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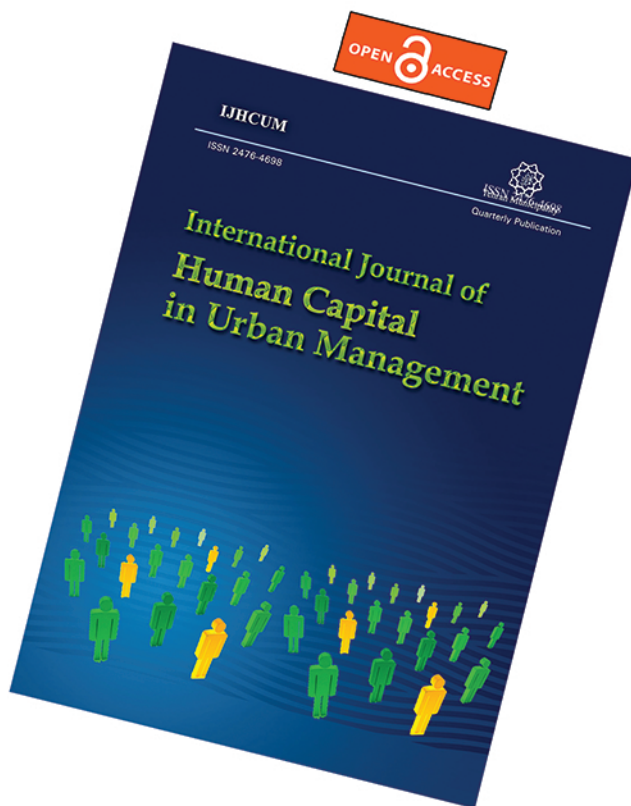
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REVIEW PAPER

Various impacts of COVID-19 on environmental pollution

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ABSTRACT

BACKGROUND AND OBJECTIVES: The COVID-19 pandemic has created a global health crisis that had a deep impact on the world and our everyday lives. The deadly virus i.e. SARS-CoV-2 has rapidly spread around the world, posing enormous health, social, economic, and environmental challenges to the entire human population. Countries around the world have implemented complete or partial lockdown measures to mitigate the spread of the coronavirus. Corona lockdown has profound social implications and it has sparked fears of impending economic trouble and recession.

METHODS: However, this lockdown has also shown some positive effects on the natural environment due to the reduction of pollutant loading from vehicle emission, industries, and other sources. Based on a review of recent research in the relevant area, this paper assesses the effect of COVID-19 pandemic on air and water quality as well as on environmental noise.

FINDINGS: A substantial reduction in the level of noxious NO₂, particulate matter, and carbon emissions have been observed during the lockdown period, the lockdown also led to an appreciable drop in BOD (biological oxygen demand) and a significant increase in DO (dissolved oxygen) of different river water globally. In addition to this, the anthropogenic noise level has fallen by about one-third due to the COVID-19 lockdown.

CONCLUSION: This study reveals that there is a substantial possibility for healing the environment from the detrimental effects of anthropogenic activities through partial or temporary lockdown measures.

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INTRODUCTION

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) that causes coronavirus disease, namely COVID-19, as implied in its name, 'CO' stands for 'corona,' 'VI' for 'virus,' and 'D' for disease, and 19 is used for the year of its existence. The first case of COVID-19 was detected in Wuhan city, Central Hubei Province of China in December 2019 (Ashour *et al.*, 2020; Lu *et al.*, 2020; Shi *et al.*, 2020; Xu *et al.*, 2020). In subsequent months, it spread rapidly to the rest of China, which has later become a global public health problem (Casella *et al.*, 2020; Chen *et al.*, 2020a; Gilbert *et al.*, 2020; Sohrabi *et al.*, 2020). This name SARS-CoV-2 was taken because the virus is genetically related to the coronavirus responsible for the 2002-2004 SARS outbreaks. Which was first identified in Foshan, Guangdong, China, on November 16, 2002 (Tang *et al.*, 2020; Cheng *et al.*, 2007; Wen *et al.*, 2020; Xu *et al.*, 2004). Over 8,000 people from 29 different countries were infected, and at least 774 died worldwide. The more influence of the outbreak lasted about 8 months; however, several SARS cases were reported until May 2004 (Pasley 2020; WHO, 2004). In 2020, SARS-CoV-2 struck the world through widespread human transmission creating fears of a new afflicts. Generally, most SARS-CoV-2 infected patients have mild symptoms including common cold or flu, dry cough, and trouble breathing (Bchetnia *et al.*, 2020; Grant *et al.*, 2020; Huang *et al.*, 2020a; Larsen *et al.*, 2020). However, some patients could also have severe complications such as hemoptysis, lymphopenia and acute respiratory distress syndrome (Chen *et al.*, 2020; Peeri *et al.*, 2020; Wang *et al.*, 2020). Further, the temperature, relative humidity,

and wind speed have also affected SARS-CoV-2 transmission. Optimal humidity, temperature, and wind speed are variables that can determine the survival and transmission of the SARS virus. These climate variables can be a direct cause of biological interactions between SARS-CoV-2 and humans. Changes in weather are very significantly correlated with changes in mortality rates due to pneumonia (Tosepu *et al.*, 2020). As per WHO, over 6 million cases of COVID-19 have been reported in 200 countries and territories resulting in more than 350K deaths till the end of May 2020 (Fig. 1). Among the total coronavirus tests conducted so far in the world, USA is at the top of the list (Fig. 2). The number of coronavirus cases is changing rapidly and detailed up-to-date information about COVID-19 is available on the WHO website. At present, the whole world is struggling to contain the virus because of the unavailability of any specific and effective pharmacological treatment. Hence, social distancing is the only option to combat novel coronavirus. Consequently, in order to confine further transmission of the fatal virus in the community, most of the afflicted countries have decided to undergo complete lockdown. Due to lockdown all air and rail travel, bus, truck, and private transportation are restricted, several types of industries are not functioning or significantly reduced the operations, even entire educational institutions, religious places, sports stadiums, and recreational activities are also closed. This worldwide lockdown is menacing the world economy. According to the International Monetary Fund (Global Financial Stability Report, 2020), the global economy is expected to fall by over 3% in 2020, which is the worst recession since

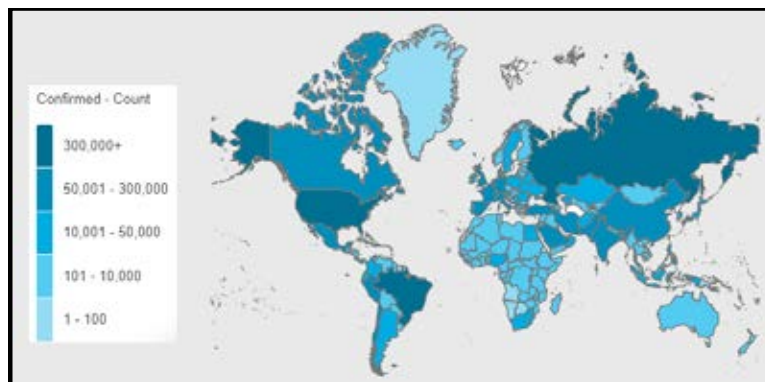


Fig. 1: Distribution of COVID-19 in different countries (WHO, 2020)

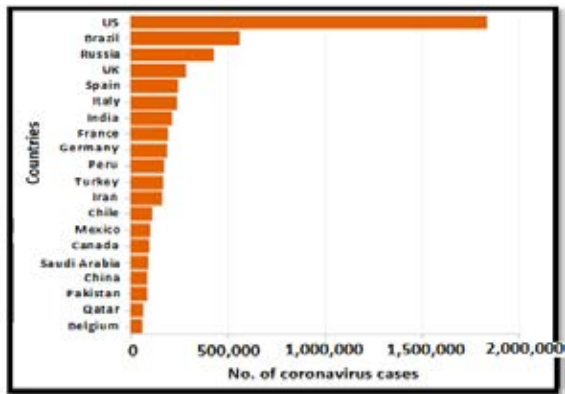


Fig. 2: Top countries affected by COVID-19 (WHO, 2020)

the Great Depression of the 1930s. This has been an extremely painful time for communities across the world. But there is news in the midst of all this, which gives some relief that our nature is recovering gradually. Before the beginning of the COVID-19 pandemic, the air around us had been very harmful to breathe in due to the higher concentration of noxious or greenhouse gases that had been emitted over the centuries. The increased concentration of greenhouse gases in the atmosphere causes an increase in the earth's temperature, which results in the rising sea levels by melting of glaciers (Khan *et al.*, 2017; Maurer *et al.*, 2019; Manisalidis *et al.*, 2020). Environmental deterioration was happening rapidly due to various anthropogenic activities. But after the COVID-19 lockdown start, there have been dramatic transformations in the environment. Due to the standstill of transportation, different industrial process, and anthropogenic emission, their adverse effects on the environment has reduced considerably. And in this way, the environment is being greatly improved. This paper gives a brief sketch of the different potential effects of COVID-19 pandemic on environmental pollution, such as noise level, air, and water quality.

IMPACT OF COVID-19 ON ENVIRONMENT

Effect on air quality

Air quality is one of the world's largest health and environmental problems at the present time, due to this nearly 7 million peoples die globally every year. Air pollution affects all regions of the world, and around 91% of the world's population lives in places where air quality levels higher than WHO limits (Neisiani *et*

al., 2016; Torres *et al.*, 2020). According to WHO, 9 out of 10 people breathe in such air containing high levels of pollutants. State of Global Air Report (2019) exhibits that air pollution contributes to about 8% of total deaths in the world and also the fifth leading risk reason for mortality worldwide. It is the reason for more deaths than many well-known risk factors such as high LDL, malnutrition, and alcohol use. Even every year, many people die due to air pollution-related diseases than road traffic accidents and malaria (Polk, 2019). Most of the mortality is due to exposure to fine particulate matter with a diameter of 2.5 microns or less, (< PM2.5), which may cause respiratory problems, asthma, lung cancer, and nonfatal heart attacks (Brauer, 2010). Majorly, South Asia, Southeast Asia, and Western Asia are the highest affected regions in terms of the higher concentration of fine particulate matter (PM2.5) worldwide. Even most of the cities within these regions also placed at the top of the world polluted city ranking. All the top 30 cities are within Asia, where 21 of the 30 most polluted cities in the world are located in India, and Ghaziabad emerged as the most polluted during 2019, Table 1 (World Air Quality Report, 2019). Due to the pandemic effect on industry and travel, many countries experienced a drop in air pollution recently. The minimal activities of factories, industrial sites, construction sector, and transportation bought a sudden decline in carbon, nitrogen dioxide, and particulate matter emissions. Consequently, Air Quality Index (AQI) levels have regularly fallen, which led to improving air quality, therefore, the skies are suddenly piercing blue even the birdsong seems louder than before. A considerable reduction in AQI was observed worldwide during the lockdown. The major improvement was observed in South-East

Table 1: Most Polluted cities in 2019 (World Air Quality Report, 2019)

Rank	City	PM2.5 ($\mu\text{g}/\text{m}^3$)
1	Ghaziabad, India	110.2
2	Hotan, China	110.1
3	Gujranwala, Pakistan	105.3
4	Faisalabad, Pakistan	104.6
5	Delhi, India	98.6
6	Noida, India	97.7
7	Gurugram, India	93.1
8	Raiwind, Pakistan	92.2
9	Greater Noida, India	91.3
10	Bandhwari, India	90.5

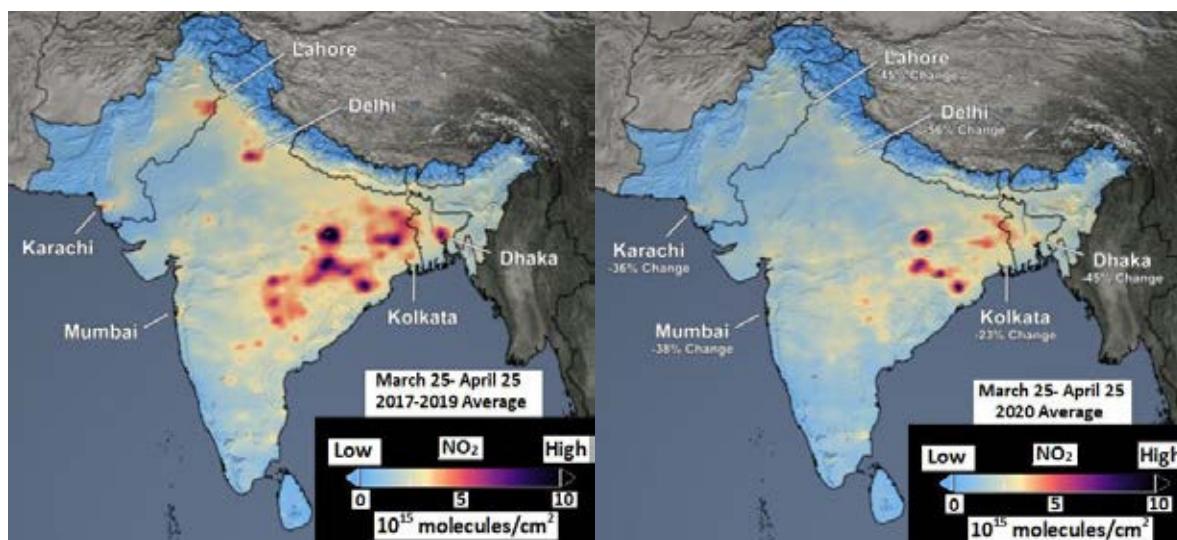


Fig. 3: Reduction in NO₂ Air Pollution over South Asia with Efforts to Control the Spread of COVID-19. (Can et al., 2020)

Asia and South Asian countries including major parts of Indian regions, where NO₂ concentration was drastically reduced during the shutdown of various industries and a travel ban issued (Lal et al., 2020). Fig. 3 displays that a significant reduction of NO₂ levels around 30-60% has been recorded in most of South Asia during the shutdown. For example, NO₂ levels reduced by around 45% in Lahore, Pakistan, and Dhaka, Bangladesh, while almost 55% in Delhi, India. The strong NO₂ levels that remain in eastern India are associated with electricity generation by thermal power plants (Can et al., 2020).

Recently a study also showed there is a significant improvement in the air quality of Delhi during the lockdown phase. Around 54%, 49%, 31%, 43%, and 37%, reductions in AQI were recorded in central, eastern, northern, southern, and western regions of Delhi, respectively (Mahato et al., 2020). Another study of COVID-19 impact on air quality has also been performed in several regions in Indonesia before and during the pandemic. In a nutshell, the results revealed that there are remarkable differences of CO, HCHO, and NO density before and during public activities restrictions in Jakarta, West Java, East Java, and South Sulawesi (Caraka et al., 2020). The Centre for Research on Energy and Clean Air reported that methods to reduce the spread of the COVID-19, such as social distancing, stoppage of factories, and travel bans, resulted in almost 25% fall of carbon

emission in China (Myllyvirta, 2020). Fig. 4 depicts the concentrations of noxious gas i.e. NO₂, detected by NASA, and ESA pollution monitoring satellites. A dramatic drop of NO₂ was observed across China from January 2020 before the restriction and February 2020 during the restriction (NASA, 2020). Similar reductions in air pollution have also been observed over the major metropolitan areas of the Northeast United States by NASA satellite, recently. The study revealed a 30% drop in the concentration of NO₂ over the Northeast U.S. for March 2020 compared to 2015 and 2019 (Schindler et al., 2020). These recent improvements in air quality have come due to widespread lockdowns.

Effect on water quality

Many researchers have reported the substantial drop in air pollution in response to the restrictions imposed by the pandemic. However, the impact on hydrosphere like rivers, seas, and oceans is not much studied yet. Since air quality also affects water quality, hence it is expected to see improvements in water properties too. Clean water has a positive impact on human health and environment, and the COVID-19 lockdown has also contributed to minimize pollution and improve water quality. Recently, the European Space Agency has taken the images of famous canals of Venice by the Copernicus Sentinel-2 mission, which depicted the

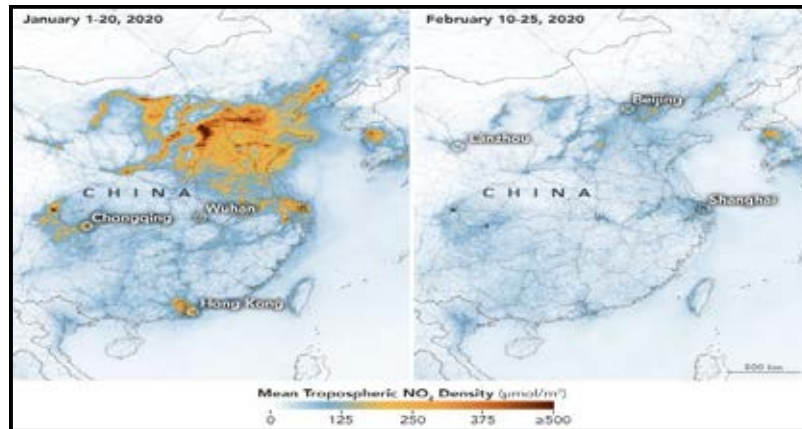


Fig. 4: NO₂ levels of China before and after the pandemic effect (NASA, 2020)

difference in the pollution level and the boat traffic during the lockdown due to the COVID-19 across the region (Brando *et al.*, 2020). In waterways of Venice, the water became so clear with better water flow allowing aquatic life to be visible from the surface, this incredible improvement occurred because boat traffic was drastically reduced in the canals during restriction. One another study conducted by satellite images to analyze the water transparency of Venice's lagoon during the lockdown (Braga *et al.*, 2020). This investigation also revealed that the turbidity of Venice's canals substantially decreased by the reduction of boat traffic and tourism. The lesser turbidity levels of the water increase the intensity of light and may also have positive impacts on aquatic ecosystems in the area. The unprecedented water transparency of the canals is certainly a positive environmental consequence of the pandemic lockdown. In India, water bodies are in a miserable condition, most rivers and lakes have transformed into sewer canals, which are getting difficult to be treated now. More than 1.3bn liters of sewage and industrial effluent enter rivers and other water bodies every day in India (Rajaram and Das, 2008; Iqbal *et al.*, 2019). Ganga which is the largest river in India flows for a length of 2,500-kilometer has been an important part of India's history, religious beliefs, as well as a source of livelihood for millions since time immemorial. But today the holy river Ganga is considered to be the sixth-most polluted river in the world (Trivedi, 2010; Paul, 2017). Over the hundreds of industries release their waste directly into the river, as per the Central Pollution Control Board

(CPCB); more than 50% of wastewater treatment plants do not follow the discharge norms (Ministry of Environment, Forest and Climate Change, India 2020). However, the water quality of the Ganga River considerably improved due to enforcement of the nationwide shutdown. According to the real-time water quality monitoring data of CPCB, there are 36 monitoring units of the Ganga, out of which 27 have become safe for bathing and propagation of aquatic organisms. To assess the health of the river different parameters including dissolved oxygen (DO), biological oxygen demand (BOD), total coliform levels, and pH were analyzed by CPCB, recently. The study demonstrated that the river water contained > 6 mg/L of DO, < 2 mg/L of BOD, and 5000/100 ml of total coliform levels, while, the pH of river water was found between 6.5 to 8.5 (Real-Time Water Quality Monitoring of River Ganga, 2020). This observation clearly shows that water quality has significantly optimal for bathing and wildlife. Meanwhile, another study on Ganga water carried out by the Mahamana Malviya Research Centre for Ganga, River Development and Water Resource Management at Banaras Hindu University also showed that river pollution during the lockdown period has decreased by 25% to 30% than before the lockdown (Kumar and Roy, 2020). Recently, Yunus *et al.*, (2020) also estimated the surface water quality in terms of suspended particulate matter (SPM) of the Vembanad Lake, the longest lake in India. The SPM was evaluated by the turbidity algorithm showed that the SPM concentration during the lockdown phase decreased by 15.9% compared

with the pre-lockdown phase. While compared with preceding years, the reduction in SPM for April 2020 was recorded up to 34%.

Effect on environmental noise

Environmental noise is an accumulation of noise pollution defined as excessive or unwanted noise resulting from modern industrialized urban life and congestion due to overpopulation. Environmental noise in recent times has been well recognized as one of the major apprehension that affects the quality of life worldwide (Srivastava, 2012). Noise pollution can cause a number of short and long-term health problems, such as sleep disturbance, hearing impairment, high blood pressure, heart failure, etc. It has also a huge environmental impact that can alter the natural conditions of the ecosystem and can seriously affect wildlife (Pal and Bhattacharya, 2012; Sadeghi and Panahi, 2016; Monserrate and Ruano, 2019). Since to curb the spread of SARS-CoV-2, most anthropogenic activities that usually take place have now discontinued for longer than usual, and this has resulted in a rapid and substantial change in noise level worldwide. Seismologists of Royal Observatory of Belgium has reported that inland anthropogenic noise level has fallen by about one-third due to the COVID-19 lockdown. This has opened a new possibility to detect minor seismic noises and monitor volcanic activity (Gibney, 2020). Noise pollution generated by stone quarries is also one of the major troubles which can adversely affect environmental quality. There are a number of operations, which lead to high noise levels in the quarrying industry for instance crushing, blasting, drilling, heavy machinery, and transportation. Recently, during the COVID-19 lockdown, the noise level is significantly dropped to < 65dBA in the stone quarrying area of eastern India, which was above 85dBA in the pre lockdown period (Mandal and Pal, 2020). Regarding oceanic activities, oceans are more tranquil than before; the level of anthropogenic noise in the ocean can inflict irreversible damage to marine life, habitat displacement, reduced reproduction, and even leading to death. As global trade has significantly slowed down due to the coronavirus pandemic, therefore maritime transport has also drastically dropped. Recently, a study showed a reduction of noise 4 to 5 decibels in underwater near the port in the busy Strait of

Georgia during the shutdown. The researcher says, it's a small but remarkable reduction and may even larger decreases in the near future (Thomson and Barclay, 2020). The reduction in acoustic levels in the ocean due to COVID-19 may be a positive mark for whales and other sea mammals.

Effect on lifestyle

Food waste is one of the biggest problems facing mankind today (Karin *et al.*, 2018; Massow *et al.*, 2019; Huang *et al.*, 2020; Gandhi *et al.*, 2020). The leftover food puts a redundant burden on the environment by wasting precious resources, such as water and agricultural land. Food waste that ends up in landfills also generates a higher amount of methane, which is a more powerful greenhouse gas than even carbon dioxide (Clune *et al.*, 2017; Poore and Nemecek, 2018; Moulton *et al.*, 2018). The excess amounts of methane and carbon dioxide absorb infrared radiation and heat up the earth's atmosphere, resulting in global warming and climate change. COVID-19 has obligated people to stay at home and cook, which also a beneficial impact on the environment because it requires lesser resources than an online food ordering system or food eating outside, processing, packaging, and transporting of food. In addition to this after the experienced the view of empty shelves in supermarkets during the pandemic, the people may also aware to waste less food. Nowadays people are more conscious of healthy eating to increase immunity, hence people may move away from processed foods, and opt to eat more organic, vegetarian, and vegan foods or grow a garden. Researchers expect that shifting to plant-based diets would reduce the individual's average carbon footprint by 900 kg of carbon dioxide/year. A vegetarian diet may decrease CO₂ emissions more than 1200 kg of CO₂/year, and for vegans, it may reduce up to 1500 kg of CO₂/year (Scarborough *et al.*, 2014; Rosi *et al.*, 2017; Lacour *et al.*, 2018). Recently a study also revealed that dietary patterns, such as, vegetarian, or vegan significantly favorable for both individual health and the environment (Wilson *et al.*, 2013; Smith 2014; Aleksandrowicz *et al.*, 2016). As gym, restaurants, and movie theaters shuttered or limited, most people have to found recreation by walking outside in parks and in nature. This experience could contribute to enrich nature and increase the human understanding of anthropogenic activities on

the environment. Expectantly, it will transform into an impetus to protect and care for the environment. Furthermore, cultural sites can be peace hubs that help maintain reconciliation processes, which in turn can enrich environments that bring communities together within the framework to learn, understand, and live peacefully together (Sumaryana *et al.*, 2020; Toharudin *et al.*, 2020). These favorable effects are especially important in the pandemic time when the mental and emotional effects of social isolation are slowly becoming clearer.

Effect on medical waste

Medical waste is a subset of wastes generated at health care facilities, which includes various types of waste obtained from clinics, nursing homes, hospitals, medical research centers, and medical shops, etc., (Windfeld and Brooks, 2015). Medical waste is considered one of the biggest challenges faced by healthcare providers, around 10% of the waste produced in health care facilities is contagious and improper disposal of such waste exposes human beings and the environment to serious health risks (Manzoor and Sharma, 2019). As the COVID-19 pandemic is increasing exponentially, resulting in a huge growth in medical waste in particular plastic waste. Different types of masks are made of polypropylene, a kind of plastic, which is not going to break down easily, and its safe disposal is becoming a major concern nowadays. It is estimated that one single positive COVID-19 cases generate 10 times higher medical waste than the average patient. Due to pandemic in Hubei Province, People's Republic of China, infectious medical waste increased by 600% from 40 tons per day to 240 tons per day (Jiangtao and Zheng, 2020). The US has also seen a growth in medical waste from discarded personal protective equipment as well as in other items, such as surgical masks, respirators, goggles, or face shields (ResearchAndMarkets.com, 2020). The world these days is affected by the fear of coronavirus hence face masks and hand gloves have become an essential component of everyday life to protect from infection. However, the large amount of waste being created as the single-use items tossed aside has also the potential to become an ecological disaster. This huge amount of medical waste generated by COVID-19 in 2020 will seriously affect sustainable medical waste management practices in the near future, globally.

CONCLUSIONS

Based on the above discussion, it is concluded that during the COVID-19 control period, anthropogenic activities have been lowered greatly, causing significant reductions in industrial operations, constructions, and other activities which further leads to improving noise level, air, and water quality. However, these positive impacts on the environment are ephemeral and the pollution level is likely to worsen again after the ends of the pandemic. But the common people and governments can learn lessons from the lockdown that pollution can be reduced to a great extent only by taking some steps. When the whole world is anxious about the suitable policies for decelerating pollution, this emergency lockdown shows the perfect way to heal the environment and ecosystem. It needs to be researched, but broadly not averse to saying that pollution can be controlled. For this, the participation of common people, experts, and NGOs with the administration will be important.

AUTHOR CONTRIBUTIONS

N. Kumar conceptualized, writes, and edited the manuscript. R. Tyagi supervised and review the manuscript.

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CONFLICT OF INTEREST

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

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ORIGINAL RESEARCH PAPER

Soundscape Assessment in Historical Urban Spaces Using Sound Walk Method and Kano Model

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ABSTRACT

BACKGROUND AND OBJECTIVES: Sound is one of the most important tools for recognizing urban spaces. Zandieh area of Shiraz as one of the historic context shaped during the ages has been chosen in order to obtain a proper response to the individual's perception of urban historic spaces soundscape. The main object of this manuscript achieves a sufficient way in order to organize urban soundscape by utilizing assessments and perception data perceived by users.

METHODS: The narrative interview method (a sample group of 129 users who were active in space for more than 30 minutes) and behavior observation which are subsets of the sound walking technique have been used; Also, the data which were collected in the previous stage, based on the components of the Kano model, were categorized into three categories of basic, performance and attractiveness.

FINDINGS: With regard to the findings and assessments in the case study, it can be inferred that 69% of the urban space's users perceive noises such as underpass fans' noise more than any others; Consequently, this has led to the lack of acceptance by space users; Also, it was cleared by interviewing listeners in urban space that 59% of the interviewees have preferred natural Sounds to human and 76% preferred tranquility at the urban environment While only 11% of the users preferred the development of a vibrant space.

CONCLUSION: Base on that strategies such as planting vegetation in order to prevent the street noise, allocating water bodies in order to have water sound with proper shading and a Desirable view of historical spaces to increase the sense of richness have been presented. Also, in order to achieve an efficient method to improve the soundscapes of urban environments, basic strategies, performance strategies and at last strategies for increasing the attractiveness of urban environments' soundscape should be implemented.

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INTRODUCTION

Cultural spaces are composed of socio-cultural, functional, physical, and sonic environments in their heart (Fig.1, Leus et al, 2015; Hong et al., 2017). In this regard, “sound” and “noise” as two members of the subsets forming sonic environment are of great importance, that majorly due to misconception of their meaning, they are mistakenly used interchangeably in the literature dealing with them (Brambilla et al., 2013; Leus and Herssens, 2015; Carvalho et al., 2019). Therefore, the need to study soundscape as a process based on how citizens perceive sonic environment is important in order to better recognize it (Jennings and Cain, 2013; Steele et al., 2019; Jo and Jeon, 2020). With a quick look at the literature on this subject we can see that designers in the past decades have only sought to eliminate noise based on physical criteria such as sound volume and level, and a purely quantitative and technical look has overshadowed the concept. This became a reality while users’ perception of urban spaces, which is one of the basic pillars of their structure, has been neglected in these studies. Meanwhile, the contradiction between urban spaces, and especially historical environments, with the sonic environment existing in them and lack of a disciplinary method in the form of a coherent framework for properly recognizing, evaluating and analyzing the elements of soundscape in accordance with their context have caused quality degradation of these spaces (Berglund and Nilsson, 2006; Axelsson et al., 2010; Cobiانchi et al., 2019; Hong and Jeon, 2017; Liu et al., 2020). Therefore, the present study majorly aims to identify the main components of soundscape and understand it as a generality related to users’ perception of urban space and to provide a disciplined framework and style in order to identify, evaluate, and design soundscape of historical spaces of Islamic-Iranian cities. The issue of soundscape has been ignored in the field of urban studies for many years. Thomas Schafer, for the first time under the World Soundscape Project published in 1977, emphasizing examination of how users perceive urban spaces using interview method, concluded that just by reducing the volume of sound, an ideal sonic environment cannot be achieved (Schafer, 1977). Regarding the different perceptions of professionals and users from soundscape of urban space, Kang in his study entitled “Urban sound environment” published in 2006 concluded that

designers’ understanding of soundscape differs from users’ perceptions and this has caused failure of the activities performed in relation to soundscape (Kang, 2006). Regarding the executive plans prepared by government agencies, the “Westminster Sound Strategy” guideline was published in 2015 by Westminster Municipality. In this study, given the unique features of the historical heart of this city, the main emphasis has been on creation of calm environments and elimination of noise pollutions (Westminster Council, 2015). Aiming to use positive sound capacities in order to enhance urban spaces “Positive urban soundscape” studies were conducted and published as a report in 2013. In this study, an attempt has been made to provide frameworks for designers in order to make the soundscape of urban spaces positive. Although the efforts made in this field are in the field of research and have not yet achieved practical application (Cain et al., 2013; Davies et al., 2013; Kang et al., 2016; Aletta et al., 2018). The concept of soundscape, given the different perceptions of it in Iran and in the analysis of today’s Iranian Islamic cities, has been ignored and sometimes undergone content errors such that few coherent researches in the field of soundscape can be found in the country. Among the researches done in this field, the study titled “Investigating soundscape of Valiasr Street in Tehran with an emphasis on people’s perception of soundscape” can be mentioned. In this study published in 2016, by using a combination of Sound Walking and Sound Mapping methods and comparing them with users’ perceptual information of spaces, an attempt was made to provide strategies in order to improve soundscape of Valiasr Street (Shahabian and Larimian, 2016). Also in the same year, an article entitled “Assessment of soundscape in urban space (a case study of Khayyam Pedestrian Street in the city of Urmia)” was published. The authors of this article by considering 14 stations and measuring physical characteristics of the environment tried to create a model to evaluate the relationship between quantitative components of soundscape and space syntax and its effect on citizens (Ghaleh Noei and Haghghi, 2016). According to what has been said, the novelty and innovation of the present study is in the research method of this research and its focus on citizens’ preferences (narrative interview) and observing the behavior of users of urban spaces along with using Kano model for analysis and evaluation of

soundscape. In recognizing the components of soundscape, a distinction must be made between sound and noise. In fact, sound is the mechanical feature of a dynamic event that becomes a sound wave that indicates existence of the event in an area (Blesser and Salter, 2009; Gale et al., 2020), but noise is mostly referred to negative aspects of sound and requires solutions in order to eliminate them (Guski et al., 1999; Brambilla and Maffei, 2006; Farina, 2014; Aumond et al., 2019). Therefore, the nature of sound as all the good features of sonic environment is very important in the process of forming mental image of citizens of the urban spaces. Soundscape is a combination of the two words of sound and landscape, and this proves that in its themes it has different aspects and many complexities that in addition to qualitative components of sound, also depends on landscaping cases and its considerations too. Thomas Schafer considered soundscape a complex issue that depends on how people perceive urban spaces (Schafer, 1977). In another view of this concept, the International Organization for Standardization considers soundscape as a mental structure of the physical phenomena of sonic environment but separate from them (International Organization for Standardization, 2014). In another definition, Truax consider soundscape as a means of how a person perceives his/her sonic environment (Truax, 1978). In a comprehensive definition of soundscape, Payne believes that this concept is applied to all sounds existing in a place with an emphasis on the relationship between individual and collective perception and understanding of the sonic environment and their relationship to themselves (Payne et al., 2009). Given the definitions, it can be concluded that the common

point in all these definitions is the dependence of soundscape on how users perceive space and their human characteristics including their perceptions, collective memories and similarities, and their positive and negative perceptions of urban spaces (Brown et al., 2011). Since soundscape takes its components from research literature of different sciences, thus, different components have influenced its formation and quality (Payne et al., 2009; Hong and Jeon, 2013; Liu et al., 2020). Based on the literature, it can be concluded that soundscape generally depends on the characteristics of space, time, and users of space, such that people with different personality traits will have different perceptions of space during day and night (Van Renterghem et al., 2013; Jeon and Jo, 2020; Liu et al., 2020). Therefore, in order to find the components affecting soundscape, a very diverse range of its forming components have been introduced. For example, some have classified soundscape into the sounds caused by vehicles, sounds caused by the environment, and sounds caused by music (Saunders and Moles, 2016). In another classification, Raimbault and Dubois (2005) in the course of their studies classifies environmental sounds into the sounds of transportation, neighborhood units, industrial units, and sounds related to recreations. Accordingly, in a general view, the components constituting soundscape are classified into two categories of personal cultural components and environmental components. In this regard, the elements constituting environmental components are divided into three categories of artificial, natural, and human (Table 1) components based on their nature. Each of the proposed issues can include its own specific subsets which in turn affect perception of soundscape. Therefore, in recognizing

Table 1: Categorization of urban soundscapes (Dubois et al., 2006; Davies et al., 2013; Liu et al., 2014; Gale et al., 2020; Jeon and Jo, 2020)

Main-Category	Sub-Category	References
Artificial	Traffic Flow	(Raimbault and Dubois, 2005; Dubois et al., 2006; Gale et al., 2020)
	Roaring of Engine Factories	
	Industrial Units	
Natural	Wind	(Liu et al., 2014; Saunders and Moles, 2016; Gale et al., 2020; Jeon and Jo, 2020)
	Birds	
	Water	
	Rain	
Human	Music and Chat	(Raimbault and Dubois, 2005; Saunders and Moles, 2016; Gale et al., 2020; Jeon and Jo, 2020)
	Noise of people walking	
	Shoppers Shouting Children Playing	

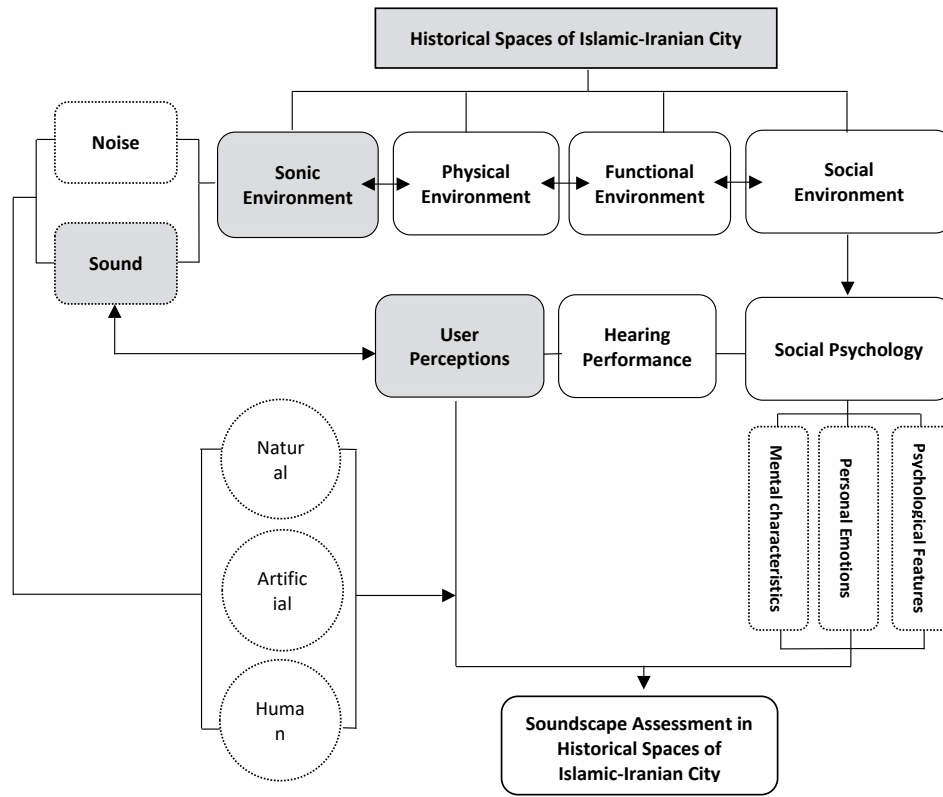


Fig. 1: The status of soundscape studies in the studies on historical spaces of Islamic-Iranian cities (Hong and Jeon, 2017; Leus and Herssens, 2015)

the positive factors affecting listeners' perception, one should pay attention to the temporal and spatial position and the type of activity performed by them. In fact, although none of these factors are components of sound, but they have a great impact on how people perceive space and their perception of positivity of soundscape (Dubois et al., 2006; Davies et al., 2013; J. Liu et al., 2014; Gale et al., 2020; Jeon and Jo, 2020).

