Environmental Design": tries to express the role of behavioral sciences in architecture and aims to increase the ability of behavioral sciences to enhance the design of interiors, buildings, residential complexes, environment, and landscape. Therefore, it emphasizes the two-way effect of the physical environment and current patterns of behavior and considers behavioral settings as a container for synomorph between the two	- Behavioral science - Physical environment behavioral patterns
Roberts et al. (2018)	In "Identifying effective behavior change techniques inbuilt environments interventions to increase use of green space" examines long-term studies over fifteen years on the use of green and open spaces, the behaviors that take place, and the interventions needed to encourage the use of such spaces. At the end of the research, referring to the effect of open spaces on the mental health of users, the author considers the two basic strategies of "adding objects to the environment" and "physical reconstruction" as the basis for inviting the population to space and represents modifying these two factors as the beginning of population space.	-physical foundation -Perception and mental health
Motahari Rad (2016)	The study of "Components affecting perception and visual communication in the historical urban landscape" examines the situation of cities with historical landscape and development problems in the landscapes of these cities, by examining the perception process and explaining the attainment of behavior to the center of this process by maintaining the historical landscapes of cities. Finally, tries to explain the conceptual model of perception, behavior and urban landscapes that this series of effective measures are effective on the preservation of these landscapes for today and future generations.	- Perception from an urban perspective - Perception of historical contexts Behavior-based on perception
Shahcheraghi et al. (2016)	The book "Enclosed in the Environment" examines the human interaction with the environment as well as the learning that occurs from this attitude in humans. In line with the topics of environmental psychology, it deals with issues such as environmental behavior and behavioral environment and discusses different dimensions of perception in the environment. In the continuation of the analysis of environment and perception, it discusses the perception and sense of place, and to conclude it presents all the topics of psychological design and creation of beauty of the environment in different scales, especially the city.	-Environmental psychology - Enclosed in interior and exterior environments
Lawson (2001)	Space is an important and constructive component of the setting; the behavior takes place in the setting. Assigning a time and place to a behavioral setting is one of the most prominent views on synomorphs of the physical environment and human behavior. It also expresses the language of space, including the space setting, people, and their activities; settings, whether they are part of a particular realm or not, are important as a way to generate security. Culture plays a role in the readability of the settings; how to behave in a setting and the effect of space on the behavior of people under the title of "space language" which expresses its non-verbal nature and control over how to behave properly in space.	-Language space: interaction of Behavior on space and space on behavior Behavioral settings

general characteristics of urban spaces. Features of open space to attract people are: easy and increase access. Urban spaces should be accessible to all at different times of the day. Location: Physical access to space, psychological and visual access to space, environmental awareness, monitoring in others view, presence of shops and regular customers, presence of people at night, access control and permeability, management, and maintenance. Sensory richness: In examining the sensory richness of urban spaces is the visual proportions. The concept of proportion and proportionality is in the relationship between the dimensions of an intrinsic composition (Mohammadi *et al.*, 2016). Based on all the above explanations, the features of urban space can be categorized and differentiated based on the needs of users. These needs are categorized in different levels from personal and basic needs to social needs of culture, which include the cornerstone of the characteristics of urban space.

*Perception, from nature to theories of environmental perception*

The subject of perception, on the one hand, includes the discussion of the physical characteristics of the stimulus or transmitter and how a person responds to it, and on the other hand, includes the psychological characteristics, learnings, experiences, and motivations of the individual in social situations and his/her perception (Pakzad, 2018). When it comes to perception, it should be noted that humans are not affected by a single stimulus or transmitter, but they are affected by a collection of information sent by senders at different times and places that form a phenomenon in their mind. Therefore, without selecting the message from specific senders and without perceptual organization and permanent activities of the mind, perceptual is not possible (Pakzad, 2018). In art and architecture, the perception and thinking were the basics of the process of urban planning and continue to be, as architecture throughout history, has been a vehicle for expressing the innate human thoughts and desires that have tried to crystallize their intellectual and cultural themes to draw and visualize material symmetry. Therefore, with this view, the city can also be considered the crystallization of ideas, historical backgrounds, and cultural roots of society (Abbasi *et al.*, 2015, 293). In terms of perception type,

Nasar (2014) believes three types of environmental perception theories have ideas for urban design: The first is the level of adaptation theory, which indicates that people adapt to the level of dominant stimuli. The second theory is the ecological approach to perception, which considers the environment to be composed of meaningful structures and stimuli. The active observer recognizes the structures of the environment and provides a basis for his or her search. The concept of environmental capability plays an important role here. One first perceives the nature and levels of collections and objects by examining their appropriateness to one selves. The pioneer of this theory, which is a leading approach, is Gibson (2014). Gibson's view of perception, with its emphasis on movement and how to use perspective, explicitly relates perception to the direct experience of the environment. The third theory is Probabilistic functionalism that believes that human evaluation of the environment has probabilities that depend on people's perception of physical clues, which also depends on the probabilities that have always been placed next to the physical characteristics of the environment. This model which has been invented by Brunswick (1956) suggests that designers focus on outstanding features in people's perception, evaluation, and discussion (as cited in Feizi *et al.*, 2013). Following the theories proposed in the field of environmental psychology, theories of environmental perception are discussed in Table 2. Perception in all issues can be considered as a basis for behavior, which by accepting this issue, behavior in the environment can also be considered a function of environmental perception. Behaviors are actions that motivate the user to perform compulsory, optional or social behaviors in a space-based on perceptions influenced by environmental design components. Table 2 summarizes the theories put forward in the field of environmental perception.

The science of environmental psychology has different dimensions, one of which includes environmental perception. According to theories about the perception of the environment, all theorists agree without disagreement about the data that humans receive from the environment, the difference in the views of these theorists is in the type of perception or understandings made by the receiver. Brunswick (1956), for example, sees the type of data receiving as scattered and orderly

Table 2: Environmental perception theories

	Theorists	Views
Environmental perception	Brunswick (1956) Lens pattern	Use of irregular and scattered received data of environmental stimuli and categorization and refinement perceptually in an orderly and integrated manner
	Ittelson (1960) Perception interaction	Perception is a part of the life process in which each person, from a specific theoretical point of view, imagines a world in which her needs are met.
	Lynch (1960) Space resolution	Five factors: path, node, edge, sign, and area increase the level of readability and of course ease of navigation
	Berlyne (1971) Attractive features	Environmental characteristics can be: a) Have a physical-psychological nature (such as rank, intensity); b) Have an ecological nature or c) Have a structural and social nature
	Gibson (2014) Environmental capabilities	Capability: Recognizing the capabilities of an object or environment is based on the characteristics, experiences, competencies, and needs of the observer

in different categories, which is eventually received and then perceived as a whole, while [Ittelson \(1960\)](#) sees perception based on an individual theoretical perspective. Contrary to popular belief, these similarities and differences in each theory not only do not cause a rift between the topics of receiving and perceiving environmental messages, but each of them completes the information about the cycle of sending, receiving, and perceiving in the view of researchers and has created a single expression of this issue. Therefore, to better understand this issue, it is necessary to examine all these dimensions together and in a single sequence.

*Behavior, from nature to how it occurs in the environment*

Human behavior is the result of a person's motivations and needs, the capability of the environment, a person's mental image of the outside world, resulting from his/her perception and the meaning that this image has for him/her, which occurs in public spaces, with the presence of humans in one space and one time ([Askarizad et al., 2020](#)). Therefore, behavior, while having a tangible and known nature, has a very complex mechanism ([Shahcheraghi et al., 2019](#)). Behaviors are formed to satisfy human needs. Human needs can be classified into different categories, one of which is a hierarchical model of needs, which Maslow has developed and used in environmental design disciplines ([Pakenjad et al., 2018](#)). All human actions that are performed to meet one of his/her needs are called activity and how to perform an activity is called behavior. Human

behavior is the result of a person's motivations and needs, the capability of the environment, a person's mental image of the outside world resulting from his/her perception, and the meaning that this image has for him/her. Therefore, each activity under the influence of the above conditions can take different forms and cause various behaviors. Activities are the basis of the structure of a space. The fact that there is something to do causes people to have a reason to enter and leave space ([Haji Ahmadi Hamedani et al., 2015](#)). Some behaviors are related to activities that do not take place in urban space and all these behaviors are outside the scope of this discussion. What falls into this category are behaviors resulting from activities in the urban space. Lack of proper planning for people's behavioral patterns in public spaces causes anomalies. If the factors affecting people's behavioral patterns in daily life are not properly planned, consequences will occur such as crime, fear, stress, reduced security, and consequently the loss of social stability among citizens ([Askarizad et al., 2020](#)). According to [Gehl \(1987\)](#), people's activities in public spaces can be classified into three groups, each of which requires different characteristics in the physical environment: compulsory activities, optional activities, and social activities. It is obvious that the combination of these three types of presence in space, which are the result of the characteristics of the structure of spatial psychology, affects the understanding of the identity of the place. The environment refers to what is around and potentially communicates with the individual. However, it is not possible to receive all the available information. The

Table 3: Theories of behavior in the environment

	Theorists	Comments
Behavior in the environment	Lewin (1944) (Psychology of the field)	"Bio space": person's beliefs about the environment, which are mentally represented, affect his/her behavior more than the environment itself
	Barker (1989) Ecological Psychology	The environment creates behavioral settings and is more important than the individual in determining behavior. That is, the behavioral setting context determines the range of behaviors that may occur
	Sitte (2015)	Emphasis on creating desirable effects in the human mind street panorama design
	Rogers (1989)	A person's perception of self and her/his environment is the main and determining factor of behavior

environment is all the information that is sent from around. However, only some of them are absorbed in the selection of perception (Khatibi, 2013). In the category of activity that can be observed, behaviors in the same format can be divided into compulsory, optional, and social behaviors. It should also be noted that behaviors in different situations of a person can be normal or abnormal, which depends on the type and extent of perception of the environment and current activities in it. With all the interpretations of behaviors derived from current activities and the nature of the environment, it is necessary to focus more on theories of behavior in the environment and considers the most important of them. Lewin (1890-1947) considers behavior as a function of the living space and states that behavior is a function of the perceived environment. He believes that behavior is a function of the interaction of factors that originate from the individual on the one hand and from the environment on the other. For stating the event resulting from the interaction of individual and environmental factors, he says: "Whenever we want to predict someone's behavior, we have to use the mathematical symbols to reflect all available factors in the 'psychological field' " (Lewin, 1944). This theory is known as the Kurt Lewin psychological field theory. In parallel with this topic, Barker's "ecological theory" or "ecology" is introduced, which examines the behavioral processes that occur collectively and occur in specific behavioral settings. The field of ecological psychology emphasizes the role of physical position in creating human behavior and the impact of the physical environment on the people who benefited from it. "Ecological psychology has made fundamental changes in traditional approaches to psychological research. This approach, instead of studying the behavior of the individual in the laboratory, focuses

on ultra-individual behavior in everyday life" (Lang, 2018). According to Barker (1989); "To gain scientific knowledge about the average indicators of psychological phenomena and their diversity in the population, it is necessary to study behavior in the context of its natural environment, because with the help of laboratory research it is not possible to understand how much love, pressure, conflict, play, punishment, or encouragement is in the world" (as cited in Mortazavi, 2001). In addition to the theories presented above, theorists such as Sitte (2015), and Rogers (1989) also point to the effect of the physical environment on an individual's behavior and vice versa, that is, the effect of behavior on the physical environment through the environmental perception that occurs in a person and confirms it. Table 3 demonstrates the theories of behavior in the environment.

Theories of behavior in the environment, which are considered as branches of environmental psychology, are very diverse and wide. However, due to the criteria of the research, Barker (1989) ecological theory has been used. Barker's theory, which is also a basic theory for research, deals with behavioral settings, in which the synomorph of the environment and the behavior are inseparable and obvious parts of these settings. If behavioral settings are considered as components of urban space, then it can be said that urban space is a space that acts as a whole with the characteristics of the behavioral settings that form it.