Zandieh area of Shiraz has always been one of the most important public territories of Shiraz due to its antiquity. Therefore, over the years, it has undergone many changes in terms of physical, functional, and social structures. The latest example of these changes can be seen in creation of a pedestrian street inside this historic site and guiding the automobile road by an underpass under the complex and placing the ventilation of this underpass in the pedestrian street, which has caused a transformation in the structure of sonic environment in this complex. This is while given the unique features of this complex, by considering

scientific and purposeful measures to improve the quality of sonic environment of this urban space, its capacities can be used. Therefore, the present study, by using sound walking method and evaluating the data existing in the urban environment of Zandieh Area by Kano model, tries to provide a suitable model for recognizing sonic environment of historical complexes in order to improve their soundscape. Accordingly, the research questions are expressed in the form of the following statements: 1) What are the components and indicators of soundscape analysis and evaluation in historical spaces of Islamic-Iranian city? 2) How is the status of soundscape in the urban spaces related to the Zandieh Area in Shiraz? And 3) Based on the analysis of the current status of soundscape, what are the strategies and policies affecting promotion of soundscape in urban spaces related to the Zandieh Area in Shiraz?

The current study have been carried out in Zandieh Area of Shiraz in 2019.

MATERIALS AND METHODS

Case study (Zandieh Area, Shiraz)

Zandieh Area (Fig. 2) is one of the most important historical and cultural complexes in Iran and Shiraz.

In the past, Shiraz Toopkhaneh Square was located in this place, but after street constructions in the Pahlavi period and splitting of the urban fabric by Zand Street, this space became a hotbed of



Fig. 2: Situation of the urban environment of the case study; source: authors: a) and b) are maps of Shiraz and Zandieh area, respectively to show the context; and c) Sonic environment of case study



Continued Fig. 2: Situation of the urban environment of the case study; source: authors: a) and b) are maps of Shiraz and Zandieh area, respectively to show the context; and c) Sonic environment of case study

motor vehicles. In the 1990s in line with creation of pedestrian-friendly spaces in Iran, this space was also turned into a pedestrian-friendly space. Therefore, it was decided to direct the automobiles flow through construction of an underpass. But the problem began when the issue of ventilation of the underpass was not considered and its ventilators were installed in the pedestrian-friendly space. This caused a lot of noise pollutions in the urban space of Zandieh Area.

Data collection

In this research, library method, review of the literature, and global practical and theoretical experiences in this field have been used in order

to collect the theoretical foundations (Fig. 3). Also, according to the basic condition of this study being prioritization of users' perception of the space, narrative interview method has been used as a subset of Sound Walking method in order to understand users' perceptions and to have behavioral observations in order to recognize their unconscious behaviors of the space. In this study, given the environmental characteristics and the primary purpose of recognizing users' perceptions, narrative interview method has been used. For this purpose, in this study, a set of two-level questions was used. In the first level, individual characteristics of users such as age, gender, and the amount of using urban spaces

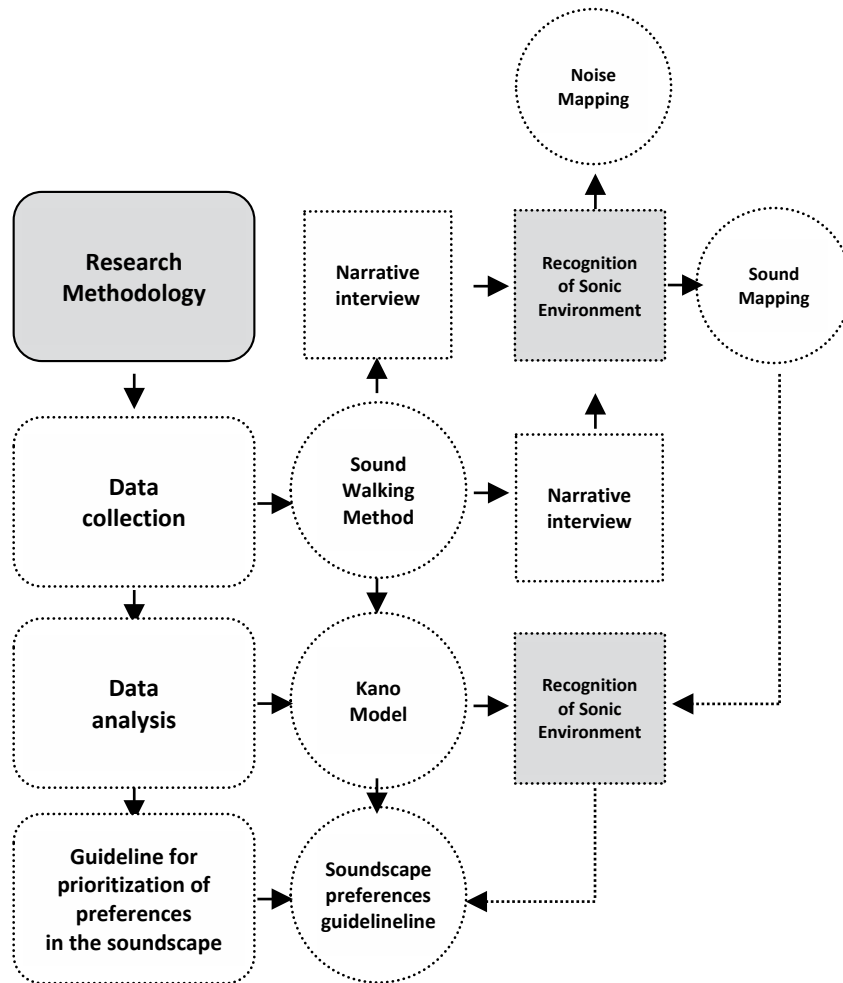


Fig. 3: The process of soundscape data collection and analysis

were examined as the characteristics affecting users' individual perceptions. In the next level they were asked to while their eyes are closed as well as while walking and sitting in the case study space answer the pre-designed questions. The size of the sample group participating in this study was 129 people (regarding the uncertainty of the number of statistical population and based on Cochran's formula ($d = .1$)) and when selecting the statistical sample, as the demographic characteristics of the different groups participating in the target sample space were unknown and in order to prevent bias and delete specific group opinions including age or gender groups, random sampling method was used so that equal chance is given to every member of the community. Since

users' perception requires spending a certain amount of time in the space, attempts was made that the sample group will be selected among volunteers who are actively present in the case study space for more than half an hour and are actively engaging with it. In order to achieve the main purpose of this study, first, some preliminary questions were asked about the quality and nature of the impact of soundscape components on users' perception of urban space. Then, these preliminary questions were asked in a sample of 15 people as the pilot sample and the results were evaluated. The results of this evaluation were compilation of 15 questions in order to recognize individual characteristics affecting users' perception and 15 questions in order for narrative interview in

urban space in order to recognize how users perceive soundscape of urban space. Authors believe that each group of questions can indicate the features affecting how users perceive soundscape of urban spaces. Therefore, the questions were evaluated in three natural, artificial, and human levels based on the nature of the sounds existing in urban space. It should be noted that validity of the questions was determined by content validity method (verification by experts) and reliability was determined by Cronbach's alpha method. In this study, Cronbach's alpha for all questions of the questionnaire was 0.805. In order to recognize subconscious perception of users, behavioral observation method has been used. In this regard, in the first step, sound sources were identified based on the classification into artificial, human, and natural groups using users' perceptions and sounds heard by them in narrative interviews, and users' behaviors were evaluated based on proximity to these sources. The obtained data in this stage was analyzed by content analysis method and was analyzed in comparison with the data obtained from narrative interviews. For this purpose, some points in the case study space were selected for placement of the observer in a way that they do not interfere in the process of users' behavior. Given the limitations in selecting the sample population in this method, the behavior of users was examined in three twenty-minute intervals in the morning, noon, and night in a working day.

Evaluation of citizens' preferences using Kano model

Due to the complexity of the perception of soundscapes and the diverse perspectives of the various stakeholders, a single approach to assessing interventions is therefore not likely. In fact, a variety of approaches should be considered. As a result, Kano model can be used to facilitate categorization of users' perceptions of soundscape (Kano, 1984). Given its features and experiences of its being used in world literature (Positive Soundscape Project of the University of Salford), this model can be very effective in providing a suitable framework for designing soundscape of urban spaces (Jennings and Cain, 2013). This model consists of a diagram and three main level (Fig. 4). The horizontal axis shows service provision aspects and the vertical axis indicates the level of customer satisfaction. The constituting components are divided into six categories:

Performance (One-dimensional):

This component is a linear characteristic, such that the higher it is, the more satisfaction exists. For example, this component is used in automotive industry in relation to the components of fuel, economy, etc (Jennings and Cain, 2013; Dace et al., 2020).

Basic (Must be):

This component works very differently such that its presence does not increase satisfaction much, but in its absence, there will be lack of satisfaction (Jennings and Cain, 2013; Dace et al., 2020; Inayah and Indrawati, 2020).

Excitement (Attractive):

This component is in the opposite point of the basic component such that its absence does not cause much dissatisfaction, but its presence will greatly increase satisfaction. For example, in automotive industry, heating systems and seat quality can be mentioned as examples of this feature (Jennings and Cain, 2013; Inayah and Indrawati, 2020).

Indifferent:

The attributes towards which customers feel indifferent. Fulfillment or absence of these attributes has no effect on customers' satisfaction or dissatisfaction (Chen and Chuang, 2008; Dace et al., 2020).

Reversal:

This attribute brings more satisfaction, if absent, and vice versa (Chen and Chuang, 2008; Dace et al., 2020).

Questionable:

The questionable quality is the one that cannot be mapped because any level of its performance can lead to the customers' satisfaction or dissatisfaction (Min et al., 2018). In the formal usage of Kano's methods, questionnaires and other tools are used to categorize the various aspects of a product or service. As a result, the relationship or the attributes are translated into five categories of perceived quality: attractive quality (A), must-be quality (M), one-dimensional quality (O), reverse quality (R), and indifferent quality (Min et al., 2018; Dace et al., 2020)(Fig.4). The categories of perceived quality are based on two feelings of

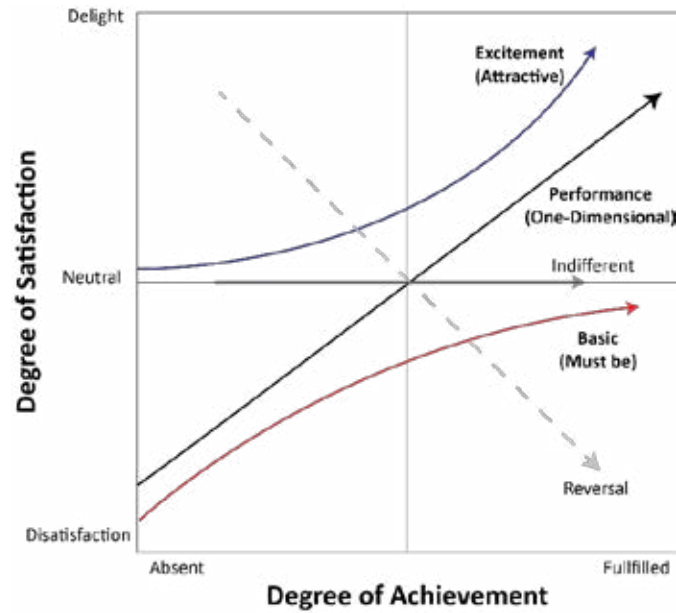


Fig. 4: Kano Model components (Chen and Chuang, 2008)

Table 2: Survey Questions and Analysis method base on the Kano model (Mikulić and Prebežac, 2011)

How do you feel about water sound in the urban space?	1. I like it that way 2. I expect it that way 3. I am neutral 4. I can accept it to be that way 5. I dislike it that way
How do you feel about absent of water sound in the urban space?	1. I like it that way 2. I expect it that way 3. I am neutral 4. I can accept it to be that way 5. I dislike it that way

Customer requirement	Response to dysfunctional question				
	Like	Expect	Neutral	Accept	Dislike
Like	Q	A	A	A	O
Expect	R	I	I	I	M
Neutral	R	I	I	I	M
Accept	R	I	I	I	M
Dislike	R	R	R	R	Q

Conclusion:
Water sound must be in the urban spaces

A-Attractive; M-Must be; O-One dimensional; R-Reverse; I-Indifferent; Q-Questionable

customers, namely, a feeling experienced when a product has the attribute and a feeling when a product does not have the attribute (Finster et al., 2001), resulting as satisfaction, dissatisfaction, or indifference. The relationship between various quality attributes is nonlinear. In addition, attributes are dynamic—the perception of an attribute by

customers will change over time. The attribute can change, for example, from being satisfier (being exciting) to dissatisfier (being expected by default), because once introduced, this attribute initially being exciting will soon be imitated by competitors and expected by customers from every provider (Fig. 4). The methodology uses a structured questionnaire

that consists of pairs of questions for each attribute of the specific product or service. In each pair, the first question asks how a customer would feel if an attribute is present or fulfilled (functional question) whereas the second question asks about the customer's feelings in the case of absence or nonfulfillment of the attribute (dysfunctional question). Further, the data are analyzed using an evaluation table (Fig. 4) that results in the

categorization of the attributes for each respondent (Table 2). Finally, the frequencies of the correspondent categorizations are used to find the final classification of the perceived quality of an attribute (Mikulić and Prebežac, 2011). In this study, Kano model was used to analyze and evaluate the data obtained from narrative interviews and behavioral observation in order to create positive mental perception in the soundscape of the case study. For this purpose, the

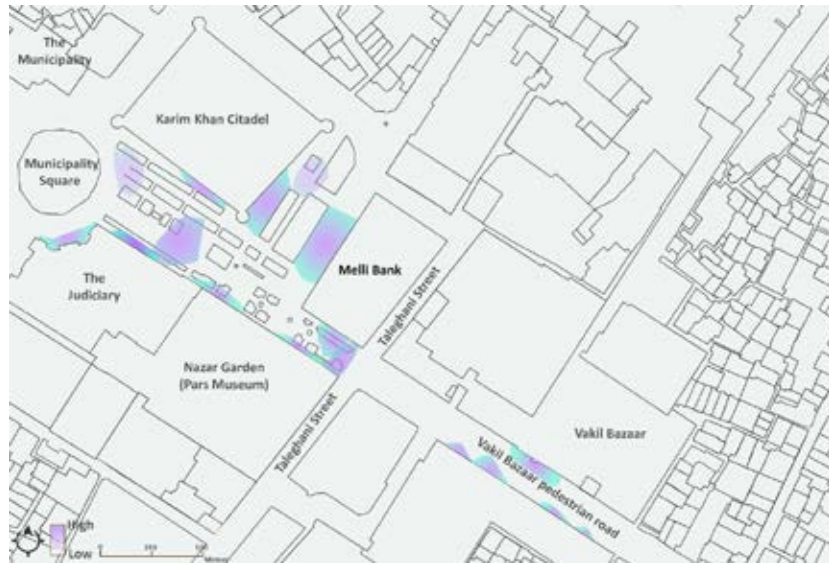


a) Map of natural sounds in the case study

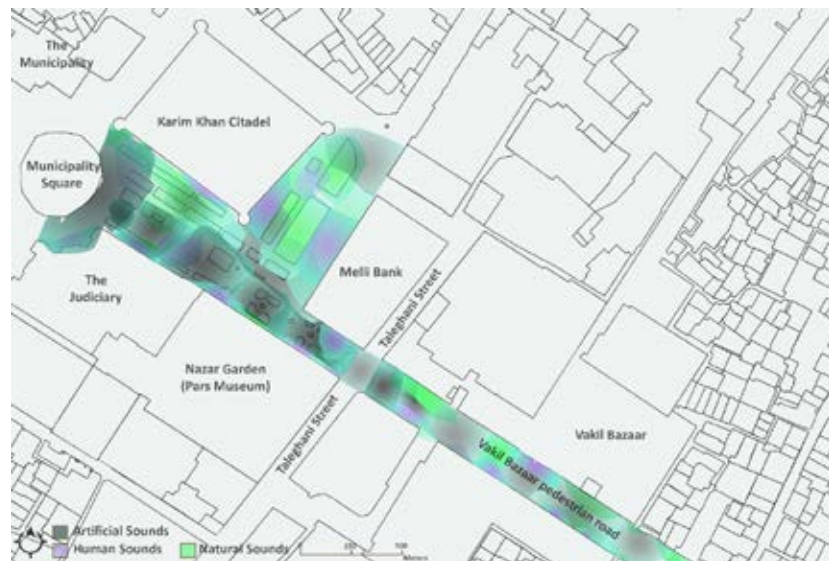


b) Map of artificial sounds in the case study

Fig. 5: Soundscape map of the case study



C) Map of human sounds in the case study



d) Map of Soundscape components in the case study

Continued Fig. 5: Soundscape map of the case study

results obtained from users' preferences of the space were classified into three categories of performance, basic, and excitement according to their nature and main stages of Kano model; and based on them, the strengths, weaknesses, opportunities, and threats were identified in the case study. Finally, based on the criteria mentioned in the case study area, a framework was provided to prioritize the strategies

in order to make the soundscape of the case study area suitable.

Analysis of research results

According to the statistical analyses, out of 129 people in the sample group, 34% of the interviewees were women and 66% of them were men, and they were generally in the age group of 18 to 25 years. It

should be noted that in the surveys on the motivation to be present in this space, 12% mentioned working near this space; 12% living around this space; 4% meeting friends; 17% exercising; 31% recreation and spending leisure time; 1% eating; 2% shopping; and 21% just mentioned passing the space to reach their destination. The 21% share of passing the space despite the space being highly qualified for attractiveness indicates lack of attractiveness due to the high amount of annoying noises in this urban space. Most of the interviewees in their perceptions referred to the ventilators in the urban space and considered it disturbing and annoying. In this study, it was also found that the effect of ventilators is such that the sounds of water and birds are not heard in places close to the ventilators. According to these interviews, it became clear that users in the space need a calm atmosphere and prefer calmness to dynamism, and a small number of users sought to create an exciting atmosphere. After the interviews and observations made in the case study space, sound maps of the urban space were prepared according to the users' perceptions of urban spaces based on natural, human, and artificial origins. It should be noted that in preparing the maps the "Spatial Analysis" plugin of GIS software has been used in

order to illustrate users' perceptions in creation of surface maps. Given the maps of human and artificial sounds (Fig. 5), it was found that users have faced with a huge congestion of annoying artificial and human sounds around the area of Melli Bank and Taleghani Street.

According to the human sound map, it was found that at the entrance of the pedestrian-friendly space, due to dynamic activities, sounds with human origin have been very actively present, but due to existence of artificial sounds such as the sound of public transportation buses at this point, artificial sounds have overwhelmed natural and human sounds. Also, in the eastern part of the design space, due to being far from noise polluting sources such as ventilators and the calmer position of the street leading to the eastern part of the urban space, natural and human sounds dominate. In this section, before behavioral observation, first the sound sources were identified and then the users' behavior was recognized (Fig. 6). In recognizing the behaviors of users, it was understood that due to the very annoying sound level in the points identified in the previous step, the rate of voluntary and social activities has greatly reduced in practice, and these parts were used only as a passageway for passing the space. It was also found

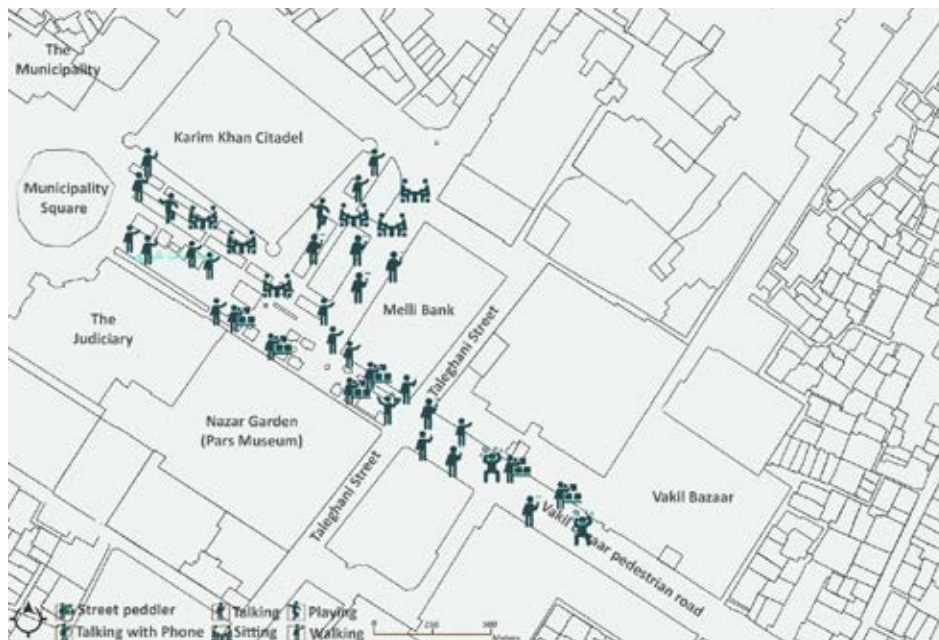


Fig. 6: Behavioral patterns of the case study

that in the afternoon time intervals due to existence of some activities such as peddling and book selling and the attractive nature of these uses, this space sees presence of many users and as a result, human voices are increased in its southern part.

Case study

After interviews and behavioral observations in the urban space and preparation of its sound maps based on natural, human, and artificial origins, it became clear that there is a huge congestion of annoying artificial and human sounds around Melli Bank and Taleghani Street. Also, by examining the behaviors of people present in this space and comparing them with the existing sound maps, it was found that in the space in front of Karim Khani citadel, due to existence of pleasant sounds and being far from noise sources, especially ventilators, people showed more desire to be present and perform voluntary behaviors. People also considered ventilators’ sound to be the dominant sound, and because of this they could not easily recognize natural and human sounds. In addition, given the personality traits of space users, a wide range of preferences can be observed based on gender and age. For example, young people preferred more dynamic spaces, while older people preferred more calmness. Also, a wide range of middle-aged

and elderly people did not prefer human sounds for urban spaces, and mostly considered natural sounds to be suitable for urban spaces. It should be noted that among natural sounds, most users of the space considered the sounds of birds and water to be suitable sounds for the urban space. Given the initial purpose of the study and the set of results in the case study, sound and noise maps in urban space were prepared to provide a suitable situation measurement (Fig. 7) (Table 3).

Based on these maps, it can be inferred that in prioritization in order to interfere in urban space of the case study, there is a wide range of aggressive and defensive strategies. Therefore, different positions can be taken in exposure to each part of the urban space. For example, in the northern part of the urban space, due to high congestion of noise pollution sources, the priority is to adopt defensive strategies, while in the eastern part, due to presence of appropriate sounds and far distance from artificial sound sources, aggressive strategies are needed. In order to apply Kano model to create positive soundscape in urban space, strategies that meet the basic needs existing in the space must first be prioritized. Then, attention must be paid to functional features, and finally, the soundscape must become attractive. Therefore, according to

Table 3: Kano Model Questionnaire Results

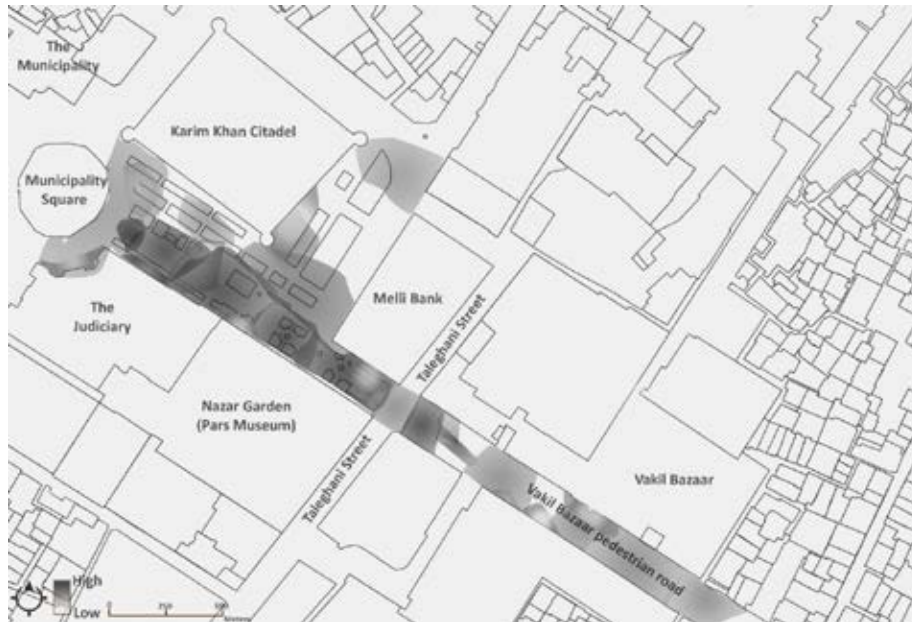
Main-Category	Sub-Category	Label	M*	O*	A*	I*	R*	Q*	Total	Result
Artificial	Traffic Flow	Ar1	0	6	0	0	123	0	129	R
	Roaring of Engine	Ar2	0	24	0	8	97	0	129	R
	Factories	Ar3	0	3	0	11	115	0	129	R
	Industrial Units	Ar4	0	1	0	7	121	0	129	R
Natural	Wind	N1	4	31	63	21	3	7	129	A
	Birds	N2	32	23	74	0	0	0	129	A
	Water	N3	26	8	93	2	0	0	129	A
	Rain	N4	4	72	16	1	4	32	129	O
Human	Music and Chat	H1	19	9	93	8	0	0	129	A
	Noise of people walking	H1	13	8	2	2	43	61	129	Q
	Shoppers Shouting	H1	13	41	6	67	2	0	129	I
	Children Playing	H1	6	14	4	32	71	2	129	R
		H1	61	20	23	18	7	0	129	M

*A-Attractive; M-Must be; O-One Dimensional; R-Reverse; I-Indifferent; Q-Questionable

the data collected in the previous step and the components of Kano model, it is possible to have a proper evaluation of soundscape status in urban spaces as in Table 4, and then given the existing evaluations, appropriate strategies can be obtained.

According to the sound and noise maps in the

previous step, it can be realized that the soundscape of the case study faces many contradictions in the design dimension. For example, as mentioned earlier, in some parts of the urban space, there is a need to adopt strategies for excitement, while in some other parts, such as the northern part, basic level



a) Noise map of the case study

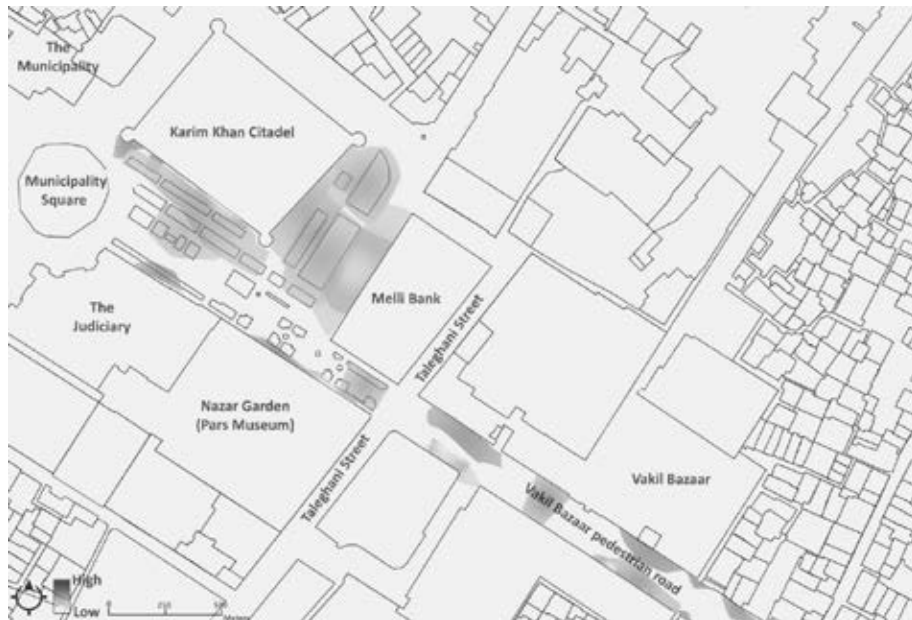


Fig. 7: Sonic Environment Structure of the case study

Table 4: Evaluation of the status based on the components of Kano model in the case study

Kano model components	Strengths	Weaknesses	Opportunities	Threats
Basic (Must be)	Existence of suitable green space in order to improve soundscape of urban environment Presence of suitable urban furniture to increase human sounds	Existence of noise caused by the ventilators in Zandieh historical site Existence of noise caused by passing cars around Zandieh historical site Existence of a lot of noise around Melli Bank	Possibility of using the existing vegetation to reduce the noise level in urban environment . Possibility of using the existing urban furniture to increase human sounds in urban environment	Possibility of loss of prosperity of urban space due to presence of a lot of noise in urban environment
Performance(one-dimensional)	Existence of natural sounds in Zandieh area	Improper placement of the fountains existing in urban environment Gathering of peddlers in certain parts of the urban space and gathering of human sounds in these places	. Possibility of using the existing fountains to increase natural sounds in the urban space	. Possibility of diminishing the effect of natural sounds in the urban space due to improper placement of natural sound sources
Excitement(Attractive)	. Existence of historical and valuable buildings within the area of the case study . Existence of suitable greenery around the urban environment of the case study	. Lack of appropriate facilities and contexts for presence of music and theater groups	. Possibility of using presence of historical buildings around the urban environment to increase the number of users of space and increase human sounds	. Possibility of loss of attractiveness of the urban space of Zandieh Area due to lack of proper soundscape



Fig. 8: Guideline for prioritization of preferences in the soundscape of the case study

Table 5: Strategies for enhancing soundscape in the study area

Objectives	Strategies		
	Basic (Must be)	Performance (one-dimensional)	Excitement (Attractive)
Elimination of annoying noise from the public spaces	<ul style="list-style-type: none"> . Creating vegetation to prevent the noises of Shahr-dari Square . Eliminating noisy activities in front of Melli Bank . Preparing less noisy ventilators in the historical Zandieh Area . Using noise-insulated Using acoustic sound wall with specific material, length, shape and height, and special designs in the wall of Shahr-dari Square 	<ul style="list-style-type: none"> . Adapting sidewalk and street floors to eliminate some undesirable noises, especially in high-traffic areas of sidewalks . Use of porous materials in the floor and walls to prevent sound propagation and increase comfort in the space 	<ul style="list-style-type: none"> . Creating a sloping land that is a barrier between the entrance space of historical buildings and the front space
Improving the quality of green infrastructures and enhancing natural sounds in urban areas	<ul style="list-style-type: none"> . Playing the sound of birds in the space 	<ul style="list-style-type: none"> . Placement of fountains in spaces with proper shading and favorable view of historical spaces to increase sensory richness 	<ul style="list-style-type: none"> . Strengthening green space of the area with sufficient height and proper width and density to attract birds
Facilitate voluntary and social activities in public spaces in order to enhance desirable human sound	<ul style="list-style-type: none"> Creating spaces for presence of different social groups at a distance from the spaces in need of tranquility 	<ul style="list-style-type: none"> . Providing a suitable place for presence of peddlers and reducing congestion in this space Enabling music playing by recorders in the space 	<ul style="list-style-type: none"> . Building special spaces for presence of the youth and university students and performance of various activities such as music, street theater, and painting . Creating a context for presence of various groups of street music in the historical Zandieh Area

of the space should first be designed and then its performance and excitement dimensions should be increased. Thus, Kano model has been used according to sound and noise maps in order to adopt appropriate policies. According to the sound and noise maps, a framework for recognizing each of the levels of Kano model in the case study space has been provided as a useful guide to explain prioritization of appropriate strategies based on their nature (Fig. 8).

According to the presented matrix and research literature and the contexts existing in the case study, strategies can be presented to improve soundscape of Zandieh Area as one of the historical urban spaces of Iran. These strategies are presented in Table 5.

CONCLUSION

Soundscape as an inseparable part of human emotional environment today plays an undeniable role in their lives. In new approaches to the issue

of soundscape in world literature, much emphasis has been made on the need for paying attention to users' perception of historical spaces of cities beyond their physical characteristics. However, due to the multifaceted nature of this issue, providing a framework for recognizing soundscape themes and prioritizing the actions has been neglected. For this purpose, in the present study attempts have been made to, given the world literature, guidance will be provided for prioritizing the actions related to soundscape in the space of Zandieh Area as one of the historical spaces of Iran. In this regard, Sound Walking method which includes narrative interview method and behavioral perception was used as the cornerstone for recognizing users' perceptions. According to the results obtained from analysis of research findings, it is inferred that despite the desire of most users to be in a quiet space to perform voluntary and social activities, this has not

been achieved due to congestion of artificial sounds and lack of appropriate natural and human sounds in the mentioned space. It should be noted that given the different perceptions of people in urban spaces due to their different personal, personality, and social characteristics, it is very difficult to present a comprehensive plan that will satisfy all individual citizens. In this regard, users' perceptions of the soundscape existing in the case study space taken from sound and noise maps are prioritized at three basic, performance and excitement levels derived from the Kano model. So, it is suggested that in the hierarchy of making soundscape appropriate, in the first step, the basic level such as eliminating noise pollutions is considered; then performance level such as injecting quality factors, and in the final step, excitement level should be considered. All the measures taken to make the soundscape of historical space of cities appropriate are suggested to be done in the form of this hierarchy. The framework proposed in this paper is an attempt to make tangible the classification of soundscape preferences perceived by users of the urban spaces and it takes as its inspiration, approaches which have been proven to work in other domains where listener perception is important. In order for the framework to be useful to planners and those involved in design decision-making for urban environments, it is necessary to evaluate components of soundscape according to features such as gender, educational attainment, and monthly income to obtain a more explicit perspective. As a result, due to the impact of the location of urban spaces on the attraction of different social classes, comprehensive research on multiple urban spaces and compare the result with the results of this research is recommended.

AUTHOR CONTRIBUTIONS

R. Alishahi performed the literature review, analyzed and interpreted the data, prepared the manuscript text, and manuscript edition. A.R. Sadeghi and M. Sholeh performed the literature review and helped in the analysis and interpretation of the data and manuscript text preparation.

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CONFLICT OF INTEREST

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

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ORIGINAL RESEARCH PAPER

The effects of social capital and human resources on financing and SMEs performance

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ABSTRACT

BACKGROUND AND OBJECTIVES: Small and medium enterprises (SMEs) still exhibit dominant contribution to the economy. SMEs manage to absorb greater labor force and to survive the economic crisis. Various efforts to empower SMEs have been less successful. Financing constraint, low quality of human resources, and limited marketing competence have been the typical problems of SMEs that harm SMEs' performance. Despite these problems, SMEs still manage to survive.

METHODS: Using the sampling method of stratified random sampling with area strata, this study generates 203 small business units as the sample. The research was conducted by using accidental sampling. The quantitative and qualitative data are from primary and secondary sources. The data was collected by using observation, interview, and in-depth interview. The variables in this research was analyzed by using path analysis.

FINDINGS: Social capital positively affect SMEs' financing as indicated by the significance value of 0.000 ($\alpha = 5\%$). The stronger social capital of SMEs implied greater access of external financing sources. Social capital, and SMEs' financing positively affect SMEs' performance with 1% confidence level, and human resources positively affect SMEs' performance with 6% confidence level. The finding shown the stronger social capital and human resources increases SMEs performance.

CONCLUSION: The results show that social capital and SMEs' financing positively affect SMEs' performance, and human resources positively affect SMEs' performance. The results imply that stronger social capital and human resources increases SMEs performance. Social capital facilitates access to finance, marketing, production, and information. The results shows that human resources affect SMEs' performance. Social capital and human resources positively affect SMEs' financing. Similarly, social capital, human resources, and financing positively affect SMEs' performance.