*Performing activities and behaviors based on needs Human needs to be based on Maslow theory*

According to Maslow (1996), each person has an innate tendency to achieve self-actualization, reaching the highest level of human need involves

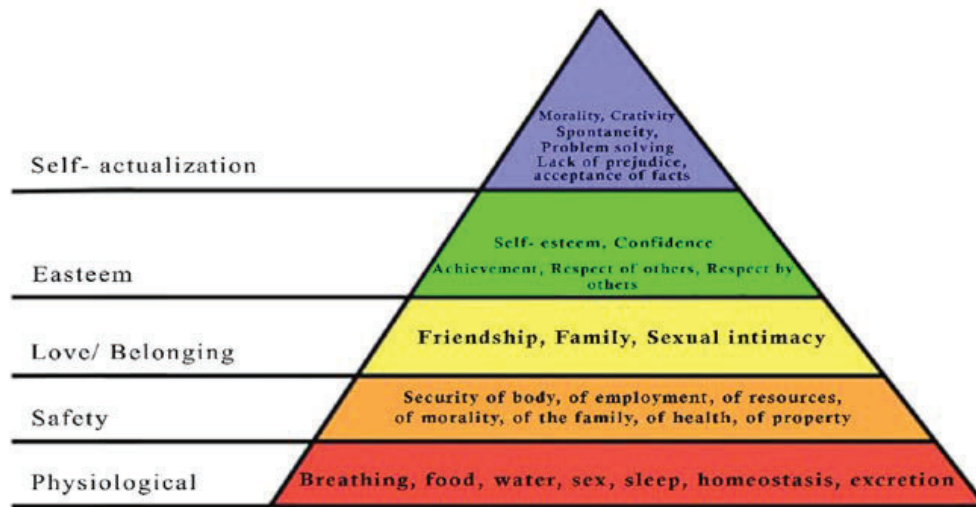


Fig. 1: Maslow needs pyramid (Maslow, 1996)

the active use of all qualities and capabilities that is the realization of all potential talents. To be self-actualizing, it is necessary to satisfy the needs that are at the lower levels of the hierarchy of needs (Schultz *et al.*, 2016). Maslow did not discuss the hierarchy of needs as a dry and inflexible set, meaning that a person can to some extent satisfy the lower needs and then allow the higher needs to be partially activated. The lower needs of the organism eliminated the shortages and the higher needs are transformations that depend on increasing the attraction and breadth of the spiritual horizon. Maslow's criteria are integrity, perfection, justice, beauty, creativity, and truth. Maslow also argues that the extent to which needs are met in human behavior is that meeting low-level needs, even on a large scale, is far less effective than meeting a small number of high-level needs (Khodapanahi, 2008). Classification of needs according to Maslow's theory is classified in 5 parts: 1- Physiological need, 2- Needs for safety and comfort, 3- Needs for love and affection, 4- Needs for self-esteem and 5- Needs for Self-actualization. This classification of needs is based on sociological theories and is made based on them. Equivalent to the needs of the Maslow pyramid (Fig. 1) in urban spaces can be presented in a similar category and with design literature. A) Physiological needs in urban space mean that an urban space must have healthy and sufficient air with heat and humidity in the range of comfort. This comfort is needed to establish the biological and

mental balance so that the users can find the space suitable for their use. B) The need for safety and comfort in the form of urban space can make sense as needs for safety and security. The physical dimension of space design that provides safety, along with the psychological dimension that provides security, has a great impact on the dynamism and attractiveness of the space population. C) The middle layer of Maslow's pyramid of needs and synonymous with the need for love and affection in urban space can be meant as the need to belong. A sense of belonging that, despite the intimacy, family presence, and self-concept of a space, induces a pleasant feeling when using the space to the audience and will result in the use of different gender and age groups of that space. D) As the approach is headed to the top of the pyramid, needs also take on a different nature. The need for self-esteem in an urban space is manifested in the need for respect and value from oneself and others, the respect that the designer gives to users by observing scale, landscaping, etc. and respect for the privacy that each person should have for other people is another manifestation of human needs in Maslow's theory in the form of urban space design. E) Finally, there is the need for self-actualization, which is an urban space is synonymous with the possibility of performing the in-time function for each of the audiences of the space, enriches this feeling. Creating a variety of activities, the ability to change the position and access to different parts of the space

due to this need, and the possibility of enriching it by designing the space, can create a turning point in its dynamism and vitality. All this transformation in the form of a space design language specifies the components needed to measure an urban space, which provides the indicators and items needed for space design to designers and planners in a suitable range.

#### *Behavioral settings*

According to [Barker \(1989\)](#); the environment creates behavioral settings and is more important in determining behavior than the individual. That is, the behavioral setting determines the range of behaviors that may occur. In his opinion, every behavioral setting has recognizable stimuli that include both physical and social aspects. Therefore, by changing the objects in a behavioral setting, it is possible to change the behavior in it ([Imamgholi et al., 2012](#)). Humans are social beings, and behavioral settings are important dimensions to understanding this ([Ma et al., 2020](#)). [Lang \(2018\)](#) defines behavioral settings as follows: "Behavior settings or places are considered to be a stable combination of activity and place, which includes the following components: a recurring and repetitive activity or current pattern of behavior, a specific design of the environment or physical environment, compatible relationship between the two or synomorphy, specific period". [Lawson \(2001\)](#) offers a different definition of behavioral settings: "space is an important and constructive component of the setting; behavior takes place in the setting; settings, whether they are part of a particular realm or not, are important as a way to generate security; Culture plays a role in the legibility of the setting; How to behave in a setting and the effect of space on people's behavior is called "space language", which expresses its non-verbal nature and control over how to behave properly in space". According to the [Barker \(1989\)](#) theory, a behavioral setting is a space that is related to two sets of elements: psychological elements and non-psychological elements. The psychological element refers to a particular form of behavior according to Barker, and the non-psychological element includes material objects that facilitate the occurrence of certain behaviors. It was seen that the probability of a particular behavior occurring in a particular behavioral setting is greater than the probability of

another behavior. Such a probability of a behavior is directly related to our understanding of the identity of the place. The relationship between environment and behavior has been classified into three levels: This relationship is demonstrated by examining the two categories of "the relationship between the two issues" and "reactions following the environment ([Khatibi, 2013](#)). One of the characteristics that Barker has proposed for behavioral settings and it can be called the most important feature of behavioral settings is called synomorph or coordination of environment and behavior. At every moment, the entanglement of human behavior and the body within it occurs. With this concept, it becomes clear that behavior and body are two components that are integrated into one time and place ([shahcheraghi, et al., 2019](#)). Depending on the degree of dependence on other synomorphs, the synomorphs in which the component and the environment surrounding the pattern of behavior may or may not be like an independent and self-sufficient behavioral setting. In short, the synomorph relationship is the structural homogeneity between behavioral patterns and environmental components ([Barker, 1989](#)). Roger Barker cites the eight factors of physical forces, social forces, physiological processes, visual perception (the appearance of the environment), the learned reactions (learning), selection of settings by the person, selection of persons by behavior settings, and the influence of behavior on the physical container as the most important factors which form the synomorph ([Shahcheraghi et al., 2019](#)). Later, Schoggen, who is theoretically very similar to Barker, examines behavioral settings in two structural and dynamic dimensions. This study is also true in the field of synomorphs and two new factors add to the characteristics of Synomorph: the beginning and end of behavioral settings and the non-transferability of current patterns of behavior. Based on all the definitions of Synomorph in behavioral settings, it can be argued that the synomorph of environment and behavior is a powerful indicator of behavioral setting design in different scales and considering its items makes it possible to control social anomalies, crimes, and offenses without physical interference. In addition to anomalies and attention to the negative aspects, its positive effects on population, dynamism, and vitality of urban space are inseparable and it is a very important tool to create places 24 hours a day.

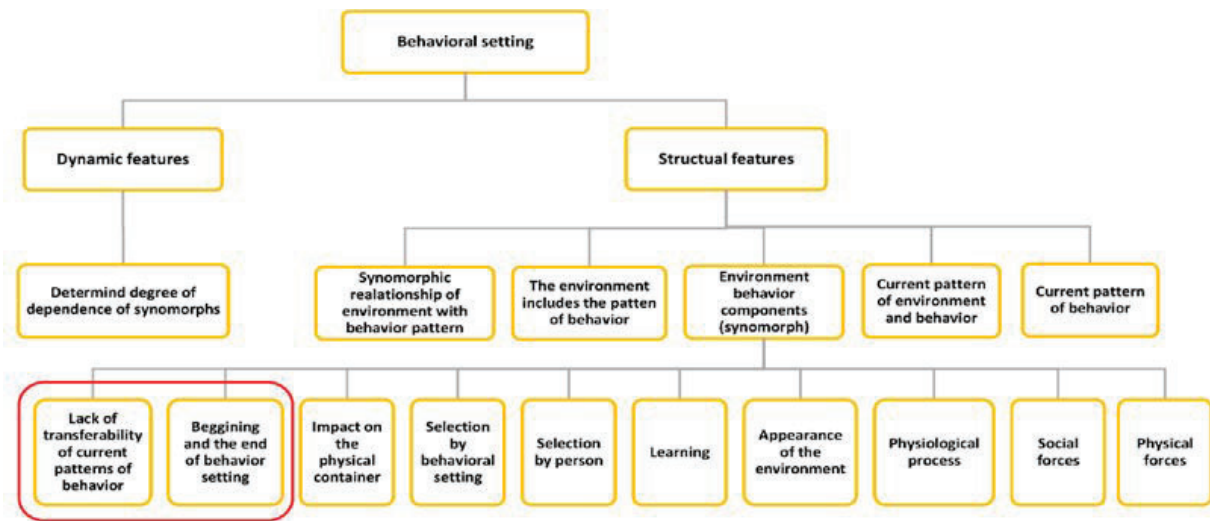


Fig. 2: Recognition of the behavioral settings of Barker theory from Schoggen's point of view (Schoggen, 1989)

According to Fig. 2, not only the components of the synomorph are influential in the occurrence of this synomorph within a behavioral setting, but they also have interrelationships, both overt and implicit (Schoggen, 1989). For example, the mental and educational contexts that are formed in the subconscious of individuals have a direct effect on a person's visual perception of the environment, or on the other hand, social and physiological forces have an undeniable effect on the individual's selection. Therefore, these indicators can be considered as continuously related to each other, which adds the complete concept of environment and behavior synomorph to the behavioral setting.

#### Developing a theoretical framework

The main purpose of this study is to investigate the impact of human needs on behaviors performed in an urban space. Behavioral settings are components of a whole, which is known as urban space or public space. The use of urban space is based on one or more human needs, which are categorized according to Maslow's theory. The transformation of a need for behavior goes through a cycle in which environmental and social factors are the most important components influencing this cycle so that one must rely on the factors that affect the occurrence of behavior before the behaviors are performed (Fig. 3). Users of space perceive from two components, the physical container in which they are placed and the

activities that take place in it. The components of the environment, whether artificial or natural, provide a meaningful framework for space perception. It can lead a person to the desired type of behavior, force him/her to do something, or allow him/her to perform various behaviors, which in the long run can also have a direct impact on a person's behavioral framework and even learning. In the second place, it is possible to perceive the types of activities carried out in space. As mentioned, the activities that take place in space are divided into three categories: compulsory, optional, and social. At this point, the perception of activity in the current environment takes place and shapes the behavioral frameworks of individuals. For example, in a park, the behavior is usually fun and leisure, but if a classroom is set up in a park, the students' behavior in that park will be matched to what they do in the classroom, given the perception of the environment as a park. Of course, it should be noted that this perception in different people depends on several factors, including different perceptual tools (human senses), age, gender, etc. Needs are different at different ages and genders, so the behaviors to address them are different from each other, and each person's sensory tools are different according to the archives he/she has with him/her and his/her learning contexts, which can also be an effective factor in perception, therefore human needs are emphasized in this study. The current research was conducted in 2020 in Tehran.