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INTRODUCTION

Lack of management competence, low quality of human resources, and limited access to financial institutions (especially banks) have been the typical problems of SMEs (small and medium enterprises). With regard to financing constraint, the government has launched numerous efforts to mitigate the problem such as people business credit (*KUR – Kredit Usaha Rakyat*) to assist SME owners to overcome their financing problems. However, SME owners have not optimally utilized this credit scheme because of numerous requirements of the credit. The government-sponsored financing potentially mitigates SMEs' financing problems. However, greater financing constraint arguably hampers firm growth (Beck et al., 2005) in Beck and Demirguc-Kunt (2006). In this respect, external equity financing plays a significant role in overcoming limited financing sources (Colombo and Grilli, 2005). External financing constraints faced by entrepreneurs are closely related to information asymmetry and moral hazard problems (Denis, 2004). Thus, it is very important to maintain relationships in the form of networks to gather valid information about financing problems and to enhance the role of social capital to facilitate trust in engaging transactions and eventually to minimize moral hazard risk. Chua et al., (2011) explain that social capital reduces the concern of limited financing from financial institutions. Similarly, Bosse (2009) also emphasizes the important role of social capital in applying for credits. Koszan et al., (2011) suggest the importance of maintaining a relationship. Specifically, they demonstrate that a key variable to predict small firms' growth dynamics uses three different factors, namely personal, financial, and relational capital. Investors invest their resources carefully. Thus, investor protection positively affects the access to external financing regardless of the investor type (Nofsinger and Wang, 2011). Wu et al., (2007) explain that equity financing is very important in financing firm growth. Alternative financing forms, such as non-bank and non-market financing constitute the most important external financing for small firms that usually operate outside formal institutions and are supported by various financing mechanisms such as reputation, relationship, and trust (Allen et al., 2012). The alternative financing sources are not explicitly associated with firms' financial performance, but with firm growth. Eventually, firm growth, as indicated

by sales growth, reflects firm performance. Human resource characteristics such as age, education level also likely affect firm financing. Younger entrepreneurs are more willing to take risks than the older ones. In a similar vein, the educational level is closely related to the willingness to make decisions related to external financing. Younger and less educated SME owners are more active in relying on external financing while older and more educated (arguably wiser) SME owners rely less on external financing (Vos et al., 2007). Further, educational level and training contribute to SMEs' growth. Consequently, educational level and experience as the characteristics of human resources significantly affect firm performance, both in manufacturing and service industries (Okafor, 2012). Innovation leads to creativity that manages to distinguish firms' products to exhibit excellence (Tayyebirad and Vakil Alroaia, 2020). Through innovation, firms adapt and affect their surrounding environment by developing and sustaining their competitive advantage in various forms that eventually facilitate their survival and growth. Thus, it is important to investigate the role of social capital in contributing to SMEs' innovative performance (Roxas, 2008). Firms with innovative employees exhibit the intellectual capability of their resources as their key success factors. Institutional environment and cultural attributes will determine the relative weight of certain elements of intellectual capital that are closely related to each other. For example, relational capital is very important for Chinese and Japanese firms (Adreeva, T, and Garanina, T, 2017). Innovation produces highly qualified outputs and increases firm revenues. If SMEs manage to survive market competition, they can increase their sales and eventually their performance. Various indicators represent firm performance, such as increased sales or revenues. When industries grow, eventually economy also grows (Purnomo, 2008). Human resources, social, and financial capitals facilitate entrepreneurs to run more profitable businesses and to contribute more to an economy (Vakil Alroaia and Mesaeli, 2020). Human resources (education and experience) are very important for service and manufacturing firms. Meanwhile, financial capital, including the intention to use bank credit, is more significant for manufacturing firms than for service firms (Okafor, 2012). Human capital (age, professional education, entrepreneurial

experience, working experience, and the relationship with banks) significantly predict firm performance (average ROA). From various human capital indicators, working experience is the most significant predictor of firm performance (Ha Lien Chi, 2016). Financial, human, and social capitals facilitate firms to access human and financial resources (Tihula and Uovinen, 2010). Further, social capital facilitates financing, marketing, production, and information access (Fornoni et al., 2012). Highly qualified human resources do not only depend on formal educational level, but also on high skills from informal education. Formal and informal institutions will affect individuals' behavior in interacting with each other to produce outputs, such as economic performance, efficiency, and economic growth (Kherallah and Kirsten, 2001). Highly qualified human resources arguably produce highly qualified products that significantly contribute to the development of product quality and production process (Shaikh, 2012). Thus, greater human capital will significantly enhance firm performance (Oforegbunam and Okorafor, 2010). Innovative entrepreneurs will develop their social capital by building networks that provide external information sources, financial supports, and skills that enable them to learn from and help each other (Cope et al., 2007). Wu (2008) shows that information sharing play an important mediating role between the three dimensions of social capital (trust, networks, and continuous transactions) and increasing firm competitive advantage. Networks between creditors and debtors will enable financing access. More networks with other parties will enhance the access to bank credits. Further, more networks between SMEs and financial institutions imply greater probability that firms will easily have financing access (Kurniawan, 2018). The important roles of SMEs in various economic conditions makes SMEs need more attention to be more survive. The government has made some regulations to support SMEs, but the results have not been optimal. This is partly due to limited funding and the low quality of human resources. The existence of the importance of SMEs requires further analysis of what has led the government program to support SMEs so far. Therefore, researchers conducted a study on whether financing, human resources, social capital greatly influence the development of SMEs, so that the results of this study can be an input in making

regulations by the government. By using the ability to create the uniqueness of the resulting product so that it can compete with similar products, for example wood crafts with distinctive carvings, employees who come from a business environment with their skills can contribute to improving the performance of SMEs in trading businesses with packaging attractive, and delicious taste, service businesses with friendly service, and using environmentally friendly materials such as salon services, SMEs are able to establish relational relationships by forming networks of new entrepreneurs as well as with raw material suppliers and customers. So that information can be received symmetrically. Although the level of ability in the SMEs studied is relatively low, they still try to increase innovation. Based on these arguments, the research problem of this study is the enhancement of SMEs' performance in the Sarbagita Area, Bali Province. This study aims to answering the new issues of the constraints of SMEs' in Bali especially Sarbagita Area, it's because the other researcher were analyzed about of human capital and social capital affecting to SMEs', but basically the problem of SMEs' to grow up is about the financing. In this research will be analysed how the important of social capital and human resources support the financing of SMEs', based on these conditions, the aims of the research are: 1) analyze the effects of social capital and human resources on SME financing in the Sarbagita Area, Bali Province; 2) analyze the effects of social capital, human resources, and financing on SMEs' performance in Sarbagita Area, Bali Province; 3) analyze the role of financing in mediating the effects of social capital and human resources on SMEs' performance. The current study has been carried out in Sarbagita Area (Denpasar, Badung, Gianyar, and Tabanan Regency) in 2018.

Literature review

Social Capital

Social capital is information, trust, and norms from reciprocity attached to social networks (Woolcock 1998, in Voydanoff 2001). Social capital refers to the characteristics of social organizations such as networks, norms, and trust that facilitate reciprocally beneficial coordination and cooperation. Social capital also adds subjective elements and cultural processes such as trust and norms from reciprocity that facilitate social actions.

The difference shows the reciprocal relationship between social capital, social organization, and social networks. Social networks and organizations provide resources to facilitate actions. In turn, social capital produces resources that further contribute to social organizations and networks (Chitsaz *et al.*, 2019). Bowles and Grintis (2001) explain that in general social capital refers to trust, care for others, and willingness to behave guided by existing norms in a community and to accept sanctions when violating these norms. Putnam (2000) emphasizes the role of social organizations, involvement in public affairs, societal voluntary, informal friendship, and social trust in shaping the whole social capital within a society. The differences exist between capital ties, or values given to homogenous inter-group social networks, and social networks between heterogeneous social groups. The fundamental principles of social capital claim that the capital sources are larger communities in which business organizations are attached. Capital from networks, social norms, and trust are equally important as financial and human capital in sustaining firms' value creation, such as organizational innovative performance (Renko *et al.*, 2002; Tsai, 2006). Coleman (1988) defines social capital based on its functions. Social capital is a complex entity that consists of several aspects of social structure that facilitates certain actions of actors, both individuals, and firms, within the structure. Similar to physical and human capital, social capital cannot be fully explained but can be specifically explained in certain activities. Conceptually, social capital is a debatable concept. A disputed issue is whether social capital differs from existing concepts such as communities or institutions (Lochner *et al.*, 1999). Studies on social capital within societies as a whole and its relationship with business organizations such as SMEs are very rare (Westlund and Bolton, 2003; Suseno and Ratten, 2007 in Roxas, 2008). Another main issue lies in the aggregation levels (households, organizations, societies, or nations) as the focus (Schuller *et al.*, 2000). Further, other issues are the argument whether social capital is the effect, not the cause (or vice versa), and whether the quantitative or qualitative method measures social capital better (Patulny and Svendsen, 2007). Firms' competitiveness mostly enhances their innovative

performance that is conditioned by their technological ability. However, small firms, especially in developing countries, exhibit weak technological ability and innovative performance, especially those that are related to the ability to adjust with the advancement of knowledge and technological system (Arnold *et al.*, 2000). With regard to the fact that SMEs have poorer networks with other SMEs or with other agents such as universities, governmental agencies, and other industries, their ability to share and acquire knowledge is limited (Intarakumnerd *et al.*, 2002). Pittaway *et al.*, (2004) argue that it is very necessary to fill in the research gap in investigating how informal networks (social capital) are related to various innovation, such as process and product improvement. Lastly, in investigating the economic behavior of SMEs, it is important to analyze social capital as an economic concept, namely as a form of capital (Westlund, 2006, in Roxas, 2018), while financial capital has been a general issue. In analyzing SMEs' growth, social capital provides another dimension in analyzing why business organizations survive, generate profits, or decline. By improving social networks, norms, and trust as the capital sources, it is likely to quantify social capital similar to financial and human capital to measure firm performance. Human Capital and Firm Performance. Human capital can be defined as the attribute inventory of competence, knowledge, and personality competence that deliver economic value (Sullivan and Sheffrin, 2003). Individuals or organizations invest in human capital to improve their economic productivity. Chitsaz *et al.*, (2019) shown there is a significant effect of dimensions of human and social capital on entrepreneurial activities. The human capital theory is proposed by Schultz (1961) and extensively developed by Becker (1964) (Fatoki, 2011). Public investment through education and training is the concept of human capital. Schultz compares the acquisition of knowledge and skills to acquire productive tools. Schultz argues that human capital investment improves individual productivity that eventually increases return (Fatoki, 2011). Hatch and Dyer (2004) demonstrate that firm performance depends on firms' knowledge and human capital. Further, Ofoegbu *et al.*, (2013) indicate that firms, especially SMEs, need sufficient human capital development.

Human capital is an important variable in determining firm performance. Because it is closely related to intellectual capital, human capital is a dimension of intellectual capital from the human perspective and their experience that together with other elements affect firm value (Mushrel, 2014). Firms that employ more experienced and knowledgeable individuals are more likely to increase their added values. Employees can improve their competence through training. They can also acquire knowledge through formal and informal education to enhance their competence. Highly competent individuals tend to be better able in managing firms and improving firms' competitiveness. There are several basic characteristics that can be measured from human capital, such as training, experience, competence, recruitment, mentoring, and individual potentials and learning program (Brinker, 2000). Meanwhile, Mayo (2000) holds that human capital can be classified into three dimensions, namely ability and potentials, motivation and commitment, and innovation and learning. Humans exhibit different ability and potentials. Thus, it is necessary to develop their ability and potentials. Competitive advantage plays an important role in explaining SMEs' performance by fully mediating the effects of human and entrepreneurial capital on performance. Ngatno and Widayanto (2016) show that human and entrepreneurial capital intrinsically improve SMEs' performance as manifested by competitive advantage. Competitive advantage is an important mediator in the relationship between human and entrepreneurial capital and SMEs' performance. Human and entrepreneurial capital exhibit similar effects on SMEs' performance. Human capital can be classified into general and specific human capital. General human capital is usually measured by educational qualification and years of working experience. Specific human capital consists of business-specific elements, such as education, specific skills, and industry-related and managerial experience (Ganotakis, 2010). Leitao and Franco (2008) empirically show that studies on the relationship between human capital and performance exhibit inconsistent results. For example, Shiu (2006), Appuhami (2007) and Chan (2009) find an insignificant relationship between human capital and firm performance. Thus, these

findings do not support the hypothesis that predicts that human capital significantly affects performance. However, Fatoki (2011) find a significantly positive relationship between social capital, human capital, and financial capital and SMEs' performance. The findings are consistent with the human capital theory of Schultz (1961) and Becker (1964) In Fatoki (2011) that argues that human capital investment improves human productivity. Further, social and human capital positively affect the empowerment of woodcraft small firms in Bangli Regency (Yuliarmi and Setiawina, 2017). In line with Pena (2001) and Sharafat (2017) concludes that training and experience in economic activities significantly affect firm growth. These results are also consistent with Hisrich and Drnovsek (2002) who argue that education and experience positively affect new firm performance.

Firm Performance

Petersen and Robert (2002) demonstrates that a higher dependency on internal financing sources limits SMEs' growth. The results indicate that external (debt) financing access likely improves firm performance. Performances as the results of organizational activities or investment in a particular period (Fatoki, 2011). Further, Fatoki (2011) explains that numerous studies that consider a single dimension or a narrow range of performance (e.g. several profitability indicators) are subject to descriptively and normatively theoretical errors. Studies have to cover several performance indicators, including sales growth, market share, and profitability. In general, performance assessment in an organization should have the characteristics to foster creativity and entrepreneurship in an organization in a better way (Salamzadeh *et al.*, 2019). Besides, nonfinancial factors such as customer satisfaction are also very important to evaluate performance, especially in private firms. These arguments are in line with Zahra (1993) who emphasizes that firms have to use both financial and nonfinancial objectives in evaluating organizational performance. In the SME context, it is important to consider more detailed environmental factors to reflect SMEs' condition better and to provide more effective guidance to evaluate SMEs' performance, especially in relation with government-backed credit supply.

Financial Capital and Firm Performance

Similar to other capital, financial capital finances firms, including SMEs. In their initial stage, firms need financial capital to acquire physical needs, working capital, and other assets. [Elsenhardt and Martin \(2000\)](#) use resource theory to show the importance of financial capital in explaining SMEs' performance. Access to financial capital to acquire current and fixed assets is very important to sustain firms' competitive advantage. The empirical study of [Zhou and Chen \(2008\)](#) identify that SMEs need financial capital to acquire physical capital and exploit business opportunities. [Bartocho \(2016\)](#) finds that financial capital greatly affects employee performance and eventually organizational performance.

MATERIALS AND METHODS

Research Design

This study is a quantitative research that uses associative research design. The variables in this research are latent ones, namely SMEs' performance, social capital, human capital, and financing. Each latent variable uses several perceptual indicators that are measured with the Likert Scale. This scale ranges from one to five that reflects perception from "fully disagree" to "fully agree". [Fig. 1](#) below explains the relationship between a latent variable and other latent variables.

Research Location

This study is located in Sarbagita Area (Denpasar City, Badung Regency, Gianyar Regency, and Tabanan Regency) in Bali Province. This area contributes the largest SMEs in the province (61%). Based on the data of SME and Cooperatives Provincial Office, there are 265,558 SMEs in this province.

Variable Identification

There are three variables in this study: 1) exogenous variable, 2) mediating variable, and 3) endogenous variable. There are two exogenous variables: social capital (X_1) and human resources (X_2) while the mediating variable is financing (Y_1) and the endogenous variable is SMEs' performance (Y_2). This study classifies the research variables into two groups, namely latent variable that is formed from observed indicators. This variable is not directly measured but formed by several observed dimensions through factor analysis ([Agung, 2003](#)). The latent variables in this study are 1) social capital, 2) human resources, 3) financing and 4) SMEs' performance. Meanwhile, the measured variable is directly measured through field research.

The Operational Definition of Variables

This study uses four latent variables, namely social capital, human capital, financing, and SMEs' performance. All of the latent variables derived

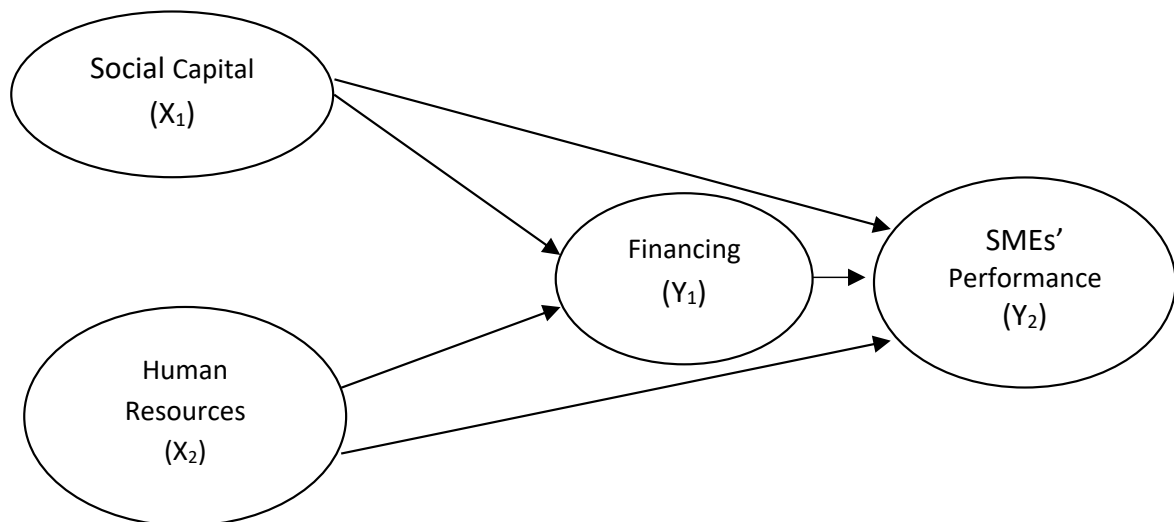


Fig. 1. Research Design ([Writer, 2018](#))

into several research indicators and instruments. Latent variables was measured by using respondents' perception about their understanding of the variables. The Likert scale that measures respondents' perception of which option ranges from strongly disagree to strongly agree. Specifically, the following is the value range of our Likert scale: SA= strongly agree (5), A = agree (4), MA= moderately agree (3), D= disagree (2), SD= strongly disagree (1). SMEs' performance is the ability of SME owners to manage their firms sustainably that is measured by three indicators, namely innovative capacity, ability to increase sales, and ability to retain customers to be loyal to their products. Social capital is a complex entity that consists of several aspects of social structure and facilitates certain actions of both individuals and firms in the structure. The social structure was measured by using norms, trust, and networks. Human resources are the dimension of intellectual capital based on human knowledge and experience that will affect firm values through other elements. Further, human resources are measured with knowledge, skills, and commitment. In this study, financing refers to the ability of SMEs to actualize their financing sources to run their businesses and to improve operational performance. Financing sources are from self-financing, rural credit institutions (*LPD – Lembaga Perkreditan Desa*), banks, cooperatives, and friends/families.

Data Types and Sources

This research was conducted by using quantitative and qualitative data. Qualitative data is countable such as the number of business units, production volume, and number of employees, age, educational level, and income level. Qualitative data is non-countable data that takes the form of explanation and supports the analysis through in-depth analysis about SME owners' perception of social capital, human resources, financing, and SMEs' performance. According to the sources, primary and secondary data are used in this research. The primary data was collected through direct field research using questionnaires. The secondary data was collected from the Provincial Office of Cooperatives and SMEs, especially related to the number of SMEs in Bali Province.

Test of Research Instruments

The validity and reliability tests to test our research instruments that gather primary data on respondents' perceptions. Using product moment correlation, the validity test indicates that our research instruments are valid when the correlation coefficient exceeds 0.3. Meanwhile, the validity test uses the internal consistency method by analyzing Cronbach's Alpha. The instruments of this research will be valid when Cronbach's Alpha exceed 0.6.

Population, Sample, and Sample Determination

The population of this study is all SMEs in the Sarbagita Area, Bali Province. In 2016, there were 162,010 SMEs in this area. Using error level of 5%, Slovin's formula produces a sample number of 203 SMEs. Each business unit is represented by one sample that also acts as the business owner. Stratified Random Sampling used for the sampling method based on geographical location. Thus, we select a certain number of sample for each city/ regency in the Sarbagita Area to have the total sample size of 203. Further, we use accidental sampling to determine which sample units to be interviewed.

Data Collection Methods

We combine several data collection methods ([Jogiyanto, 2004](#)) as follow:

- a) Observation Method: the non-behavior observation method to collect secondary data from related institutions, such as the number of SMEs in the Sarbagita Area, Bali Province.
- b) Interview Method: We use both structured and in-depth interview methods. The structured method aims to gather primary data from SME owners by using a prepared questionnaire. Meanwhile, the in-depth interview collects primary data from the representatives of SME owners who are competent enough to provide relevant information.

Data Analysis Technique

This study uses both quantitative and qualitative analyses. The qualitative analysis gathers in-depth information from competent informants to answer issues asked by using interview guidelines. The data from informants will be analyzed to support the results of this research by using descriptive technique. Further, the quantitative analysis uses both descriptive and

inferential analyses using Path Analysis and the data from respondent been collected by using questionnaire analyzed by using SPSS Statistical Software to find the result of statistical analysis. The inferential analysis starts with factor analysis to generate factor score for each latent variable, and path analysis follows. The following is the structural equation used in this study are Eqs. 1 and 2 (Jogiyanto, 2004).

Explanation:

Y_2 = SMEs' performance

Y_1 = Financing

X_1 = Social capital

X_2 = Human resources

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ = Parameter

ε = Error

$$Y_1 = \beta_1 X_1 + \beta_2 X_2 + \varepsilon_1 \quad (1)$$

$$Y_2 = \beta_3 X_1 + \beta_4 X_2 + \beta_5 Y_1 + \varepsilon_1 \quad (2)$$

RESULTS AND DISCUSSION

The Characteristics of Respondents

Table 1 displays respondents' characteristics that consist of age, educational level, industry type,

Table 1: The Composition of Respondents' Age, Educational Level, Industry Type, and Length of Operation

No.	Age Group (Years)	Number of Respondents	
		Number	Percentage
1.	< 30	6	3.0
2.	30-34	22	10.8
3.	35-39	41	20.2
4.	40-44	65	32.0
5.	45-49	34	16.7
6.	50-54	19	9.4
7.	55-59	9	4.4
8.	60-64	5	2.5
9.	65+	2	1.0
Total		203	100.0
Educational Level			
1	Junior High School	27	13.3
2	Senior High School	128	63.1
3	Diploma	5	2.5
4	Bachelor	42	20.7
5	Master	1	0.5
Total		203	100.0
Industry Type			
1	Manufacturing	62	30.5
2	Trade	74	36.5
3	Service	67	33.0
Total		203	100.0
Length of Operation (Years)			
1	< 5	34	16.7
2	5-9	72	35.5
3	10-14	44	21.7
4	15-19	19	9.4
5	20-24	19	9.4
6	25-29	10	4.9
7	30-34	4	1.9
8	≥ 35	1	0.5
Total		203	100.0
Sales			
1	Remain constant	59	29.1
2	Increase	108	53.2
3	Decline	36	17.3
Total		203	100.0

length of operation, and sales condition. Age likely describes respondents' condition. In this respect, age informs whether the respondents can mostly be classified as productive or unproductive ages. However, all of our respondents are more than 15 years of age. Respondents who are between 15-64 years of age are classified as in productive ages while those who are more than 65 years are classified as in unproductive ages. Most of the respondents are in their productive ages (99%). The respondents can also be classified based on sex. Specifically, most of them are male (137 respondents or 68% of total respondents) while the rest are female. Further, most of them (about 63% of total respondents) are senior high school graduates with only 0.5% of respondents have master degree. We classify industry type into three: manufacturing, trade, and service. The respondents of this research, most of them were operated in trade industry (36%), service industry (33%), and manufacturing industry (30.5%). Meanwhile, respondents' length of operation varies, from less than 5 years to more than 35 years. Specifically, the respondents (about 46%) have the length of operation between 5 to 9 years. Only a small proportion of respondents operate more than 30 years. Besides internal financing, respondents rely on various financing sources, such as banks, cooperatives, LPD or Rural Credit Institutions, and friends/ families. Most of our respondents (about 62%) use external financing such as (private and state) banks, followed by LPD and cooperatives (about 28%), and about 5% from friends or families. The external financing supports business growth greatly. Greater trust from financing sources will enhance the likelihood that SMEs generate external financing and eventually improve their operational performance. [Table 1](#) shows the composition of respondents based on age, educational level, industry type, and length of operation.

Besides financial capital, human resources are very important for firms. Most of our SMEs' employees are male (about 66%) while the rest are female. On average, SMEs have two employees. And more than a half of respondents (53%) have employees who require specific skills. Further, most of them (about 53%) opine that their sales fluctuated in the last six months, while 29% of total respondents hold that their sales remained constant and only 17% of total respondent's experienced sales decline

([Table 1](#)). In general, economic condition significantly affects sales. Besides, competition between SMEs and novel sales platforms such as online marketing also exhibit a significant effect on sales. Our further analysis reveals that most of our respondents (87%) never participated in government-sponsored programs, such as business training, production training, low-interest lending, and exhibition. Thus, these figure indicates that the government has to be more active in implementing their programs to facilitate SMEs, especially those that are related to loans with low interest. This issue is important because only a small percentage of our respondents (about 9%) have received credits with relatively low interest. However, SME owners have to survive by continuously innovating to enhance their sales. Consequently, they can compensate their financing constraints with government-sponsored financing sources that offer low interest or by participating in training related to their business activities.

Validity and Reliability Test

Using the correlation coefficient of each instrument with the total score, our validity test produces a correlation coefficient greater than 0.3, indicating that our instruments are valid. Further, our reliability test produces Cronbach's Alpha greater than 0.6, thus implying that our instruments are reliable.

The Effects of Social Capital and Human Resources on SMEs' Financing in Sarbagita Area, Bali Province

Several indicators were used by the researchers such as norms, trust, and networks as the proxies of social capital. The results suggest that social capital positively affect SMEs' financing in Sarbagita Area, Bali Province as indicated by the significance value of 0.000 ($\alpha = 5\%$) ([Table 2](#)). Working hard and upholding honesty values reflect strong norms that need to be preserved by SME owners. Further, controlling product quality and increasing trust in transactions reflect trust. In a similar vein, maintaining networks with customers, suppliers, financial institutions (LPD, banks, cooperatives), and governments (training, technical assistance, etc.) reflects the importance of well-maintained networks. In this study, we use several indicators of the financing variable, namely internal financing, banks, LPDs, cooperatives, and friends/ families.

It then can be argued that stronger social capital of SMEs imply greater likelihood that they access external financing sources. Further, SMEs have to maintain and enhance their social capital because of the positive effect of social capital on access to financing sources. Human resources, with the indicators of knowledge, skills, and commitment, also positively affects financing SMEs in Sarbagita Area, Bali Province as indicated by the significance value of 0.038 ($\alpha=5\%$) (Table 2). The findings suggests that greater knowledge, skills, and commitment of SME owners imply better access to external financing sources from various institutions, such as banks, LPDs, and cooperatives. Entrepreneurs who are strongly committed to their firms' development

are more likely to generate trust from their financing sources. Consequently, there exists a synergy between human resources and financing sources to enhance operational performance. It is then very important to maintain highly qualified human resources that can be reflected by previously mentioned indicators to mitigate the problems of accessing external financing sources. It is expected that the positive effects of social capital and human resources on financing will increase SMEs' performance. Table 2, demonstrates the results of our regression analysis by using the factor score of social capital, human resources, and financing.

Previous studies support the results of this study. For example, Denis (2000) explains the

Table 2: The Results of the Regression Test – The Effects of Social Capital and Human Resources on SMEs' Financing in Sarbagita Area, Bali Province

Coefficients ^a					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	2.414E-016	.065		.000	1.000
1 REGR factor score 1 for analysis 2	.372	.065	.372	5.728	.000
1 REGR factor score 1 for analysis 3	.137	.065	.137	2.108	.036

a. Dependent Variable: REGR factor score 1 for analysis 4

Explanation:

REGR factor score 1 for analysis 2 = Social Capital

REGR factor score 1 for analysis 3 = Human Resources

REGR factor score 1 for analysis 4 = Financing

Table 3: The Results of Regression Analysis -The Effects of Social Capital, Human Resources, and Financing on SMEs' Performance in Sarbagita Area, Bali Province

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	3.165E-016	.064		.000	1.000
1 REGR factor score 1 for analysis 2	.354	.065	.354	5.459	.000
1 REGR factor score 1 for analysis 3	.122	.065	.122	1.891	.060
1 REGR factor score 1 for analysis 4	.142	.065	.142	2.178	.031

a. Dependent Variable: REGR factor score 1 for analysis 1

Explanation:

REGR factor score 1 for analysis 2 = social capital

REGR factor score 1 for analysis 3 = human resources

REGR factor score 1 for analysis 4 = financing

REGR factor score 1 for analysis 1 = SMEs' financing

importance of maintaining a relationship in the form of networks to acquire valid information about financing problems. Further, [Chua et al., \(2009\)](#) emphasize that social capital reduces concerns on lack of access to external financing sources from financial institutions. In a similar vein, as suggested by [Bosse \(2009\)](#), the existence of social capital is important to apply for credits. SMEs with more networks with outside parties enable them to have greater access to bank credits ([Wu, 2008](#)). SMEs with more networks with credit-supplying financial institutions are more likely to access financing sources ([Kurniawan, 2018](#)). Investor protection positively affects external financing sources regardless of the types of investors ([Nofsinger and Weicheng \(2011\)](#)). This study is also supported by [Vos et al., \(2007\)](#) who indicate that human capital affects individuals in accessing financing sources. Altogether, financial, human, and social capital provide opportunities to access financing sources ([Tihula and Uovinen, 2010](#)). Social capital facilitates access to financing, marketing, and production, and information ([Fornoni et al., 2012](#)). SMEs performance was measured by using several indicators, namely innovation, sales, and customer retention. Our empirical results demonstrate that social capital and SMEs' financing positively affect SMEs' performance with 1% confidence level, and human resources positively affect SMEs' performance with 6% confidence level. The results imply that stronger social capital and human resources increases SMEs performance. Similarly, more financing sources that can be accessed by SMEs enhance SMEs' performance in the Sarbagita Area, Bali Province. Stronger social capital and more varied financing sources likely increase innovation, sales, and the ability to retain customers that facilitate firms' business sustainability. Thus, SMEs have to emphasize the importance of human resources as reflected by knowledge, skills, and commitment that will significantly enhance SMEs' performance. [Table 3](#) below demonstrates the results of the regression analysis using the factor score as suggested by structural [Eq.2](#).

This study is empirically supported by previous studies that also analyze the effects of social capital, human resources, and financing on firm performance, such as [Wu et al., \(2007\)](#); [Okafor, \(2012\)](#); [Ha Lien Chi \(2016\)](#); [Tihula and Uovinen,](#)

[\(2010\)](#). Also, our findings are also consistent with [Fornoni et al., \(2012\)](#) who indicate that entrepreneurs' social capital facilitates access to finance, marketing, production, and information. Capital that emerges from networks, social norms, and trust is equally important as financial and human capital in sustaining firms' value creation activities such as firms' innovative performance ([Renko, Autio, and Tontti, 2002](#); [Tsai, 2006](#)). Further, [Bartocho \(2016\)](#) show that the ability of financial resources to significantly affect employee performance plays an important role in organizational performance.

The results of this research shown that human resources affect SMEs' performance. These results do not supported by [Shiu \(2006\)](#), [Appuhami \(2007\)](#) and [Chan \(2009\)](#) who find the insignificant relationship between human resources and firm performance. Our findings are consistent with [Ngatno and Widayanto \(2016\)](#) who suggest that human capital and entrepreneurial capital are intrinsically important to improve SMEs' performance. This study is consistent with [Fatoki \(2011\)](#), [Sharafat \(2017\)](#), [Pena \(2001\)](#), and [Hisrich and Drnovsek \(2002\)](#) who find a significantly positive relationship between human capital and SMEs' performance.

The Effects of Social Capital and Human Resources on SMEs' Performance through Financing (the Mediating Role of Financing)

As shown by [Table 2](#) and [3](#), the results suggest that social capital and human resources positively affect SMEs' financing. Similarly, social capital, human resources, and financing positively affect SMEs' performance. The findings imply that financing partially mediates the effect of social capital and human resources on SMEs' performance ([Hair et al., 2010](#)). Consequently, SMEs' have to pay special attention to their financing sources to increase their performance. The importance of financing to enhance performance is also supported by [Petersen and Robert \(2002\)](#) who demonstrates that financing constraints limit SMEs' growth. The study implies that access to external debt financing likely increases firm performance. Similarly, [Bartocho \(2016\)](#) shows that the ability of financial resources in significantly affecting employee performance plays an important role in organizational performance. Also, [Zhou](#)

and Chen (2008) identify that SMEs need financial capital to acquire physical resources to enable them to exploit business opportunities.

CONCLUSION

Most of the respondents were in trade industry (36%), service industry (33%), and manufacturing industry (30.5%). The respondents (about 62%) using external financing such as (private and state) banks, LPD and cooperatives (about 28%), and about 5% from friends or families. The external financing supports business growth greatly. Most of the SMEs' employees are male (about 66%) while the rest are female. On average, SMEs have two employees. In general, economic condition significantly affects sales. Besides, competition between SMEs and novel sales platforms such as online marketing also exhibit a significant effect on sales. Social capital positively affect SMEs' financing in Sarbagita Area, Bali Province as indicated by the significance value of 0.000 ($\alpha = 5\%$). In this study, the researcher was using several indicators of the financing variables, namely internal financing, banks, LPDs, cooperatives, and friends/ families. Financing variables shown that stronger social capital of SMEs implied greater likelihood that they access external financing sources. Social capital and SMEs' financing positively affect SMEs' performance with 1% confidence level, and human resources positively affect SMEs' performance with 6% confidence level. The results imply that stronger social capital and human resources increases SMEs performance. Social capital facilitates access to finance, marketing, production, and information. Our results show that human resources affect SMEs' performance. Social capital and human resources positively affect SMEs' financing. Similarly, social capital, human resources, and financing positively affect SMEs' performance. The finding implied that financing partially mediates the effect of social capital and human resources on SMEs' performance. Consequently, SMEs' have to pay special attention to their financing sources to increase their performance. The financing was being a constraint limit SMEs' growth. The study implies that access to external debt financing likely increases firm performance. The SMEs need financial capital to acquire physical resources to enable them to exploit business opportunities. The

results imply that stronger social capital and human resources increases SMEs performance. Similarly, more financing sources that can be accessed by SMEs enhance SMEs' performance in the Sarbagita Area, Bali Province. Stronger social capital and more varied financing sources likely increase innovation, sales, and the ability to retain customers that facilitate firms' business sustainability. The results of this research shown: 1). Social capital and human resources have a significant positive effect on funding for SMEs in the Sarbagita area of Bali Province; This can be explained that the stronger the social capital owned by SMEs, the easier it is to get funding from several financial institutions, both formal financial institutions such as those from government-owned and private-owned banks, as well as informal financial institutions, for example from family, friends, , as well as those from other financial institutions such as cooperatives and People's Credit Institutions (LPD). The higher the social capital shown by norms, trust, networks formed in the business environment, the easier it will be for SMEs to gain trust in relation to the company's funding needs. Likewise, related to the human resources of SMEs which significantly affect funding. The higher the capacity of human resources, which is shown by knowledge, skills and commitment to keep producing, the more trustworthy the funding sources will be to finance their capital needs, because there is a high willingness to succeed as an SME actor; 2) Social capital, human resources, and funding have a significant positive effect on the performance of SMEs in the Sarbagita area of Bali Province. The higher social capital can also improve the performance of SMEs. The stronger the network that is formed in the SME environment, both with fellow SME players and with other parties involved, can improve the performance of SMEs. The stronger the social capital of SMEs is shown by norms, trust and networks, so based on the honest behavior of SMEs, as well as relationships to obtain symmetrical information regarding the sources of raw materials used and other information, the performance of SMEs is measured using increased innovation. , increasing turnover and maintaining good relationships with customers or consumers. Likewise, the quality of human resources continues to be improved and maintains good relations with

financial institutions to obtain funding, so that the performance of SMEs also increases; 3) Funding partially mediates the influence of social capital on the performance of SMEs, and funding fully mediates the influence of human resources on the performance of SMEs in the Sarbagita area of Bali Province. If social capital is strong and human resources are in accordance with the criteria needed to carry out business activities, support from funding sources will be strong so that the performance of MSEs will also increase.

Suggestion

By the results of this research, this study suggests that: 1) SMEs have to sustain their social capital because it positively affects their financing and performance; 2) SMEs need to improve the quality of their human resources that is very important in increasing their performance; and 3) SMEs need to maintain their networks, especially with their financing sources and select financial institutions that offer affordable interest rates; 4) The government has to be more active in implementing their programs to facilitate SMEs, especially those that are related to loans with low interest.

Limitations

The limitations of this research are the researcher only using three variables that are perceived to affect the performance of SMEs, the variables are social capital, human resources, and financing, the next researcher can added other variables such as entrepreneurial and funding sources with venture capital and other variables that are relevant. The other limitations of this research is because of the geographical location between regency in Sarbagita Area, Bali located in different part of Bali and it makes the researcher need more time to collecting data than predicted.

CONTRIBUTION OF AUTHORS

N.N. Yuliarmi added reference data for background and conducted a literature review. N.P. Martini Dewi made research designs and instruments used in the study. S.D. Rustariyuni processed the data with the help of statistical tools. A.A.I.N Marhaeni conducted an analysis of the processed data and added literature review. G. Andika conducted data collection and further observation of the truth of the field data.

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CONFLICTS OF INTEREST

The authors of this study hereby declare that there is no potential conflict of interest regarding the publication of this research work. Matters relating to ethics in research such as plagiarism, informed consent, falsification of data, and related to publication have been fully witnessed by the author. So the author is responsible for it.

ABBREVIATIONS (NOMENCLATURE)

Y_2	SMEs' performance
Y	Financing
X	Social capital
X	Human resources
$B_1, \theta_2, \theta_3, \theta_4, \theta_5$	Parameter
ϵ	Error
REGR factor score 1 for analysis 1	SMEs' financing
REGR factor score 1 for analysis 2	Social Capital
REGR factor score 1 for analysis 3	Human Resources
REGR factor score 1 for analysis 4	Financing

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ORIGINAL RESEARCH PAPER

Evaluation of temperature and urban heat island variability in days of the week and weekends

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ABSTRACT

BACKGROUND AND OBJECTIVES: This study evaluated temperature and urban heat island variability in days of the week and weekends of Port Harcourt city, due to the continuous heat stress and resultant health disaster common in tropical countries such as Nigeria.

METHODS: The data were generated from field observation and Satellite Remote Sensing using Google Earth Engine of Landsat 5, 7, and 8 thermal infrared sensors. Temperature data from the field were captured with LCD Digital Multi-Thermometer Loggers located at different land-use types of 35 sample points in wet and dry seasons. Analysis of Variance was used to establish the temperature difference between days of the week and weekend.

FINDINGS: The rural site during days of the week had temperature of 29.30C and the weekend had 29.50C indicating a concentration of human activities at the rural fringes during the weekend. The temperature of Saturday and Sunday varied between 33.20C and 27.60C (5.60C) with an urban heat island difference of 1.90C. Saturday was the coolest day having 3.70C. During days of the week, Monday had the highest UHI of 70C with the least UHI of 4.20C recorded on Friday showing the coolest day. The temperature difference between days of the week and weekend was 0.20C and UHI variation of 0.40C indicating that days of the week were warmer. The result showed that temperature in days of the week and the weekend differed significantly.

CONCLUSION: It was established that days of the week contributed 52% of the temperature condition of Port Harcourt city and weekend donated 48% showing that 3,095,342 occupants of the city experienced lesser thermal stress during the weekend. Thus, the study concluded that the temperature of urban areas decreased from the city center to the rural fringes. The land surface temperature indicated that the north-eastern part of the city was the warmest. The study recommends proactive city planning and management framework with effective urban greening implementation for a healthy city living.

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INTRODUCTION

Today, the world population has increased to 7.7 billion people with over 4.2 billion living in the cities (UNDESA, 2018; UNDESA, 2019). It is estimated that 60% of the world population will live in the city by 2030 and in 2050 the population of cities will attain 70% (WHO, n.d.). Thus, rise in city population will cause the modification of the natural environment resulting to rise in city temperature and Urban Heat Island (UHI) phenomenon. However, UHI is the cumulated temperature in the city that is greater than the temperature of the outskirts and fringes caused by anthropogenic activities and modification of the natural city surface (Maria et al., 2013; Tan et al., 2015) as in Fig.1 and adapted from (William et al., 2004). In other words, temperature of the city tends to increase from the rural outskirts to the city center modified by urban fabrics and other human activities. These modifiers are in the form of urban geometry and morphology, loss of urban tree cover, rise in urban fabrics and pavement materials, emission of greenhouse gases, low material albedo, size of city and material thermal properties (Kotani et al., 2005; Qian et al. 2006; Hart et al., 2008). Other factors that could cause rise in temperature are vehicular and industrial emissions as well as the emissions from cooling systems (Memon et al., 2008; Papanastasiou et al., 2012). Brain (2001) concludes that UHI will rise up to the rate of 0.25-2°F in each decade and will double in high metropolitan cities in the next 50 years. Rise in temperature and heat waves of cities have been associated with heat stress especially during the night. Temperature increment creates enabling environment for the spread of vector diseases which could be harmful to humans and animal species (Samuels, 2004; Ifeoluwa et al., 2012). During hot weather, city dwellers will increase their consumption of electricity and other energy sources (Nuruzzaman, 2015). It is very obvious that rise in ambient air temperature will bring about discomfort in the city with associated poor economic activity, heat cramp, heat stroke, respiratory attack and death (Stephen et al. 2016; Ojeh et al., 2016). Thus, every 0.6°C rise in temperature will trigger 2% consumption of energy in a city and will cost 10% of energy budget at a worldwide scale (James, 2002). Increase in temperature has the capacity to cause death of flora and fauna species in an urban environment (Dejene, 2018). However, due to the psychological and

physiological effects of high temperature and UHI, city dwellers will loss economic hours of labour and productivity (ILO, 2019). Increased temperature and UHI have been studied in several cities of the world. Enete et al., (2013) examined the temperature and UHI of Enugu city using remote sensing technique. The findings showed that the city center had temperature above 37°C and 4°C to 6°C warmer than the rural fringes. Alenka et al., (2017) studied the temperature performance of two residential neighborhoods in Ljubljana, Slovenia using thermal satellite images. The study showed that summer period had higher temperature variation and areas with higher concentration of urban pavement materials displayed more urban temperature. Elsayed (2012) studied the urban heat island and temperature variability of Kuala Lumpur, Malaysia. The results showed that Sunday recorded the highest temperature and weekly urban heat island variation of 3.9°C to 5.5°C respectively. Reuben (2012) studied the spatio-temporal dynamics of UHI in Singapore using ground observation. The findings showed that UHI was highest in the night. Thus, weekday and weekend UHI at maximum levels were significantly different. These studies showed the use of remote sensing and ground observation to measure temperature and UHI variability across the cities. Efe et al., (2014) carried out a study on the effects of urbanization in Benin City temperature using weather station data and mobile transverse approaches for a one-year period. Findings showed that temperature varied with 0.50C from rural fringes to city center which was 2% warmer than the rural fringes. The study concentrated on ground observation and secondary data from Nigerian Meteorological Agency and did not consider the spatial spread of temperature across different land use types in the city as well as weekday and weekend heat variation of the city. Quah et al., (2012) studied the diurnal and weekly variations of human generated heat on three land use types in the city of Singapore using both top-down and bottom-up modelling techniques for ascertaining energy intensity. Findings indicated that buildings contributed the highest urban energy with 49-82% energy released in the weekdays and 46-81% during the weekends. The study did not consider the rural and urban area heat variation as well as the application of satellite remote sensing in the analysis of the city thermal environment. Kim et al., (2004) studied the daily maximum urban heat island severity

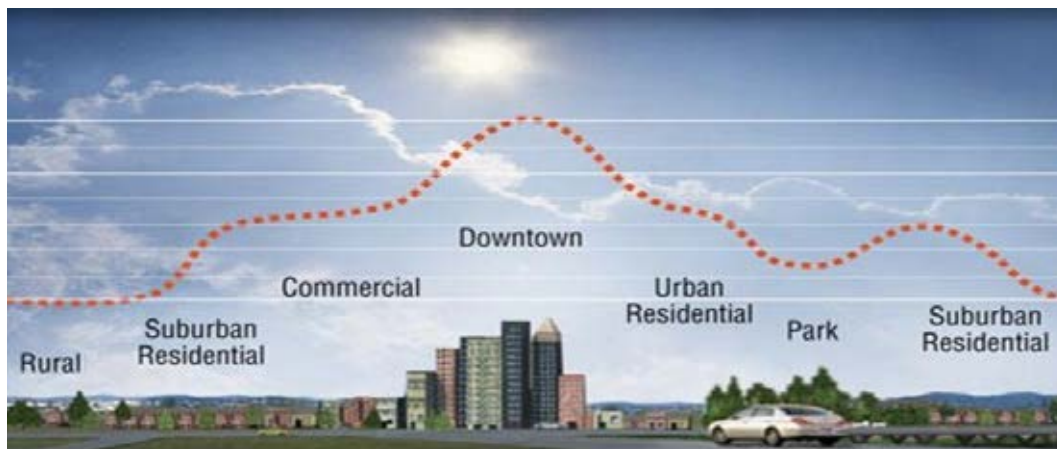


Fig. 1: The Distribution of Temperature and UHI across Urban Area

of South Korean cities of Seoul, Incheon, Daejeon, Daegu, Gwangju, and Busan (1973–2001) using spectral and multidimensional scaling analyses. The findings showed that the daily maximum urban heat island per year in the cities rose over time, decreased according to size of cities and availability of water bodies to the cities. Thus, the cities located at coastal areas such as Incheon and Busan had low urban heat island than cities inland such as Daejeon, Daegu and Gwangju respectively. However, this study did not consider weekday and weekend urban heat island differences across the various cities. However, satellite remote sensing was not used in the methodology for assessing the urban heat island of the various cities. Vincent *et al.*, (2016) studied the differences in temperatures between Lagos city center and the rural fringes using a one-year meteorological field observation located at both rural (Okofo) and city centers (City Hall). It was found that the urban heat island of Lagos city could exceed 70C which can be influenced by seasonal variation. The study did not consider urban heat island phenomenon in multiple land use types and satellite remote sensing technique was not adopted in the investigation. Furthermore, the study did not consider the weekdays and weekend urban heat island variability of Lagos city. The study of urban heat island is an evolving one that has attracted limited attention but facilitated by the current global warming. From the preceding literature, it is notable that the study of urban heat island using ground observation for a full year and satellite remote sensing in Port Harcourt coastal city of Nigeria does not exist

in the public domain. Furthermore, investigation of weekdays and weekend urban heat island of cities has not been given adequate attention and urban heat island literature is highly limited especially for Port Harcourt city in Rivers State, Nigeria. However, with the influx of population and urbanization processes in Port Harcourt city, increased temperature and UHI phenomena have become a critical problem that needed to be investigated. The modification of streets and roads of Port Harcourt Diobu area, Trans-Amadi, Port Harcourt Township, Rumuokoro, Ada-George, Port Harcourt NPA; industrial and daily vehicular traffics as well as general economic activities in the city are capable of triggering the temperature rise and UHI performance of the tropical city. Therefore, this study will serve as part of the urban management framework for those in charge of the planning and management of Port Harcourt city in order to make the city a comfortable place free from thermal stress and death. In this vein, this study investigates the temperature and UHI dynamics in days of the week and weekends across different land use types of Port Harcourt tropical city of Nigeria. The study was carried out from 2017 to 2019.

MTEHRIALS AND METHODS

As a tropical city located at the coast of the Atlantic Ocean, Port Harcourt is approximately founded within the longitude 7°E and 7°5 E and latitude 4°45'N and 4°50 N. The metropolitan city is occupied by two main Local Government Areas (LGAs) of Obio/Akpor and Port Harcourt City. The city extends to the

Urban Thermal Variability in Days of the Week and Weekend

fringes of Okiri, Bakana, Oyibo, Ozuoba and Ogbogoro respectively (Fig. 2). Thus, Port Harcourt city and environs has projected population size of 3,229,384 persons (NPC, 2006) as in Fig. 3, Port Harcourt has annual monthly average temperature of 31.3°C and monthly minimum average temperature of 21.8°C as

well as average maximum temperature of 31°C. The city has average monthly solar radiation capacity of 10.55mJm⁻²/day and average annual radiation of 9.25mJm⁻²/day. It has 80% annual average relative humidity, average annual evaporation of 97.3mm and average annual rainfall of 2000mm to 2500mm

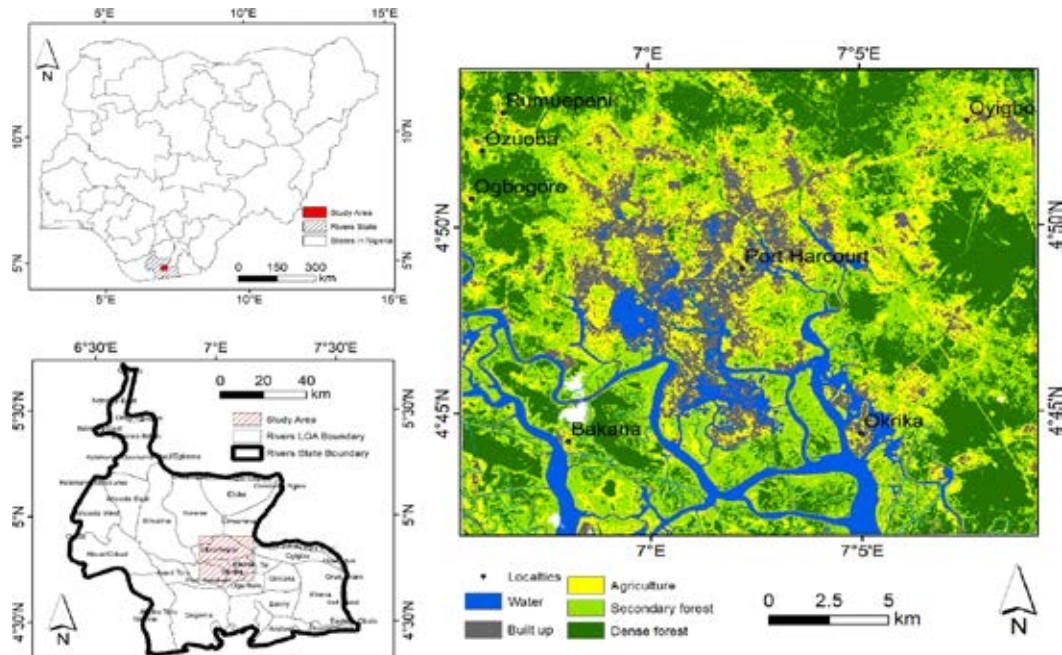


Fig. 2: Location Characteristics of Port Harcourt City

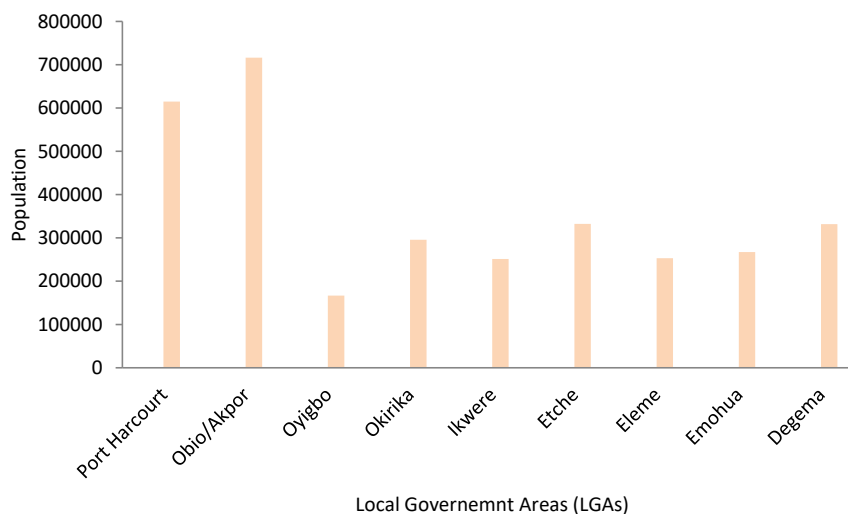


Fig. 3: Population of LGAs in Port Harcourt Metropolitan City

respectively. The city climate is influenced by the sea-land breezes resulting from the close proximity to the Atlantic Ocean and located in the mangrove and rain forests of the Niger Delta Area of Nigeria (Olofinoye et al., 2010; Ike et al., 2012; Odu et al., 2013) The first dataset was gathered from the field using the digital thermometer in 35 locations conducted in dry and rainy seasons. The second dataset was retrieved from the Satellite remote origin using the thermal infra band (Fig. 4 and Table 1). The data capturing was carried out simultaneously with the help of field

assistants from private homes, business areas and offices. The air temperature measurements were carried out for 12 months of April, May and June (AMJ, early wet season), July, August and September (JAS, late wet season), October, November, and December (OND, Early Dry Season) and January, February and March (JFM, late dry season) in 2017/2018. The measurement took place at 0006 (Morning), 1200 (Afternoon) and 1800 (Evening) hours respectively. Thus, change in temperature readings (ΔT) were converted and analyzed on daily

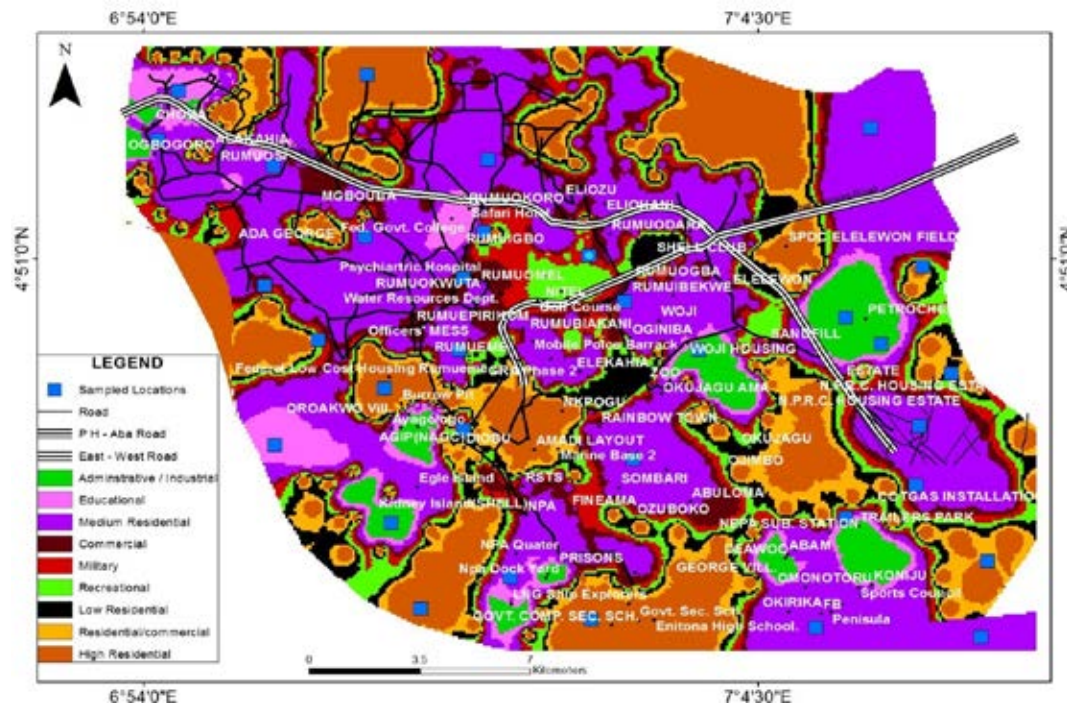


Fig. 4: Sample Locations across Different Observation Sites

Table 1: Land Use Types of Sample Locations

Land use Types	Location
Low Residential	Eleme, GRA, Intel zone, Total Estate, Oyibo, Shell estate, Bolokiri, Igwuruta, Etche, Iwofe, Jetty, Choba, Elemenwo, Okirika, Rumosi, Elekahia, Mgbuoba, Eagle Island.
High Residential	Diobu, D-Line, Enitona School Area
Medium Residential	Ada-George, Abloma, Rumuigbo, Port Harcourt Township, Rumuola, Choba, Mgbuoba, Woji, Okirika, Rumuodara
Educational	University of Port Harcourt, University of Science and Technology, Port Harcourt Poly Technique, Ignatious Ajuru University
Commercial	Mile One market, Rumuokoro Market, Mile 3 Market, Slaughter, Ikoku market, Oil Mill Market
Military	Navy barracks, Bori Camp, Airforce
Recreational	Boro Park, Port Harcourt Tourist, Rainbow Zoo, Port Harcourt Pleasure Park, Woji Housing
Residential/Commercial	Orazi, Rumuokwursi, Rumuaghorlu, Rumuibekwe, Rumuodomaya, Ogbunabali, Rukpoku, Rumuokwuta
Admin/Industrial	Eleme Petrochemical area, Marine Base, BMH, UPTH, Transamadi, Agip, NPA, Rivers State Secretariat.
Rural	Elibrada, Aletu, Dankiri, Obeta, Omagwa (control sites)

Table 2: Details of Google Engine Satellite Remote Sensing for LST

Dates of Retrieval	Satellite/Sensor	Reference System/Path/Row
01/01/16 - 30/01/16	GEE/Landsat 5/7/8	AoI
01/01/02 – 30/01/02	GEE/Landsat 5/7/8	AoI
01/01/86 – 30/01/86	GEE/Landsat 5/7/8	AoI

average values of urban (u) and rural (r) differences ($\Delta T(u-r)$) from the datasets and organized into days of the week and weekends for a year. The temperature devices were Handheld Digital Thermometer ST9269 model with St-9283B/St-9269B, factory-made by MEXTECH. The thermometers resolution were 0.1°C (0.2°F) having measuring range between -50°C and 300°C (-58°F to 572°F) at St-9283B and -50°C and 200°C (-58°F to 372°F) at St-9269B respectively. The thermometers accuracy constant was $\pm 1^\circ\text{C}$, ranging between -50°C to 150°C ($\pm 2^\circ\text{F}$ in the range of -22°F to 302°F). The interpolation technique was used to complete few missing data (Ayoada, 2008; Schneider, 2001). However, the rural sites were characterized with plots of deciduous plants, low plants and grasses as the thermometers were mounted on an average wooden pole or handheld. The rural sites that served as the control were Omagwa, Aleto, Elibrada, Obeta and Dankiri. The sites were purposively sampled based on the homogeneity and shared characteristics of sample sets of delineated land categories. (Acerio et al., 2013; Papanastasiou et al., 2012; Giannaros et al., 2009; Hawkins et al., 2012). However, for the urban area temperature data were drawn from sites characterized by urban pavements as stones, tiles, bricks, concretes, general construction materials, built-up and treeless portions approximately at height of a head (1.5 meter) above the ground level of the canopy layer (Annamaria et al., 2017; Ifeoluwa et al., 2012; Fortuniak et al., 2006; Ram et al., 2015; Salah et al., 2010; Jacob, 2015; Gianmarco et al., 2012; Brian et al., 2013). However, for satellite data retrieval and analysis on the Land Surface Temperature (LST) of Port Harcourt city, the algorithm for extracting LST from Landsat 5, 7 and 8 thermal infrared sensors, using different surface emissivity sources from the Google Earth Engine (GEE) was adopted. The LST from satellite remote sensing imageries were used for the analysis as in the directory of Table 2. Finally, the Analysis of Variance (ANOVA) was employed to understand the statistically significant difference between days of the week and weekend

temperatures. Thus, in order to manage urban heat island in days of the week and weekend, the study adopted a framework that would evaluate temperature and urban heat island variability by analyzing the existing conditions of temperature and urban heat island as well as recommend mitigation strategies. However, temperature and urban heat island were evaluated by carrying out temperature observations across the different land use types and satellite remote sensing in both urban and rural settings. The data were captured in the field and analyses were carried out using Statistical Package for Social Science (SPSS) and Geographic Information System (GIS). The results of temperature and urban heat island variability as well as satellite imageries were established for use. Finally, urban greening and tree planting were recommended as development planning and management for decision making in intervening for heat disaster in days of the week and weekend in Port Harcourt city, Nigeria.

RESULTS AND DISCUSSION

Temperature of the ambient air and the resultant UHI are displayed in Table 3. The difference between the rural site and other urban sites yielded the urban heat island ($\text{UHI} = \Delta T_{u-r}$) which was the quantity of heat added by man's activities and urban fabrics across the days of the week and weekend. During days of the week, rural site had mean temperature of 29.3°C and urban site had highest mean temperature of 33.3°C at residential/commercial land use types with UHI difference of 5.1°C. In the days of the week, temperature was highest on Friday in residential/commercial site (33.6°C) and lowest in the rural site having temperature of 29°C on Tuesday with a range of 4.6°C. During days of the week, Monday had the highest UHI of 7°C with least UHI of 4.2°C recorded on Friday showing the coolest in the days of the week (Figs. 5 and 6). During the weekend, highest temperature was recorded on Sunday in residential/commercial site having temperature of

Table 3: Temperature and UHI Variability in Days of the Week and Weekend

Day/Land Use	Rural	Military	Admn /Indust.	High Res.	Res/Comer.	Med Res.	Commer.	Low Res.	Educt.	Recreat.	Mean Temp.	UHI = (ΔT_{u-r})	
Days of the Week	Mon	29.1	29.3	30.6	29.4	34	30.6	30.1	30	28	29.8	7	
	Tue	29	31.5	31.6	31.3	33.5	31	31	29	30.4	30.6	5.6	
	Wed	29.1	28.7	31.8	31	33	30.2	30.4	29.2	30.7	30.3	4.3	
	Thurs	30	30.2	28.3	30	32.4	29.5	28.9	29	29	29.7	4.6	
	Fri	29.4	31.9	31.9	30.8	33.6	31.4	31.6	30	30.4	29.9	28.5	4.2
	Mean	29.3	30.3	30.8	30.5	33.3	30.5	30.4	29.4	29.6	28.4	29.9	5.1
Weekend	Sat	29.5	28.5	29.7	30.2	32.1	28.4	31.2	29.2	30.8	29.8	3.7	
	Sun	29.4	29.1	28.8	30.5	33.2	31	29.1	28.6	27.9	29.5	5.6	
	Mean	29.5	28.8	29.3	30.4	32.7	29.7	30.2	29	29.4	28.2	29.7	4.7

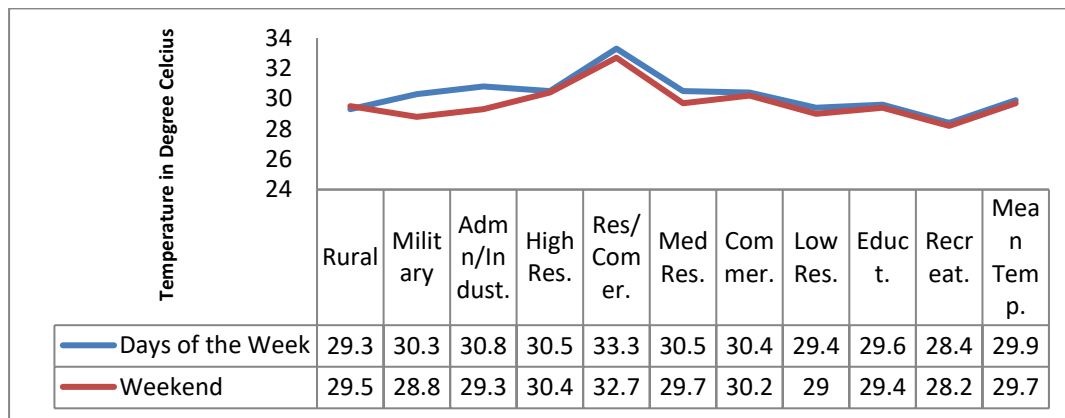


Fig. 5: Temperature Variability in Days of the Week and Weekend across different Land use Types

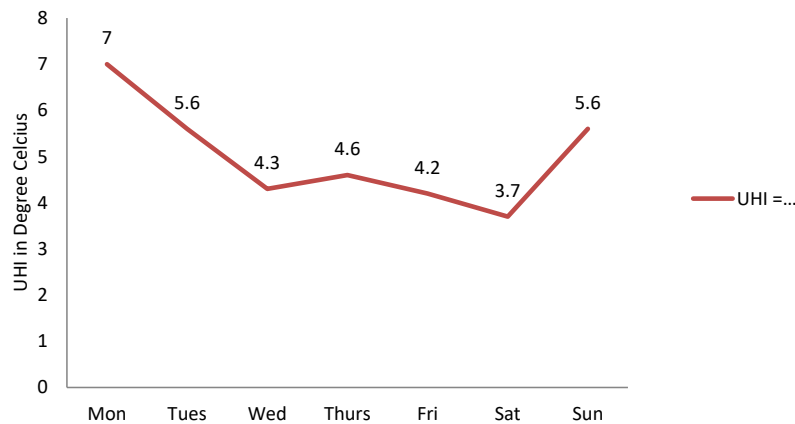


Fig. 6: Daily UHI Variation

33.2°C and UHI value of 4.7°C. Temperature in the weekend varied between 33.2°C and 27.6°C (5.6°C) with UHI difference of 1.9°C having Saturday as the

coolest day at 3.7°C (Figs. 5 and 6). Comparison of the two categories in the week showed some degree of interaction and characteristics across the various

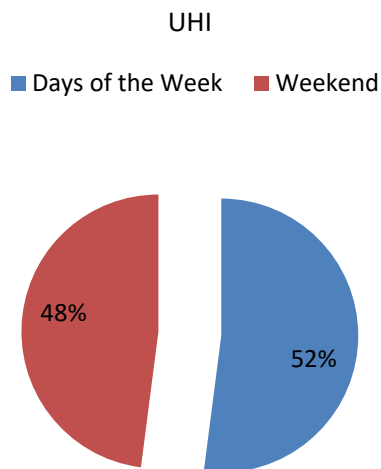


Fig. 7: The Distribution of UHI in Days of the Week and Weekend

land use types (Fig. 5). In the rural site, days of the week had temperature of 29.3°C and 29.5°C during the weekend indicating that rural sites were warmer during the weekend. This could be as a result of movement of vehicles and human activities at the rural fringes during the weekend. Port Harcourt city people are known for their recreational activities in the rural villages during weekend. The mean temperature difference between days of the week and weekend was 0.2°C and UHI variation of 0.4°C indicating that days of the week were warmer than the weekend. The residential/commercial land use recorded the highest temperature in days of the week and weekend with 33.5°C and 32.7°C respectively. This was followed by residential and high residential land use types which were made up of Orazi, Rumuaghorlu, Rumuibekwe, Rumuodomanya, Ogbunabali, Rukpokwu, Rumuokwuta and others which were warmer than other land use types. Other places of warmer temperatures were Diobu, D-Line,

Enitonia High School area, Ada-George, Abloma, Rumuigbo, Port Harcourt Township, Rumuola, Choba, Mgbuoba, Woji, Okirika, Rumuodara (Tables 2 and 1). Days of the week contributed 52% of the total city UHI and weekend UHI contributed 48% with a difference of 6% UHI (Fig. 7). The urban pavement materials and the general anthropogenic functions of Port Harcourt city had modified the entire land use types (Fig. 8). The northern part of Oyibo had the highest thermal radiation at 35.1°C of surface temperature. The southern part (Bakana and Okirika) had warmness lower than the other parts of the city due to the influence of mangrove, rain forests and the Atlantic Ocean characteristics which usually caused the sea to land breezes from the southern part of the city. The eastern part of the city was warmer than the western segment due to the differences in urban pavement materials and general human activities. Land surface temperature in Port Harcourt city had variation of 13.7°C from the lowest areas to the highest sites. The land surface temperature and UHI characteristics had the capacity to influence weekend and days of the week thermal performance. The hypothesis (H_0) stated that there is no statistically significant difference in days of the week and weekend temperatures. The Analysis of Variance (ANOVA) test was applied (Table 4). The results showed that P-value of 0.017802245 and 9.84451E-05 were greater than 0.05 Significant Level (SL). This shows that temperature in days of the week and the weekend varied significantly. This is in tandem with the earlier view that days of the week had different mean temperature of 29.9°C and weekend mean temperature of 29.7°C; days of the week military temperature had 30.3°C and weekend military temperature recorded 28.8°C supporting the hypothesis results. The results and findings of this study are in line with the view of Ifeoluwa *et al.*, (2012) who observed temperature difference between the

Table 4: ANOVA Test Explaining the difference in Days of the Week and the Weekend

Source of Variation	SS	df	MS	F	P-value	F-crit
Rows	1.4045	1	1.4045	8.368421053	0.017802245	5.117355029
Columns	27.2905	9	3.032277778	18.06719629	9.84451E-05	3.178893104
Error	1.5105	9	0.167833333			
Total	30.2055	19				

SS* Sum of Square, df** degree of freedom, MS*** Mean Square, F**** F-statistics

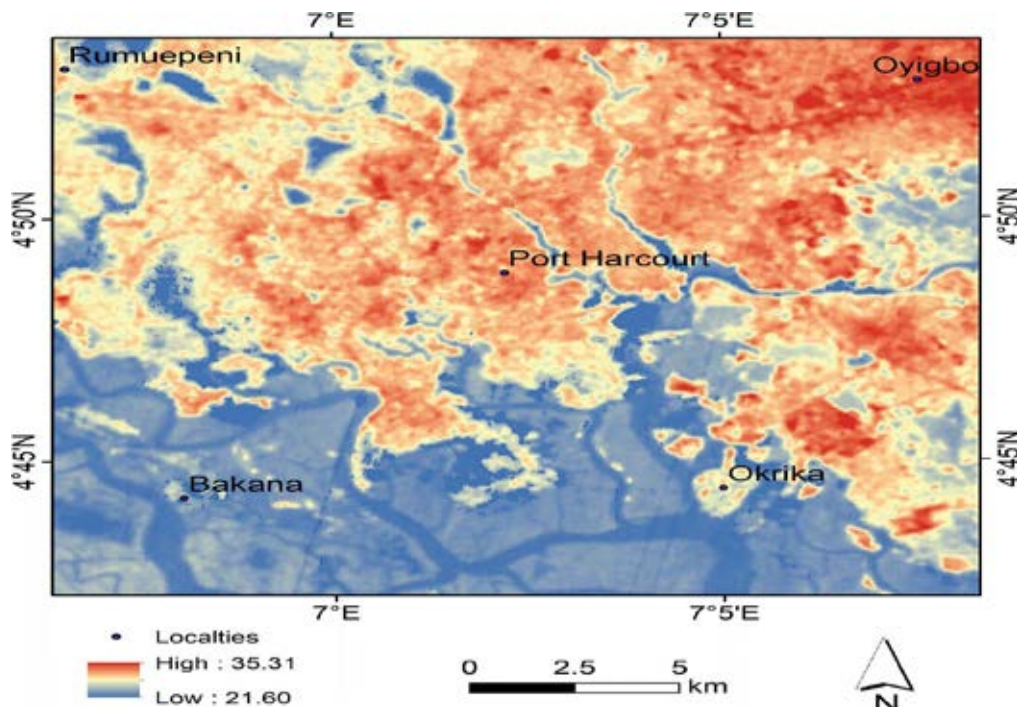


Fig. 8: Land Surface Temperature (LST) of Port Harcourt City

rural fringes and the city center at 4°C in nocturnal period and 2°C in the afternoon. Temperature varied across measurement days, weeks, months and seasons in the city of Akure, Nigeria. [Elsayed et al., \(2012\)](#) who studied temperature and UHI in the City of Kuala Lumpur, Malaysia established temperature difference from weekday to weekend during the study period which the working days were warmer than weekend and UHI was not the same across the city area having its peak at Puduraya part of the city. [Reuben \(2012\)](#) in a study in Singapore noticed variation in the city temperatures across sample points, time of the day and weekdays. [Quah et al., \(2012\)](#) in a study using satellite remote sensing on Zhujiang Delta showed that temperature (LST) in the urban site was 4.56°C higher than the rural fringes due to the pattern of urban development. [Baumer et al., \(2007\)](#) affirmed that during days of the week, people travel, take children to school and engage in other human activities which contribute to thermal variation across the weekdays. [Earl et al. \(2016\)](#) observed that the city center is known to generate intense heat from the dense pavements, population and economic activities in a weekly cycle.

All of these are in tandem with this study having LST difference of 13.7°C from the lowest rural outskirts to the city center, UHI of 4.1°C weekend and 5.1°C days of the week. These studies recorded variations of temperature at different locations, time, weekdays and seasons. The management of urban temperature is a compendium of various temperature monitoring at different locations and time, weekdays as well as seasons.

CONCLUSION

Urbanization has modified the natural biophysical components of Port Harcourt city surface resulting to variation in the temperature and UHI characteristics across different land use types, days of the week and weekend. The study has employed the combination of temperature field observation and remote sensing of satellite origin from Landsat images and thermal infrared characteristics. Temperature raw data were produced from the field using LCD Digital Multi-Thermometer Loggers located at different land use types of 35 sample points of wet and dry seasons. Thus, Port Harcourt city dwellers receive their thermal discomfort based on the land use type they

find themselves, days of the week and weekend. This study has shown that days of the week (Monday to Friday) have higher temperature and UHI regime than the weekend (Saturday and Sunday). However, days of the week has contributed 52% of the temperature performance of Port Harcourt city and weekend has 48% indicating that the Port Harcourt city dwellers are more comfortable with less thermal stress during the weekend having population of 3,095,342 occupants. Elsayed *et al.* (2012) has similar view for the City of Kuala Lumpur which reveals that temperature in working days are warmer than weekend with the city of Puduraya having the highest temperature. It is therefore conclusive, that some cities such as Port Harcourt and Puduraya have temperature rise and heat stress during days of the week than the weekend. Furthermore, in Port Harcourt, at the rural fringes, days of the week cumulates temperature of 29.3°C and the weekend has 29.5°C showing that rural fringes are warmer during the weekend due to more concentration of people and economic activities at the outskirts during the weekend. Temperature in the weekend varies between 33.2°C and 27.6°C (5.6°C) with UHI difference of 1.9°C having Saturday as the coolest day at 3.7°C. During days of the week, Monday has the highest UHI of 7°C with least UHI of 4.2°C on Friday showing the coolest in the days of the week. The study shows that temperature in days of the week and the weekend differs significantly. The rural land use remains the coolest and commercial/residential sites maintains the highest thermal discomfort in Port Harcourt city. This difference between urban and rural segments of the city is similar to the study of Ifeoluwa *et al.*, (2012) who establishes that the city center is warmer than the rural sites in Akura, Nigeria. Also, that temperature varies in weeks, months and seasons in Akure city. Similarly, Quah *et al.*, (2012) establishes that urban area of the city of Zhujiang is higher than the rural fringes. It is conclusive, therefore, that some cities across the world have their city centers warmer than their rural fringes during the days of the week. Although, in this study, the rural sites are warmer than the city centers during the weekend but cooler than the city center during days of the week. The northern and eastern parts of Port Harcourt city are the warmest segments of the city while the southern and western parts remain relatively cooler. In this same vein, Reuben (2012) establishes that temperature varies across

different sample points in Singapore depending on the characteristics of the area and weekdays. Thus, rise in urban fabrics and expansion of human activities will continue to trigger the thermal condition as temperature of the city decreases from the city center to the rural fringes. This is similar to the observations of Baumer *et al.*, (2007) and Earl *et al.*, (2016) who affirm that human activities, population and urban pavement variations of different city sites will result to variability of temperature and urban heat island effects. Therefore, it has become very pertinent for development authorities to engage the residents of Port Harcourt city to practice serious urban greening and tree planting as part of the environmental heat management strategies for inhabitable tropical city free from heat disaster.

AUTHOR CONTRIBUTIONS

P. Nwaerema Peace retrieved, analyzed and interpreted the data, prepared the manuscript, wrote the texts and edited the manuscript. S.N. Jiya compiled data, wrote the literature review, and reviewed the entire manuscript.

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CONFLICT OF INTEREST

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

ABBRAVIATION

<i>df</i>	degree of freedom
<i>F</i>	F-statistics
<i>F-critic</i>	F-critical value of distribution

<i>ILO</i>	International Labour Organization
<i>LST</i>	Land Surface Temperature
<i>MS</i>	Mean Square
<i>NPC</i>	National Population Commission
<i>P-value</i>	Probability value of distribution
<i>SS</i>	Sum of Square
<i>UHI</i>	Urban Heat Island
<i>UNDESA</i>	United Nations Department of Economic and Social Affairs
<i>WHO</i>	World Health Organization

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ORIGINAL RESEARCH PAPER

Traffic management via traffic parameters prediction by using machine learning algorithms

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ABSTRACT

BACKGROUND AND OBJECTIVES: One of the short-term strategies to manage the traffic and make a balance between travel supply and demand for the near future is the short-term prediction of traffic parameters and informing the passengers. Therefore passengers are more likely to avoid traveling during traffic peak hours. In this study, hourly average traffic speed and hourly traffic volume as two traffic parameters that indicate traffic state are predicted for Karaj-Chaloos road in Iran.