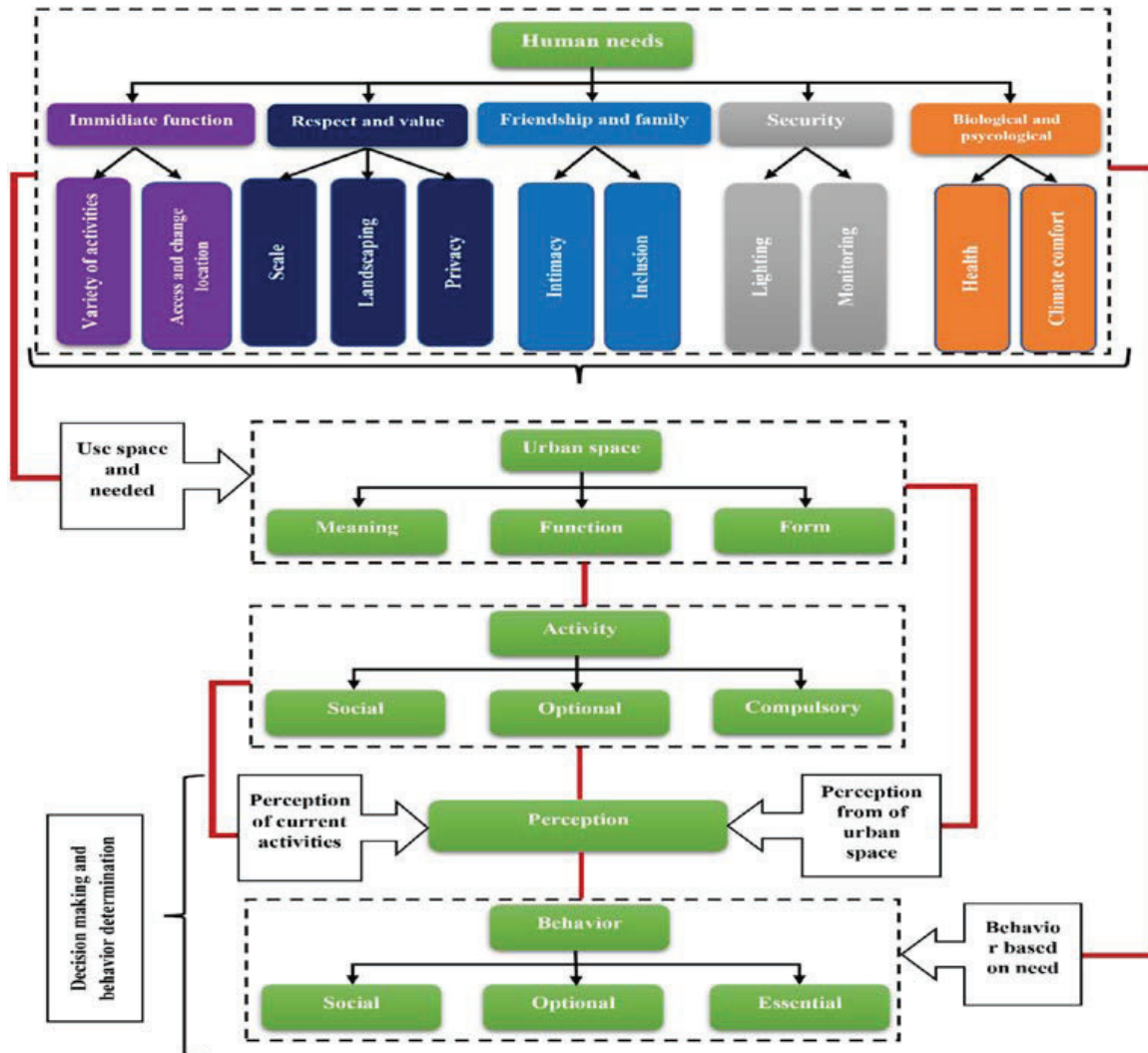


Fig. 3: Hierarchy of Need to Behavior

## MATERIALS AND METHODS

### Cochran sampling method

Calculating the sample size is very important in statistical inference and findings. In this research, Cochran model has been used. This model is used to estimate the sample size with statistical population information and 5% estimation error. Given the population of 39841 people in the study area, to collect information, 384 people should be interviewed based on the calculation of the Cochran model.

### Questionnaire

Relying on the main purpose of this research, to

examine the components of the Maslow needs pyramid, an attempt has been made to design questionnaire using items that can be converted into statistical data. The completed questionnaire collected from the target community, assesses the need for assessment of these needs from each of the five classes of Maslow's human needs from different components and different items according to the Likert scale to assess empathy between body and behavior based on the type of activity. The statistical population was 384 who randomly been selected from the inhabitants of this area. Due to the timing of the outbreak of the COVID19 virus, those questionnaires were collected virtually from the sample

Table 4: Cronbach's alpha calculation (Reliability Statistics)

Cronbach's Alpha	N of Items
.789	14

community via an Internet link. Finally, SPSS software was used to analyze statistical data, classify, perform tests, and convert them into analyzable information. Cronbach's alpha test in SPSS was used to evaluate the reliability and validity of the questionnaire used in this study. The results obtained in this test are presented in Table 4, which with an alpha value of 0.789, was acceptable in terms of reliability and the data collected from the received responses were suitable inputs for other statistical tests and data analysis.

#### Likert Scale

The Likert scale is a psychometric scale that is frequently used in research questionnaires. The Likert scale is commonly used to measure views, feelings, opinions, and the like that are not visible but can affect audience behavior. This scale is a type of score classification that classifies the intensity and weakness of an index into 5 levels: very low, low, medium, high and very high and prepares this data for statistical tests. Further to these questions, the level of satisfaction with the current situation in the Likert spectrum has been measured. The very low, medium, and very high options respectively mean the least satisfaction, the relative satisfaction, and complete satisfaction with the current situation

#### Kolmogorov–Smirnov (K-S) statistical test

When choosing a statistical test for research, it must be decided whether to use parametric or non-parametric tests. One of the main criteria for this choice is the Kolmogorov-Smirnov test, which shows that the distribution of data is normal or not. That is, it compares the distribution of a property in a sample with the distribution assumed by the sample society. If the data have a normal distribution, it is possible to use a parametric test, otherwise a non-parametric test should be used. In SPSS software and in the result page of Kolmogorov-Smirnov test, if this test is significance ( $\text{sig} < 0.05$ ), which means that the data distribution is not normal and non-parametric tests must be used. Conversely, if this test is not significance ( $\text{Sig} > 0.05$ ), parametric tests should be used to analyze the data (IBM SPSS).

#### Kruskal-Wallis statistical test

The Kruskal-Wallis test is a non-parametric test used to compare three or more independent groups measured at the rank level. This test is in fact equivalent to the non-parametric independent F test in one-way analysis of variance. Kruskal-Wallis test is used when the basic assumptions of analysis of variance such as normal data distribution and equality of variance of groups are not established, for this reason, this test is sometimes called "analysis of variance ranking". This test can be applied to continuous data (distance or relative), in which case it should be noted that the data is converted into grade data and used. Hypothesis zero in this test is that there is no difference between the groups in terms of the sum of their rankings.

#### Case Study

Enqelab Street (Fig. 4d) is an urban space that, along with its special uses that many people visit for different purposes every day, can be suitable areas for examining the effective factors and codifying these patterns in the tradition of creating a quality urban place. Each research, according to the goals that it seeks to achieve, adopts its appropriate strategy to advance the research and achieve the desired goals. The strategy of the present study is ethnography and case study. According to the objectives of this research, it is practical in terms of purpose, in terms of nature is descriptive-analytical and the type of research is quantitative-qualitative research that seeks to investigate the relationship between research components and the whole subject. In simpler terms, it can be stated that all studies follow two types of applied and theoretical studies and seek to solve problems. The variables studied in this study are qualitative and discrete that the information needed to study them was collected by studying and reviewing library resources, using images, maps, and text, taking notes from sources, and extracting the necessary data from the collected answers of a distributed questionnaire. The study area of this research is from Vesal Shiraz Street to Hafez Street, the axis of which and one of its important edges is Valiasr crossroads (Fig. 4d). Enghelab Street is known as an important axis in mega city of Tehran (Fig. 4b) (capital of Iran) in terms of public transportation as well as functional direction. It is noteworthy that the study area is located between the two districts 6 and

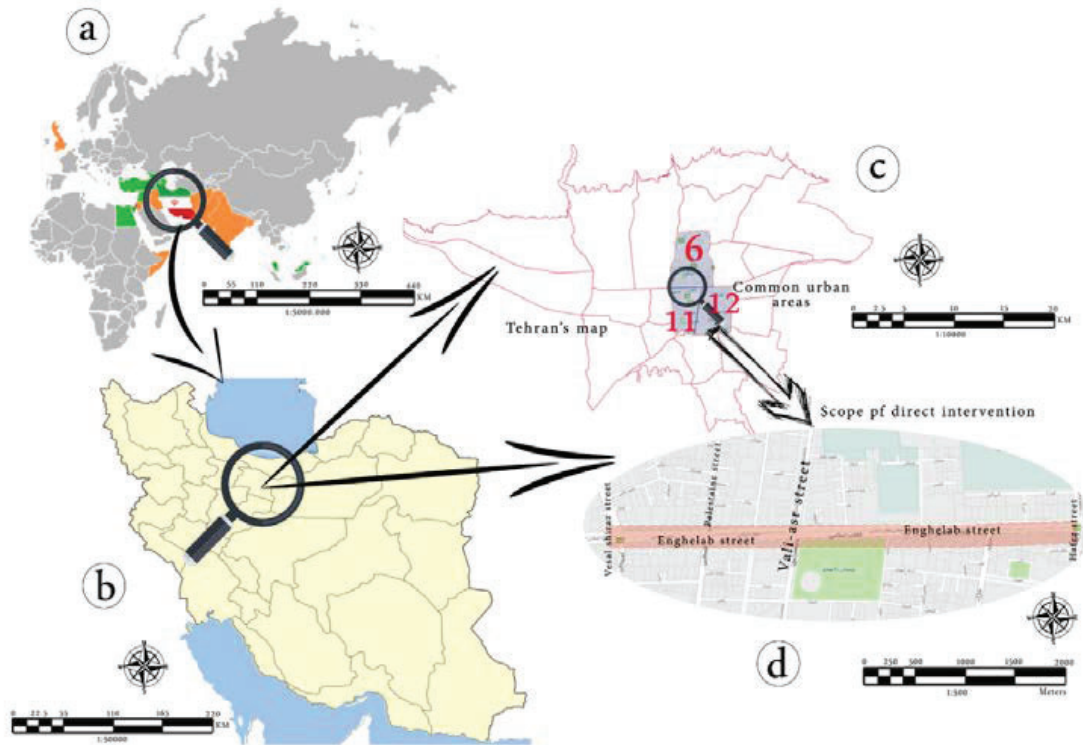


Fig. 4: Location of the scope of direct intervention in Tehran

11 (Fig. 4c), which puts the area in a special position in terms of managerial decision making.

As shown in Fig. 5, this street include a wide range of commercial, administrative and service activities, educational and cultural, green space and tourism, which expands the scope of its uses, and leads to guiding people with various activities including compulsory, optional and social activity to be in this street and the range of various behaviors in this space can be seen.

## RESULTS AND DISCUSSION

### Descriptive analysis

In addition to the questions raised in the Likert scale, questions that are important and significant in the use of a space, such as a gender, hours of space usage and type of activity can be directly related to synomorphs. According to the results obtained from the statistical population in question, 56% were men and 44% were women, which is a small difference indicating appropriate participation in terms of gender. One of the most important questions that

has been assessed and determined the reason for the presence of people in space and have been showed (Fig. 6), 44% of the statistical population are present to do something in space (compulsory activities), 25% for walking and recollection of memory goes to Valiasr crossroads (optional activities) and 35% of people who participate in a socio-cultural event or a celebration choose the Valiasr crossroads (social activities). Fig. 7 also shows the use of space in different time periods through which the ability of the studied space to accept the population in different times can be inferred. By separating these questions from the category of spectral questions about human needs, in Table 5, the distribution of answers to the status of each of the items considered has been developed for the needs codified in the theoretical framework of the research.

An overview of the responses received from the sample community showed (Table 5) that from the perspective of all three categories of activities, the status of indicators that meet human needs in the physical space is average. Of course, these answers

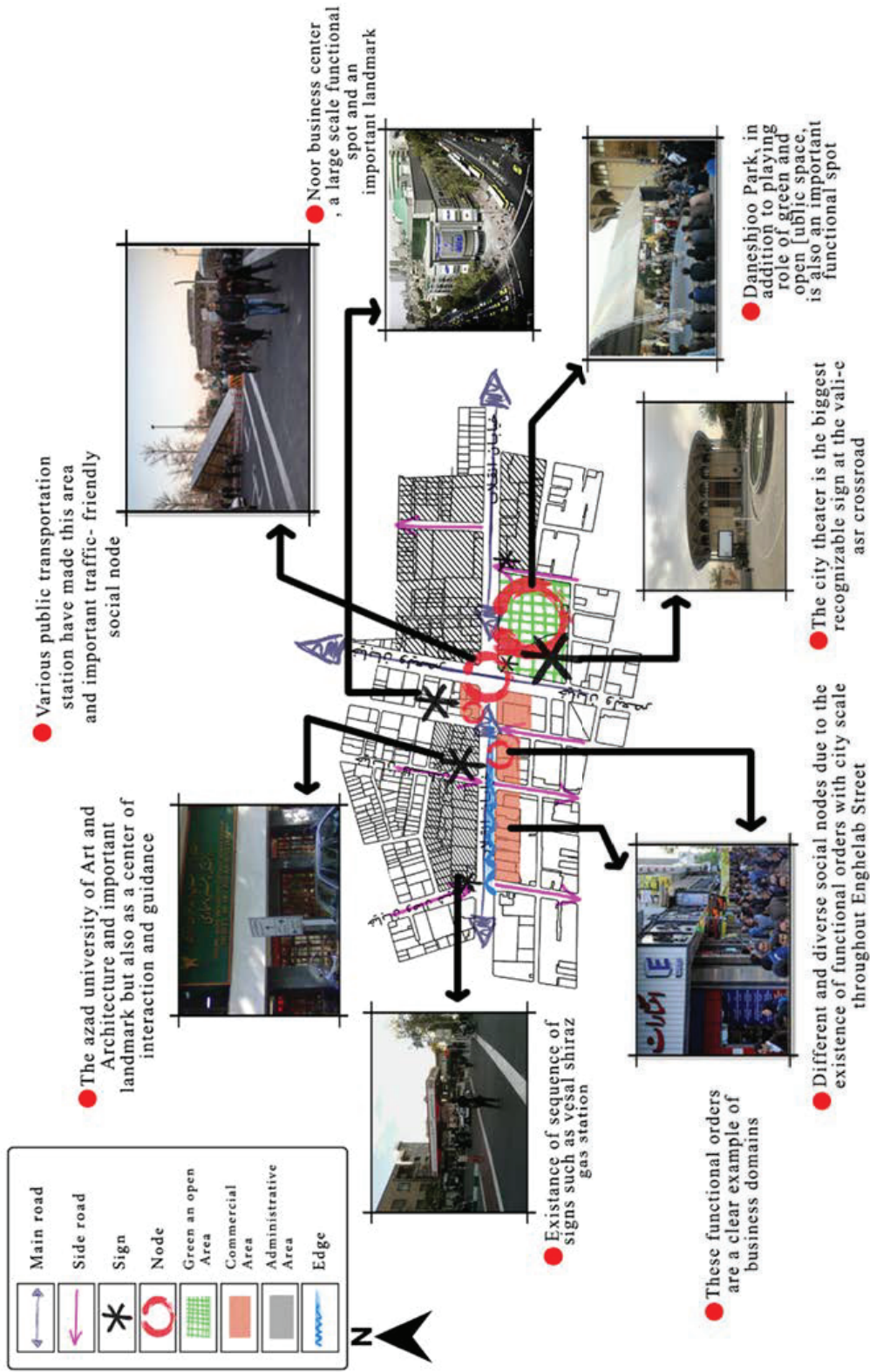


Fig 5: Mental image map (Legibility map) from the field of direct intervention

Table 5: Assessing the status of space delivery to human needs from the perspective of the sample community

Row	Component	Item	Very high	High	Average	Low	Very low
1	Intimacy	Ability to sit and talk with others	3%	13%	58%	13%	13%
2	Intimacy	possibility to attend with family or friends to spend leisure time	1%	5%	45%	22%	27%
3	Health	The level of cleanliness of spaces and streets, comfort and ambient noise	1%	5%	49%	35%	10%
4	Landscaping	Urban furniture (benches, trash cans, mailboxes, etc. Use in places to rest on the bench, the possibility of throwing garbage	3%	15%	55%	20%	7%
5	Landscaping	The visual beauty of the street and the surrounding area and buildings	2%	14%	51%	27%	6%
6	privacy	Possibility of solitude and cozy places to relax, have lunch, work chats, and ...	1%	7%	37%	41%	14%
7	privacy	Feeling suffocated and uncomfortable when moving or working in space due to population and construction density	3%	24%	37%	26%	10%
8	scale	The proportion of street width to the height of the surrounding buildings	4%	11%	56%	23%	6%
9	lighting	Light and lighting at night	4%	27%	49%	4%	16%
10	Monitoring	The degree of monitoring over businesses established by law enforcement forces (presence, distance, etc.)	12%	17%	38%	25%	8%
11	Inclusion	Possibility of activity, movement, and walking for all classes (both in terms of gender and age	1%	15%	47%	32%	5%
12	Climate comfort	Climate comfort (such as being safe from wind, sun, rain, etc.)	1%	5%	49%	18%	3%
13	Variety of activities	Existence of various activities to meet your needs, such as various shops and the existence of other uses such as medical, religious, etc.	2%	28%	49%	18%	3%
14	Access and change location	Possibility of moving freely throughout the space (such as crossing the street, moving freely in different parts of space, etc.	2%	14%	39%	36%	9%

(average option) can be considered as a middle ground for the situation, and the options that are prioritized after that, indicate the relative prediction of the future of space in the index. It can be found

that in many fields, in particular, climate comfort, access and change of location, privacy, health, and inclusion are among the components that space has not been able to meet the needs of users, and

Table 6: Comparison of item rankings in the Kruskal-Wallis test

	Visual beauty	Urban furniture (benches, trash cans, etc.)	Environmental hygiene and noise pollution	Ability to attend with friends and family	Possibility of gathering and talking
Kruskal-Wallis H	.255	.389	.027	7.426	.413
Df	2	2	2	2	2
ASYMP. Sig.	.88	.823	.987	.024	.814
	Physical and non-physical monitoring of businesses	Light and lighting	The proportion of street width to building height	Population and building density	Possibility of solitude
Kruskal-Wallis H	3.958	1.173	2.491	3.106	1.827
DF	2	2	2	2	2
ASYMP. SIG	.138	.556	.288	.212	.401
		Ability to move freely	Variety in activities	Climate comfort	Possibility of activity and walking for everyone
Kruskal-Wallis H		.787	2.756	1.876	1.617
DF		2	2	2	2
ASYMP. sig		.657	.252	.391	.446

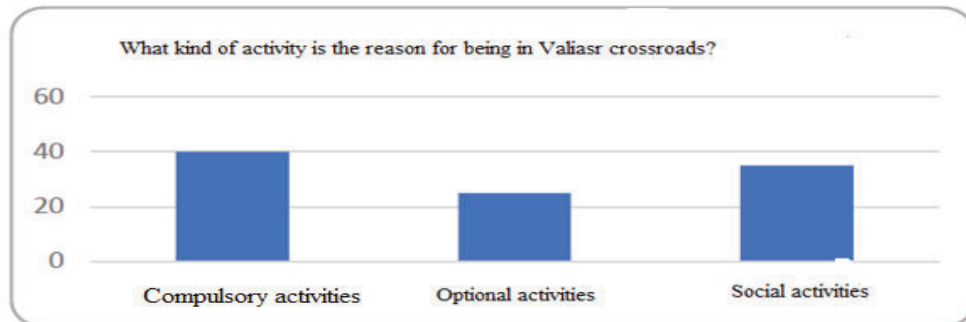


Fig. 6: Separation of sample community activities

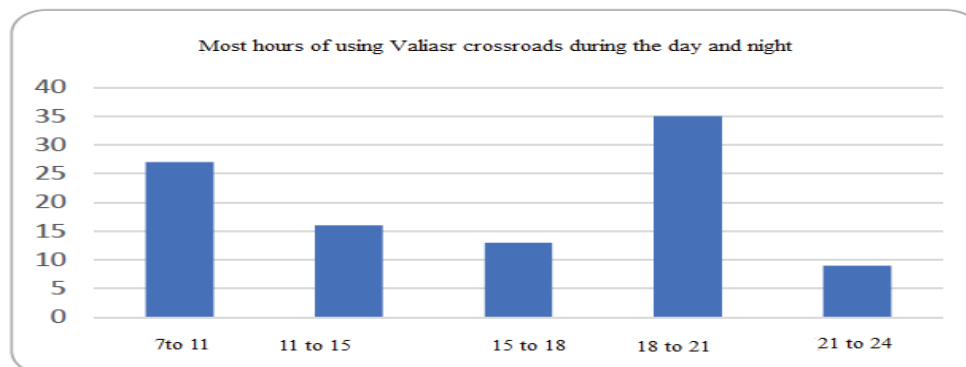


Fig. 7: Hours of community use of sample space

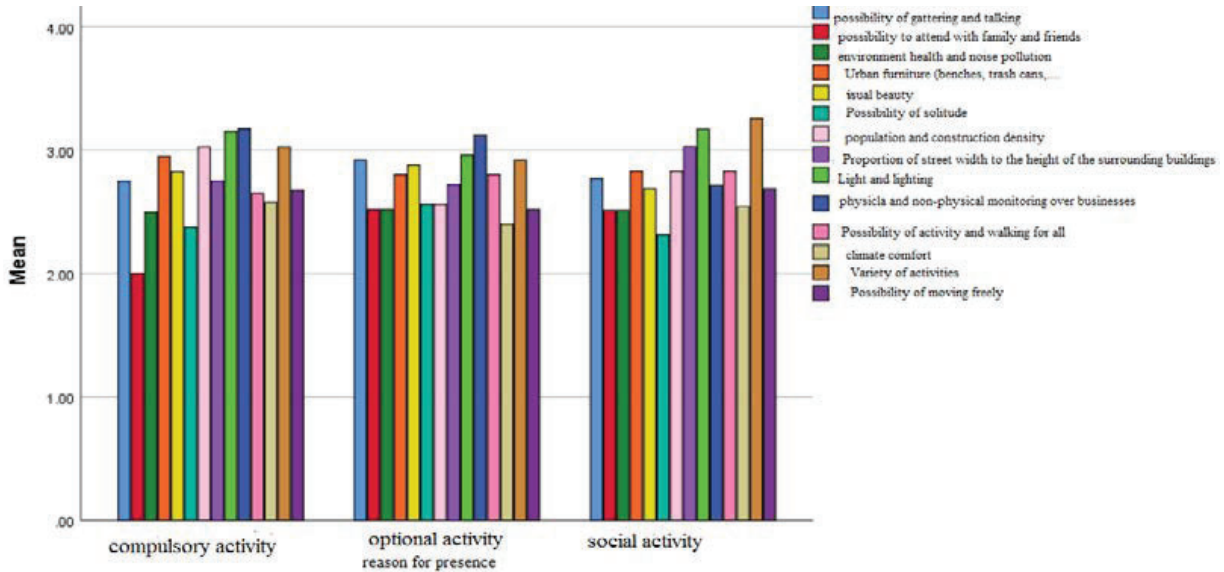


Fig. 8: Diagram of the difference between the independent groups in the Kruskal-Wallis test