METHODS: Since traffic data have large volume, machine learning-based models have more suitable performance than traditional models. However, it is not merely possible to discover the cause and effect relationships and the importance of features. In this study, after using the artificial neural network and K-nearest neighbor models to predict traffic parameters, to analyze the sensitivity of the results, the importance of used features is investigated. Also, the effect of passing the time over the accuracy of predictions has been examined.

FINDINGS: According to the results, the highest accuracy of predicting hourly traffic volume and hourly average traffic speed is achieved by the K-nearest neighbor that is equal to 61% and 91%, respectively.

CONCLUSION: Compared to the historical average as a benchmark model, a significant improvement in the accuracy of predictions has been obtained by the artificial neural network and K-nearest neighbor models.

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INTRODUCTION

Nowadays, by facilitating travel and greater human need of movement, the demand for travel has increased dramatically, and it is considered a severe challenge to meet the high volume of travel demand (Ferguson, 2018). One of the essential goals in transportation planning is making a balance between travel supply and demand (Miller, 2017). This balance can be achieved through the management of travel supply or demand. Generally, the two concepts of planning and prediction are closely related (Ziebart et al., 2009). In transportation planning, while trying to maintain this balance in current conditions, it is essential to make it for the future. The balance between travel supply and demand is made for two short-term and long-term futures. Long-term planning is known as 4-steps classical models (Rasaizadi and Askari, 2020), but in short-term planning, which is the purpose of this study, making balance is done for the near future through short-term prediction (Vlahogianni et al., 2004). For this purpose, some traffic parameters such as traffic volume (Song et al., 2018; Wu et al., 2016), average speed (Zhu et al., 2019), travel time (Zhao et al., 2018; Azad et al., 2019), traffic density (Raj et al., 2016) and traffic state (Li et al., 2020, Ren et al., 2018) are predicted and provided to travelers via intelligent transportation systems. It is expected that traffic volume will be reduced during peak hours, and some travelers will shift their departure time to off-peak hours. In this study, the hourly traffic volume and hourly average traffic speed of Karaj-Chaloos road as a suburban road in Iran are predicted using big traffic data collected by loop detectors. By predicting these two traffic parameters for the next hours until next months, a more stable traffic state can be expected (Jia et al., 2018). Traffic data of this road is collected in one-hour periods for several years, so the number of observations is very high. On the other hand, many features are extracted from the calendar and traffic state. Classical models such as ARIMA (Auto-Regressive Integrated Moving Average) (Makridakis and Hibon, 1997) are not compatible enough with big traffic data (Davenport et al., 2012). Therefore, this study employs the artificial neural network (ANN) and K-nearest neighbor (K-NN) as two methods based on machine learning for short term prediction using big traffic data, and the prediction accuracies

are compared with the historical average model (Campbell and Thompson, 2005) as a benchmark. However, one of the disadvantages of the ANN and K-NN models is the lack of sensitivity analysis (Chang, 2005). In these models, the importance of predictive parameters is not determined by estimating the coefficients (Elevitch and Johnson Jr., 2020), such as statistical models (Alsolami et al., 2020). In the current study, to overcome this defect and determining the importance of the predictive features, the accuracy of the model is calculated and compared with and without each feature. Another sensitivity analysis that is discussed in this study is to determine the accuracy of short-term predictions over time. For this purpose, the test data is divided into ten days periods, and the accuracy of each of these periods has been investigated over time. By performing these two analyses, the lack of interpretability of the ANN and K-NN models, which is always considered one of the weaknesses of these models, is partially resolved. In the rest of this section, previous studies related to the short-term prediction of traffic parameters through machine learning methods are reviewed. Karlaftis and Vlahogianni (2011) have analyzed similarities and dissimilarities of statistical models versus ANN models in transportation studies; they concluded that however, researchers had applied machine learning models in transportation studies, but because of lacking explanatory power and interpretability, the machine learning methods are like a black-box. Also, this is approved by other studies (Ibrahim et al., 2019; Moreira et al., 2020). Lou et al., (2019) proposed a spatiotemporal traffic flow prediction method combined with the K-NN algorithm, which their results exhibited the proposed model can achieve a better performance compared with ARIMA, SVR, and wavelet neural network models. Li et al., (2020) proposed an algorithm based on partial least square to predict traffic state. This algorithm extracts dominant spatiotemporal features. Also, it captures day-to-day variations from collinear and correlated traffic data. Three case studies assess the performance of the proposed method. Do et al., (2019) predict traffic flow by using a deep learning-based traffic flow predictor with STANN (Spatial and Temporal Attentions). They compare STANN's prediction with support vector regression, random forest regression, feed-forward neural network,

gated recurrent unit, long-short term memory, and basic sequence to sequence predictions. This comparison shows the superior performance of the proposed model. Wang et al., (2019) predict traffic speed by using a path based deep learning approach. They determine critical paths. Then, each critical path is modelled using the bidirectional long short-term memory neural network. Under a series of scenarios, the proposed model performance is compared with benchmark methods in which the highest accuracy is achieved for the proposed method. Bai and Chen (2019) developed a deep architecture to predict the short-term traffic flow in an urban traffic network. A deep machine learning architecture consisting of three modules: a pre-training module, a classification module, and a fine-tuning module, have been proposed to predict the short-term traffic flow. With the comparison analysis over the existing approaches, the proposed model showed superiority in short-term traffic prediction, especially under incident conditions. To achieve a more accurate and robust traffic volume prediction model, Shen and Li (2013) analyzed the sensitivity of the WNNM (Wavelet Neural Network Model). They assessed different numbers of input neurons, different number of hidden neurons, and traffic volume for different time intervals. The test results show that the performance of WNNM depends heavily on network parameters and time intervals of traffic volume. Using machine learning algorithms to predict traffic parameters is not limited to these studies, and it is investigated in many studies (Tan et al., 2016; Tang et al., 2017; Wu et al., 2018; Zhao et al., 2019). Li et al., (2019) predict day-ahead traffic flow by using an optimized deep belief network. Sharmila and Velaga (2020) predict travel time by SVM and ANN. Naderpour et al., (2018) investigate on compressive strength prediction of environmentally friendly concrete by using ANN. Also, Singhal et al., (2017) use machine learning techniques for text mining problems.

The current study aims to the short-term prediction of hourly traffic volume and hourly average in Karaj-Chaloos road; that could be a useful management data which can be used for making some decision and improve the traffic circumstance. This research has carried out in Tehran, Iran, in 2020.



Fig. 1: Map of Karaj-Chaloos road

Table 1: Description of the raw dataset

Name	Details
ID	Road identification code
Mehvar_id	Route identification code
Start_time	Starting date and time of periods
End_time	Ending date and time of periods
TotalCarCounter	Hourly traffic volume
AverageSpeed	Hourly average traffic speed

MATERIALS AND METHODS

Data

In this study, hourly average traffic speed and hourly traffic volume are predicted for Karaj-Chaloos road in Iran. Fig. 1 shows the map of Karaj-Chaloos

Table 2: Description of considered features

Symbol	Description
ssn	Season
m_sc	Month in the solar calendar
d_sc	Day in the solar calendar
m_lc	Month in the lunar calendar
d_lc	Day in the lunar calendar
wd	Weekday
hr	Hour in day
d_n	Is it day or night?
hl	Is it a holiday or not?
n_phl	Number of past consecutive holidays
n_3phl	Number of holidays in 3 past days
n_fhl	Number of future consecutive holidays
t_hl	Type of holiday including national, religious, new year and weekends

road, in the north of Iran. Chaloos is a tourist city that attracts many recreational trips on weekends and holidays. The length of this spectacular mountain road is about 170 kilometers. Chalous-Karaj Road is one of the most popular roads to the north of Iran, which has so many sightseeing areas. That is why the road is sometimes mobbed with passengers during holidays.

Table 1 presents the detail of raw data. This data is collected by loop detectors vehicle by vehicle and aggregated in 1 hour periods.

An important point is the possibility of extracting more features with pre-processing of the data. By matching the solar and lunar calendars with the traffic date, a clear relation between traffic data and holidays was observed. The traffic data is not solely dependent on the holidays; also, it depends on the type of holiday. So it is essential to consider the calendar-related feature to predict traffic parameters. Aiming to train ANN and K-NN models for predicting speed and volume of traffic for the mentioned road, data of two first years is used to train models, and data of six subsequent months is used to test the accuracy of models. Table 2 introduces the extracted features and their description.

Another effective feature is related to weather and climate changes, which is not considered in this study because of two reasons. First, weather and climate indices are measured for Karaj and Chaloos cities and not for the Karaj-Chaloos road, and the distance between the considered road section and cities is far. The second reason is that weather and climate indices are measured daily for these cities

while the traffic parameters are collected hourly. However, season and months are reasonably suitable representatives for weather and climate changes. These features are examined in previous studies. For example, Dunne and Ghosh (2013) develop a weather adaptive traffic predicting model that considers the effects of rainfalls. In another study, Koesdwiady *et al.*, (2016) predict traffic flow with weather information in connected cars. The proposed method enhances the accuracy of traffic flow prediction.

Artificial neural network

ANNs are a machine learning model in which its function is similar to human brain function. One of the usages of these models is to predict time series data. Similar to the human brain, the ANN tries to identify the order and patterns of input data, learn from experiences, and provide new results based on prior knowledge. One of the widely used ANN for prediction is the multilayer perceptron. This model is characterized by a three-layered network consisting of input, hidden, and output layers. Neurons in different layers are known as processing elements. The steps that are used to calibrate an ANN model are as follows (Daniel, 2013):

Step 1: Data segmentation

To use the ANN for time series prediction, data are divided into two segments of training dataset and test dataset. The network is trained using the training dataset, and the test dataset is used to test the performance of the network. Data from March 21st, 2017 to March 20th, 2019 of Chaloos-Karaj road

used for training the ANN and data from March 21st, 2019 to September 22nd, 2019 of the same road is used for test and determining the accuracy of that network.

Step 2: Data pre-processing

Data preprocessing improves the learning process. Normalization is one of the most common methods of preprocessing data. In this method, the data are changed so that the range of data changes in the range [L, H].

Step 3: Train

ANN training algorithms are diverse. Momentum, Levenberg-Marquardt (LM), and Conjugate Gradient (CG) algorithms are the most known algorithms for training ANNs. In this study, the conjugate gradient algorithm is used to train the ANN. In this algorithm, the parameters of the ANN model are corrected to achieve minimum prediction error by using second derivatives.

Step 4: Test

The goal of the test step is to ensure that the model can predict properly. So part of the data which is not included in the training phase is used for prediction. Using RMSE (Root Mean Square Error) and MAPE (Mean Absolute Percentage Error), the accuracy of prediction can be calculated.

In the ANN model, the input of each neuron is as Eq. 1:

$$u_j = \sum_{i=1}^n w_{ij} x_i + \theta_i \tag{1}$$

Where w_{ij} is the corresponding vector of connection weights between neuron j and previously connected neurons, i. x_i is a vector of used features in the input layer and θ_i is a threshold.

By using the sigmoid function, the output of neurons (h_j) is as Eq. 2:

$$h_j = \frac{1}{1 + \exp(-u_j)} \tag{2}$$

Eq.3 shows the weight error δ_k connected to neuron k in the output layer.

$$\delta_k = (c_k - h_k) h_k (1 - h_k) \tag{3}$$

Where, c_k is the sample expectation.

The weight error δ_j connected to neuron j in hidden layers is calculated as Eq. 4:

$$\delta_j = \sum_{k=1}^q \delta_j w_{jk} h_j (1 - h_j) \tag{4}$$

Connection weights are updated as Eq. 5.

$$w_{ij}(t+1) = w_{ij}(t) + \eta \delta_j x_i + \alpha \Delta w_{ij}(t) \tag{5}$$

Where η and α are the learning rate of the ANN.

K-nearest neighbor

K-NN algorithm is a data classification approach that is nonparametric and calculates the distance between observations. This algorithm predicts the class of test data set according to the class of nearest observations. The steps that are used to calibrate a K-NN model are as follows (Neath and Johnson, 2010):

Step 1: Data Segmentation

In the K-NN algorithm, data is separated to train data and test data, just like the ANN segmentation.

Step 2: K value

K value in K-NN is a parameter that indicates the number of nearest neighbors to include in the voting process.

Step 3: Test

After calibrating the K-NN model, predictions on test data were assessed. It is notable that the maximum accuracy refers to the optimum value of K.

This paper used Euclidean distance to calculates the distance between data points, p, and q (Eq. 6).

$$d(p, q) = \sqrt{(q_1 - p_1)^2 + (q_2 - p_2)^2 + \dots + (q_n - p_n)^2} = \sqrt{\sum_{i=1}^n (q_i - p_i)^2} \tag{6}$$

Euclidean distance is a mathematical straight-line distance between two points in Euclidean space. It

would be zero for identical points and high for points that show little similarity. Euclidean distance is widely used for k-nearest neighbors because it measures the regular distance between two points in Euclidean space (Hossain and Abufardeh, 2019).

volume by using the ANN and the K-NN is evaluated. Also, the sensitivity analysis of the result is examined by showing the importance of features and accuracy changes during the time.

RESULTS AND DISCUSSION

In this section, the prediction of traffic speed and

Prediction accuracy

The ANN and K-NN algorithms are trained to predict traffic parameters, and to measure the

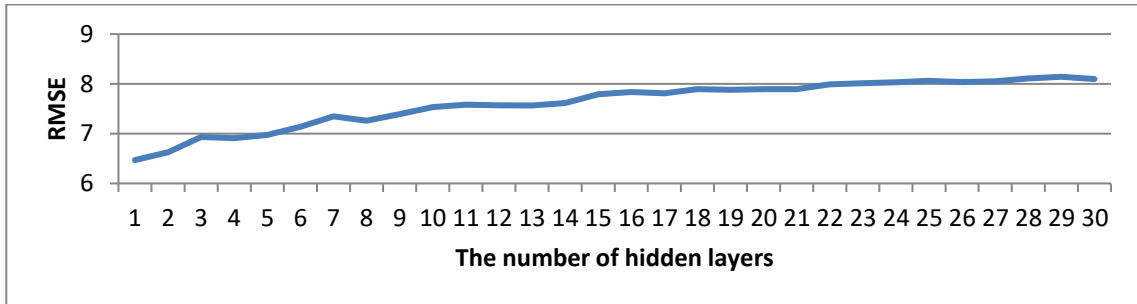


Fig. 2: Traffic speed prediction RMSE for different number of hidden layers

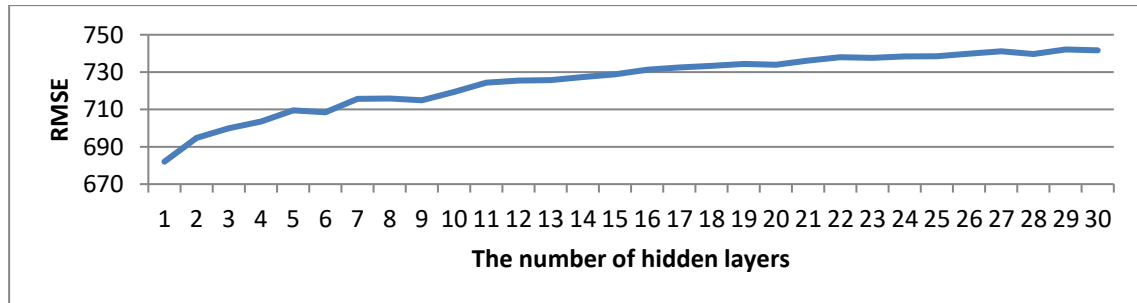


Fig. 3: Traffic volume prediction RMSE for different number of hidden layers

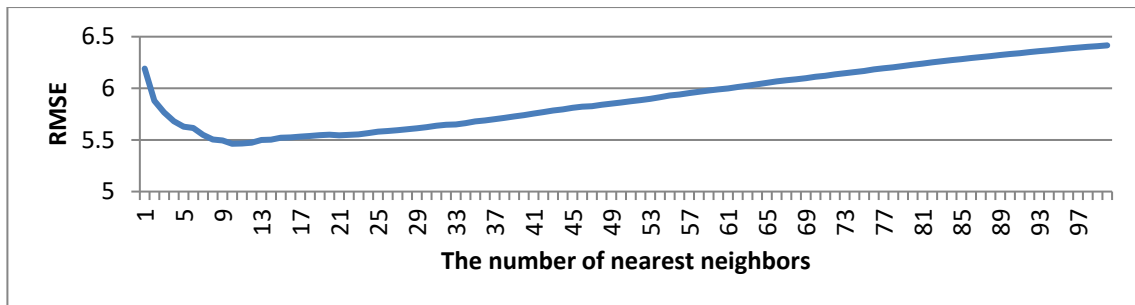


Fig. 4: Traffic speed prediction RMSE for different K

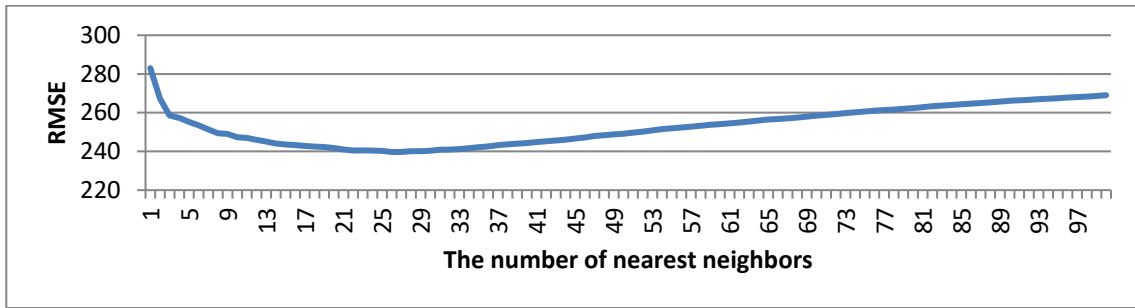


Fig. 5: Traffic volume prediction RMSE for different K

Table 3: ANN and K-NN prediction results in comparison to the HA

Predicted parameter	K-NN		ANN		HA	
	RMSE	MAPE	RMSE	MAPE	RMSE	MAPE
Hourly volume	239.7	39%	682.0	75%	963.5	>100%
Hourly average speed	5.5	9%	6.4	11%	15.9	26%

Table 4: the importance of features for predicting the hourly volume and hourly average speed

Features	K-NN				ANN			
	Volume		Speed		Volume		Speed	
	RMSE	Change percentage	RMSE	Change percentage	RMSE	Change percentage	RMSE	Change percentage
ssn	306.00	0.26	7.29	0.00	713.90	4.68	6.46	0.16
m_sc	321.80	5.44	7.69	5.49	709.47	4.03	6.65	3.10
d_sc	284.88	-6.66	6.76	-7.27	712.69	4.50	6.45	0.00
m_lc	317.90	4.16	7.89	8.23	695.30	1.95	7.10	10.08
d_lc	285.60	-6.42	6.71	-7.96	715.90	4.97	6.47	0.31
wd	335.30	9.86	7.30	0.14	733.80	7.60	6.45	0.00
hr	344.30	12.81	8.18	12.21	723.30	6.06	7.62	18.14
d_n	305.70	0.16	7.30	0.14	705.40	3.43	6.50	0.78
hl	335.20	9.83	7.30	0.14	724.20	6.19	6.47	0.31
n_phl	308.55	1.10	7.42	1.78	714.90	4.82	6.69	3.72
n_3phl	305.30	0.03	7.30	0.14	711.73	4.36	6.47	0.31
n_fhl	331.40	8.58	7.29	0.00	727.20	6.63	6.46	0.16
t_hl	305.73	0.17	7.31	0.27	713.32	4.59	6.51	0.93
All	305.20	0.00	7.29	0.00	682.00	0.00	6.45	0.00

accuracy of the predictions, Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE) are calculated. Eq. 7 and Eq. 8 show RMSE and MAPE formulas.

$$RMSE = \sqrt{\sum_{i=1}^n \frac{(\hat{y}_i - y_i)^2}{n}} \quad (7)$$

$$MAPE = \frac{100}{n} \sum_{i=1}^n \left| \frac{y_i - \hat{y}_i}{y_i} \right| \quad (8)$$

To reach the maximum accuracy on the test dataset, it is essential to find the optimum value of K in the K-NN model and the number of hidden layers in the ANN model. Fig. 2 to Fig. 5 show the prediction error of each model based on a different value of parameters.

One hidden layer leads to the maximum accuracy of traffic volume and speed prediction by the ANN model. The optimum value of K in K-NN models for traffic volume and speed prediction is

equal to 27 and 10, respectively. Table 3 presents the results of final ANN and K-NN models besides the results of the historical average (HA) as a benchmark.

The presented results in Table 3 evinces that the K-NN model has a far better performance for hourly volume prediction in comparison with the ANN and the HA. Also, the K-NN model predicts hourly average speed more accurately compared to the ANN and the HA. The ANN outperforms the HA in terms of

prediction error for both traffic volume and speed. In the next section, the effect of each considered feature on prediction accuracy is analyzed.

The importance of features

To find out the effect of each feature on prediction accuracy, the final K-NN and ANN models are trained with all the features except that considered feature. Table 4 exhibits the results of sensitivity analysis for all the available features in terms of RMSE.

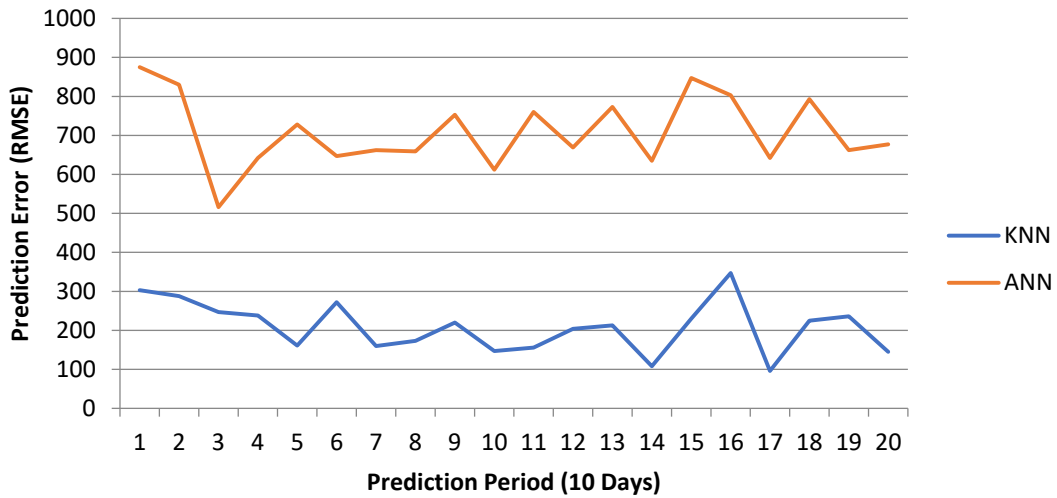


Fig. 6: Prediction error for the hourly traffic volume over the test dataset

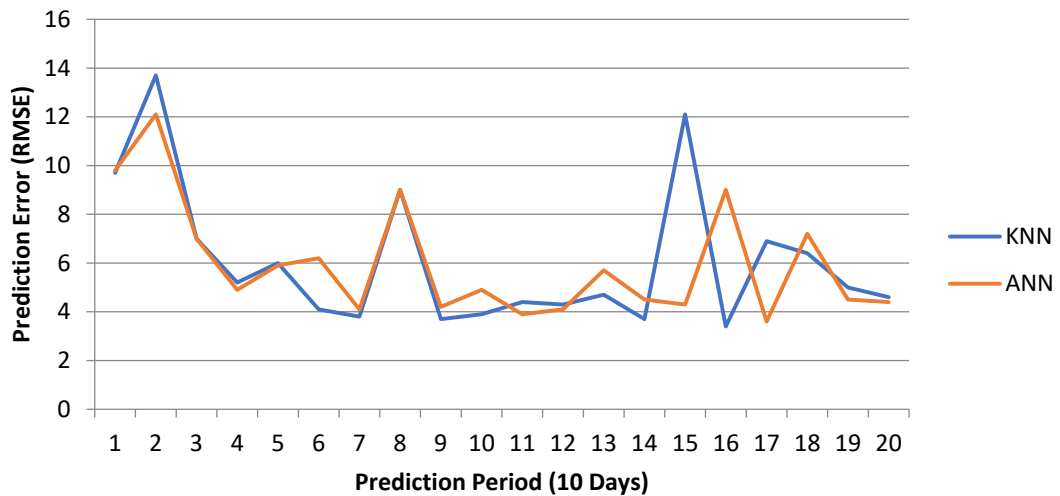


Fig. 7: Prediction error for the hourly average traffic speed over the test dataset

The ANN model, with all features, has the lowest prediction error for both traffic volume and speed. Although, in the K-NN model, removing *d_sc* and *d_lc* leads to achieving less traffic volume and speed prediction error compared to the K-NN model with all features. Based on the sensitivity analysis for the K-NN model, six features, including *m_sc*, *m_lc*, *wd*, *hr*, *hl*, and *n_fhl* have the most considerable effect on the accuracy of hourly volume prediction. If the trained K-NN for predicting traffic volume does not involve *m_sc*, *m_lc*, *wd*, *hr*, *hl*, and *n_fhl*, RMSE of the model would be 5.44, 4.16, 9.86, 12.81, 9.83, and 8.58 percent higher than the model with all features, respectively. For predicting traffic speed by K-NN, compared to the model with all features, eliminating *m_sc*, *m_lc*, and *hr* increases the RMSE by 5.49, 8.23, and 12.21 percent, respectively. For the ANN model, adding all of the features decreases the traffic volume prediction error. *m-sc*, *m_lc*, and *hr* are the essential features for traffic speed prediction by ANN, which ignoring them increase the RMSE, 3.1, 10.08, and 18.14 percent (Bratsas et al., 2020).

Accuracy changes during the time

Another critical point is the validation of predictions during the time. As this type of prediction is known as short-term prediction, it is essential to answer this question, how the accuracy of predictions varies over time and in different situations? Another sensitive analysis is done based on this question. Fig. 6 shows the hourly traffic volume prediction error in terms of RMSE within the six following months, which is separated in 10 days intervals. At the first interval of the diagram (first ten days of the test dataset), it could be seen that the calculated error is the maximum, and that is because of the new year's holidays in Iran and the occurrence of flood at that moment. This period generates an abnormal pattern of traffic in this case study. Then, in the next few months, prediction error significantly dropped due to getting back the trips to the routine. In June and July in Iran, there are many holidays, and this causes to increase the error of prediction. Lastly, by analyzing the summer results, it could be seen that the prediction error is getting stabilized, and the prediction error slightly oscillates. Besides, axiomatically is evident that the prediction error for the K-NN is significantly less than the error for the ANN in the short-term prediction of hourly

volume in this case study.

Fig. 7 exhibits the hourly average traffic speed prediction error in terms of RMSE within the test dataset. Because of New Year's holidays in Iran and the occurrence of flood at that moment, the prediction error at the first interval is the maximum. By scrutinizing Fig. 7, it could be seen that significant changes in the eighth and fifteenth-period interval, and that is because of heavy rains in those mentioned days, which directly affect traffic speed (Hogema, 1996). Finally, on the other days that have neither precipitation nor a special holiday, the prediction is moderately fluctuating.

In previous studies, the MAPE of speed and volume prediction varied between 5-30% and 15-50% (Tan et al., 2016; Tang et al., 2017; Wu et al., 2018; Zhao et al., 2019). The calculated MAPEs in this study seem to be acceptable compared to these ranges.

CONCLUSION

In transportation studies, short-term predictions aim to make a balance between supply and demand. In this paper, ANN and K-NN models have predicted the hourly traffic volume of and hourly average traffic speed in Chaloos-Karaj road, which is one of the most critical roads of Iran. For training the ANN and the K-NN models, traffic data of the two years (March 2017 - March 2019) have been used, and for determining the precision of models, traffic data of the six subsequent months (March 2019 - September 2019) have assessed. To find the importance of each feature in the prediction of the traffic volume and speed, sensitivity analysis is done, and results show that *wd*, *hr*, *hl*, and *n_fhl* have the most significant impact on traffic volume and *m_sc*, *m_lc*, *hr*, and *n_phl* have the most significant effect on traffic speed prediction accuracies. Analyzing graphs of the prediction error over the whole six months period exhibits that by increasing the number of holidays, error of prediction will escalate in abnormal conditions. Results show that the lowest RMSE and MAPE for hourly volume prediction are achieved by the K-NN model, which is equal to 239.7 veh/hr and 39%, respectively. These two metrics for hourly average speed prediction are 5.5 veh/hr and 9%. As a suggestion for future studies, to reduce the prediction error using deep machine

learning methods and compare the results to the ANN and K-NN could be helpful.

AUTHOR CONTRIBUTIONS

S. Seyedabrishami commenced the process by conceptualizing and formulating the research idea. A. Ardestani implemented the ANN training and investigated the importance of features. Data preprocessing and cleaning, K-NN implementation, analyzing the accuracy changes during the time, reviewing the literature, results interpretation and discussion, and preparing the manuscript is done by A. Rasaizadi.

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CONFLICT OF INTEREST

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

ABBREVIATIONS

<i>ANN</i>	Artificial neural network
<i>K-NN</i>	K-nearest neighbor
<i>HA</i>	Historical average
<i>RMSE</i>	Root mean square error
<i>MAPE</i>	Mean absolute percentage error
<i>ARIMA</i>	Autoregressive integrated moving average
<i>STANN</i>	Spatial and temporal attentions
<i>WNNM</i>	wavelet neural network model
<i>ssn</i>	Season
<i>m_sc</i>	Month in the solar calendar
<i>d_sc</i>	Day in the solar calendar
<i>m_lc</i>	Month in the lunar calendar
<i>d_lc</i>	Day in the lunar calendar
<i>wd</i>	Weekday

<i>hr</i>	Hour in day
<i>d_n</i>	Day or night
<i>hl</i>	Holiday or not
<i>n_phl</i>	Number of past consecutive holidays
<i>n_3phl</i>	Number of holidays in 3 past days
<i>n_fhl</i>	Number of future consecutive holidays
<i>t_hl</i>	Type of holiday
<i>w1</i>	One-way road
<i>w_b</i>	Impeded way
<i>w_ob</i>	Impeded opposite way
<i>w_pb</i>	Impeded parallel way

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CASE STUDY

Feasibility study and modeling of the concept of participatory urban management

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ABSTRACT

BACKGROUND AND OBJECTIVES: People usually welcome the spirit of cooperation to meet their needs using different methods and goals. In cities, the formation of non-governmental councils and organizations reflects this trend with the aim of creating equal social opportunities and positions (power, dignity). Participation and e-participation offers an intellectual and doctrinal framework with major applications in social, economic, cultural, and political dimensions of a country. This article aims to explore the association between participation and moral, religious, political, and psychological variables in Iranian urban management as a mode.

METHODS: This is a qualitative research and a descriptive-analytical method has been adopted for modeling.

FINDINGS: The results suggest a positive correlation between participation and four variables studied along with their applications in the Iranian urban management. Another finding of the research is the modeling of moral, religious-Islamic, political, and psychological variables related to Iranian participation and urban management toward urban governance.

CONCLUSION: The elevated social and political awareness of citizens has also led to social solidarity and the strengthening of democracy based on participation. Efforts to redistribute power in the urban system management represent another effect of social participation in urban management and urban governance in Iran. It is also experiencing the transition from urban government to urban governance with participatory, law-abiding, transparency, justice, efficiency, accountability, and decentralization approaches.

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INTRODUCTION

As a measure of governments, participation plays an important role in the equal distribution of social, economic, and political opportunities in terms of structure and function. Inequalities in social, cultural, economic, and urban sectors underline the need for participation in management in various affairs. However, social participation is not unique to humans. For example, in Surah An-Nahl of Qur'an, reference has been made to the participation of creatures such as bees in doing ordinary things (Elahi Ghomshei, 2007). From a religious point of view, limited participation is one of the main issues concerned with the application of Islamic rules (Entezarian and Sanjari, 2013). The cooperation of community members in meeting human needs and addressing social, economic and cultural problems has a religious and intellectual basis. The school of Islam considers participation as one of the requirements of normative thinking. Islam emphasizes benevolence, piety, and haste in cooperation and participation of believers. Throughout the Holy Qur'an, people are also forbidden from participating in hostilities (Elahi Ghomshei, 2007). In religious and Islamic schools, participation and cooperation is rooted in the Holy Quran and emphasis has been placed on social justice. Participation has also been a key component in non-Islamic social schools, but it faces some challenges. In this context, the main drawback is constrained participation in business management (Ortmann and King, 2007) Creative and innovative managers that advocate participation are major competitive instruments in productivity (Abdollahi and Ebrahim, 2011). Meanwhile, disregarding participatory approaches for the empowerment of managers is one of the main challenges (Vakil Alroaia and Bidakhti, 2018). Therefore, this research seeks to answer the following questions:

- Is it possible to establish a link between moral, religious-Islamic, political, and psychological variables and the participatory approach in the urban management?
- Is it possible to model and apply participation process in Iranian urban management?

LITERATURE REVIEW

Pluralism, is central to participatory governance. Also, Participation is a key dimension of governance (UN, 2018). Habermas communication theory has

provided a good theoretical basis for analyzing participatory processes in urban affairs (Piotr et al., 2020). Participation can increase the legitimacy of policy-making and endorse managerial decisions (Luigi, 2019). Limited research has explored participation and its relationship with urban management at the international and domestic levels. In this regard, Birchall (2001) conducted a study on the association between values and principles of participation and the emergence of moral, political, and psychological values. The results of this research revealed that participation leads to the creation of effective values in management and fosters participatory affairs such as planning. Len and Chong (2015) also pointed to the role of power in organizational leadership and management improvement, considering participation as a behavioral approach that is positively correlated with work environment, personal development, and the quality of a system like city and can therefore influence management. Mangi et al., (2018) explored land use management and planning as well as sustainable development in social and economic development. In their research, they also discussed the positive relationship between socio-economic affairs and development and management programs in cities, arguing that urban management goals and organization of social and economic affairs of the city can be achieved with the participation of citizens. In the context of Iran, Pilehvar (2002) looked at participatory approaches in urban management, reporting that the council system in Iranian urban management offered a valuable experience by implementing the Articles 100 to 106 of the Constitution. To him, the formation of the first Islamic city councils in 1998 marked the foundation of urban management and the crystallization of a democratic process in urban management, which was unprecedented in the Islamic Republic of Iran. Nouri and Nouripour (2013) examined the application of conscious behaviors in participation in Boyer-Ahmad province. The results of their research showed that citizens are not eager to participate in planning. However, in terms of intention and readiness to engage in such works, more than 50% of participation in planning and management is promising. Ansari et al., (2016) studied the effect of religiosity on participation, reporting a positive relationship

between religiosity and participation. To do so, they evaluated the religious and Islamic values of subjects in their decision for social participation in important matters. In a similar study, Meshkini *et al.*, (2017) looked at the relationship between urban justice and social capital in the city of Ferdowsi. The results of their research showed that urban management is significantly and directly related to the fair distribution of urban services. A greater participation of citizens in the urban management system indicates fair urban services and distribution. In another study, Soltan nejad *et al.*, (2018) explored the positive relationship between citizens' behavior and organizational management in Kerman. They concluded that optimal organizational management is a function of psychological empowerment and behavior of citizens, which can ultimately reinforce participation in the management of urban affairs. Therefore, participation can be considered an important and democratic principle in organizational and urban management of Iran with more than two decades of experience. In these two decades, the strategy of e-government was considered in the law of the fourth, fifth and sixth programs. Therefore, through this, e-participation and e-democracy have been considered by the government as a valuable global

experience. E-participation is usually considered part of e-government. E-participation refers to "those participation initiatives that are mediated through ICTs". Therefore, e-participation is an important tool for governments to achieve growth and development. Because e-participation is one of the accountability mechanisms of governments in the management process. (UN, 2019). At present, some strategies of smart city, e-city and e-services have been in this direction to finally lead to urban governance and its principles such as participation, transparency, legitimacy, efficiency, justice and decentralization. The latest study by Le Blanc at the UN department of economic and social affairs on e-government and e-participation has shown that government and e-participation contribute to the goals of sustainable development and smart management (Le Blanc, 2020). This article aims to explore the association between participation and moral, religious, political, and psychological variables toward management and urban governance as a model. The current study has been carried out in Bojnord in 2020.

MATERIALS AND METHODS

This is a qualitative research and a descriptive-analytical and descriptive-argumentative method

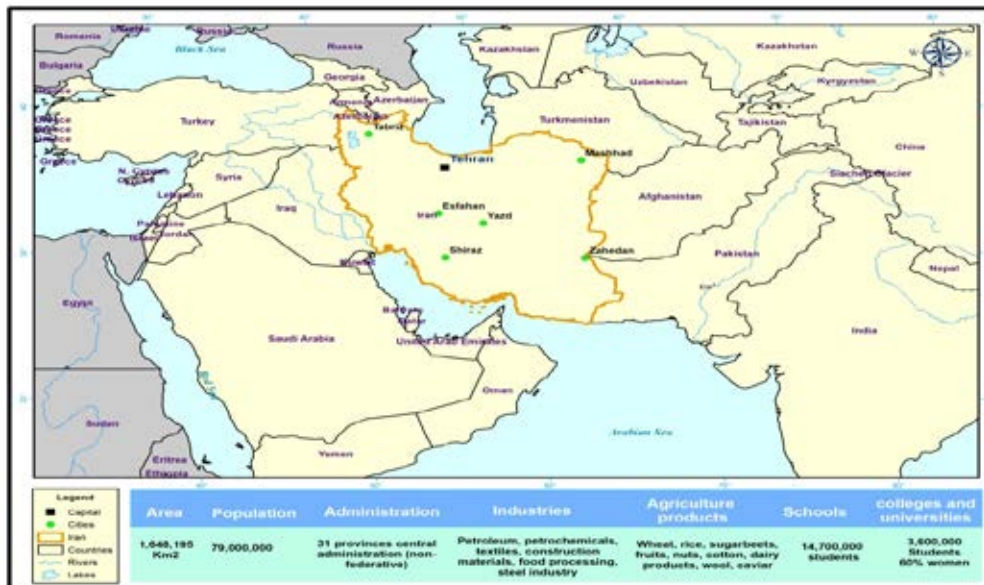


Fig. 1: Basic statistics of Iran (Pilehvar, 2020)

has been adopted. The research variables were selected based on their importance and relevance to the concept of participation and urban management. To analyze findings, first the research framework was developed by researching valid sources and reviewing different schools of thought, theories, and models. In the next step, based on four moral, religious-Islamic, political, and psychological variables, the association of these variables with the participation index was examined to develop the final model for the management of Iranian urban system. In the last step, the research variables of modeling and its analysis are presented.

Research area

Iran is a country that sits on the southwest Asia, with population of 79 million, as shown in Fig. 1.

At present, Iran has 1245 cities and 8 cities with a population of more than 1 million people and is known as a middle-income developing country (Pilehvar, 2020).

Theoretical Foundations

Social participation

The United Nations Development Program defines social participation as active involvement of users in time and resources, decision-making and actions to achieve a desirable development goal (Esmail Asadi and Godarzi, 2018). On the other hand, social participation can be considered as the mental and emotional conflict of individuals in a group that spurs them to share responsibilities in achieving each other's group goals (Hosseini et al, 2012). Participation is a complex concept that depends on a wide array of variables with different relative weights (Hashemian et al., 2013). In general, the factors affecting social participation can be divided into two categories: internal variables and variables derived from the external environment (Alizadeh Aghdam et al., 2013). The development of civil society relies on the process of internalizing and institutionalizing public participation. Accordingly, three processes and strategies have been defined to strengthen social participation:

- A) Elaborating on the value of participation
- B) Institutionalization and reduction of social disorders
- C) The development of civil society, through the formation of unions and guilds (Rajabi, 2011)

When the central government interferes with the affairs of local communities, the actual needs of these communities would be dependent on the central government and the local people would lose their power and facilities (Turner, 2005). Hence, by classifying the types of participation in his famous table, Turner (2005) has made a significant contribution to the formation of the participation theory (Alizadeh et al., 2014). A city represents a complex form of human community that is home to rural communities. In an urban society, there is a need for social discipline to establish the foundations of democracy and social justice as the law is institutionalized. On an urban scale, social participation marks a step towards growth and development and the dismantling of barriers through the implementation of urban development projects (Rydin and Holman, 2004). Therefore, several indicators have been emphasized for citizen participation in urban management:

- 1- Participation in urban affairs is a goal per se. (meting out justice).
- 2- Participation is a valuable learning process that helps people deal with various issues and problems in their lives. (Boost self-confidence).
3. Participation makes the project more effective by meeting the real needs and needs of the people.
- 4- Participation and cooperation increase the productivity of a project by stimulating people's desires for investors.
5. Participation strengthens national unity and cohesion (social cohesion).
- 6- Participation strengthens the sense of citizenship and develops a participatory culture (strengthening the sense of spatial belonging).

People's participation plays an essential role in strengthening the proper management of the urban system by converging in the institutionalization of civil rights. Thus, social participation provides an effective strategy for decentralization and distribution of social and political capacities in each country.

Participation from the perspective of social schools

Social participation is a system of mutual aids and universal values for human beings. From a social point of view, the core of participation is the formation of family, and its evolutionary process is closely interlinked with specialization

and delegation of social works, with the fulfillment of collective through the practice of participation has being high on agenda (Akhtar Mohagheghi, 2006). The participatory approach was developed in response to challenges mounted by the industrial system in Europe (Taleb, 2012), and this idea swiftly spread to Asia in the twentieth century. From a global perspective, four schools of thoughts have provided valuable insights into participation (Sabbagh Kermani and Aqeli, 2004):

- A. The Commonwealth School, which underscores the role of participatory movement in socio-economic affairs in the form of a limitless system in the development process, which is considered as an idealistic school for the discussion of participation.
- B. The capitalist school, according to which participation and participatory approach is based on a materialistic and profitable basis, considering the participatory system as a special type of capitalist system.
- C. The socialist school that gives participation to public credit, considering the government as the system leader and the participatory system as a subset of that system. In this school, the participation index is a process for transition from capitalism to socialism.
- D. The participatory school, in which participation is an independent variable that accompanies private and public sectors. This school has presented a more valid and acceptable theory in today's society.

Participation and urban management

At present, all socio-economic affairs in the world are connected to urban programs (Mangi et al., 2018). Cities are the embodiment of man-made environments, the most concentrated development areas, the densest form of human land use and the most compact spaces for human needs, and they are constantly expanding (Dutta, 2012). A city is the reflection of human activities where various social, cultural, and economic issues are founded upon participation and a cultural perspective that has undergone massive changes in its social structure since the Industrial Revolution (Beumer, 2010). Still, they continue to grow more and more complex (Giddens, 2009). Today, cities are of great

importance in two respects: as a gathering place for a large group of people and as the main player in the national economy (Ziari et al., 2009). On the one hand, this trend has intensified the rise of social issues in urban communities (Forrest and Kearns, 2001), and on the other hand, it has led to a decrease in participation and social solidarity (Ahmadinejad Rashti et al., 2014). This trend has also affected the competition and division of social activities in the city in the process of urbanization (Afrough, 1998). From this perspective, the city is a social space that, as a result of competition and division of labor, strengthens values such as responsibility and solidarity in the process of participating in the urban system.

Therefore, by modeling in urban management, the concept of participation can be analyzed and explained. Thus, recognizing the material dimensions (distribution of facilities, wealth, economy, etc.) and spirituality (justice, etc.) of a city shows the importance and level of citizen participation in the process of urbanization and urbanization.

RESULTS AND DISCUSSIONS

Moral Values

The participatory approach is one of the best systematic popular mechanisms in social activities (Nouri and Nouripour, 2013). Participation describes a sort of collective action utilized in various types of human relations and is not merely limited to a particular religion or region (Razzaqi, 1992) Also, in all divine religions, special emphasis has been placed on participation (Sabbagh Kermani and Aqeli, 2004). Since the dawn of creation, humans have used the spirit of participation to meet their needs, associating themselves with values and principles such as honesty, care, interest, and social responsibility. Thus, some recognized values of participation have gained global acceptance as moral values (Birchall, 2001). Fig. 2 shows the positive and direct relationship between moral variability and participation in the form of important criteria such as honesty (truth in purpose), openness (possibility of participation), care (self-control), interest (participation), and social responsibility (participation) as the pillars of the relationship between the two components.

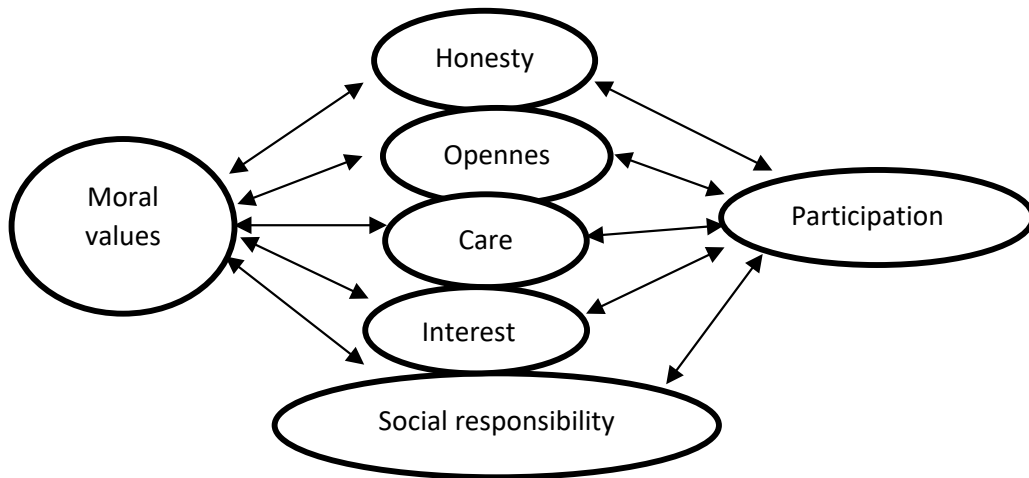


Fig. 2: Mutual relationship between moral values and participation

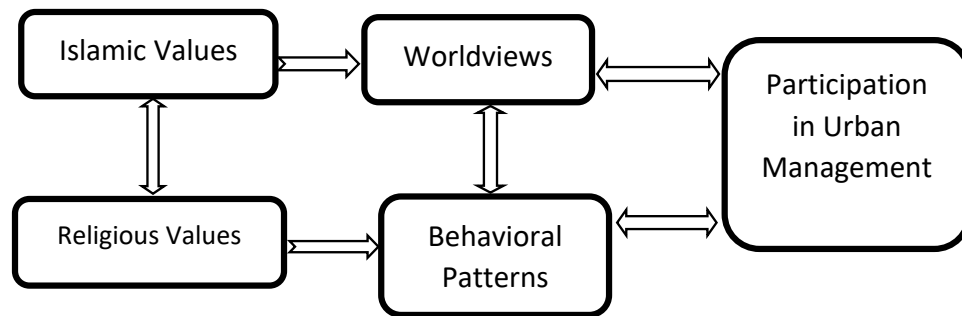


Fig. 3: The association of religious and Islamic values with participation in urban management

Religious values and Islamic views

In the Islamic school, the establishment of convergence centers like unions and councils has been stressed as a way of meeting the needs, empowering human groups, and creating equal social opportunities. In this way, people in the community can access scarce resources such as wealth, power, and prestige through participation. Islamic and religious teachings emphasize the paying attention to the spatial justice of services, piety, and participation in the urban planning system, architecture, and urban management. Islamic values have a bearing on the worldview of citizens and their behavioral models, the results of which is the interaction of worldviews on behavioral patterns and ultimately the inclusion of participation

in the planning and urban management system (Baran and Behro, 2017). Thus, there is a direct and positive association between religious and Islamic values and participation in the management of the urban system, as shown in model and Fig. 3.

Political values

In this research, political values in the analysis of governance, participation and urban management have been considered appropriate. Political values are one of the accepted principles in all social and political schools worldwide. The fact that these values are in line with the demands of citizens and consistent with psychological and moral values have something to do with their global acceptance (Birchall, 2001). The Researcher’s analytical findings

show that there is a significant relationship between political values and four indicators of equality, democracy, responsibility and social integrity, each of which contribute to the emergence of values and therefore politics. Political values are linked to sociology, which contributes to good governance.

And good governance leads to successful leadership (Mirahmadi and Mirahmadi, 2018). Leadership as the main process of management along with politics helps to create value and participation in the political and managerial arenas. Political values in the society also have a direct effect on the sustainability of the above four indicators, and therefore a positive correlation with participation can be established (Fig.4).

attention to psychological values in management and participation is its profound impact on attitudes. Each attitude affects three behavioral, emotional and cognitive factors in the individual and the manager. And the above factors appear with honesty, transparency, intimacy, merit and tolerance as capital and psychological values (Ghanbari Nasrabadi et al., 2019). It also shows the psychological values in the management and participation process of being active or passive on the one hand and being constructive and destructive on the other. Therefore, psychological values have been considered as an important factor in the analysis of this research. In fact, psychological participation represents a behavioral practice in the society and in any organizations. That is, from a psychological viewpoint, there is a positive correlation between workspace and the role of organizations and

Psychological dimensions

One of the important reasons for paying

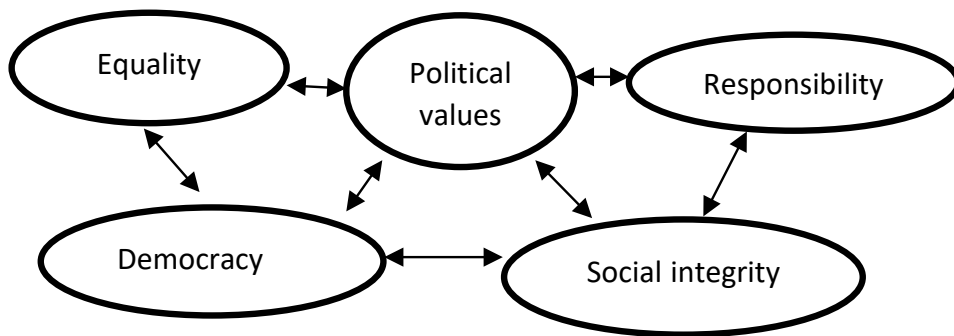


Fig. 4: Mutual relationships between political values and participatory principles

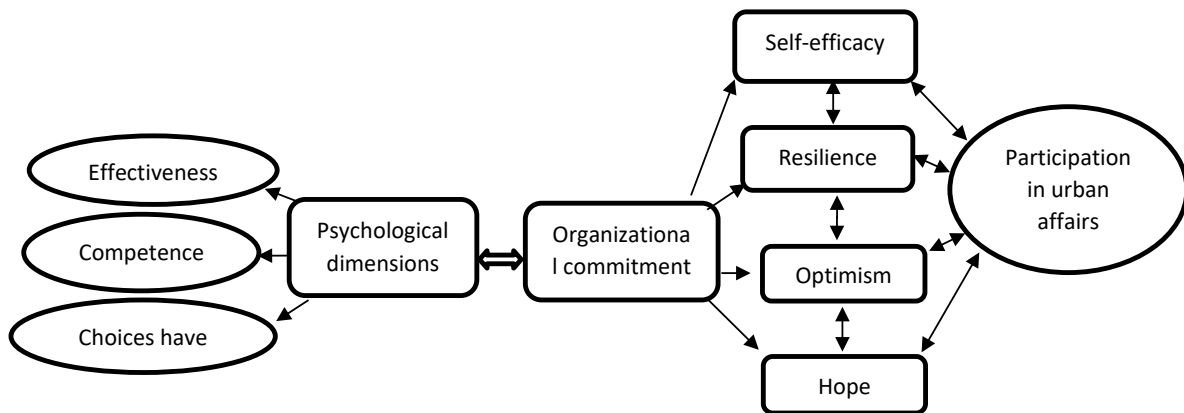


Fig. 5: Relationship between psychological dimensions and participation

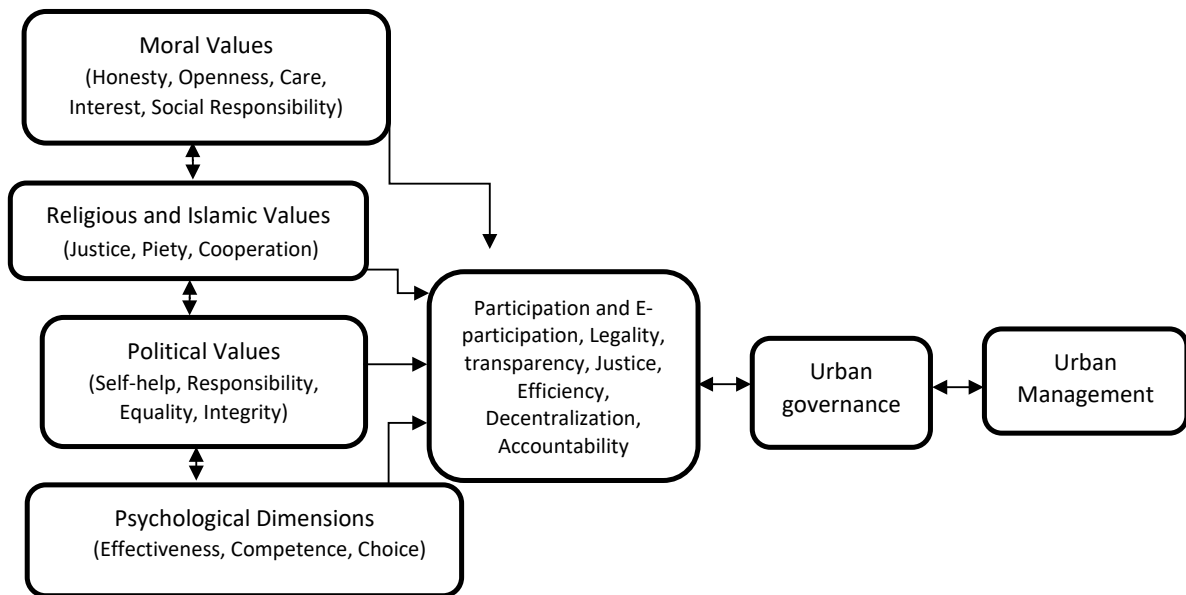


Fig. 6: The relationship between values affected by participation in Iranian urban management

individuals in the survival of system (community, city, etc.) (Lan and Chong, 2015). There is, however, little emphasis on empowerment as a key variable in promoting managerial performance in any organizations (Chiang and Hsieh, 2012), particularly in light of the effect of psychological dimensions on improving the performance of the organization and the system (Ibrahim et al., 2016). This is mainly due to the intrinsic nature of empowerment (Soltan Nejad et al., 2018), which can directly lead to effectiveness (Chiaburu et al., 2017). Therefore, psychological empowerment, commitment, loyalty, and trust in the target community will yield desired results (Yadav and Rangneker, 2015). This ultimately promotes commitment and trust in participatory behaviors (Akgunduz and Sanli, 2017); meaning that psychological values and dimensions such as effectiveness, competence, and choice are related with citizens' participatory behaviors (Memarzadeh et al., 2012). Fig. 5 shows the association of psychological dimensions and participation in the process of organizational commitment.

Participation modeling in Iran's urban management

After the 1979 revolution, according to Articles 100 to 106 of the Constitution, the council

management system in the administration of Iran was recognized as important. The institutionalization of the council management system has drawn people's attention to social participation in advancing the goals of social justice. The formation of the Islamic Council of Cities in 1998 marked a new experience and approach in Iran's urban management, which is rooted in the spirit of citizen participation and cooperation. These councils have played an important and effective role in urban management, creating suitable grounds for the improvement of the living conditions of the citizens. Efforts to protect the public interests, and reduce inequality and social injustice in the urban space are important tasks of the city's Islamic councils in Iran. Therefore, the participation and formation of Islamic city councils in urban management of Iran offers a practical model. The results of a study about the formation of Islamic city councils in Iran have shown that public participation of citizens has a positive effect on the structure and functioning of cities and contributed to more appropriate distribution of facilities (Tashakor, 1999). This action can cement justice in the distribution of urban services and strengthen the capacity to achieve goals (Hakli and Minca, 2009). According to Article

7 of the Constitution of the Islamic Republic of Iran (Fathi and Kohi esfahani, 2018), councils are a pillar of decision-making and administration of the country's administrative affairs. Cities can also have public participation through political, economic, and social participation. Therefore, the Islamic councils of the city and the council system management are a manifestation of citizens' participation in advancing urban development policies and programs in Iran. Studies show that indicators of fair distribution of urban services such as equality, balance, legality, and fairness are related to a major component of the council system and urban management in Iran (Meshkini *et al.*, 2017). Therefore, the most obvious mechanism for citizens to participate in Iranian urban management is to be active and effective in developing and presenting plans and programs. This could be achieved by sharing ideas on projects (Hui, 1998) and attending debates, training workshop, and advisory committee (Turner, 2005). The participation and cooperation of citizens in the establishment of the Islamic Council in cities has balanced expectations and demands of people from the government, institutionalized the involvement of people in diverse scenes, changing public discontent into political satisfaction, and strengthening national identity and solidarity (Tashakor, 1999). In this regard, the main priorities of participation in Iran's urban management are as follows:

1. Increasing the share of public participation in the urban management.
2. Taking a step towards decentralization of management in cities, especially administrative concentration.
3. Balancing the proportion of municipal organizations to council management.
4. Establishing a more efficient system, problem-solving strategies and advancing goals of urban systems.
5. Legalizing requests by institutionalizing participation in the planning process (Banerji, 1999).

The results of this trend in the urbanization and urbanization system have led to the emergence of new approaches by combining thinking and action. It seems that urban planning and management in recent decades is moving towards good governance and the transition from management and urban

government to urban governance is being experienced.

In urban governance according to UN indicators, participation, legality, transparency, justice, efficiency, decentralization and accountability are important principles of urban management in the new conditions (Rahnama, 2010). With this process, the Iranian government assumes the role of facilitator and facilitator of the growth and development of cities and encourages citizens to make decisions and policy on urban affairs through the tools of participation. It seems that urban management in Iran has established a significant relationship with regard to the principles of urban governance and other moral, religious-Islamic, political and psychological values of society.

From the above analysis and the relationship between the principles of urban governance and selected values in this study (moral, Islamic, political and psychological) can be presented a participatory model in urban management. Fig.6 shows a model and the relationship between moral, Islamic, political and psychological values as an infrastructure of participation on the one hand and the process of urban management and governance as a desirable strategy in the process of urban planning and management in Iran on the other hand. Considering this model in Fig.6 shows how values affect patterns of behavior and participation in management, and the principles of urban governance in relation to community values can be a valuable strategy in urban management.

CONCLUSION

In this research, the effect of assessed variables (moral, Islamic, political, and psychological) on urban participation and management in modeling and the relationship between indicators and variables have been evaluated. The results suggested that participation through assessed variables has directly correlation with urban system management. As for the management of councils in the urban system of Iran (city council and mayor), encouraging people to participate in various social, cultural, economic affairs of the city has strengthened the pillars of justice and social participation. Another outcome of this research is concerned with raising public awareness and their political knowledge of government programs

in the field of urban management by examining participation in the Iranian urban management model. That is, if the government pursues long-term plans (e.g. implementation of e-government, etc.) in the urban context, people can be informed about these plans through their representatives (city councils) with the participation of the government, councils, and people. The persistence of this process will be an effective step in the realization of civil society and social justice. Entering decision-making areas and urban development programs are other ways to participate in the urban management. This has contributed to improved quality of life and social satisfaction. The elevated social and political awareness of citizens has also led to social solidarity and the strengthening of democracy based on participation. Efforts to redistribute power in the urban system management represent another effect of social participation in urban management in Iran. People's participation has also affected material aspects (the reduction of social inequality, profitability and concentration of wealth) and spirituality (strengthening the spirit of brotherhood and cooperation), preparing the grounds for the spread of social justice and social capital in the city. Also, the management of cities and metropolises in Iran is experiencing a transition from urban governance to urban governance. This process can help democratic methods in management and strategy from the down to up by participation and E- participation. Therefore, it is suggested that the down to up management strategy in the form of promoting the culture of neighborhood management and councils will always be considered by the system and the government. Also, with the institutionalization of the participation culture, the participatory approach constitutes a social and religious capital in the urban management of Iran.

AUTHOR CONTRIBUTIONS

A.A. Pilehvar performed the literature review, experimental design, and analyzed and interpreted the data, prepared the manuscript text, and manuscript edition.

CONFLICT OF INTEREST

The author declares 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 author.

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ORIGINAL RESEARCH PAPER

Assessment of how Ride-Hailing services affect individual's travel mode choice in urban transportation

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ABSTRACT

BACKGROUND AND OBJECTIVES: Ride-hailing is a term to describe booking rides and paying for car services through a smartphone app with a Transportation Network Company. As an innovation in the ride-hailing investigation in Iran, this paper is sought to analyze the influence of individual's demographic characteristics on their travel mode choice between ride-hailing, traditional taxi and private car. For this purpose, questionnaires in six different statuses have been designed, and 414 questionnaires have been completed in 22 districts of Tehran metropolitan region.

METHODS: To check the utility of choosing private car and traditional taxi compared to ride-hailing, on short, medium, and, long travel distances with commuting and non-commuting purposes in the peak hours of morning and evening, the six multinomial logit models have been done by considering the ride-hailing option as reference alternative, and the private car and traditional taxi options as the first and second.

FINDINGS: Initially, six logit models were generated, which fitted models are all appropriate. All of the variables used in these models in choosing private car or traditional taxis compared to ride-hailing in different models were statistically significance. But, gender, household dimension, and individuals' educational level didn't affect the individual's choice.

CONCLUSION: The results showed that ride-hailing is more acceptable to younger people, and high-income people attract more to it. Therefore, ride-hailing services can be considered as a wealthy phenomenon and for the young generation. In addition, given the 67% response of individuals incline to use ride-hailing services in a shared way, because of the interest of individuals to use this mode of travel due to its lower cost in some situations, which can be considered as a separate mode of transportation.

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INTRODUCTION

Ride-hailing is one of the most rapidly growing forms of shared-mobility services. These services are also known as on-demand ride services, or Transportation Network Companies (TNCs), such as Uber and Lyft in the international transportation markets (Alemi *et al.*, 2019). These are a type of taxis, which offer personalized vehicle services. Ride-hailing, like traditional taxis, serves passengers to urban trips; but the main difference between them and traditional taxis is in the way that passengers request their travels, which is done through internet-based applications with GPS technology in smartphones. In this regard, ride-hailing services, while simplifying fare payment through online payment within the application, provide passengers with instant travel information, including the travel time within the vehicle and the waiting time for a taxi to arrive (Young and Farber, 2019). These services also have dynamic pricing, so that the price varies depending on the amount of route traffic, weather conditions, the request time, and other similar factors. The dynamic price of the ride-hailing can increase the tendency of people to request a taxi, which sometimes may even be lower than the usual and expected price (Rayle *et al.*, 2016). These applications minimize the chain which links a passenger to a driver by connecting the passengers to a network of available drivers (Contreras and Paz, 2018). Ride-hailing drivers are generally non-professional drivers (drivers who have other main occupations, and ride-hailing in their spare time with these applications as a part-time job) (Alemi *et al.*, 2018). Ride-hailing, like any other mode of transportation, has positive and negative consequences throughout the city. The negative consequences of this system are the competition with public transportation and reduce the use of public transportation, competition with active transportation systems (walking and cycling), increase the single-passenger car travel, and as a result, increase traffic congestion and greenhouse gases emission. But the positive consequences of this system are the replacement of this method instead of a private car in order to reduce the utility of owning a private car and play a complementary role for other modes of urban transportation, especially public transportation by providing these services and filling existing gaps in this area at the times and places where the available public transport services

are weaker than required (Habib, 2019). There are a limited number of studies that investigate the behavior of urban passengers in choosing the travel mode in the field of ride-hailing services alongside other modes of urban transportation. (Rayle *et al.*, 2016) compared Uber and Lyft ride-hailing services to the traditional taxi industry but focused more on the features of the users of these services. They regarded ride-hailing as both a competitor and a complement to public transportation. According to them, ride-hailing is a hidden demand in urban transportation, and its users are much younger and more educated and much less inclined to own a private car than traditional taxi users. These findings were also confirmed by (Clewlow and Mishra, 2017), who compared ride-hailing passengers to other people in seven major US cities. The results of this study showed that ride-hailing users are younger, more educated, and have above-average incomes. In addition to traditional taxis, ride-hailing may be an alternative to other modes of transportation; in fact, they may deviate users from more sustainable systems such as public transportation and active transportation systems. This issue has become one of the criticisms of ride-hailing services and has made these services considered harmful to the goals of sustainable urban transportation. For example, the consequences of Uber's entry into urban transportation in major US cities showed a 6% reduction in public transportation use (Clewlow and Mishra, 2017). In addition to the above, there are other factors involved in choosing ride-hailing services as a way for people to travel, among them can be mention to safety and cost as the main reasons for deciding to trip via ride-hailing (Lavieri and Bhat, 2019; Souza Silva *et al.*, 2018). Often, the presence of children or the elderly in the household has a negative impact on the use of ride-hailing (Sikder, 2019). Also, ride-hailing does not have the problems of a private car, such as searching for a parking lot and driving while drunk or tired (Young and Farber, 2019; Rayle *et al.*, 2016). Furthermore, these services often attract people who want fast and affordable transportation and are looking to move directly from one place to another (Tang *et al.*, 2018). According to what was mentioned; in metropolitan regions, choosing a vehicle for traveling has always been one of the challenges facing people. Every day, people face the challenge of choosing the mode of available transportation for trips with different

purposes. This step is called the modal split or choose a vehicle for travel. The modal split step is the third step of urban transportation system models, which also called four steps models. The four steps of these models include trip generation, trip distribution, modal split, and network assignments (Goulias, 2002; Hensher et al., 2015). The four-step process is one of the most common methods of demand analysis in transportation planning. The modal split step plays a crucial role in public transport policy-making due to its manageable variables (Ortúzar and Willumsen, 2011). Despite increasing the commercial value of ride-hailing service provider companies and their effective role in urban transportation, limited information still exists about the type of people who use ride-hailing services, likewise, the purposes and distances of the trips made with this new mode of transportation. Besides, its impact on other modes of transportation, including traditional taxis and private cars, remains extensively unknown in many aspects. This issue has been considered as the main gap and the main sentence in this research. In addition, the main question of this research was who used the ride-hailing option compared to traditional taxis and private car for what distances and what purposes,

and who did not? In this direction, for the first time in Iran, in this article the alternatives of Ride-hailing (RH), Traditional Taxi (TX; named as *taxi khatti* in Iran) and Private Car (PC) in the existing transportation system in the Tehran metropolitan region have been studied. Eventually, a road map for expressing the article structure presented in Fig. 1. That is the innovation of this study and also, one of the first ride-hailing studies in Iran. The current study has been carried out in Tehran metropolitan area in December 2019.

MATERIALS AND METHODS

Discrete choice method

The principal hypothesis of discrete choice models is that in the encounter with the situation of choosing, individual preferences for each option can be described by measuring the utility associated with each option. This tool is a function of the characteristics of the options and the decision-maker. It is assumed that the decision-maker chooses the option from which he receives the highest utility. However, the degree of utility is not directly observable or measurable. The discrete choice theory also assumes that the decision-maker

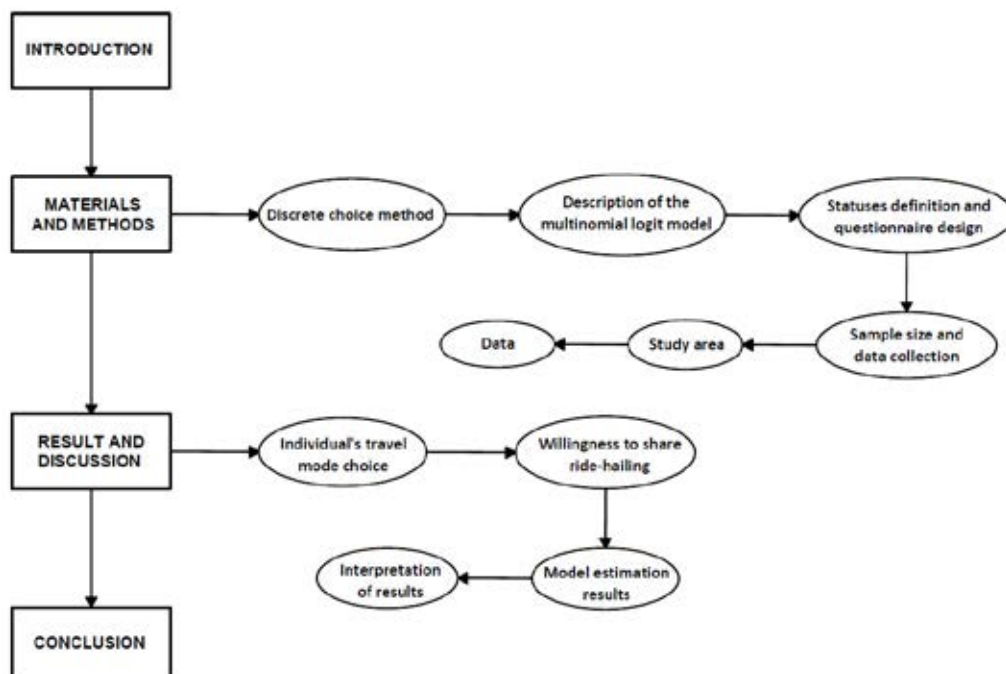


Fig. 1: Road map of paper

is faced with a set of options that he can choose only one of them, not some of each. Ultimately, the utilities are modeled stochastically, meaning that the selected models can only offer the probability of choosing options and cannot pick them directly (Ben-Akiva and Lerman, 1985; Sheffi, 1985; Antolín, 2018).

Description of the multinomial logit model

The choice of transport mode is probably one of the most important classic models for modal split in transport planning. This is because of the key role played by types of transport modes in policy making. (Ortúzar and Willumsen, 2011). Hence, a multinomial logit model (MNL) has been used to study who choose each of the mentioned modes in each status and figure out the mode share in this research. The multinomial logit models (MNL) are used when the dependent variable is nominal (a set of classes that cannot be meaningfully ranked). The existence of these three hypotheses together leads to the development of a well-known structure called the multinomial logit model (Ben-Akiva and Lerman, 1985):

1. The error components in the logit model have a Gumbel distribution.
2. The error components are distributed independently and uniformly in all alternatives.
3. The error components are evenly and independently distributed to all individuals or observations.

In discrete choice modeling, the utility function defined for decision-maker n is represented as Eq. 1. To select option i from the set of available choices. In this approach, stochastic modeling of each option for each individual has two components, a definite component and a random component. A variable is random, in which (Train, 2009; Tutz, 2002):

$$U_{in} = V_{in} + \varepsilon_{in} \quad (1)$$

In the above Equation, U_{in} is the perceived stochastic utility of option i for the n th individual, V_{in} is the measurable and predictable (systematic) utility of option i for the n th individual, and ε_{in} is the random component of error for option i and n th individual. According to logit models, by obtaining the utility function of each option (alternative), the probability of selection for each option is calculated according to Eq. 2 (Train, 2009; Tutz, 2002):

$$P_{in} = \frac{e^{U_{in}}}{\sum_{j=1}^k e^{U_{jn}}} \quad (2)$$

In the above Equation, P_{in} is the probability of choosing the i th option (alternative) by the n th individual, U_{in} is the utility of the option (alternative) i for the n th individual, and U_{jn} is the utility of other options (alternatives) for the n th individual. The multinomial logit model is a generalization of the simple logit model (binary) with the difference that in the simple logit model, the dependent variable takes one of the two values 0 or 1, but the dependent variable in the multinomial logit model can have more than two values. For example, suppose the variable $Y \in \{1, 2, \dots, k\}$ is a dependent variable of the model that takes one of the numbers $1, 2, \dots, k$ for each set which has k member. For example, if the variable Y is the vehicle chosen for travel by one of the modes of a private car, traditional taxi, and ride-hailing the value of k is equal to 3. By considering the k th option (alternative) as the reference option (alternative), Eq. 3 is expressed as follows (Train, 2009; Tutz, 2002):

$$U_{in} = \log \left(\frac{P(Y = i)}{P(Y = k)} \right) = \beta_{0i} + \beta_{1i}x_1 + \dots + \beta_{qi}x_q + \varepsilon, \quad i = 1, 2, \dots, k - \quad (3)$$

In the above Equation, U_{in} is the utility of the i th option (alternative) compared to the k th option (alternative) for the n th individual, x_1, \dots, x_q are independent variables from 1 to q , β_{0i} is the constant coefficient of the i th option, $\beta_{1i}, \dots, \beta_{qi}$ are coefficients of the independent variables from 1 to q for i th option (alternative), and ε is the random component of error.

Also, after fitting the logit model, an index called McFadden's R^2 (Pseudo- R^2) can be used to measure the goodness of fit of the model; the value of this index varies between zero and one. The closer this index is to one, the more the model matches the reality and the higher goodness of fit; conversely, the closer this index is to zero, the lower the goodness

of fit. In the logit model, *McFadden's R²* statistic is obtained from Eq. 4:

$$McFadden R^2 = \rho^2 = 1 - \frac{LL(\beta)}{LL(0)} \quad (4)$$

In the above Equation, $LL(0)$ is the log-likelihood of the reduced model and $LL(\beta)$ is the log-likelihood of the full model. In other words, $LL(\beta)$ represents the maximum log-likelihood function calculated by Eq. 5:

$$LL(\beta) = \log(L(\beta)) = \sum_{n=1}^N \sum_{j=1}^J [\delta_{jn} \times \ln(P_{jn}(\beta))] \quad (5)$$

In the above Equation, $L(\beta)$ is the maximum likelihood function, P_{jn} is the choice probability of the j th option (alternative) by the n th individual and δ_{jn} is also an index that if the n th individual chooses the j th alternative is equal to one, otherwise, it is zero. Moreover, in the interpretation of the goodness of fit of the logit model, according to Eq. 4, (McFadden, 1974) states that, for example, if *McFadden's R²* is between 0.2 and 0.4, it is entirely appropriate. Many empirical studies have also found that values greater than 0.1 are appropriate (Cohen et al., 2002; Hu et al., 2006).