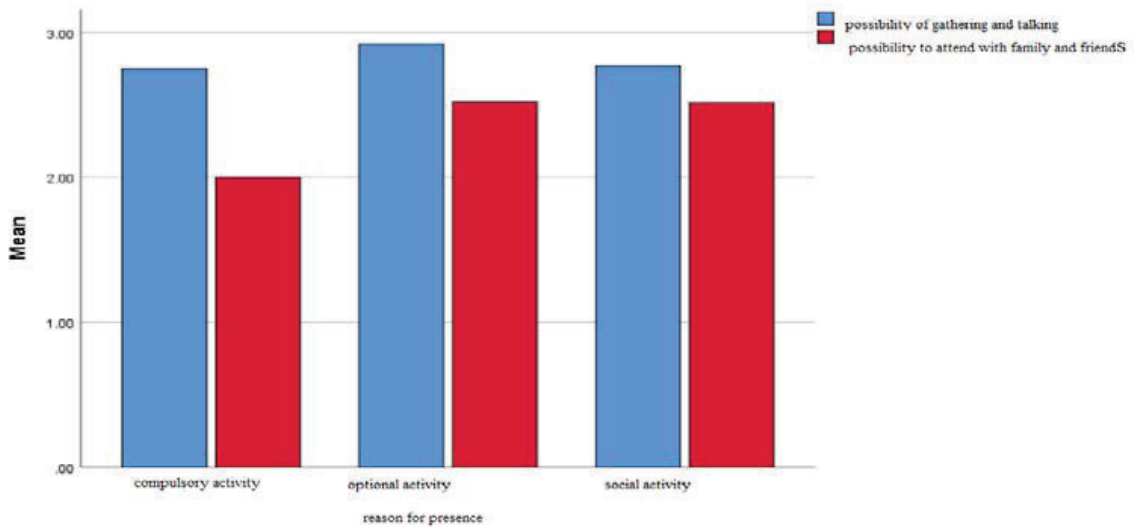


Fig. 9: The difference between items of intimacy component

in the medium and long term can be a threat to the vitality and dynamism of the space. In cases such as lighting and variety of activities, designers in space have been able to attract the relative satisfaction of citizens, which is one of the positive points of this environment, but it should be considered that all these threats can be modified by appropriate policy-making and corrective solutions for intervention and it will be possible to turn them into opportunities.

*Statistical analysis of research*

By confirming the initial condition of the K-S test and the significance value is less than 0.05, the non-parametric Kruskal-Wallis test was used for ranking between independent groups. This ranking is obtained for each item and separately for the activities performed in space (compulsory, optional, and social), which shows the importance and difference of these independent groups with

each item for the proposed activity categories. In addition to the specified ranking, there is a significant difference between each group that is ranked in this test which in [Table 6](#) has been specified.

Due to the Sig condition being less than 0.05 for the significance of the statistical test, this condition is only in the item of “possibility to attend with family and friends” with a value of 0.24. The obtained is the null hypothesis for this index, which is the sub-component of intimacy in the classification of needs, and is rejected and shows that the ability to be with the family is not the same in terms of different activity categories. To explain this component, the phrase “possibility of gathering and talking” has also been used, and the test condition for it is 0.814 which is not true and the null hypothesis, like other indicators for this indicator, has been confirmed and opinions have been collected equally for all these indicators from different activity categories of the statistical community, and this has caused a significant difference between the two items. [Fig. 8](#) shows the rank differences in general and in the form of a bar graph, which in [Fig. 9](#) shows in more detail the differences in the indicators of the intimacy component. The test results prove the hypothesis that the importance of designing urban space under behavior and needs are of equal importance among space users who choose Valiasr crossroads with different social, optional, and compulsory activity purposes. Of course, only in the case of presence with family, this importance is different, so that the preference of those space users who have chosen Valiasr crossroads for a compulsory activity for any reason, choose this spaceless to be present with their family and friends.

#### *Discussion*

The results of this study, which are taken in terms of adaptation to human needs proposed in [Maslow \(1996\)](#) theory, who believes that the activities that humans do are in line with reaching to their individual to social needs, are consistent. In another dimension that pertains to perception of human about the environment, the agreement of this research can be seen with the [Ittelson’s \(1960\)](#) point of view, who considers perception as a part of the process of each person’s life, which is based on the needs of the individual and the imagination that he/she has of the world around him/her. According to [Gehl \(1987\)](#) the

types of the activities that take place in a space fall into three categories of compulsory, optional, and social, which in this study the indicators of human needs are analyzed above the three categories. What that complements the current research is also the [Barker’s \(1989\)](#) thinking about occurrence of behavior in behavioral contexts, meaning that behavioral contexts are containers in which behavior takes place, and directly or indirectly affects an individual’s behavior. However, it is important to note that this effect is reciprocal and, as [Shoggen \(1989\)](#) in complementing Barker’s theory has put in emphasis, behavior has also affected on the environment in which the behavior has taken place. The result of these theories led to the formation of the structure of this research to achieve the overall goal of the research, namely the effect of coordination and environmental behavior on the activities selected by each individual.

#### **CONCLUSION**

The harmony between environment and behavior as a feature of behavioral settings has a substantial role in shaping the perception and behavior of users of a space. However, unfortunately in the design of today’s environments, this issue has been much neglected, and the lack of attention to environmental psychology discourses is strongly felt in the design of public open spaces. The objective of this research is also to design urban spaces with an emphasis on the harmony between environment and behavior. The behaviors that are influenced by many internal and external factors, in addition to being affected by the surrounding environment, can also exert an effect on that environment. Hence, the design of the body of collective spaces can be considered as the first influential factor in shaping or guiding the behaviors exhibited in these spaces, on which other factors are somehow dependent. The results of the current study, considering the effective data received from the sample population in question, show that the study sample space (Enghelab St., between Vesal Shiraz to Hafez St.) in terms of meeting the needs of all classes of the Maslow Pyramid and compliance of these needs with the concepts of urban space design has a middle line in all indicators. This average that is in the minds of citizens can have a variety of reasons, which is not important for the design process of the source of reasons, but the effects it has on urban

space. So here, in addition to this moderation, attention can be paid to other perspectives that analyze the space in positive and negative directions. The threats and opportunities of urban space are also from the same points that show themselves and affect over time. When using different categories of activities (compulsory, optional, and social) in the discussed space, the same importance and public attention with different causes of presence that result from data processing, indicates that the sample space in the current situation can meet the current needs of users relatively, but this over time whether time will be like this or not depends on the ability of the space to adapt to new needs in different types of activities and its physical modification in different periods. These findings may indicate that in cases where a person suggests using the space does not matter, the quality of the urban space should be present in the design of all public spaces in the city. One of the most important factors in the destruction and loss of function of urban spaces is the lack of attention to human desires and needs at all levels. Just paying attention to design criteria without considering individual desires or paying too much attention to social interactions can also lead to a decline in space and bring as much division or separation of thoughts. As much as collective activities are needed, the same individual activities and solitude are necessary, like talking to others, watching, listening to music, and thinking. Therefore, in designing and redesigning urban spaces, all individual and collective needs of human beings should be examined from all aspects. The current research has two significant aspects in practical terms: A) Classification of the statistical community by activities that persuade them to use space to meet individual or collective needs and B) What are the strengths and weaknesses of human needs in the form of activities performed in a space and what behaviors will follow subsequently? Therefore, the results of this research could be laying the groundwork for future designs in different urban spaces. As mentioned in the materials and methods, the most obvious limitation of this study was the concurrence of the study with the epidemic of Covid 19 (Corona virus), which made it difficult to interview and question space users face to face and the questionnaires were collected electronically. This limited the choice of respondents and created many barriers to interviewing people with a thorough

knowledge of the space.

#### AUTHOR CONTRIBUTIONS

S. Sharifkazemi performed the literature review, experimental design, analyzed and interpreted the data, prepared the manuscript text, and manuscript edition. M. Ghalambor Dezfuly supervised the experiments, literature review, data compiling 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 observed by the authors.

#### ABBREVIATIONS

<i>K-S</i>	Kolmogorov- Smirnov
<i>Sig</i>	Significance

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ORIGINAL RESEARCH PAPER

## Designing a strategic human resource management model with the approach of promoting innovation capability

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### ABSTRACT

**BACKGROUND AND OBJECTIVES:** Today, creative and innovative human resources play a crucial role in the optimal performance and achievement of long-term goals of organizations. Therefore, organizations must use different methods to lay the groundwork for innovative activities, one of the most important of which is the use of strategic human resource management measures. Therefore, the purpose of this study is to design a model of strategic human resource management with the approach of promoting innovation in Municipality of Tehran.

**METHODS:** The present study from the purpose point of view is applied-development study and is in the mixed research category. In the qualitative stage of the research, the theme analysis method was used. Participants in the present study included 13 university professors and 19 senior managers of Tehran Municipality, who were interviewed to the point of saturation. Based on the results of the qualitative stage of the study, a model for strategic human resource management with the approach of promoting innovation capability was designed. In a quantitative step, in order to validate the model, the structural equation modeling method and smartPLS software were used. For this purpose, 169 managers and experts working in Municipality of Tehran, who were randomly selected were interviewed using a questionnaire.

**FINDINGS:** Based on the findings, the relationship between strategic human resource management subsystems; including employee recruitment, supply and adjustment system, performance management system, human resource development system, service compensation and reward system, job analysis and design system, talent and succession management system and employee relations and innovation management system were approved. Also, the results showed that the coefficient of determination for the variable of strategic human resource management was 0.649 and for the variable of innovation capability improvement was 0.578 which were significant. Therefore, it can be concluded that 57.8% of changes in innovation capability can be predicted by strategic human resource management measures.

**CONCLUSION:** The results showed that by using the capacity of strategic human resource management subsystems, innovation capability and innovative performance in Municipality of Tehran and the results of the research, in general, can be applied to organizational units with almost similar and with the same structure and missions.