Statutes definition and questionnaire design

For conducting this research, statistical modeling has been used. For this purpose, the *nnet package* has been used for modeling in the *R Studio* programming environment, and the multinomial logit model has been used with the maximum likelihood method in 6 statuses; In these 6 statuses, short, medium, and long-distance trips with commuting (work and study) purposes in the morning peak hours and non-commuting purposes (recreation, shopping, social, etc.) in evening peak hours, are separated from each other. The criteria for classifying travel distances and determining the peak time in the morning and evening are also presented in the following. In this study, trips less than 5 km are considered as short-distance trips, trips between 5 to 15 km are considered as medium-distance trips and trips longer than 15 km are considered as long-distance trips in urban trips (Agyemeang, 2017). Finally,

the route from Sanat Square to Vanak Square as a short-distance route (5 km), Sanat Square to Seyed Khandan Bridge as a medium-distance route (12 km), and Sanat Square to Resalat Square as a long-distance route (18 km), are considered. Besides, according to Col. Abedi, Deputy Chief of the Greater Tehran Traffic Police, in an interview with ISNA News Agency: "Urban traffic reaches its peak between 7 and 8 a.m., in the morning. Also, in the evening, between 6 and 8 p.m., we see a high volume of traffic on city routes." As a result, in this article, the morning peak time is considered between 7 to 8 a.m. and the evening peak time between 6 and 8 p.m. Finally, by preparing the relevant surveys, according to the appendix at the end of the article in which 6 statuses of the article, the identification of way that individuals choose from the alternatives (ride-hailing, traditional taxi, and private car) according to the travel time and travel cost of each of the mentioned transportation systems, has been discussed in each of the six statuses. Whereas many private car and ride-hailing drivers use navigation applications such as Waze and Google Map to determine the optimal route with the least traffic and travel time, the travel time variable (within the vehicle) for private car and ride-hailing options is obtained according to the estimated time for the optimal route between the known origin and destination by Google Map application, and for the traditional taxi option, is obtained according to field research on the intended path in the morning and evening peak hours. The variable of travel cost for a private car has been calculated by considering the current annual expenses according to the prices in 2019 for a Pride car due to its multiplicity and prevalence. These costs include parking costs, fuel consumption based on distance traveled, insurance, car maintenance during the year according to the prices in 2019. This variable for a traditional taxi has been the same price approved by the Taxi Organization of Tehran in each of the known lines so that for Sanat Square to Vanak Square has been \$0.31 for Vanak Square to Seyed Khandan Bridge has been \$0.37 and for Seyed Khandan Bridge to Resalat Square has been \$0.21 (in general approximately, 1 US Dollars is equal to 100,000 Iranian Rials in November and December 2019). For ride-hailing on the mentioned routes, both in the morning peak hour (7 to 8 a.m.) and the evening peak hours (6 to 8 p.m.), the prices in the Snapp application have been calculated every 10

minutes for a week on November 2019. The mean of them is considered as the price of ride-hailing for that route at that time (commuting trips in the morning peak hours and non-commuting trips in the evening peak hours).

Sample size and data collection

According to the statistics published in 2017, among 700,000 trips made every day and night in Iran, which was made by the Snapp service, 420,000 trips were made by the residents of Tehran metropolitan region (Etmiani-Ghasrodashti and Hamidi, 2019). The minimum size of the statistical population according to these statistics, and by using Cochran's formula based on knowing the statistical population volume (Cochran, 1963), the number of 384 samples were obtained. In this study, 414 questionnaires were completed and collected. Data were collected from people living in Tehran on December 2019, in the form of face-to-face polls in collaboration with a questioning statistical team within the geographic location of studied routes. That is around the Sanat Square, Vanak Square, Seyed Khandan Bridge, and Resalat Square. So that initially, the person was asked whether he lives in Tehran or not, and if the answer was yes, he/she has been questioned.

Study area

This article seeks to investigate the effect of individual's demographic characteristics on their travel mode choice in 22 districts of Tehran. The study area and the geographic location of intended routes in this research is shown in Fig. 2.

Data

In order to modelling the choice of travel mode, the statistical data of the questionnaires were used, which are described in Table 1 and lists all the cases related to the demographic characteristics of the respondents in the survey as the independent variables used in the model. As can be seen, the variables of gender, marriage, having a child in the household, having a driver's license, and owning private car are defined in the form of binary variable, which success (variable equal to one) and failure (variable equal to zero). The variables of the number of household members, number of households employed members, and the number of cars in the household are defined continuous and integer. Also, other variables are defined dummy in the modeling process in which the first or last category is considered as the base category and is not included in the model. Furthermore, the dependent variables in this article are options of the private car, traditional taxi, and ride-hailing.

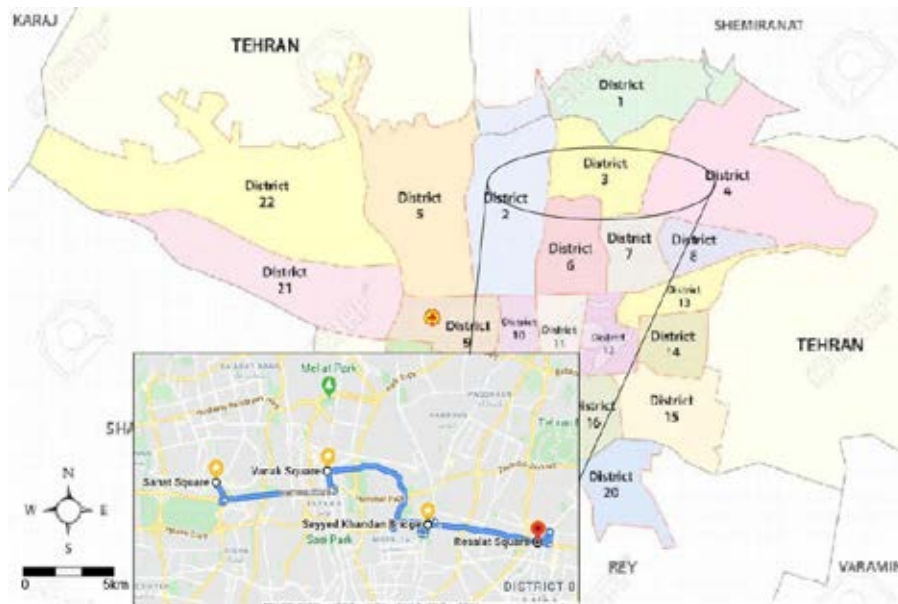


Fig. 2: Study area and geographic location of intended routes

Table 1: Descriptive statistics and definition of variables

Independent variables	Definition	Abbreviation in models	Count	Percentage
Gender	Male (Gender=1)	Gender	250	60.4%
	Female (Gender=0)		164	39.6%
Marital status	Married (Marital=1)	Marital	194	46.9%
	Single (Marital=0)		220	53.1%
Age	Age between 18-29 years	Age 18-29	203	49%
	Age between 30-39 years	Age 30-39	98	23.7%
	Age between 40-49 years	Age 40-49	73	17.6%
	Age between 50-59 years	Age 50-59	27	6.5%
	Age more than 60 years	-	13	3.2%
Job	Student	Student	98	23.7%
	Government employee or companies	Employee	158	38.2%
	Self-employment or businessman	Self-employee	114	27.5%
	Unemployed or retired	No job or retired	18	4.3%
	Other	-	26	6.3%
Monthly income (\$1 is equal to 100,000 Iranian RIALS in December 2019)	Less than \$200	-	18	4.3%
	Between \$200 to \$300	\$200-\$300	53	12.8%
	Between \$300 to \$400	\$300-\$400	61	14.7%
	Between \$400 to \$500	\$400-\$500	92	22.2%
	Between \$500 to \$600	\$500-\$600	52	12.6%
	Between \$600 to \$800	\$600-\$800	63	15.2%
Educational Level	More than \$800	More than \$800	75	18.1%
	Diploma & lower	Diploma	96	23.2%
	Post-diploma & bachelor's degree	Bachelor	169	40.8%
	Master's degree	Master	132	31.9%
	PHD	-	17	4.1%
Number of household members (household dimension)	One person	-	18	4.3%
	Two persons	-	67	16.2%
	Three persons	HHD	111	26.8%
	Four persons	-	142	34.3%
	Five persons or more	-	76	18.4%
Number of households employed members	No employed	-	3	0.7%
	One person	-	183	44.2%
	Two persons	HHEN	164	39.6%
	Three persons	-	45	10.9%
Number of cars in the household	Four persons or more	-	19	4.6%
	No car	-	49	11.8%
	One car	-	238	57.5%
	Two cars	HHCN	97	23.5%
Having child in the household	Three cars	-	23	5.5%
	Four cars or more	-	7	1.7%
	Yes (Have household child=1)	-	115	27.8%
	No (Have household child=0)	HHCh	229	72.2%
Having driver's license	Yes (Have driving license =1)	-	343	82.9%
	No (Have driving license =0)	DL	71	17.1%
Owning private car	Yes (Car ownership =1)	-	190	45.9%
	No (Car ownership =0)	CO	224	54.1%
Duration of residence in Tehran	Less than 1 year	-	20	4.8%
	Between 1 to 5 years	TRT 1-5Y	51	12.3%
	More than 5 years	TRT more than 5Y	343	83.9%
Residential area in Tehran	Northern areas	N residential	97	23.4%
	Western areas	W residential	61	14.7%
	Eastern areas	E residential	137	33.1%
	Southern areas	S residential	38	9.2%
	Central areas	-	81	19.6%

RESULTS AND DISCUSSION

Individual's travel mode choice

Diagrams of the choice of each travel modes by the respondents between the alternatives of the private car, traditional taxi, and ride-hailing (modal split) according to the six statuses for short, medium

and long-distance travel in each of the trips with commuting purposes (work and study) in the morning peak hours and with non-commuting purposes (recreation, shopping, social, etc.) in the evening peak hours are shown in Fig. 3a and 3b, respectively. According to these figures, it can be seen that the

Effect of ride-hailing services on individual's travel mode choice

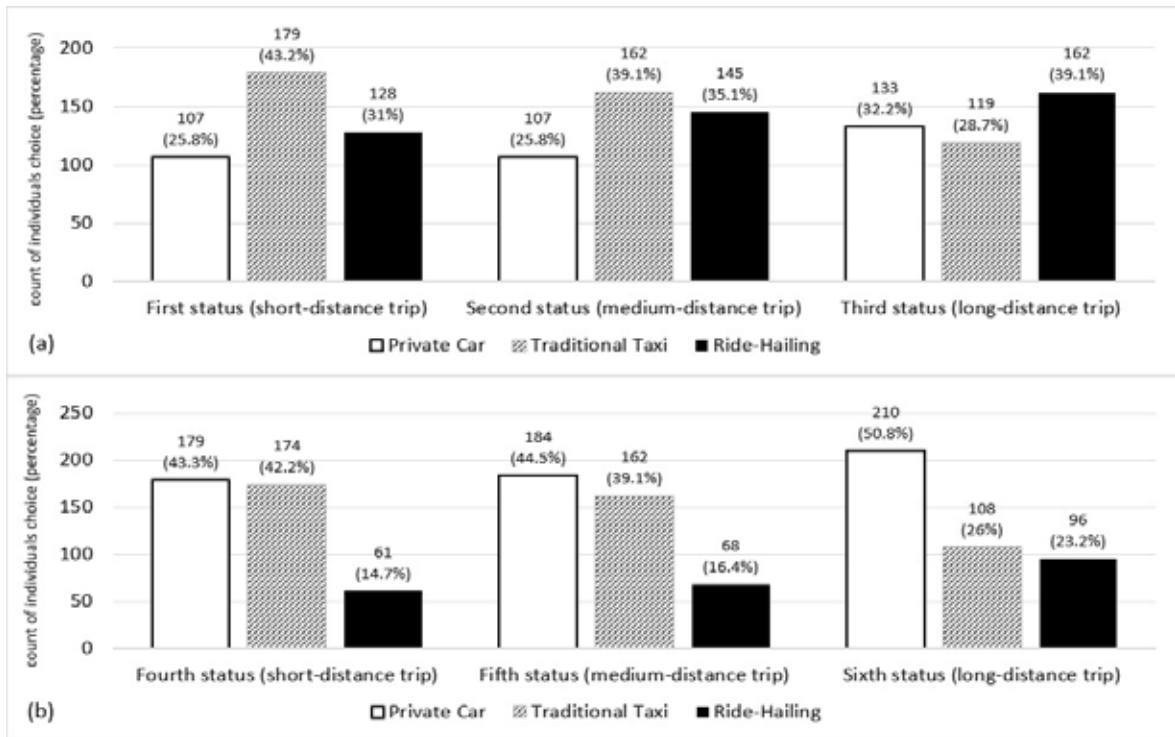


Fig. 3: Frequency distribution chart of individuals' chosen travel modes for: (a) commuting trips in the morning peak hours, (b) non-commuting trips in the evening peak hours

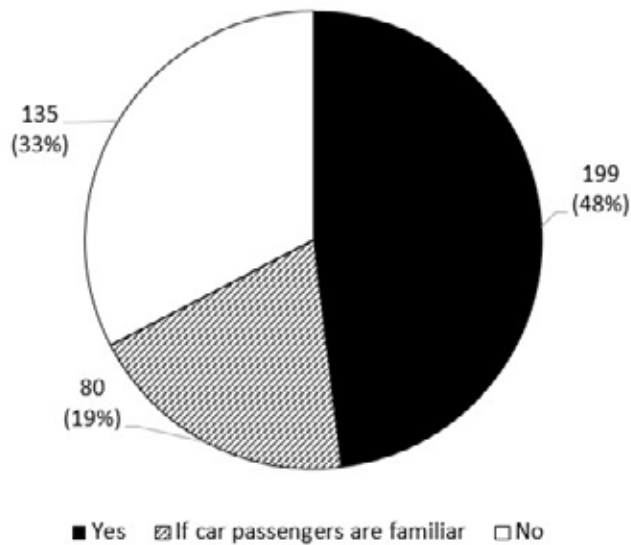


Fig. 4: Frequency distribution chart of individuals' willingness to share ride-hailing

demand of individuals to choose the option of ride-hailing for commuting trips in the morning peak hours is clearly higher than non-commuting trips in the evening peak hours, and vice versa for private car. Also, in general, the demand for traditional taxis is higher than the other two modes; however, with increasing travel distance, this demand decreases.

Willingness to share ride-hailing

According to previous studies result, other flexible and collective transports such as the emerging ridesharing and shared ride-hailing services might be, in some situations, more convenient means of transport (Gilibert *et al.*, 2020). In this section, the degree of respondents’ willingness to the shared use of ride-hailing services if the travel destinations of passengers are close to each other is presented in Fig. 4. As can be seen, the highest relative frequency with 48% is related to people who agree with the shared use of ride-hailing regardless of other car passengers and by taking into account the other 19% for whom passenger familiarity is important, the 67% of people can be considered willing to use these services:

Model estimation results

In this article, in order to analyze the data and inference about the choice of individuals’ travel mode

in each of the six statuses, it has been investigated what variables are identified to be significant and have an influence on the choice of individuals’ travel mode in the proposed statuses. In this modeling, the ride-hailing option is considered as a reference alternative, and the private car and traditional taxi options are considered as the first and second alternatives. In the modeling process for each status, a multinomial logit model is fitted to choose the Private Car as the first alternative compared to the Ride-Hailing as the reference alternative (PC/RH) and the Traditional Taxi as the second alternative compared to the Ride-Hailing as the reference alternative (TX/RH) for short, medium and long-distance travel in the form of commuting trips at the peak hours of the morning and non-commuting trips at the peak hours of the evening. Thus, the variables that have become significant at the 95% confidence level in the models, which means that the variables for which the P-value is less than 0.05 and according to this the t-statistic is out of the critical range (-1.96 and +1.96) is presented in Tables. 2, 3, 4, 5, 6 and 7:

According to above tables, the utility functions for each status in choosing Private Car and Traditional Taxi compared to Ride-Hailing (PC/RH and TX/RH) is expressed in Eqs. 6, 7, 8, 9, 10, 11, 12, 13 14, 15, 16 and 17 as follows:

Table 2: Result of multinomial logit model for 1st status

1 st status	Variables	Coefficient	P-value (t-statistic)
PC/RH	HHCh	0.885	0.028 (2.210)
	DL	1.131	0.050 (1.968)
	CO	0.879	0.031 (2.164)
TX/RH	Marital	-0.845	0.021 (-2.317)
	Age 30-39	-1.995	0.033 (-2.140)
	More than \$800	-1.637	0.042 (-2.039)

Table 3: Result of multinomial logit model for 2nd status

2 nd status	Variables	Coefficient	P-value (t-statistic)
PC/RH	DL	1.670	0.004 (2.917)
	Student	1.310	0.040 (2.062)
	No job or retired	1.915	0.027 (2.226)
	\$200-\$300	-1.672	0.028 (-2.204)
	More than \$800	-2.182	0.005 (-2.769)
TX/RH	HHCN	-0.648	0.003 (-3.025)
	DL	1.154	0.002 (3.117)
	E residential	0.957	0.012 (2.525)
	N residential	0.898	0.034 (2.121)
	W residential	1.011	0.021 (2.323)

Table 4: Result of multinomial logit model for 3rd status

3 rd status	Variables	Coefficient	P-value (t-statistic)
PC/RH	HHCh	0.811	0.029 (2.185)
	DL	1.258	0.016 (2.423)
	CO	0.923	0.011 (2.549)
TX/RH	Age 18-29	-2.852	0.005 (-2.827)
	Age 30-39	-3.199	0.002 (-3.136)
	Age 40-49	-2.582	0.011 (-2.546)
	More than \$800	-1.608	0.030 (-2.171)

Table 5: Result of multinomial logit model for 4th status

4 th status	Variables	Coefficient	P-value (t-statistic)
PC/RH	Age 50-59	-2.224	0.045 (-1.999)
	HHCN	0.905	0.002 (3.133)
TX/RH	Constant	3.294	0.050 (1.977)

Table 6: Result of multinomial logit model for 5th status

5 th status	Variables	Coefficient	P-value (t-statistic)
PC/RH	Age 50-59	-2.458	0.036 (-2.097)
	HHCN	0.991	0.005 (3.522)
	Constant	5.624	0.005 (2.835)
	Marital	-1.217	0.015 (-2.450)
TX/RH	\$200-\$300	2.394	0.044 (-2.021)
	More than \$800	-3.135	0.011 (-2.565)
	HHEN	-0.538	0.030 (-2.176)
	E residential	1.240	0.008 (2.662)

Table 7: Result of multinomial logit model for 6th status

6 th status	Variables	Coefficient	P-value (t-statistic)
PC/RH	Marital	-1.215	0.007 (-2.716)
	HHCN	0.945	0.001 (3.555)
	DL	1.124	0.011 (-2.564)
	CO	1.121	0.007 (2.727)
	TRT 1-5Y	2.062	0.008 (2.691)
	TRT more than 5Y	0.954	0.050 (1.966)
	Constant	3.536	0.031 (2.161)
TX/RH	Marital	-1.355	0.002 (-3.179)
	\$200-\$300	-1.716	0.015 (-2.451)
	\$400-\$500	-1.952	0.023 (-2.285)
	More than \$800	-2.380	0.007 (-2.747)
	HHCN	-0.548	0.025 (-2.242)
	CO	-1.021	0.008 (-2.687)

Table 8: Final results of goodness of fit and validation of models in six statuses

	1 st status	2 nd status	3 rd status	4 th status	5 th status	6 th status
Maximum log-likelihood	-122.197	-140.796	-142.691	-154.460	-218.917	-194.230
McFadden's R ²	0.137	0.157	0.158	0.185	0.258	0.227
P-value in Hosmer-Lemeshow test	0.219	0.212	0.296	0.086	0.183	0.211

$$U_{1^{st} \text{ status, PC/RH}} = \log \left(\frac{P(Y = \text{private car in } 1^{st} \text{ status})}{P(Y = \text{ride-hailing in } 1^{st} \text{ status})} \right) = \quad (6)$$

$$0.885 \times HHCh + 1.131 \times DL + 0.879 \times CO$$

$$U_{1^{st} \text{ status, TX/RH}} = \log \left(\frac{P(Y = \text{traditional taxi in } 1^{st} \text{ status})}{P(Y = \text{ride-hailing in } 1^{st} \text{ status})} \right) = \quad (7)$$

$$-0.845 \times Marital - 1.995 \times Age30 - 39 - 1.637 \times Morethan \$800$$

$$U_{2^{nd} \text{ status, PC/RH}} = \log \left(\frac{P(Y = \text{private car in } 2^{nd} \text{ status})}{P(Y = \text{ride-hailing in } 2^{nd} \text{ status})} \right) = 1.670 \times DL \quad (8)$$

$$U_{2^{nd} \text{ status, TX/RH}} = \log \left(\frac{P(Y = \text{traditional taxi in } 2^{nd} \text{ status})}{P(Y = \text{ride-hailing in } 2^{nd} \text{ status})} \right) =$$

$$1.310 \times Student + 1.915 \times No \text{ job or retired} - 1.672 \times \$200 - \$300 - 2.182 \times Morethan \$800 - 0.648 \times HHCh + 1.154 \times DL + 0.957 \times E \text{ residential} + 0.898 \times N \text{ residential} + 1.011 \times W \text{ residential} \quad (9)$$

$$U_{3^{rd} \text{ status, PC/RH}} = \log \left(\frac{P(Y = \text{private car in } 3^{rd} \text{ status})}{P(Y = \text{ride-hailing in } 3^{rd} \text{ status})} \right) = \quad (10)$$

$$0.811 \times HHCh + 1.258 \times DL + 0.923 \times CO$$

$$U_{3^{rd} \text{ status, TX/RH}} = \log \left(\frac{P(Y = \text{traditional taxi in } 3^{rd} \text{ status})}{P(Y = \text{ride-hailing in } 3^{rd} \text{ status})} \right) = \quad (11)$$

$$-2.852 \times Age18 - 29 - 3.199 \times$$

$$Age30 - 39 - 2.582 \times Age40 - 49 - 1.608 \times Morethan \$800$$

$$U_{4^{th} \text{ status, PC/RH}} = \log \left(\frac{P(Y = \text{private car in } 4^{th} \text{ status})}{P(Y = \text{ride-hailing in } 4^{th} \text{ status})} \right) = \quad (12)$$

$$-2.224 \times Age50 - 59 + 0.905 \times HHCh$$

$$U_{4^{th} \text{ status, TX/RH}} = \log \left(\frac{P(Y = \text{traditional taxi in } 4^{th} \text{ status})}{P(Y = \text{ride-hailing in } 4^{th} \text{ status})} \right) = 3.294 \quad (13)$$

$$U_{5^{th} \text{ status, PC/RH}} = \log \left(\frac{P(Y = \text{private car in } 5^{th} \text{ status})}{P(Y = \text{ride-hailing in } 5^{th} \text{ status})} \right) = \quad (14)$$

$$-2.458 \times Age50 - 59 + 0.991 \times HHCh$$

$$U_{5^{th} \text{ status, TX/RH}} = \log \left(\frac{P(Y = \text{traditional taxi in } 5^{th} \text{ status})}{P(Y = \text{ride-hailing in } 5^{th} \text{ status})} \right) = \quad (15)$$

$$5.624 - 1.217 \times Marital - 2.394 \times \$200 - \$300 - 3.135 \times Morethan \$800 - 0.538 \times HHCh + 1.240 \times E \text{ residential}$$

$$U_{6^{th} \text{ status, PC/RH}} = \log \left(\frac{P(Y = \text{private car in } 6^{th} \text{ status})}{P(Y = \text{ride-hailing in } 6^{th} \text{ status})} \right) = \quad (16)$$

$$\log -1.215 \times Marital + 0.945 \times HHCh + 1.124 \times DL + 1.121 \times CO + 2.062 \times TRT1 - 5Y + 0.954 \times TRT \text{ more than } 5Y$$

$$U_{6^{th} \text{ status}, TX/RH} = \left(\frac{P(Y = \text{traditional taxi in } 6^{th} \text{ status})}{P(Y = \text{ride-hailing in } 6^{th} \text{ status})} \right) = \log \left(3.536 - 1.355 \times \text{Marital} - 1.716 \times \$200 - \$300 - 1.952 \times \$400 - \$500 - 2.380 \times \text{More than } \$800 - 0.548 \times \text{HHCN} - 1.021 \times \text{CO} \right) \quad (17)$$

Furthermore, the information about the goodness of fit and validation of the models is provided in [Table 8](#), which includes the value of the maximum likelihood function and the *McFadden's R²* index to evaluate the goodness of fit of each of the fitted models in each of the six statuses; According to the ([McFadden, 1974](#); [Cohen et al., 2002](#); [Hu et al., 2006](#)), the accuracy of the fitted models is appropriate. Moreover, Hosmer–Lemeshow test was used to models' validation. Given that the P-value in the Hosmer–Lemeshow test for these models is higher than 0.05 ([Hosmer and Lemeshow, 2004](#)), the test shows that the fitted models are all appropriate.

Interpretation of results

According to the created models, variables of gender, educational level, and household dimension were not significant at the 95% confidence level. In other words, these variables in the above models do not affect the choice of travel mode of individuals. Unlike some studies in Western countries ([Young and Farber, 2019](#); [Rayle et al., 2016](#); [Tirachini and Río, 2019](#)), in Iran, this article does not confirm the effect of gender, education, and the household dimension of individuals. The variable of individuals' age in the first status in the category of 30 to 39 years, and in the third status in the categories of 18 to 29 years, 30 to 39 years and 40 to 49 years, have become significant with negative coefficients in the utility of choosing a traditional taxi compared to ride-hailing. In other words, in this article, younger people increase the utility of choosing ride-hailing services compared to traditional taxis. Besides, this variable in the fourth and fifth statuses in the category of 50 to 59 years, have become significant with negative coefficients in the utility of choosing a private car compared to ride-hailing. This choice by the elderly can be due to inability, avoidance of driving, or lack of driver's license. Individuals'

monthly income variable in the first and third statuses in the category more than \$800, in the second and fifth statuses in the categories between \$200 to \$300 and more than \$800 and in the sixth status in the categories between \$200 to \$300, \$400 to \$500 and more than \$800 were all have become significant with negative coefficients in the utility of choosing a traditional taxi compared to ride-hailing. Significance of the income range more than \$800 per month in all statuses except the fourth status indicates that with increasing income, people tend to use ride-hailing compared to traditional taxis. Therefore, individuals' income factor can be named as one of the motivating factors for people to use ride-hailing services. Besides, in this study, the individual's income amount does not affect the utility of choosing a private car compared to ride-hailing. The job variable of individuals in the second status in the categories of students and unemployed or retired have become significant with positive coefficients in the utility of choosing a traditional taxi compared to ride-railing; The results of this variable indicate that people who do not have a permanent job (student or unemployed) are likely, for economic reasons, to be less inclined to use ride-railing and prefer the traditional taxi option. The variables of having child in the household and owning private car in the first and third statuses, as well as having driver's license in the first, second and third statuses in the utility of choosing a private car compared to ride-railing were all have become significant with positive coefficients. Therefore, it can be concluded that these three variables can be used as a deterrent factor to the use of ride-hailing services, especially on commuting trips in the morning peak-hours. The variable of the number of cars in the household in the fourth, fifth, and sixth statuses in the utility of choosing a private car compared to ride-hailing have also become significant with a positive sign. This result indicates that the increase in the number of cars in the citizens' household directly affects their use of private cars compared to ride-hailing, especially on non-commuting trips during the peak hours of the evening. Therefore, the variable of the number of cars in the household is also one of the deterrent factors in the use of ride-hailing. Also, the variable of residency time between one to five years and more than five years in the Tehran metropolitan regions in the sixth status has become significant

with a positive sign in the utility of using a private car compared to ride-hailing. From this factor, it can be concluded that Tehran citizens who have lived in Tehran for a long time, especially on their non-commuting long-distance travel, prefer to use their private cars.

CONCLUSION

Ride-hailing services as a newfound mode of transportation have grown significantly and are expected to continue to evolve. However, while it becomes stable in the urban transportation market, the impact of passenger behavior on the choice of this travel mode, both in short and long-distance urban trips, remains unknown. This article seeks to spread the existing studies by understanding trip behavior and demographic characteristics of individuals to use ride-hailing on trips with different distances, and commuting and non-commuting purposes. The various results of this article are as follows: As shown in the [Fig. 3a and 3b](#), demand for ride-hailing option for commuting trips in the morning peak hours is clearly higher than non-commuting trips in the evening peak hours. This choice may be due to the fact that the passenger goes to work or study in the early-morning hours and spends several hours until the afternoon at work and study place, and during these hours, there is practically no need to trip and reuse the private car. As a result, instead of using a private car, which sometimes has problems such as parking and traffic restrictions at the location of the destination, the passenger prefers to use the best second option ([Mahmoudifard et al., 2017](#)) after a private car, which is the ride-hailing. It does not have the problems of a private car and provides more comfort and less travel time than other modes of transportation, including public transportation and traditional taxis. It should be noted that for non-commuting trips in the peak hours of the evening, the predominant demand of people has been to use a private car. This choice may be due to the fact that these trips may be multi-destination, which can last until the last hours of the night. At this time, despite security concerns, in order to return home, other modes of transportation will not be readily available, in which case a private car is the best option in terms of comfort and safety in the late hours of the night. It is also observed that with increasing travel distance,

the individuals' tendency to choose a private car and ride-hailing increases, and the choice of traditional taxi mode decreases. But in general, the demand for traditional taxis is higher than private cars and ride-hailing, although this high demand for traditional taxis seems to originate from its lower travel cost than the other two modes. The demand for this mode of transportation also decreases in a long-distance trip, which can be due to a significant increase in travel time compared to the other two methods. In addition to the direct relationship between the number of cars in the household and the choice of the private car instead of ride-hailing, especially in non-commuting trips during the peak hours of the evening and according to the analysis of descriptive statistics, it indicates the higher choice of the private car in these trips; In order to reduce the utility and multiplicity of private car ownership in the household and thus minimize the use of private cars, the government and responsible organizations by adding public transport stations and terminals and traditional taxis in areas where public transportation modes are less available, as well as increasing public transportation service in areas where there is insufficient service; Besides, disposal policies in this regard, such as parking and fuel pricing, can have a negative impact on the use of private cars. As another result in evaluating the models, considering the significance of the three variables of having a child in the household, having a driver's license and owning a private car in all statuses of the commuting trip in the morning peak hours, indicates that people with a driver's license, owning a private car and also having a child (under 12 years old) in the household, prefer to use the option of the private car instead of the ride-hailing for commuting trip (for example, trips for their work or education of their children). In this field, the Transport and Traffic Organization of Tehran Municipality, with the necessary policies, including restricting the movement of private cars in the peak hours of the morning in the central core of the city and districts with high population density and traffic, should reduce the desirability of owning a private car for such trips. Also, the significance of both private car ownership and the presence of a child in the household for the utility of choosing a private car on these trips show the safety and security concerns of parents about sending their children to school and,

also, the lack of alternative and safe transportation mode. To this end, ride-hailing companies can attract a large share of trips by adding services for transporting children. Thus, many people who prefer a private car for their commuting trips in the morning peak hours, gradually turn to this mode of travel due to the convenience and many similarities that it has to travel by the private car. According to the modeling performed and the non-significance of the gender variable can be concluded that there was no gender sensitivity in choosing this mode of travel in this study. As a result, while there are public concerns of some women for safety and social security in the city, this can be considered as a sign of high safety and security of this mode of travel in public opinion, and it is necessary for the companies providing these services to maintain the safety of passengers, especially women. According to the results presented on the age and income of individuals similar to most studies conducted in Western countries (Rayle *et al.*, 2016; Dias *et al.*, 2016; Conway *et al.*, 2018), ride-hailing services can be considered a wealthy phenomenon and for the young generation. Therefore, in order for this travel mode to become widespread, the government must use the media to direct public opinion towards the use of the internet and technology for all segments of society, including the elderly, and thus to encourage citizens to choose this new mode of transportation for urban travel. Also, companies providing these services can adopt policies to reduce travel fares and offer special discounts and tariffs, to be successful in attracting and encouraging people with lower than average incomes, including young people and students, who are generally unemployed and do not have much income. As future studies, walking and public transportation modes (bus rapid transit and subway) can be considered in urban transportation, because many respondents in the survey process stated that they use public transportation to a great extent. Therefore, comparing ride-hailing and public transportation in metropolitan regions is also one of the important issues. Moreover, investigating the willingness of people to use ride-hailing at a lower price but sharing the ride with other people if their travel destinations are close to each other, given the 67% response of individuals incline to use ride-hailing services in a shared way, which is presented in Fig. 4., it is one of the most important and

thought-provoking issues in this regard, which can be considered as a separate mode of transportation.

AUTHOR CONTRIBUTIONS

A. Edrisi conceived and defined the idea of research. H. Rezaei performed the literature review and conducted the field research, questionnaires, and sampling with the statistical team of the survey. E. Edrisi and H. Rezaei modeled and analyzed the data. H. Rezaei wrote the article. A. Edrisi revised the draft manuscript and finalized and approved the manuscript.

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CONFLICT OF INTEREST

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

ABBREVIATION

CO	Car Ownership
DL	Driving License
HHCh	Household Child
HHCN	Household Car Number
HHD	Household Dimension
HHEN	Household Employee Number
MNL	Multinomial Logit
PC	Private Car
RH	Ride-Hailing
TNC	Transportation Network Company
TRT	Tehran Residence Time
TX	Traditional Taxi
Y	Years

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ORIGINAL RESEARCH PAPER

Suitable site selection for urban green space development using geographic information system and remote sensing based on multi criterion analysis

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ABSTRACT

BACKGROUND AND OBJECTIVES: The study was conducted with the objective of selecting suitable site for urban green space development of Arba Minch town in Ethiopia using geographic information system and remote sensing based multi criterion analysis.

METHODS: To produce suitable site, four parameters were considered, these are slope, land use land cover, distance to the main river and distance to road. Supervised classification followed by reclassification were done to classify suitable land use land cover for urban green space, digital elevation model data were used to generate slope suitability and buffering with different distance were used to produce suitable site using distance to the road and distance to the main river parameters. Although a variety of techniques exist for the development of weight, one of the most promising techniques was the Pairwise Comparison Matrix in the context of a decision making process known as the Analytical Hierarchy Process and ratings were provided on a nine-point continuous scale, which ranges from 1 to 9.

FINDINGS: So, on the bases of the ranks given by the experts the highest value was calculated for river which was 51.28%. The result shows that high suitability accounts 36.3 % of the total area, 45.5 % of the area is moderately suitable and the remaining 18.5 % of the town is not suitable for urban green space.

CONCLUSION: The most important parameters to predict the location of urban green space in the study area were distance to the main river followed by distance to the road as the experts' rate it. Although, slope and land use land cover parameters are very important, they do not seem to have noticeable effect on urban green space development as of the experts' response.

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INTRODUCTION

In today's changing world, values and standards of human were changed with urbanization (Bayram and Gökyer, 2012). Urban green space is a component of "green infrastructure". It is an important part of public open spaces and common services provided by a city and can serve as a health-promoting setting for all members of the urban community (World Health Organization, 2017). In the other way it is defined as those land uses and land covers that are covered with natural or man-made vegetation in the city and planning areas (Bayram and Gökyer, 2012). Urban areas always present some risk of flooding when rainfall occurs. Buildings, roads, infrastructure and other paved areas prevent rainfall from infiltrating into the soil and so produce more runoff. Heavy and prolonged rainfall produces very large volumes of surface water in any city. In well-governed cities, this is rarely a problem because good provision for storm and surface drainage is easily built into the urban fabric, with complementary measures to protect against flooding for instance, the use of parks and other areas of open space to accommodate floodwaters safely from unusually serious storms (Satterthwaite, 2008). Urbanization is now a common feature of all third world countries. Primate cities and megacities are emerging in developing countries. In Asia, Africa and Latin America, the unprecedented population growth that characterized much of the 20th century has evolved into unparalleled urban growth (Brockerhoff, 2000). In order to realize sustainable and environmentally friendly urbanization, there is an urgent need for comprehensive land use planning and of urban settlements by giving due consideration to create and sustain urban green spaces (UGS) such as parks, gardens, roadside vegetation, etc... (Ramaiah and Avtar, 2019). Because of urbanization the global atmospheric concentration of CO₂ in 2005 was approximately 379 parts per million, an increase from a pre-industrial value of about 280 parts per million. The approximate lifetime of CO₂ in the atmosphere is 50 to 200 years (UN-HABITAT, 2011). Throughout the world, urban areas have been increased in size over recent decades (Sandstrom, 2002; Cohen *et al.*, 2006). The United Nation report indicates that currently more people of the world (54 %) are living in urban centres and by 2050 urban environment will need to accommodate an additional 2.6 billion people, pushing urbanization to 86% in the

developed world and 64% in the developing countries (United Nation, 2014). Urbanization leads to the occupation of green areas, directly contributing to a high level of fragmentation of urban green spaces, which, in turn, results in numerous socioeconomic and environmental problems. Consequently, an understanding of the relationships between patterns of urban green spaces and urbanization processes is essential (Li *et al.*, 2019). In Ethiopia, most of the urban canters are unable to meet the minimum standard proposed by World Health Organization that is urban green area components per person is 9m² (Girma *et al.*, 2019). For instance in some Ethiopian cities like Adama, Shashemene, Dese, Jijiga, Dire Dawa and Bahir Dar had 2.1 m², 1.9 m², 3.1 m², 3.8 m², 5.6 m² and 8.2 m² urban green area components per person, respectively (Ministry of Urban Development and Housing, 2015). Moreover, urban green area components are poorly accessible (Gondo, 2012), they are not well developed and they lack basic facilities discouraging urban dwellers to utilize them (Hailegiorgis, 2017). The environmental impacts of urbanization in Ethiopia include the negative health consequences of crowding and increased exposure to concentrated waste, unsustainable resource consumption and settlement on environmentally fragile land (Mekonnen and Kohlin, 2008). So the issue of urban planning should be given much emphasis in order to reduce all environmental consequences resulted from rapid urbanization rates (Mikyias, 2011). Article 44 of the Ethiopian Constitution states that the people of Ethiopia have the right to live in a healthy environment

(Mpofu, 2013). The share of the population living in cities has increased from an estimated 7.1% in 1994 (Lamson-Hall *et al.*, 2018) to 16% in 2016 and is expected to reach 60% by 2040 at the current annual growth rate of 3.5% (United Nations, 2014; Lamson-Hall *et al.*, 2018). The selection of suitable sites for specific land uses must be based upon a set of local criteria to ensure that the maximizing cost benefit ratio for a community is attained. The various characteristics of a site (e.g. present land use, slope, water availability, distance to employment, development costs, surface water quality, urbanization, slope, landscape quality etc...) influence its suitability for a specific land use. A scoring and weighting system can be applied to the various aspects of suitability to assess the overall suitability

for a specific land use (Hazrat, 2019). According to the Arba Minch town municipality report the dominant green spaces available in the town are unplanned left over spaces which are reserved for future settlement programs. In the town priority is given for urban expansion than urban greening and majority of the investment of the town administration goes to housing expansion. Left over spaces are now become places of solid waste disposal which in turn affect the health of the peoples in the town. Even different green areas found in the peripheral area of the town are rigorously depleted in seeking of housing expansion for growing population. This makes the town climate to get worse (Wonbera, 2019). This indicates that there is a need for the development of urban green spaces such as large urban parks, area closure, public green spaces and others so as to keep the urban environment balanced with disturbances resulted from different sources (Weldegebrerial, 2013). The major purpose of this study were to identify the potential value of remote sensing and GIS techniques in selecting suitable site for urban green space system using different variables, so as to answer question of: Where is the suitable area for UGS using distance to the main river parameter? Where is the suitable area for UGS using land use land cover of the study area?

Where is the suitable area for UGS using distance to road and slope parameters? And how are overlay of all single factor maps processed to generate the suitability map of urban green space system in the study area. The studies were carried out in Arba Minch town, Ethiopia in the year of 2019.

MATERIALS AND METHODS

Study Area

Arba Minch town is one of the rapidly growing urban areas of Ethiopia. It is located in the Southern Nations, Nationalities and Peoples Region at about 505 km south of Addis Ababa (the capital city of Ethiopia) and 275km of Hawasa (the capital of the regional state). Currently the town is serving as the capital of GamoZone. The geographical location of the town extends from 5°8'26"N to 6°3"22"N and 37°32'13"E to 37°36'20"E as the grids levelled in Fig. 1. The elevation of Arba Minch ranges between 1100 and 1350meter above sea level in altitude which makes the town one of the lowland places of the country (Wonbera, 2019).

The procedure used in the current study is stated in Fig. 2, which is beginning from the acquisition and classification of multi-temporal satellite image of the study area to the extraction of the required

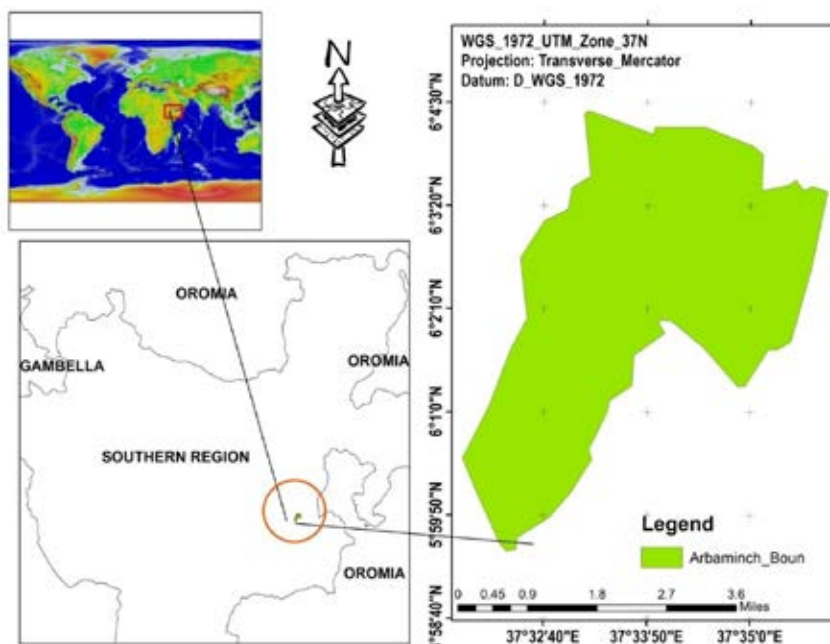


Fig. 1: Locational Map of the study area

suitability site selection. Both quantitative and qualitative research designs were employed in this study. So it was mixed type of research. Difficulties to come with successful result with a single research design, the primary and secondary data to be used in the study were analysed in both research design methods (qualitatively and quantitatively). The study employed judgmental sampling. The reason why the researcher uses this technique were since it is based on the researcher decision, since the issue of urban green space is mostly known by environmentalist and urban planners, this study by applying this method and selected ten sample respondents (six environmentalist and four urban planners) and they were interviewed to rate the suitability factors urban green space. To achieve the stated objectives both primary and secondary data were collected from various data sources. The primary data for the study were collected from ground truth data, key informant interview, and field observation while secondary data was collected from reviewing documents, books, internet and other related written materials obtained from governmental and non-governmental institutions. And AHP ranking method which was

developed by saaty (1987) were used to rank as it is described in Table 1.

Slope was extracted from DEM data of 20 m spatial resolution. The analysis of slope was based on surface analyst of Arc GIS spatial analyst tool box. Classification followed by reclassification was done in the software. And the Land Use Land Cover (LULC) factor analysis was based on the acquisition of Landsat images. This was followed by image analysis for specifying the LULC classes of the study area based on the GPS points for classification. For compatibility of this data with other maps, standardization using reclassification method from spatial analyst of Arc GIS environment are used. Distance to the road and distance to the main river were analysed using road and river exported from the master plan of study area. Buffering technique was done followed by masking at the extent of the study area after rasterization depending on the distance set. Reclassification was applied to analyse the suitable sites. Traditional methods of GIS site selection are based on the transformation of effective layers into a classified map, such as using a Boolean model or Index Overlay operations. Nowadays, the GIS approaches used in

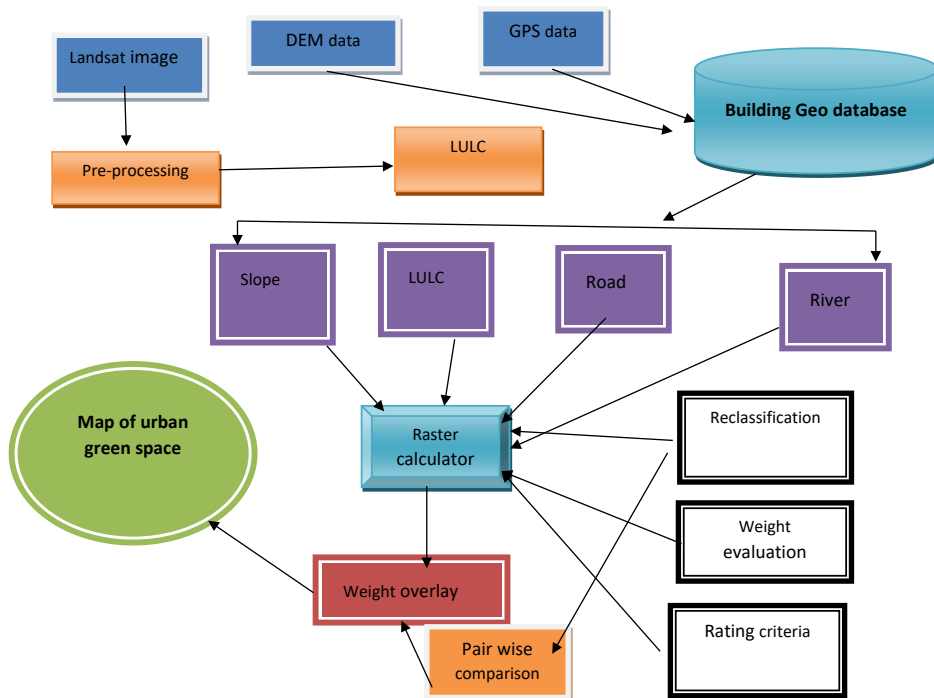


Fig. 2: Flow Chart Illustrating the Process of Digital Image processing

Table 1: Sample of AHP rating of factors for urban green space suitability by experts

Factors	LULC	Slope	River	Road
LULC	1			
Slope		1		
River			1	
Road				1

the site selection usually are network analysis, spatial analysis, proximity analysis, MCA with AHP, FAHP or ROM, etc. (Lina and Wu, 2012). In the case of this study, GIS-based MCA with AHP wins the bidding. GIS-based MCA includes two essential parts: factor criteria and constraint criteria. Each of the criteria is appeared as a map layer, no matter for factor or constraint criterion. Factor maps are represented as spatial distributions to display the opportunity criteria and the quality of achieving an objective. Constraint maps are limitations or restrictions which prohibit certain elements to be taken into account the analysis (Malczewski, 2006). Correspondingly, the GIS-based MCA includes two major methods: weighted summations procedures and Boolean overlay operations. As for the weighted summations procedures, the weighted linear combination of factor criteria is shown as Eq. 1

$$S = \sum w_i f_i \tag{1}$$

Where, S = Suitability to the objective being considered,

w_i = Weight of factor i [the sum of all weights equal 1],
 f_i = Criteria score of factor i.

As for the Boolean overlay operations, the formula for the constraint criteria is depicted in Eq. 2

$$C = C_1 * C_2 * \dots * C_n \tag{2}$$

Where C = Integrated constraint

C_n = Criteria score of constraint n

After the factor criteria and constraint criteria being settled separately, the GIS-based MCA process integrates them together by multiplying S with C, and gets the final result. But in this research the first method of MCEA were applied. GIS-based MCA has been widely used in various studies, especially in the resources allocation and land suitability evaluations (Lina and Wu, 2012). When all kinds of ecological factors' influences on the specific land use are

very obvious, it can't make a direct overlay to get the composite suitability. It must take advantage of the method of weighted score. The principle of this method is similar to that of the equal-weight summation. The difference is that it needs to identify each factor's relative importance (weight) in the weighted score. Saaty (1987) has shown that this weighting of activities in MCDM can be dealt with using a theory of measurement in a hierarchical structure. The analytic hierarchy process (AHP) is a comprehensive, logical and structural framework, which allows improving the understanding of complex decisions by decomposing the problem in a hierarchical structure (Al-Shalabi et al., 2006). The incorporation of all relevant decision criteria, and their pair wise comparison allows the decision maker to determine the trade-offs among objectives. The AHP allows decision-makers to model a complex problem in a hierarchical structure showing the relationship of the goal, objectives (criteria), sub-objectives, and alternatives. Uncertainties and other influencing factors can also be included. It is not only supports decision makers by enabling them to structure complexity and exercise judgment, but also allows them to incorporate both objective and subjective considerations in the decision process saaty (1987) as cited in Al-Shalabi et al., (2006).

RESULT AND DISCUSSION

Problems existing in the green space system

Public green space are not uniformly distributed in the town in addition to this greening rate is relatively low in contrast to numerous population in the urban centre. And some of the parks are not well protected from external influence. There is no uniform distributed park system integrated with large scale parks, middle scale parks and small scale parks. The ecological diversity is poor it lacks science and rationality to distribute the parks. That is more and more green areas are continuously replaced by other commercial land use every year. In the study

area, one of the urban construction emphases is to improve the environmental quality in the residential areas and the work unities. However, now it only focuses on the housing construction, regardless of the residential green spaces. Particularly residential greening is the weakness in the urban centre. So, greening rate of residential districts and work units is relatively low in the study area. Moreover, the quality and management of residential green space are not very good (Xiao, 2009).

Suitability analysis of green space system based on GIS

Stakeholder analysis for suitability

Stakeholders are those whose interests are affected by the issue or those whose activities strongly affect the issue. Stakeholder Analysis is a vital tool for identifying those people, groups and organizations who have significant and legitimate interests in specific urban issues. Clear understanding of the potential roles and contributions of the many different stakeholders is a fundamental prerequisite for a successful participatory urban governance process, and stakeholder analysis is a basic tool for achieving this understanding (Hemmati, 2002). As such, two group stakeholders are involved in the analysis. Six urban planners and environmentalist, who has experience in UGS, were invited for in-depth interview. This group provided the most vivid interview, mostly about the potential for the development of tourism and the problems existing in the green space system. Four urban planners acknowledged that a suitable green space system could not only play an ecological role, but also attract more tourists just because of its rational layout and high landscape quality. But two planners only concerned about the ecological benefits of urban green spaces. They felt the most important was that green spaces can effectively clean air, improve urban climate and eliminate noise, and social benefits such as improving landscape quality, historic culture value and economic benefits were not very important. Overall, the group accepted the comment that the problems existing in the green space system were because it was not systematically planned and the number of green spaces was not enough. The other and the main reason according to the group were high in-migration of the peoples from the surrounding areas which

makes urban greening to shrink since they need housing to live in and this land can be get from the peripheral part of the town, in this areas forests are the dominant land covers which will be deforested for settlement. So, urban planners had the responsibility to solve these problems by planning a suitable green space system. The group of environmentalists comprised four individuals. They were mostly concerned about the pollution being generated by degrading the urban environment; the existing green spaces were not enough compared with the fast increase of urban population. If possible, urban green spaces can be expanded at the expense of other land uses, as long as they can play an ecological role to the urban environment.

Current land use land cover of the study area

A modern nation, as a modern business, must have adequate information on many complex interrelated aspects of its activities in order to make decisions. Land use is only one such aspect, but knowledge about land use and land cover has become increasingly important as the Nation plans to overcome the problems of haphazard, uncontrolled development, deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands, and loss of fish and wildlife habitat. Land use data are needed in the analysis of environmental processes and problems that must be understood if living conditions and standards are to be improved or maintained at current levels (James et al., 2001).

The current land use land cover of the study area falls in five classes shown in Fig. 3 they are urban agriculture, forest, built-up area, banana plantation and barren land. The majority of the study area is covered by built-up areas which accounts 1666 ha of the total area. In decreasing order of the share of the coverage banana plantation come next, urban agriculture, barren land and forest which account 969, 385, 237 and 37 hectare respectively.

Green space site selection factors in the study area

Land Use Land Cover /LULC/ suitability

This suitability classes of LULC of the study area was done in two three classes this are high suitability, moderate suitability and no suitability. The study area was classified in two five land use land cover classes. This are urban built ups, urban agriculture, banana

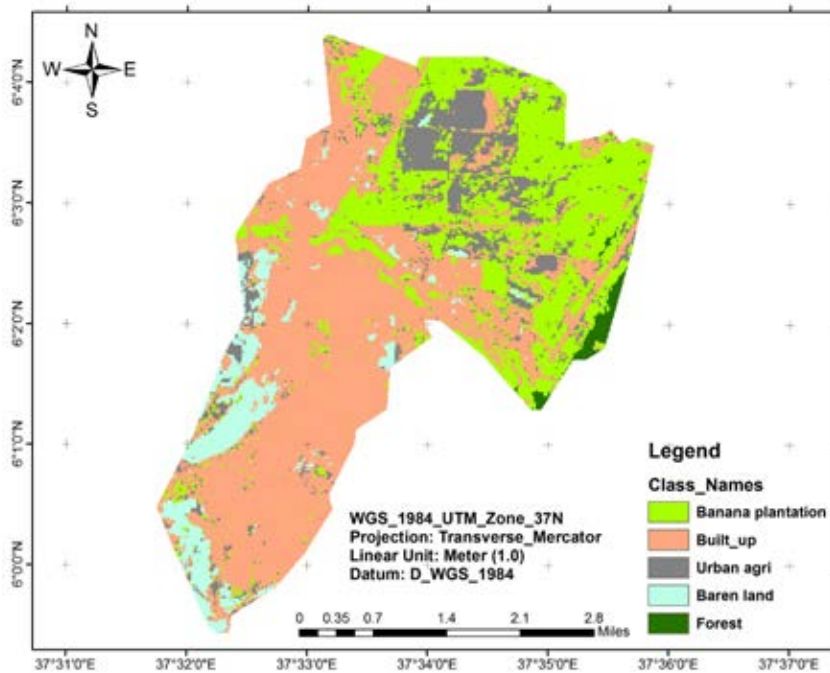


Fig. 3: Map of 2017 land use land cover of the study area

plantation, barren land and forest. This land use and cover classes are classified in to three suitability ranges in terms of their importance for urban green space site suitability analysis. In their suitability level, banana plantation is categorized under high suitability class; while urban agriculture, forest and barren land area categorized under moderate suitability classes and the remaining land use class that is built-ups are perceived as no suitability for urban green space site selection (Li *et al.*, 2018). As shown in Fig.4 land use land cover suitability, areas in which built up land use classes are not suitable for urban green space, so the central area of the town are not suitable for urban green space since most of the town built ups are concentrated at the centre of the town. The moderately suitable areas are urban agriculture areas, forest areas and barren lands. The other areas of the town which are found in the peripheral part of the town are very suitable for urban green space since this area is mostly covered by banana plantation and this is very suitable for urban green space. So considering LULC suitability in the town the green areas should be located outside of the built up areas, that means one has to think the peripheral (remote) and near the central areas to site urban green space.

According to the interview with the urban planner the built-ups are left with no suitability because the town was not planned, which is constructed randomly with no plan in the past, so it needs compensation for the peoples to make urban green space on behalf of the built-ups which is difficult for the municipality.

The percentage share show that 29.4 % of the total area are categorised as high suitability because this area is covered with banana plantation and this land cover type is highly suitable according to James *et al.*, (2001) and 20.1 % of the area are moderately suitable and this land is covered by urban agriculture, forest and barren land. The remaining 50.5 % of the land is totally not suitable for urban green space this is mainly due to the land is covered by built-ups. Now a day, the municipality of the town also gives expansion of housing for the rapid population growth. So emphasis should be given for urban green space also since the expansion of built-ups is mainly done on behalf of the extinction of forests which are moderately suitable for urban green space.

Slope suitability

Slope is the measurement of the rate of change of elevation of the land per unit distance. This slope data

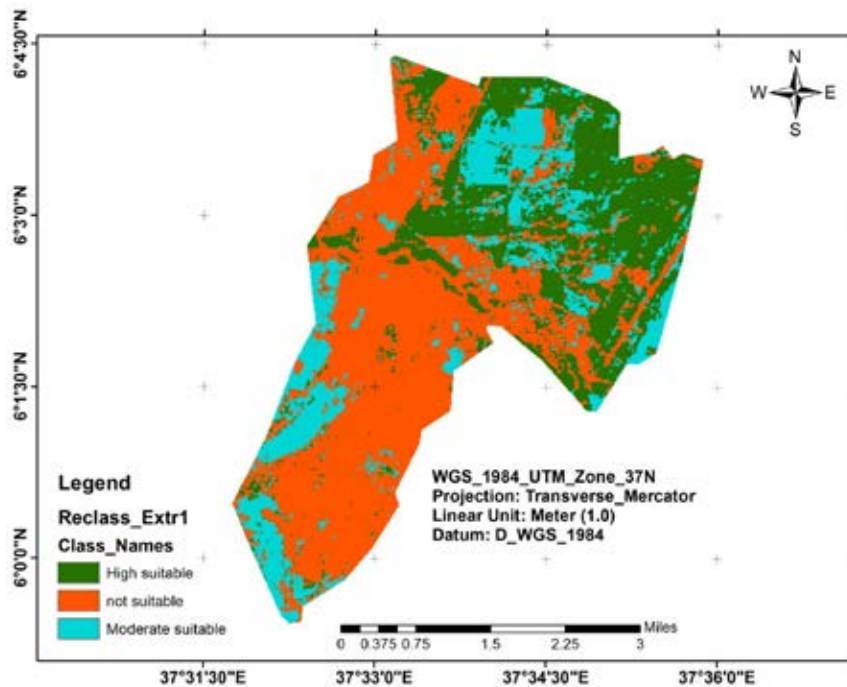


Fig. 4: Reclassified map of land use land cover factor

was generated from DEM with the spatial resolution of 20 meter. According to Manlun, (2003) the range suitably lies in to three classes. That is slope from 0-5 is categorized as high suitability, slope from 5-15 in the other way categorised as moderate suitability and slope which is above than 15 are no suitability and not recommended for urban green space development. On behalf of this standards majority of the study area falls suitable. Most part of the central as well as the peripheral part of the study area slope is categorized in suitable class for urban green space development. Fig.5 shows the suitability of slope for urban green space development. From the total area around 25 km² of the area is categorized under high suitable and moderate suitability. The remaining 8 km² is the only slope which is not suitable for urban green space development.

Distance to the main river suitability

Arba Minch has one major river which falls all year round. The suitability levels of distance to the main river were done within three ranges of suitability classes. Areas within the buffer of 250 m from the river is in the suitability range of high, areas between

250m and 750 m are moderately suitable and above 750 m from the main river are not totally suitable for urban green space (Manlun, 2003). The main rivers of the town were exported to shape file from the master plan of the study area. Buffering in to different distance followed, after this reclassification to different range of suitability classes was done. According to the reclassified data the central part of the town in which the river *Kulfo* flows is highly suitable for urban green space as shown in Fig. 6. From the field observation data the researcher found one public recreation area near the *Kulfo* River.

The calculated area shows 15.2 % is suitable for urban green space. Since this areas are not far more than 250 m from *Kulfo* River. And the other 48.3% of the area falls in the suitability range of moderate suitability. This range of suitability is in the distance between 250 m to 750 from the main river of the town. The remaining 36.5 % in the graph below is not suitable for urban green space and since this area is far more than 750 meter from the main river. According to (Manlun, 2003), areas which are far 750 meter away from the main river are categorized as no suitability.

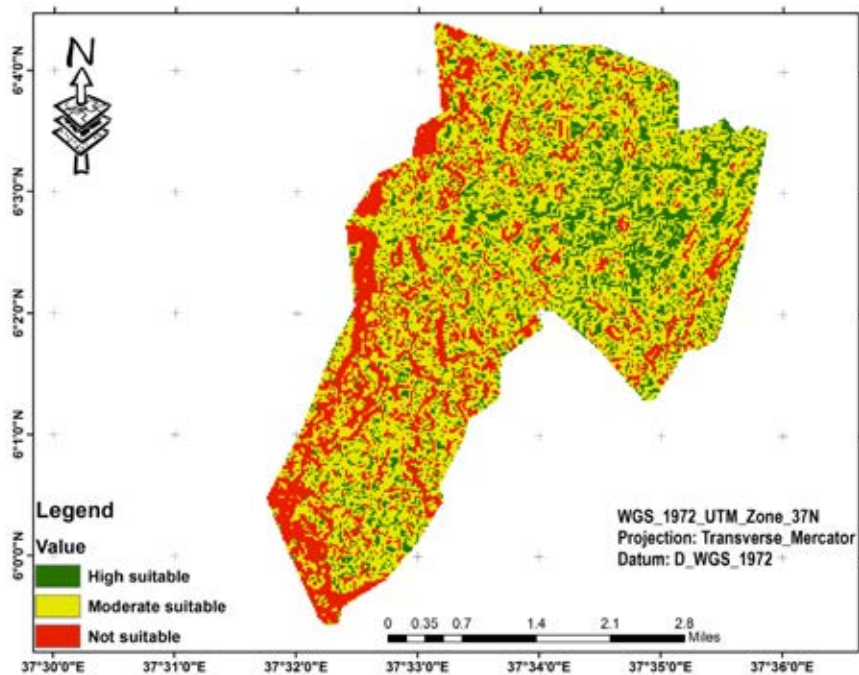


Fig. 5: Slope suitability analysis results

Distance to road suitability

English Nature believes that local authorities should consider the provision of natural areas as part of a balanced policy to ensure that local communities have access to an appropriate mix of green spaces providing for a range of recreational needs. English Nature recommends that provision should be made of at least 2ha of accessible natural green space per 1000 population. No person should live more than 300m from their nearest area of natural green space. Thus taking this data in to account areas with the buffer of 300m form the main road is considered as high suitability. And between 300m-600m buffer distance are considered as moderately suitable areas and greater than 600 m are not suitable for urban green space according to English nature. The major road of the town was exported to the shape file in Arc GIS from the town master plan of the town. After this multiple ring buffering followed and the major road buffering done with three ranges of suitability classes. That is areas within 300 m form the main road and between 300m to 600m and above than 600m. After multiple ring buffering technique has got over, rasterization by distance followed and masking to the shape of the area were done. The last step

was reclassification of the buffer road on the bases of the criteria which was set by English nature. Areas within 300m are high suitable between 300 to 600m are moderate suitable and above than 600 m are classified as permanently not suitable for urban green space site selection (Fig. 7). So, on the base of this data most areas of the town in which this road falls are highly suitable within 300 m distance from the road in any direction. So remote (peripheral) part of the town are not suitable for urban green space this is mainly due to absence of major roads on such areas and there remoteness from the major road of the town since it is above 600 m form the main road (Badri and Houssaini, 2012).

Considering distance to the main road factor, 40.6% of the land is highly suitable for urban green space and 25% of the land is moderately suitable and 34.4 % of the land is not suitable for urban green space since these areas are found far from the main road. So a total of 65.6% of the area is suitable for urban green space.

Weight results

In order to apply multi criteria evaluation (MCE), a set of relative Weight was assigned for each variable

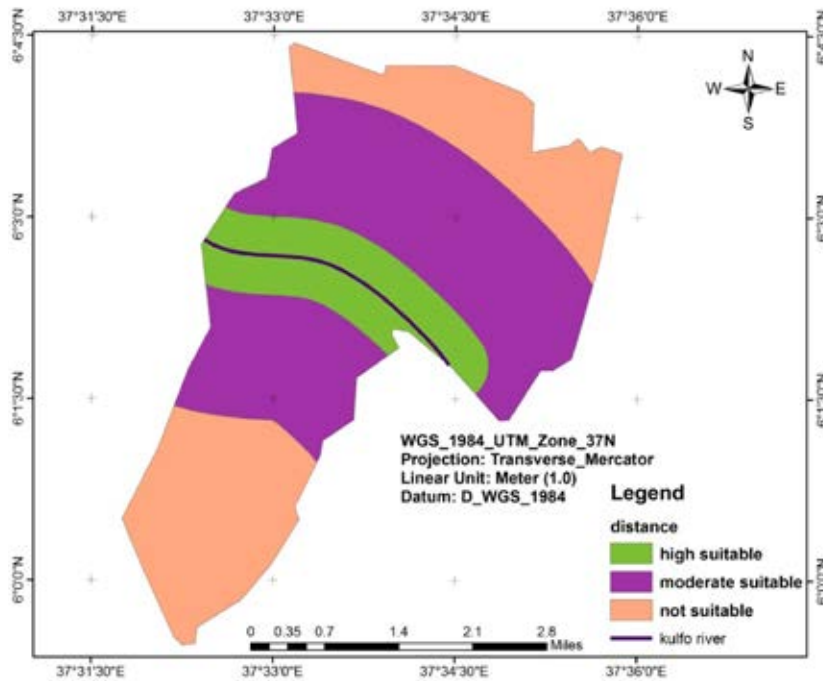


Fig. 6. Reclassified distance to the main river suitability factor

using weight module of IDRISI Andes software. The procedure was followed using continues rating scale developed by [saaty \(1987\)](#) The weights calculated for each variable were the results of pair-wise comparisons of each variable based on the relative importance for urban green space suitability. The ranks of the factors were done by experts, and based on the rank given by the experts IDRISI Andes were used to weight this ranks. The ranks are given by the experts as shown in the [Table 2](#).

As shown in the [Table 2](#) which is ranked by experts, river is considered as the first principal for urban green space site suitability, road as the second factor, slope and LULC were considered as the third and the fourth respectively. So, on the bases of the ranks given by the experts the highest value was calculated for river which is 51.28%. The consistency ratio of the matrix was acceptable which 0.005. Consistency Ratio (CR) is used to measure how consistent the judgments have been relative to large samples of purely random judgments. If the CR is much in excess of 0.1 the judgments are untrustworthy because they are too close for comfort to randomness and the exercise is valueless or must be repeated.

The overall suitability analysis for the potential of

urban green space development was then made by overlaying each of the suitability intermediate factor maps. The Weighted Overlay tool applies one of the most used approaches for overlay analysis to solve multi-criteria problems such as site selection and suitability models ([Lina and Wu, 2012](#)). The Weighted Overlay tool used to implement several of the steps in the general overlay analysis process within a single tool.

The tool combines the following steps:

- Reclassifies values in the input raster into a common evaluation scale of suitability or preference, risk, or some similarly unifying scale
- Multiplies the cell values of each input raster by the weight of importance
- Adds the resulting cell values together to produce the output raster

In a weighted overlay analysis, each of the general overlay analysis steps is followed. The respective eigenvector weight for LULC, slope, river and road is calculated as it is shown above in [Table 3](#). So the final suitable map can be obtained by multiplying this eigenvector weight by each of the factors and adding this all factors and this were done in raster calculator.

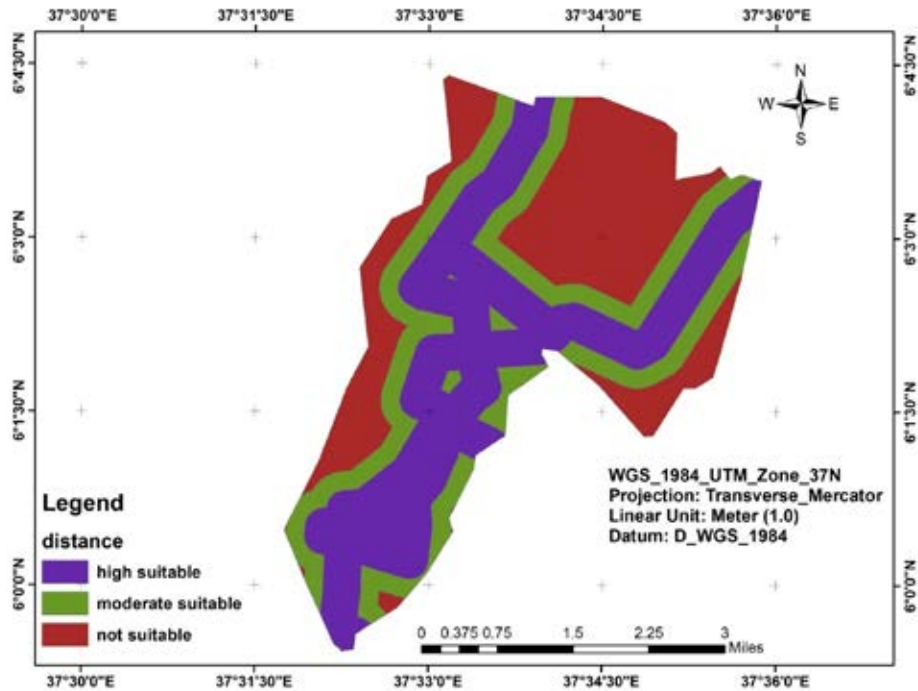


Fig. 7: Reclassified map of distance to the main road factor

Table 2. Compared and rated relative importance between row and column variables for UGS using the Pairwise Comparison Nine Point continuous rating scale

Factors	LULC	Slope	River	Road
LULC	1			
Slope	3	1		
River	7	5	1	
Road	5	3	1/3	1

In the raster calculator the weighted eigenvector for each factor multiplied by its corresponding classified factors and summing up of each factors were done.

$$\text{Final urban green space map} = 0.0634 * \text{"classified map of LULC"} + 0.1290 * \text{"classified map of slope"} + 0.5128 * \text{"classified map of river"} + 0.2615 * \text{"classified map of road"}$$

So based on the above formula it was written as the software understands in the raster calculator. The Raster Calculator tool allows creating and executing Map Algebra expressions in a tool. Like other geo-processing tools, the Raster Calculator can be used in Model Builder, allowing the power of Map Algebra to be more easily integrated into workflows in addition to this; Raster Calculator is designed to execute a

single-line algebraic expression using multiple tools and operators using the calculator tool interface. As the experts rate distance to the main river as the highest which accounts around 51 % of the other factors (Table 3), this is high suitable area of urban green space goes in line with the direction of the river. The high suitable area for urban green space based on distance to the main river is Less than 250m buffer, and the overall weighted overlay map of the study area shows the high suitable area of urban green space is concentrated in line with this factor. Since this factor has got 51% of weight by the experts. The effect of distance to the road is also visible especially in the north eastern and north western part of the study area. Road parameter has got rank of the second next to distance to the main river which

Table 3. The weight of factors calculated for urban green space suitability map

Factors	LULC	Slope	River	Road	Weight	Weight (%)
LULC	1				0.0634	6.34
slope	3	1			0.1290	12.90
river	7	5	1		0.5128	51.28
Road	5	3	1/3	1	0.2615	26.15

Consistency ratio = 0.05

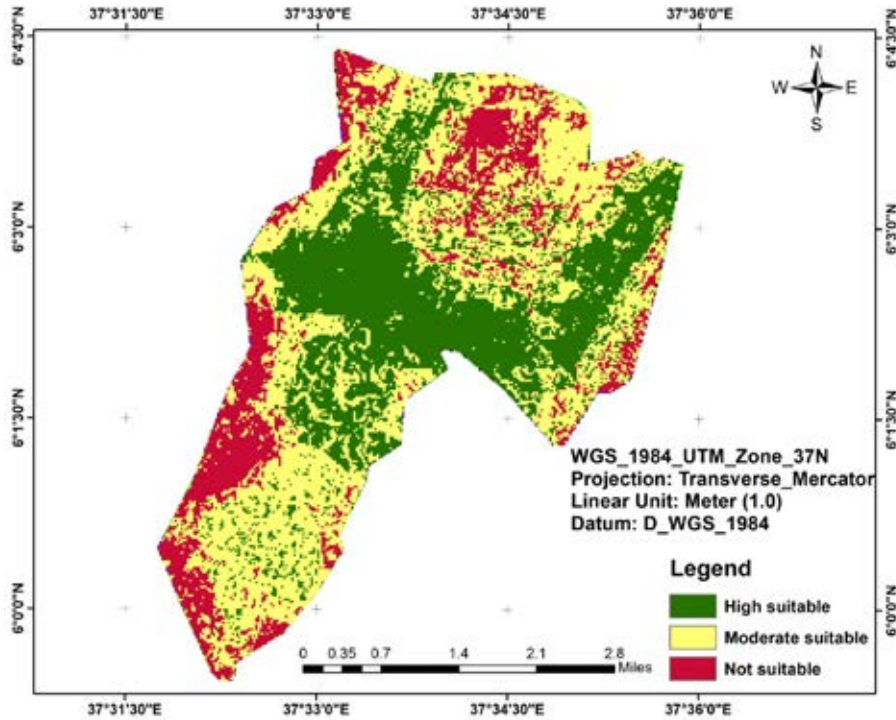


Fig. 8: Final weighted overlay map of suitability ranges of urban green space of the study area.

has a weight of 26%. So more than 75% of the overall weighted overlay map of the study area suitability for urban green space is determined by this two factors. The same is true for moderate suitability of weighted overlay map. As shown in the Fig. 8, the yellow colour indicates the moderate suitable area. It goes in line with the distance to the main river factor suitability. In the other way areas which are not suitable for green space are dispersed in the whole study area. But it is mostly concentrated in the built-ups and according to (James *et al.*, 2001) these built-ups are not suitable for urban green space.

The result of weighted overlay map was done to see the percentage of the range of suitability factors. The high suitability accounts 36.3 % of the total area,

45.5 % of the area is moderate suitability and the remaining 18.5 % of the study area is left which is not suitable for urban green space. In the same way this area is not suitable in the final weighted overlay map of the study area. Generally 81.8% of the study area has potential for green space development.

CONCLUSION

Urbanization remains a single predominant factor that is continuously linked to the destruction of urban green spaces. In Ethiopia, urban green areas have been consumed by industrial, commercial, residential and infrastructural developments, as well as by spontaneous and illegal settlements along mountain slopes, river valleys and other open spaces. However,

following the Rio Summit held in Brazil in 1992, Ethiopia took a number of initiatives to address its environmental problems, including minimizing environmental impacts induced by the urbanization process. In Arba Minch town, some green spaces are being converted to the other land uses every year. This has caused some serious environmental consequences, increased soil temperature, local climate change, instability in hydrological regime and loss of important species and all of which ultimately have negative effect on ecological environment and human settlement. So selecting suitable site for green space system by considering four environmental and socio economic parameters that is slope, land use land cover, distance to the Main River, and distance to road infrastructure are very essential for the study area. Different data, materials and software's were employed to generate suitable green space site for the study area. To produce suitable site for green space system in the study area four parameters are considered. These are slope, land use land cover, distance to the main river, and distance to road. After identifying all the parameters the next step were to go through with different data processing and analysis methods. As the expert's rate distance to the main river as the highest this accounts around 51 % of the other factors. This is high suitable area of urban green space goes in line with the direction of the river. The high suitable area for urban green space based on distance to the main river is Less than 250m buffer, and the overall weighted overlay map of the study area shows the high suitable area of urban green space is concentrated in line with this factor. Since this factor has got 51% of weight by experts. The effect of distance to the road is also visible especially in the north eastern and north western part of the study area. This road has got rank of the second next to distance to the main river which has a weight of 26%. So more than 75% of the overall weighted overlay map of the study area suitability for urban green space is determined by this two factors. On the basis of the findings and conclusion drawn with respect to suitable site selection for urban green space development using geographic information system and remote sensing multi criterion analysis, the following recommendations are identified.

✓ It's better if the urban green space of the town goes in line with the river *kulfo*, the software result shows that as well there will be a chance of getting water from the river all year round.

- ✓ One of the main cause for diminishing of urban green space is high migration from the surrounding *kebeles* to the study area, so the concerned body needs to give due attention for illegal settlements especially in the peripheral part of the town.
- ✓ It will be good other studies incorporate soil as one factor in selecting urban green space.

AUTHOR CONTRIBUTIONS

B. A. Hailemariam performed conceptualization, methodology, literature review, manuscript preparation, writing original draft preparation, writing reviewing, and editing references and did all the software tasks.

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CONFLICT OF INTEREST

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

ABBREVIATION

%	Percent
AHP	Analytical Hierarchy Process
CR	Consistency Ratio
DEM	Digital elevation model
GPS	Global positioning system
LULC	Land use Land cover
MCA	Multi criteria Analysis
MCE	Multi criteria evaluation
UGS	Urban Green Space
USGS	United States Geological Survey

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