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## INTRODUCTION

Today, the occurrence of crises such as accidents, floods and earthquakes, and the spread of infectious diseases such as Covid-19 disease, has increased the attention of employees as important stakeholders of organizations. Organizations that fail to strike the right balance between short-term financial results and employee needs, damage the interests of employees and the organization (Collins, 2021). Therefore, long-term goals and benefits need to be considered in Human Resource Management (HRM) planning to deal with the future crises. The concept of "Strategic Human Resource Management (SHRM)" refers to the fact that in order to gain a competitive advantage, the organization must look at employees as the company's top asset and have long-term plans for their development (Singh, 2018; Nemati and hasani, 2015). SHRM plays a pivotal role in creating an environment that fosters human capital for new job behaviors and leadership skills in creative problem solving (Marchington, 2015). SHRM not only deals with the relationship HRM and strategic management in the organization, but also with the needs of human capital and also handle the development of process capabilities (ie. the ability to do things efficiently). In general, SHRM pays attention to any major human issues that affect or are affected by the strategic plan of the organization (Tooranloo et al., 2017). According to Chen and Huang (2009), strategic human resource actions can strongly influence the company's innovation performance. They believed that when companies decide to develop their innovative activities, they typically face relatively higher uncertainty, risk, and instability in the innovation process. For example, using an innovation-based recruitment and selection process often plays a key role in ensuring that talented groups of innovation-based individuals are selected to ensure organizational competitiveness (Farouk et al., 2016). Or a reward system can promote innovation in an organization (Abbasi and Rana 2012). Also, intangible incentives can be used to encourage employees to create and share innovative ideas (Tsai, 2017; Goope et al., 2018). Researchers in SHRM have argued that human resource strategies have the potential to lead to a competitive advantage by creating unique and valuable employee-based resources. There is strong empirical evidence that Human Resource (HR) strategies have a significant and positive relationship

with higher levels of firm performance through impact on human resources (Collins, 2021). The functions of strategic human resource management mean that organizations can influence the skills, attitudes and behaviors of employees appropriate to their job to achieve organizational goals (Collins and Clark, 2003). SHRM plays a pivotal role in creating an environment that nurtures human capital for new job behaviors and leadership skills in creative problem-solving (Marchington, 2015). Strategic human resource management in government organizations is critical to changing the role of government and individuals in the public sector. Comprehensive human resource strategies are needed to seize new opportunities and ensure that government duties and responsibilities are performed to the highest professional standards (Jarvalt and Liiv, 2010). The strategic management literature also recognizes innovation as a vital factor for organizations and companies to create value and maintain a competitive advantage in an increasingly complex and rapidly changing environment. Innovation initiatives strongly depend on the knowledge, expertise and commitment of employees as key inputs in the value creation process (Subramaniam and Youndt, 2005). Skarzynski and Gibson (2008) explained that in order to achieve good innovation performance, a company needs to be able to innovate. The same view was put forward by Davila and Penalva (2006) which shows the need for firms to develop innovation capabilities based on positive behavior, competence and motivation of management and staff to achieve good innovation. Achieving innovation capability is not a chance but it is necessary for the organization to pursue innovation as part of its strategy (Zawislak et al., 2013). Therefore, in this research, an attempt has been made to create an innovation capability in the Municipality of Tehran based on the use of SHRM. Today, various units are responsible for managing public affairs and providing needs and services to community members. Non-governmental public organizations are among the newest institutions that have been created as a new phenomenon in public administration and show the high level of decentralization in public administration, which has been established with the aim of providing some special public services with independence and freedom of action. Article 5 of the General Accounting Law of the country, approved on 3.26.1987, defines this type of institutions: "According to this law, non-

governmental public institutions and organizations are specific organizational units that are formed or are formed with the permission of the law, in order to perform duties and services that have a public aspect "(Iran General Accounting Law of the country, 1987). Pursuant to a note of an accounting law, the law on the list of non-governmental public institutions was approved by the parliament on 7.10.94, according to which 10 organizations and their affiliated institutions, including municipalities, were recognized as non-governmental public institutions (Resolutions of the Shura Council, 1994). Although many measures have been taken in the Municipality of Tehran to promote staff creativity and innovation, but so far the capacity of SHRM has not been used to promote innovative activities. However, national and scientific research has no answer in this regard and has only examined the relationship between the two variables of strategic human resource management and innovation. However, there are questions in this area, some of which are: What are the drivers of innovation in the Municipality of Tehran? Which subsystems of human resources and promoting innovation, and are there a significant relationship? What factors affect strategic human resource management subsystems? And similar issues like what have been mentioned. Therefore, the main purpose of this study in order to fill the existing research gap and create scientific and practical results, is to design a model of strategic human resource management with the approach of promoting innovation in the Municipality of Tehran.

#### *Theoretical Foundations*

Strategic human resource management examines the relationship between HRM and strategic management, as well as the need for human capital and the development of process capabilities and the ability to carry out activities efficiently (Ren and Jackson, 2019). SHRM is the use of new techniques and methods by which the organization responds well to unstable environmental conditions and mobilizes human resources on the path to competitive advantage (Bamberger *et al.*, 2014). This method of management refers to the relationship between HRM and short-term and long-term strategic goals to improve company performance and create organizational culture, based on which flexibility and innovation can be strengthened (Zabihi *et al.*,

2017). The common ground of the SHRM literature is a set of activities that provide employees with skills, information, motivation, and independence, and lead to a competitive advantage in the workforce (Soo *et al.*, (2017). Strategic human resource activities are those that are empirically or theoretically related to the performance of the organization (Delery and Gupta, 2016). The operational measures of strategic human resource management (dependent variable) are: (1) job analysis and design; (2) human resource planning; (3) recruitment / selection; (4) education and development; (5) service compensation; (6) performance management; and (7) employee relations (Obeidat, 2016). On the other hand, innovation is considered the key to winning the competition by creating new ideas (Samuel *et al.*, 2017). Innovation in organizations is primarily an issue related to human factors. Because it is these employee who develop and implement ideas, innovation will depend on effective HRM (Kianto *et al.*, 2017). Innovation requires infrastructure that can be categorized into potential and actual groups. Its potential group is called "Innovation Capacity" and its genuine part is called "Innovation Capability". Innovation capacity is the continuous improvement of the organization's capabilities to create opportunities for innovation in the product and product production processes (Morel and Boly, 2006). Innovation capacity is the continuous improvement of the organization's ability to create opportunities for innovation in the product and product production processes itself (Morel and Boly, 2006). Innovation capacity means the potential capacity of the firm to carry out innovative activities, including the introduction and supply of new tasks, new procedures and processes with new ideas in relation to the organization (Koc and Ceylan, 2007). In other words, innovation capacity can be considered as a set of resources, capabilities and dynamic capabilities dedicated to the innovation process (Pierre and Fernandez, 2018). Innovation capacity coordinates and develops the enterprise innovation process. It also allows the firm to generate output through the inputs of the innovation process (Boley *et al.*, 2014). Given the role that SHRM measures can play in promoting innovation capability, this study seeks to provide a model of strategic human resource management with the approach of promoting innovation in Municipality of Tehran.

### Literature review

The subject of the present study has been considered in a number of national and international researches. [Azizi et al. \(2021\)](#) in a research examined innovative HRM strategies during COVID-19, and the results showed that innovative human resource management strategies include: flexibility, strengthening internal efficiency, talent identification and making innovative changes based on organizational evaluation and the needs of job activities. The findings of [Coster and Banda \(2020\)](#) showed that innovative HRM is a good predictor of organizational innovation. Findings of [Riana et al. \(2020\)](#) proved that HRM significantly affects organizational performance and innovation, and it was found that innovation can improve organizational performance. The results of [Singh \(2018\)](#) research also showed that strategic human resource management affects the performance of innovation while, knowledge management capacity is acting as the mediating variable. [Aryanto et al. \(2015\)](#) determined that strategic human resource management practices have a positive relationship with innovation capability, which in turn has a positive effect on innovation performance. Therefore, SHRM can be a good predictor of a company's innovation capability. [Mehmood et al. \(2017\)](#) research findings showed that there is a correlation between the implementation of strategic human resource management measures in an organization, innovative activity and gaining a competitive advantage. The outcome of [Uslu \(2015\)](#) research showed that strategic human resource management measures directly affect the innovative behaviors of employees and the culture of innovation in the organization, strengthens employee innovation. [Minavand and Lorkojori \(2013\)](#) in a research concluded that the three variables of strategic human resource management, innovation and company performance are strongly related. This finding suggests that implementing a strong SHRM system in a firm, can ensure successful innovation measures as well as optimal overall performance. [Mitchell et al. \(2013\)](#) showed that high-performance human resource actions mediate between the strategic performance of human resources and show that professional human resources as a strategic partner increase the legitimacy of human resource actions and also provides facilitate resources. [Jiang et al. \(2012\)](#) proved that the four functions of human resources

recruitment, reward, job design and teamwork are positively related to employee creativity; while training and performance appraisal were not. The results of [Kasirloo and Naami \(2020\)](#) research indicate a very strong relationship between strategic human resource management and its dimensions with organizational performance in a bank. Findings of [Hamidianpour and Haidari \(2019\)](#) also showed that SHRM has a positive effect on innovation capacity and also strategic human resource management through organizational learning also has an impact on innovation capacity. In the research of [Aghayei and Kavousi \(2019\)](#), the results showed that the three dimensions of organizational culture, leadership, organizational transformation and strategic planning are effective in the development of strategic human resource management in Travel agency.

According to the findings of [Soomro et al. \(2020\)](#), strategic human resource management has a significant effect on organizational performance as well as organizational innovation and organizational innovation on organizational performance. The results of [Taheriattar and Rostam Lou \(2018\)](#) determined that human resource management functions have a positive and direct effect on employee creativity and employee creativity has a direct and positive effect on product innovation as well as process innovation. [Zabihi et al. \(2017\)](#), in their research, discovered the contingency factors of strategic human resource management and identified effective human resource measures based on it. The research findings indicate the existence of two categories of external and internal contingency factors. [Rostamzadeh et al. \(2016\)](#) also presented that strategic human resource management has a positive and significant effect on attracting, retaining and empowering human resources among the employees of a bank in Urmia city. [Saadat Talab et al. \(2015\)](#) in their research concluded that strategic experiences and functional experiences of human resource management, significantly affect organizational effectiveness and especially innovative performance through strategic human resource management. [Ranjbar and Purkiani \(2013\)](#) in their research concluded that the four infrastructures of strategic human resource management are significantly related to three characteristics of labor force including human capital, employee motivation and employee turnover. Also, the characteristics of the workforce are significantly related to the ability to

create organizational knowledge. Finally, the results confirmed that significant relationship between the ability to create organizational knowledge and organizational innovation. Concluding the review of theoretical foundations and research background showed that the research and existing theories, although they have confirmed the relationship between strategic human resource management and innovation, but so far a research specifically examines the impact of strategic human resource management subsystems in creating It has not examined the capacity for innovation as well as the factors that affect the intensity of this relationship. In other words, so far no study has been done on the relationship between different subsystems of strategic human resource management with the approach of promoting innovation capability and the factors affecting the intensity of their effectiveness in creating innovation capability. The main purpose of the current research is to design a model of strategic human resource management with the approach of promoting innovation in Municipality of Tehran. The present study seeks to develop theories and concepts in the field of strategic human resource management to promote innovation capability, the results of which can be used by urban managers to promote creativity and organizational innovation; of course, the results can be used for public and private organizations, taking into account their context. Also, since the subject of research is new and innovative and there is limited knowledge and understanding of the variables of the strategic human resource management model with the approach of promoting innovation, it is considered as exploratory research. Therefore, the present study, while filling the existing research gap, seeks to provide a scientific and practical model for strategic human resource management with an approach to promoting innovation in the Municipality of Tehran. The current study have been carried out in Tehran in 2021.

#### **MATERIALS AND METHODS**

The present study from the purpose point of view is applied-development study and is in the mixed research category. In order to design the model, the theme analysis method was used and also, in order to confirm the validity of the designed model, the Structural Equation Modeling (SEM) method was used. Data collection required for design and

validation of the research model was performed with semi-structured interview tools and a questionnaire. Following the review of theoretical foundations in the previous related research, using the opinions of university professors and consultants and according to the objectives of the research, the questions were categorized for the interview. Interviews were conducted in a semi-structured manner with university professors and senior managers in the Municipality of Tehran. In order to conduct the semi-structured interviews and model design, a total of 13 university professors and 19 executive experts who were purposefully selected participated in the interview, which have been continued until reaching the theoretical saturation. After conducting the interviews and extracting the data, coding steps were performed to finally identify the components of the research model. After designing the research model, its validity was measured based on criteria related to the validity of qualitative research. Mariani (2009) has presented several criteria for the internal validity of the results of the qualitative method. In this research, triangulation methods and member checks were used. In the triangulation method, several data sources or several methods are used to validate emerging data. Respondents are also asked about the acceptability of the results in the member checks review method. In order to confirm the validity of the results of the theme analysis, a number of university professors and executive experts were consulted about the results obtained and the results were approved with some modifications. Also, the results were in line with previous theoretical foundations and research which showed that there was good a consistency between them. In the quantitative stage of the research, the model was designed to confirm the validity and in the qualitative stage, the structural equation modeling method and smart PLS software were used. At this stage in order to collect the required data, a researcher made questionnaire consisting of 88 items were designed. The validity of the questionnaire with some modifications was confirmed by 3 experts participating in the qualitative stage. Also, the reliability of the questionnaire was calculated by Cronbach's alpha method as 0.803, which indicates the appropriate value. The statistical sample at this stage was 169 managers and specialists in the field of human resources in Municipality of Tehran. The sample size was calculated using

Cochran's method and the sampling method was random.

## RESULTS AND DISCUSSION

In the present study, semi-structured interviews were used to design a research model and identify the components and relationships between them. To this end, interviewees were interviewed about human resource subsystems and the role that these factors play in promoting innovation. Also, questions were asked about the factors (drivers) that make it necessary to upgrade the innovation capability in Municipality of Tehran. Based on the summary of experts' opinions, the research model was designed. The model consists of several main components including drivers, environmental factors, internal organizational factors, strategic human resource management subsystems and implications for promoting innovation capability. Propulsion (drivers) refers to the factors that make it necessary to pay attention to promoting innovation capability, which includes organizational factors and manpower factors. Environmental factors at both macro and micro levels related to the municipality are discussed in the model. Internal factors also include variables that exist within the municipality and affect the strategic management of human resources. The experts proposed 7 subsystems of strategic human resource management which were included in the model. These subsystems include: employee recruitment, supply and adjustment system, performance management system, human resource development system, service compensation and reward system, job analysis and design system, talent management and succession management system and employee relations management system. Finally, the implications of promoting innovation capability, which include idea generation capability, innovation absorption capacity, innovation application capacity, and innovative performance, were included in the model. The model of strategic human resource management with the approach of promoting innovation capability in Municipality of Tehran is shown in Fig. 1.

### *Validation of the research model*

In the present study, the structural equation modeling approach based on the partial least squares (PLS) method was used to test the conceptual

model of the research. For this purpose, Smart PLS software was used. First, to validate the model, the adequacy of the sample size, which was 169 people, must be ensured. There are several methods for assessing the adequacy of sampling, including the Kaiser-Meyer-Olkin Measure (KMO) test, the value of which always fluctuates between 0 and 1. On the other hand, Bartlett (t) test was used to ensure the appropriateness of the data that the correlation matrix underlying the analysis is not equal to zero in the population. In other words, using Bartlett test, sampling adequacy can be ensured. The KMO and Bartlett test outputs are presented in Table 1.

According to Table 1, the sample adequacy size (KMO) and also the significance test of Bartlett sample sphericity in factor analysis by SPSS are equal to 0.822 and 0.000, respectively, which indicates the adequacy of samples for factor analysis. Cronbach's alpha is a classic measure of reliability and a good measure of internal consistency (internal consistency). Cronbach's alpha value shows the correlation of one-variable (model-independent) questions. A Cronbach's alpha value above 0.7 indicates acceptable reliability. Because Cronbach's alpha is a traditional measure of structural reliability, it uses a more modern criterion than alpha called composite reliability (CR). This criterion was introduced by Bacon et al, (1995) and its advantage over Cronbach's alpha is that the reliability of structures is calculated not absolutely but according to the correlation of their questions with each other (correlation of univariate questions in the model). According to Table 2, the values of CR and Cronbach's alpha are confirmed for all variables, because they are greater than 0.7. Also, Average Variance Extracted (AVE) criterion was used to evaluate convergent validity. This criterion represents the average variance shared between each structure and its indices. This criterion represents the average variance shared between each structure and its indices. In simpler terms, AVE indicates the degree of correlation of a structure with its characteristics that the higher the correlation, the greater the fit. Fornell and Larcker (1981) introduced the AVE criterion for measuring convergent validity and its critical value was expressed as 0.5; this means that the mean value of the extracted variance above 0.5 indicates acceptable convergent validity. The calculated values of AVE indicate the favorable convergent validity of the research variables.

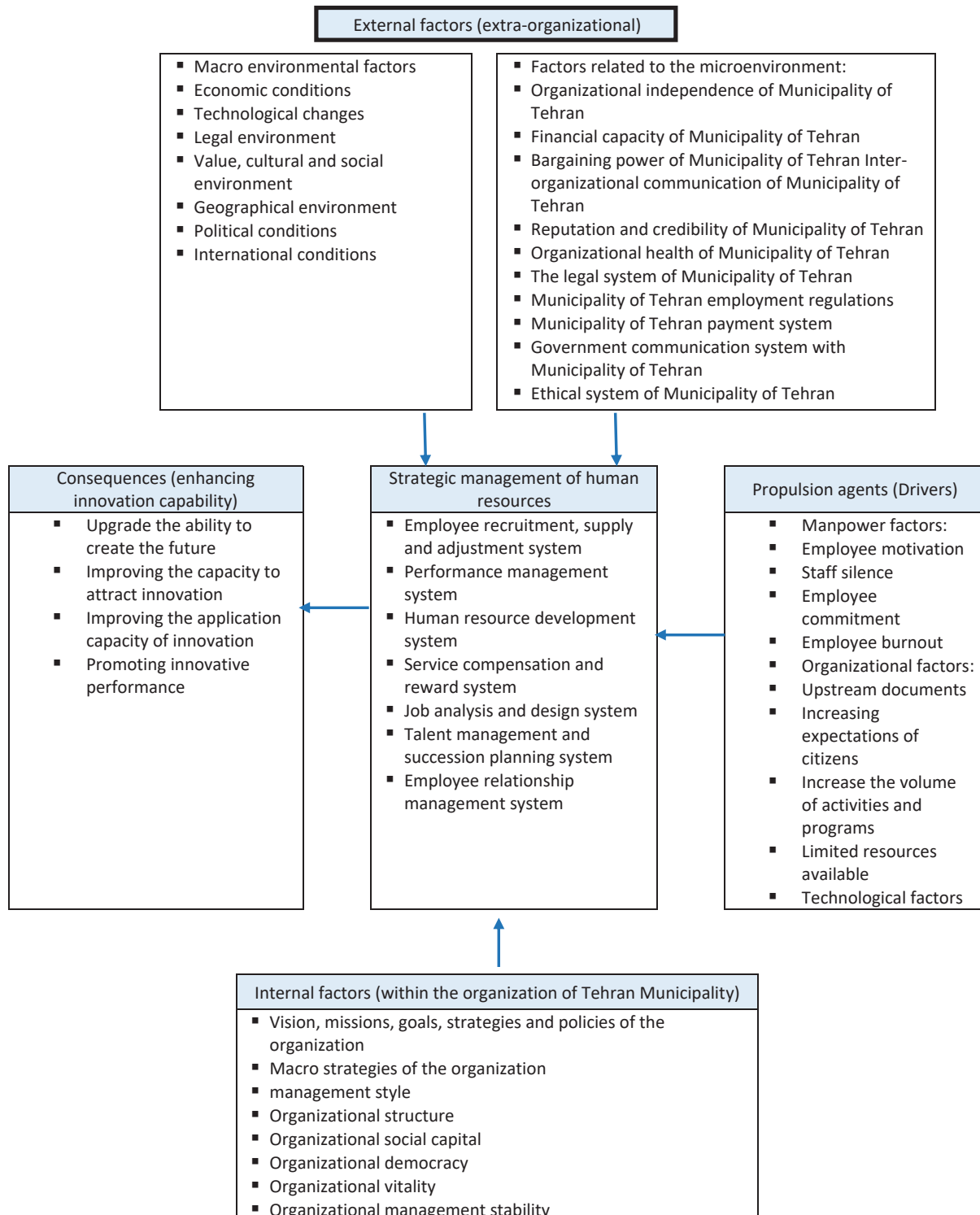


Fig. 1: Strategic human resource management model with the approach of promoting innovation capability in Municipality of Tehran

*Strategic management of human resources*

Table 1: Results of KMO index calculation and Bartlett test

Indicator	KMO	Bartlett (t) test	Sig	Degrees of freedom	Test result
Amount	0.822	45580.89	0.000	5845	Confirm

Table 2: Cronbach's alpha values, composite reliability and AVE

Variable	Cronbach's alpha	Composite Reliability (CR)	Average Variance Extracted (AVE)
Propulsion (Drivers)	0.85	0.86	0.74
Micro environmental factors	0.82	0.85	0.68
Macro environmental factors	0.84	0.85	0.67
Intra-organizational factors	0.82	0.84	0.73
Strategic human resources	0.86	0.87	0.75
Outcomes	0.79	0.82	0.69

Table 3: The Divergent validity calculations

Variable	Propulsion (Drivers)	Propulsion (Drivers)	Macro environmental factors	Intra-organizational factors	Strategic human resources	Outcomes
Propulsion (Drivers)	<b>0.816</b>					
Micro environmental factors	0.310	<b>0.807</b>				
Macro environmental factors	0.326	0.354	<b>0.781</b>			
Intra-organizational factors	0.312	0.295	0.284	<b>0.796</b>		
Strategic human resources	0.336	0.315	0.345	0.284	<b>0.844</b>	
Outcomes	0.387	0.394	0.423	0.311	0.347	<b>0.810</b>

Finally, divergent validity is the third criterion for measuring the fit of measurement models. According to [Fornell and Larcker \(1981\)](#), divergent validity is at an acceptable level when the mean variance extracted for each structure is greater than the common variance between that structure and the other structures in the model. According to [Table 3](#), it can be said that the divergence validity is acceptable. Because the root of the mean variance extracted ( $\sqrt{AVE}$ ) for each variable is greater than the correlation of that variable with other variables. Therefore, the variable narrative validity of the questionnaire variables is confirmed.

Also, the structural part of the model, unlike measurement models, does not deal with the questions and explicit variables of the model and only pays attention to the hidden variables and the relationships between them. In this study, structural model fitting was performed using coefficient of

determination ( $R^2$ ), Q2, Redundancy and significance coefficients. The most basic criterion for measuring the relationship between structures in SEM, is the t significant numbers. If the value of t is outside the range (-1.96 to +1.96), it is significant at the 95% confidence level, and if the value of t is within this range, then the estimated path coefficient is not significant and the proportional hypothesis is rejected. [Fig. 2](#) shows the conceptual model of the research in the significant state of coefficients.

According to the information provided in [Fig. 2](#), all the relationships developed in the research conceptual model were confirmed, because the value of t-statistic reported for them is more than the critical value of 1.96 at the 95% confidence level. In addition, [Fig. 3](#) shows the conceptual research model in estimating standard coefficients. Therefore, the intensity of the effect of variables on each other is

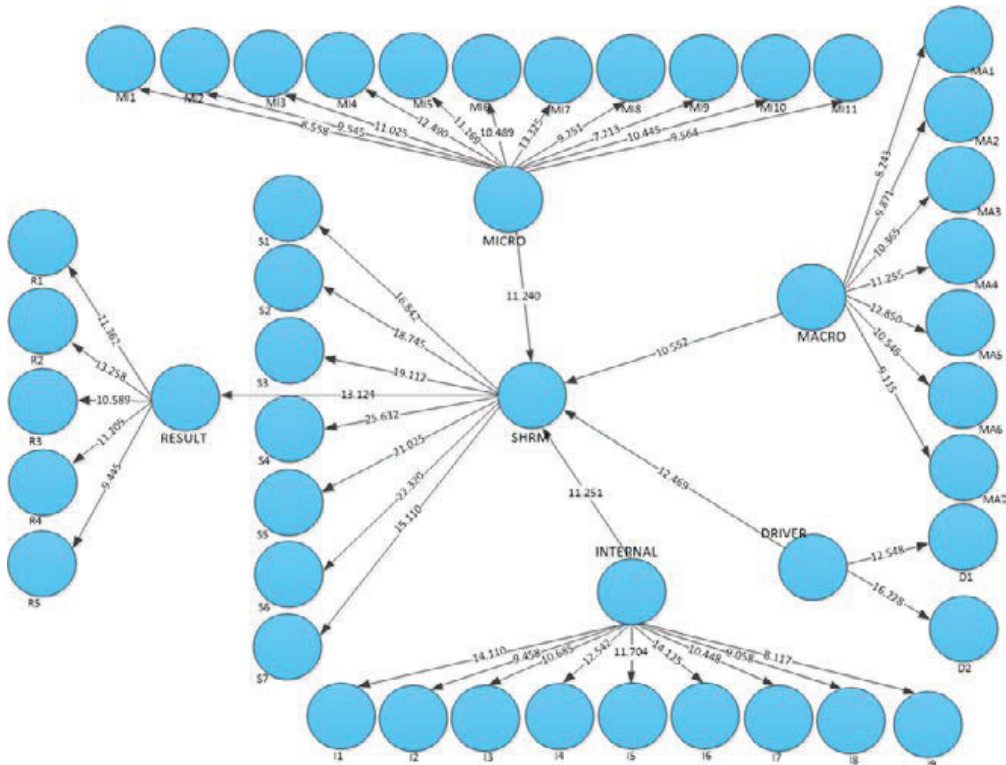


Fig. 2: Structural model of the research in the case of significant coefficients

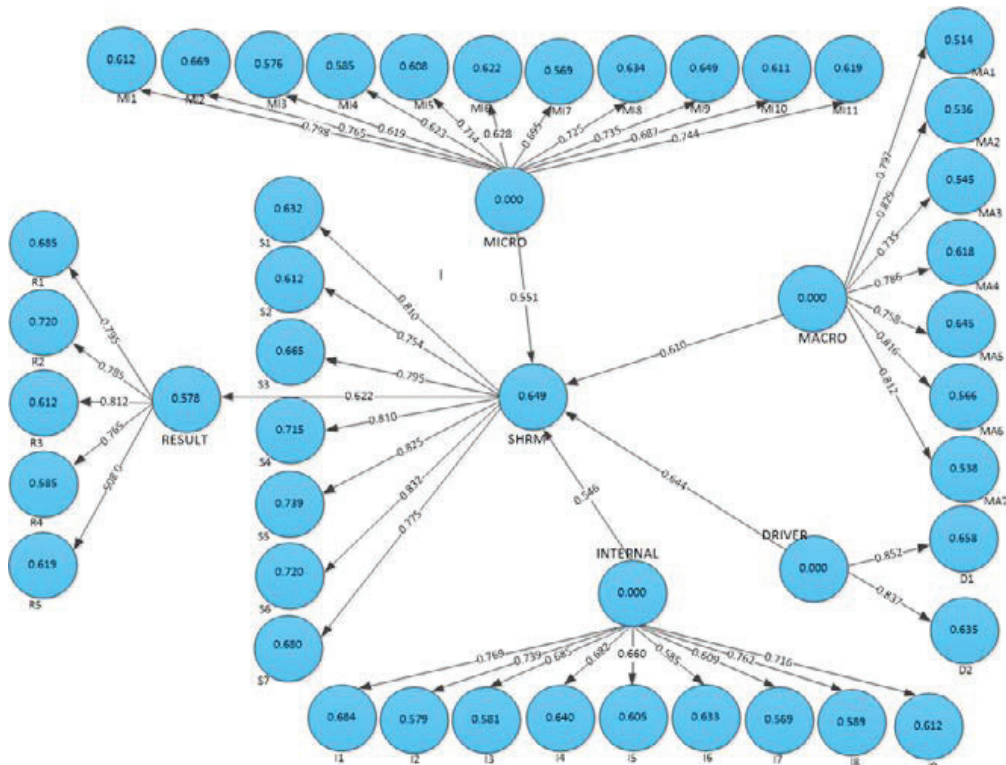


Fig. 3: Structural model of research in the standard mode

Table 4: Path analysis results

Row	Route	Path coefficient	T-Value	Result	
1	Propulsion (Drivers)	Strategic human resources	0.644	12.469	Confirmed
2	Micro environmental factors	Strategic human resources	0.551	11.240	Confirmed
3	Macro environmental factors	Strategic human resources	0.610	10.552	Confirmed
4	Intra-organizational factors	Strategic human resources	0.546	11.251	Confirmed
5	Strategic human resources	Outcomes	0.622	13.124	Confirmed

determined. Within a model of structural equations, each direct effect defines and expresses a relationship between a dependent variable and an independent variable. However, a dependent variable in another direct effect can be an independent variable and vice versa.

Table 4 shows the relationships between the components of the model. As it is apparent, all path coefficients are significant and therefore, the relationships defined in the research model are confirmed.

Also, the coefficient of determination ( $R^2$ ) is a measure that indicates the amount of change in each of the dependent variables of the model, which is explained by independent variables. It is said that the value of  $R^2$  is presented only for the endogenous variables of the model and in the case of exogenous structures its value is equal to zero. The higher the value of  $R^2$  for the endogenous structures of the model, the better the fit of the model.

Chen and Huang (2009) defined the three values of 0.19, 0.33 and 0.67 as the criterion values for the weak, medium and strength values of the structural part of the model by the coefficient of determination. The calculated  $R^2$  value in the current study is 0.810 for strategic human resource management and 0.622 for the outcome variable, which are appropriate values. The  $Q^2$  index, introduced by Stone and Geisser (1974), determines the predictive power of the model. Based on this index, models that have an acceptable structural part fit should be able to predict the indices related to the endogenous structures of the model. If the value of  $Q^2$  in the case of an endogenous structure is zero or less than zero, it indicates that the relationship between the other structures of the model and that endogenous structure is not well explained and therefore the model needs to

be modified. Hensler et al. (2009) set the values of predictive power intensity for endogenous structures at three values of 0.02, 0.15 and 0.35. According to them, if the value of  $Q^2$  for an endogenous structure is in the range close to 0.02, it indicates that the model has poor predictive power. In the present study, the  $Q^2$  criterion is 0.347 for the strategic human resources variable and 0.311 for the outcome variable, which are desirable values. The Goodness of Fit (GOF) criterion also applies to the general part of the structural equation models; this means that by this criterion, the researcher can control the fit of the general part after examining the fit of the measurement part and the structural part of the general research model. So that the average variance shared is the average of the common values of each structure and AVE  $R^2$  is the endogenous constructs of the model. It is worth mentioning that during the analysis of the results of structural equations, it was realized that three values of 0.01, 0.25 and 0.35 are weak, medium and strong values for GOF and obtaining the number 0.32 for the research model indicates a suitable fit. Based on the results, the general structure of the research model was confirmed and all variables identified by experts were approved by managers and human resources specialists in Municipality of Tehran. In this study, while examining and confirming the relationship between subsystems and innovation capability, a set of environmental and intra-organizational factors that affect strategic human resource subsystems were approved. The results are consistent with the results of Hamidianpour and Haidari (2019) and confirm that strategic human resource management has a positive effect on innovation capacity. Also, the results of the present study are consistent with the findings of Jiang et al. (2012) and the four functions of human resources recruitment, reward, job

design and teamwork are included in the research model, however, contrary to the results of those who rejected the relationship between training and performance appraisal subsystems with innovation, in the present study, these two subsystems were confirmed. Also, the results of the present study with the results of [Koster and Banda \(2020\)](#); [Singh \(2018\)](#); [Aryanto et al. \(2015\)](#); [Uslu \(2015\)](#); [Minavand and Lorkojori \(2013\)](#); [Soomro et al. \(2020\)](#) and [Taheriattat and Rostamloo \(2018\)](#), Which confirmed the impact of HRM measures on innovation is consistent. Of course, none of the researches has examined the relationship between different subsystems and innovation capability separately. In this study, the coefficient of determination for improving innovation capability was calculated to be 0.578 which shows that 57.8% of changes in innovation capability can be predicted by strategic human resource management measures.

Obtaining the number 0.32 for this model indicates a suitable fit of the research model.

## **CONCLUSION**

Today, experts in management science and organization believe that human resources are the most important assets of organizations that can bring about fundamental change in organizations. On the other hand, employee creativity and innovation is one of the most important and determining factors in the performance of organizations. Municipality of Tehran is one of the public non-governmental organizations that provides extensive services to a large number of citizens in Tehran capital city of Iran. Given the diversity and large number of stakeholders of this institution and their high expectations, it is necessary that the performance of this organization be at a desirable level. Performing innovative actions and activities has a great role in achieving the desired performance.

So far, the impact of strategic human resource management subsystems on promoting innovation capability in research has been neglected. Therefore, in this study, an attempt was made to investigate the relationship between strategic human resource management subsystems and innovation capability in Tehran Municipality and in this regard to identify the effective factors and related drivers. Accordingly, a comprehensive and systematic model for strategic human resource management with an approach

to promoting innovation in the Municipality of Tehran has been created. In this study, the drivers of strategic human resource management were identified in two groups of organizational factors and manpower factors. The identified drivers somehow confirm the need for innovation in this organization. In previous research, propulsion (drivers) has not been considered. Regarding internal factors, research results also confirmed that organizational culture, leadership, organizational change and strategic planning are effective in the development of strategic human resource management, which are included in the model. Microeconomic factors, considering that no research has been studied in Tehran Municipality so far, were specifically studied in this research and cannot be compared with other researches. Finally, the relationship between macro-environmental factors and HRM has been studied in several studies, most of which have been confirmed, and in the present study, their impact on strategic human resource management subsystems has also been confirmed.

## *Suggestions*

- The results of this study suggest that in future research, the strategies of each of the strategic human resource management subsystems that lead to the promotion of innovation capabilities will be examined.

Also, the practical suggestions of the present research are as follows:

- In order to strengthen employee participation in innovative activities, it is recommended that managers use participatory and relationship-oriented management styles;

- It is suggested to use the experiences of successful national and international organizations in both the public and private sectors in the field of defining strategic human resource management measures in order to innovate;

- It is suggested to use the experiences of successful national and international organizations in both the public and private sectors in the field of defining strategic human resource management measures in order to implement innovative procedures;

- It is suggested to use the opinions and views of employees in order to promote organizational democracy in the definition and implementation of strategic human resource management measures;

- Considering the importance of behavioral and flexible organizational factors such as culture and social capital in the success of innovative activities, it is suggested that while strengthening them in order to promote innovation, try as much as possible the actions of strategic human resource management subsystems not to contradict with cultural and capital factors;

- Considering that some micro-level factors under the control of Tehran Municipality, such as employment regulations, organizational health and ethical system can have a great impact on innovative activities, it is suggested that these factors in order to strengthen strategic human resource management subsystems, corrected with the approach of promoting innovation capability.

#### AUTHOR CONTRIBUTIONS

S. Amani performed the literature review, experimental design, analyzed and interpreted the data, prepared the manuscript text, and manuscript edition. M. Mousakhani helped in the design experimental and manuscript edition. K. Daneshfard helped in the manuscript preparation and final 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.

#### ABBREVIATION

<i>AVE</i>	Average Variance Extracted
<i>GOF</i>	Goodness Of Fit
<i>HRM</i>	Human Resource Management
<i>KMO</i>	Kaiser-Meyer-Olkin Measure of Sampling Adequacy

<i>PLS</i>	Partial least Squares
<i>SHRM</i>	Strategic human resource management

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